User Perceptions of Safety and Security: A Framework for a Transition to Electric-Shared-Automated Vehicles

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The paper has been edited to correct minor typographical errors, improve clarity and continuity, and to add two references that were omitted from the original (König, M. and L. Neumayr (2017) and Nordhoff et al (2016)). Given the non-substantive nature of these corrections, no new publication date is assigned. This version supersedes the former version.

16. Abstract

The confluence of vehicle electrification, sharing and pooling, and automation alters petroleum-fueled, human-piloted, and privately-owned and operated vehicles for personal mobility in ways that raises such questions as, "Are such systems safe and secure?" and, "Who is being kept safe and secure from what (or whom)?" Answers are implied by filling in the "who" and "whom" of the second question: system, product, producer, road, and user. This white paper focuses on (actual and potential) users of systems of electrically-powered, shared, and automated vehicles (e-SAVs) as well as other road-users, e.g., pedestrians and cyclists. The role of user perceptions of safety and security are reviewed to create an initial framework to evaluate how they may affect who will initially use systems of e-SAVs for personal mobility and how safety and security will have to be addressed to foster sustained transitions. The paper will primarily be a resource for e-SAV user research, but will also inform system development, operation, and governance. This white paper offers an overarching framework grounded in the social theory of "risk society" and thus organizes past work that, typically, focuses on only one of the constituent technologies or on one dimension of safety or security, e.g., collision avoidance as a subset of road safety.

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Author's Note

This white paper started with the idea that addressing the possibilities of different people becoming users of systems of electric-powered, shared and pooled, autonomous vehicles (e-SAVs) could be informed by a holistic view of possible safety and security concerns and benefits that systems may pose with respect to existing modes of daily travel, but primarily petroleum-fueled, privately owned vehicles driven by the owner (or other human). The intent was to document research that had been done, plans that had been formulated, policies that had been drafted or implemented. This white paper became an effort to document what has not been done. As such, much of what follows could be taken as a critique of work that did not do what it never set out to do. Many authors have described the users of electric vehicles (EVs), shared and pooled vehicles (SVs), and of some of the sub-systems of automated vehicles (AVs). Fewer have addressed who the users may be of integrated systems of e-SAVs—attempting to put the "socio" in socio-technical systems. Many authors across many disciplines have written on safety and security of transportation systems; fewer specifically address the intersections of EVs, SVs, and/or AVs. In short, this white paper has become a more difficult task of documenting the absence of something: a coherent approach to the possibility that different users and potential users of e-SAVs may perceive and experience different constellations of safety and security benefits and costs to their "immediate self" accessing, traveling on, or egressing e-SAVs as well as to their "virtual self" represented by the data created in the process of those three. As such, what may read here as complaint about what has not been done is intended to give credit for what has been done, while pointing to the possibilities for doing more.

EXECUTIVE SUMMARY

One of the primary conclusions of this white paper is that multiple definitions—and often a lack of definitions—of basic terms such as *safety* and *security* limits our understanding of how users' and potential users' perspectives affect the prospects for and implications of integrating electric-power vehicles (EVs), sharing and pooling of vehicles (SVs), and vehicle automation (AVs) into systems of e-SAVs. Therefore, this report starts by stating definitions for several key terms.

Safety is defined here to be the condition of being secure from accidental harm; *security* is defined to be the condition of being safe from intentional harm. The review of other concepts of safety and security across literatures on EVs, SVs, and AVs reveals that road safety—the potential to reduce accidental collisions—and cybersecurity—the protection from outside attack on user or system data—dominate. These are extended and elaborated in this paper with examples that illustrate the use of intention to distinguish between safety and security as proposed here.

A contribution of this discussion is to highlight the role of trust to support safety and security. Concepts of risk, uncertainty, and trust are related to safety and security. *Risk* describes situations in which an action may lead to more than one outcome. *Uncertainty* is the extent to which the possible outcomes and their probabilities are unknown. *Trust* is a willingness to accept vulnerability to the actions of other actors—in this case other e-SAV users, system operators and regulators, as well as non-users. To provide a base for the distinction of safety and security based on intent as well as to link these to risk, uncertainty, and trust, Beck's (1986) "risk society" is introduced. Giddens (1984, 1991, 1999) argues that to sustain an ongoing sense of self within risk society, actors—people and institutions—require ontological security; broadly, we have to trust the world around us. Trust requires us to be willing to make ourselves vulnerable.

To define the socio-technical system of e-SAVs considered here, the following definitions of three sub-systems are provided. Electric-powered vehicles (EVs) include plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and hydrogen fuel cell electric vehicles (FCEVs). For vehicle automation, SAE's (2016) Level 5 "fully automated driving" is the focus of this white paper, though evidence of safety and security concerns are reported from studies of lesser automation. Shared (and pooled) vehicles (SVs) facilitate sharing a vehicle with an additional passenger who has separately arranged for a ride. The term "pooled ridesharing" is used to refer to the specific case of strangers making contemporaneous use of a vehicle. The discussion allows for solo and pooled use, though looks toward pervasive pooled ridesharing.

While there is much still to be done before systems of e-SAVs are operational much less pervasive, the importance of understanding user perspectives can be seen in the effect these perspectives may have on the ultimate success—or at least the pace—of any transition. Lee et al (2018) report a greater than 50% increase in the number of respondents who state they would be willing to use a "self-driving vehicle" when the framing shifts from general willingness

(40%) to a more specific case of a self-driving vehicle that "is as good a driver as [the respondent]" (65%).

If the traveling public's acceptance of e-SAVs and the achievement of claimed road safety improvements of AVs depend on the traveling public resolving their personal risk constellations of e-SAVs, then the publics' skepticism of vehicle automation represents a barrier. The review of polling data on Americans' beliefs about vehicle automation indicates that from their present perspectives people are, at best, divided. However, the research also indicates that peoples' responses to AVs are shaped by how automated driving is defined and how safety information is presented. This last point is supported by results from other travel modes in which travelers exert no control over the vehicle.

That we may expect different people to see the same system of e-SAVs represent different personal risk constellations is evidenced by work to date on the users of the constituent technologies (EVs, SVs, and AVs), their combinations, and even other modes. Differences have been observed between demographic groups in the uptake and use of EVs, SVs, and AVs. The specific case for how women and men can be expected to have different concerns for safety and security has been used as an example to illustrate the existence of groups of people who may systematically differ in their personal risk constellations. Such differences as these overlay other reasons why we expect differences in personal risk constellations: from individuals' psychological traits, to household location and mobility contexts, to land use patterns and regional transport infrastructure systems, as well as the responsiveness of e-SAV system designers, operators, and regulators to attend to a multitude of safety and security constellations.

To address such differences, this white paper hypothesizes personal "users' risk constellations" as users' perceptions of safety and security issues pertaining to electric-drive, shared, and automated vehicles, and in particular the integration of these three socio-technical systems into systems of e-SAVs. Grunwald (2016) inferred users as "affected parties" or "beneficiaries" in what he termed "societal risk constellations." More than another "point" in societal risk constellations, it is hypothesized that users' risk constellations identify groups of users by how they perceive and experience arrangements of safety and security concerns and benefits. From these hypotheses flow these research questions:

1. Do different users and potential users of e-SAVs perceive different risk constellations?
    a. If so, what are those constellations?
    b. How does the integration of electrification, automation, and sharing or pooling affect those constellations?
2. Do these constellations vary systematically by characteristics of users?
3. As a matter of how to create and sustain transitions, how do answers to questions such as these affect societal risk constellations?

The answer offered here to the first of these questions is, "We don't know." The search for evidence of such constellations revealed no prior work that asked this or a similar question regarding e-SAVs. Some work has been done in the areas of SVs and AVs though typically addressing limited concepts of safety or security; results are reviewed in this paper.

The research questions laid out above form elements of a research agenda. The question of framing—of research questions, of information presented to respondents, and of information to audiences of potential users—relates to the relevance of several of the specific results presented in this paper for the constituent socio-technology systems of e-SAVs: EVs, AVs including those that operate at less than SAE Level 5, and SVs. The relevance flows from the argument that if people will have personal risk constellations for e-SAVs, then they already have or had such constellations for the systems of travel modes they use now.

Pulling these arguments together, examples of more specific research questions would include:

1. Do people have personal risk constellations for EVs, AVs with partial automation capabilities, and SVs whether they use them or not?
    a. If so, what are the elements of those constellations
    b. How do people form and make meaning of them?
    c. How do the constellations shape use, prospective use, or rejection?
        i. For example, if an SV user has a perception that they are secure from harm from a crime committed by the "stranger" that is their SV driver because they know the driver is registered with a company that required a background check on the driver, will (some, potentially distinguishable as a group) SV users want all users of e-SAVs to be similarly screened?
        ii. How do these present SV users' personal risk constellations affect their imagined constellations for e-SAVS?

Elaborating this example to other questions about SVs as well as extending it to EVs and AVs, fills out a research agenda on user constellations of safety and security. With answers from this research agenda, policy agendas can be formulated to address these constellations. In this way, research on extant personal risk constellations may reveal what those constellations are and more importantly how they affect present travel choices whether or not it provides specific solutions to future risk constellations associated with e-SAVs.

This white paper is a call for clarity not consensus on terminology, theory, approach, and methods. Axsen and Sovacool (2019b) describe representations of users and potential users of electrified, automated and shared mobility as forming a "rich mosaic of frameworks… each framework is better equipped to observe different aspects of the user." For all the richness across their examples, even it does not span the possibilities. Sanguinetti et al (2019) and Zoellick et al (2019) issue their own versions of this call for a broad spectrum of perspectives on users.

Further, carrying out a diverse research agenda in conjunction with hardware and software designers, system integrators, mobility service providers, legislators and regulators would be a self-aware approach—a reflexive approach (Giddens, 1984, 1991)—to socio-technical systems of e-SAVs. This socio-technical framing hearkens back to Grunwald's (2016) definition of societal risk constellations that serves as the inspiration for conceptualizing personal risk constellations. To that end, continuing efforts to hear alternative perspectives, promote multi-disciplinary research, and incorporate user participation in imagining e-SAVs may resolve personal risk constellations of e-SAVs to assure their design, deployment, and operation in ways that assures broad uptake of e-SAVs seen to be safe and secure.

Introduction

Sustainability claims for e-SAV systems include safety and security, emissions of regulated pollutants including greenhouse gases (Fulton et al. 2017), and equity in public health and access to mobility and thus economic, social, and civic participation (NHTSA, 2016). The goal of this white paper is to create a framework to guide research, policy making, and e-SAV system design, deployment, and operation toward improvements in “traditional” automotive safety outcomes, e.g., deaths and injuries, productivity, economic, and property losses from accidental collisions, collisions perpetrated intentionally as part of insurance fraud, vehicle theft, and other hazards, while minimizing new safety and security risks, e.g., exposure to strangers in shared vehicles and unauthorized release of personal information.

Defining Terms

One of the primary conclusions of this white paper is that many different definitions of safety and security across topical areas, intellectual schools, models of human behavior, research methodologies, and regulatory schemes limits our ability to generalize what is and is not known about how users’ and potential users’ perspectives affect the prospects for and implications of integrating vehicle electrification, sharing and pooling, and automation. Therefore, terms used in this paper are defined first. Safety is defined here to be the condition of being secure from *accidental* harm; security is defined to be the condition of being safe from *intentional* harm. Concepts of risk, uncertainty, and trust are related to safety and security. *Risk* describes situations in which an action may lead to more than one outcome. *Uncertainty* is the extent to which the possible outcomes and their probabilities are unknown. *Trust* is a willingness to make oneself vulnerable.

The overarching definitions of safety and security used here are more general than offered in most of the literature reviewed for this paper and more general than the language of researchers, policymakers, and ride-hailing industry representatives consulted for this paper. Traffic and vehicle engineers may use the word “safety” to refer to the prevention of accidental collisions between vehicles, between vehicles and roadway infrastructure, other road users, and other nearby objects and people. “Security” in the context of automated vehicles (AVs) and shared vehicles (SVs) is often discussed in terms of “cybersecurity” and data protections. The broader definitions offered here are intended to allow for a richer description of the possible pathways for accidental and intentional harm to which users of e-SAVs *may perceive themselves* to be exposed. The distinction made between safety and security in this paper also differs from distinctions—if a distinction is made at all—in any specific document reviewed here; here *intent* distinguishes safety from security.

In this white paper, the three constituent technologies of e-SAVS are defined as follows. Electric-powered vehicles (EVs) include plug-in hybrid, battery, and hydrogen fuel cell electric vehicles even if the longer-term transition is toward only “all-electric” battery or fuel cell vehicles. Driving automation will have to make a transition to “fully automated driving” in terms of SAE’s (2016) Level 5: AVs capable of “fully automated driving” are the focus of this white paper. Shared vehicles (SVs) are taken to include the services of car-sharing and transportation network companies, and to include both single-rider and pooled services. SVs in this context includes sharing time and space in a vehicle with another passenger. It is distinguished from single passenger ride-hailing and car-sharing, including single passenger shared autonomous vehicles (SAVs). The term "pooled ridesharing" has been used to refer to the specific case of strangers making contemporaneous use of a vehicle. As noted in the next paragraph, this pooled use behavior seems to be essential to the sustainability claims for e-SAVs. Just as the discussion allows for plug-in hybrid EVs and less than SAE Level 5 AVs, the discussion of SVs will allow for solo and pooled use but look toward systems in which pooling is pervasive.

Risk Constellations

Writing about autonomous driving, Grunwald (2016) defines "societal risk constellations" as, "the relationship between groups of people such as decision-makers, regulators, stakeholders, affected parties, advisors, politicians and beneficiaries." That is, these constellations are made up of the relationships between the risks perceived, managed, insured or otherwise experienced and mitigated by these groups. For any given risk, this concept of risk constellations leads to questions such as:

- Who is at risk?
- What is at risk?
- Who (or what) poses those risks or at least creates the conditions under which the risk exists?
- Who is responsible for ameliorating the risks?
    - How will they ameliorate the risks?
- Who pays for the risks?
- Who benefits from the risks?

Changes to societal risk constellations caused by, for example vehicle automation, are inherent in a transition to systems of operating at SAE's (2016) Level 5 "fully automated driving." A recent report from an international insurance group offers this description which may be interpreted as shifting societal risk constellations:

> *"The constant in this change is that risk will not simply disappear. It will shift, largely from human to machine, blurring the lines between personal and commercial risks. What is not clear is where the exposure will lodge itself or how quickly it will move. Is it between auto manufacturers, software developers, and parts manufacturers? Perhaps the road construction companies and local governments responsible for infrastructure that "speaks to" vehicles? The communications providers, or a new enabling technology not yet invented?"* (AIG, 2017)

This idea of societal risk constellations is a launching point, but changes in societal risk constellations are not the topic of this white paper. In this white paper, a refinement and an elaboration are made to Grunwald's societal risk constellations. First, "users" are only inferred by Grunwald as "affected parties" or "beneficiaries." Here, users are explicitly identified to include users (primarily, "riders" or "passengers") of e-SAV systems as well other road users such as pedestrians and cyclists who may be expected to also experience new safety and security concerns and benefits. Second, “constellation” is extended to refer to patterns of safety and security risks perceived by people within the types of groups identified by Grunwald.

Statement of Purpose

This white paper hypothesizes users’ “personal risk constellations” as arrangements of safety and security risks and benefits perceived and experienced by users of e-SAVs and other road users. These risks and benefits may be felt or perceived as the likeliness of events to occur and consequences should they occur; whether the risks and benefits are immediate or more distant in time; whether they are risks or benefits to the user personally and/or as a member of a group, and whether they are risks or benefits directly to the user or to data about the user (which may then pose a direct risk or benefit to the user). This paper proposed to ask whether these likelihoods and consequences for safety and security are seen by users as constellations of related risks forming negative or positive evaluations of a person’s prospects for starting to use e-SAVs and defining under what conditions or for which types of trips a person uses e-SAVs rather than other modes. Some people may balance one form of risk with another; others may have thresholds for each type of risk; still other personal risk constellations may reduce to a single risk. It is further proposed that differences across actual and potential users in these constellations may determine who initial e-SAV users will be and affect transitions to later potential users and thus the potential for any sweeping displacement of the system of privately owned and operated, gasoline-fueled, motor vehicles with systems of electrically-powered, automated, and shared vehicles.

There are several possible “points” that might make up these personal risk constellations, certainly road safety but also including new—even if transitional—sources of risk. An example from electric vehicles (EVs) would be concern about delayed response by emergency personnel due to unfamiliar hazards, for example, fires from lithium batteries in electric vehicles (Bloom, 2018). Another form might involve the transformation of a “road safety” concern such as accidental collisions into a “road security” concern through exposure of any given e-SAV or the e-SAV system to cyberattack intended to cause vehicle collisions. Personal security concerns may also be transformed. As an example of how constellations may differ by user characteristics, there are documented difference in the safety and security of women and men in terms of the use of privately-owned and conventionally-fueled vehicles (Woodcock et al, 2001) and transit (i.e., vehicles shared with strangers) (Loukaitou-Sideris, 2014). Such differences may be expected to change with any advent of e-SAVs, e.g., perceptions of immediate physical risk from the presence of strangers in a pooled light-duty vehicle.

This discussion leads to these research questions about users’ personal risk constellations:

1. Do users and potential users of e-SAVs perceive risk constellations?
2. If so, what are the safety and security risks perceived by users of electric vehicles, shared use vehicles, and automated vehicles?
3. How does the integration of electrification, automation, and sharing or pooling affects those arrangements?
4. Do these constellations vary systematically by characteristics of users?

5. As a matter of how to create and sustain transitions, how do answers to questions such as these affect societal risk constellations?

The answer offered in this paper to the first of these questions is we don't know. The search for evidence of such constellations revealed no prior work that asked and answered this question. Much research has been done on individual safety and security hazards and much policy has been made, public agencies and industries created, to manage multiple hazards.

While there is much to do to design, build, operate, and maintain safe and secure systems of e-SAVs, the importance of increasing our understanding of user perspectives is the effect the perspectives may have on the ultimate success of—or at least the pace of—a transition. Lee et al (2018) report that stated willingness to use a "self driving vehicle" increases by over 50% if the framing of that willingness shifts from a generalized willingness (40%) to the more specific case of self-driving vehicle that "is as good a driver as [the respondent]" (65%). Notably, most of the change comes via a reduction in the number of people who outright reject using a driverless vehicle (from 34% to 14%).

Research has been done on safety and security within each of the three constituent technologies and the various combinations of them. Still, these tend to focus on a single technology; for examples regarding vehicle automation, see Milakis et al. (2017) and Schoettle and Sivak (2014). Most of this prior work also deals with one type of safety or security risk at a time, for example, road accidents, or even subsets of these categories, e.g., collisions between automated vehicles (AVs) and pedestrians or cyclists (see for example, Tian et al 2017). This white paper reviews much of this work, documenting systems of electrification, sharing and pooling, and automation, and their combinations that have been examined, what measures of safety and security were measured, and what this past research has to say about the central assumption here of personal risk constellations and their potential effects on transitions toward electric, automated, and shared personal mobility. An example of the necessity of such a framework comes from Bonnefon, J.-F. et al. (2016) who show more people approve of AVs that "would sacrifice their passengers for the greater good and would like others to buy them, but they would themselves prefer to ride in AVs that protect their passengers at all costs." Additionally, questions have been raised about whether and under what micro-conditions (e.g., degree of oversight by a human "operator" in a vehicle, and macro-conditions, e.g., percentage of on-road vehicles operating at different levels of automation,) systems of AVs are safer than systems of human piloted vehicles.

Questions of whether (potential) users of e-SAV systems have safety and security constellations, and if so, what those constellations are, have implications for who actual users will be and thus the ultimate effects of e-SAVs on transport safety, climate, and other sustainability measures. This white paper suggests a framework to guide policy making and regulation, system design, deployment, and operations, as well as future research.

As a matter of defining the three technological systems and their capabilities, this review will consider studies of users of EVs, SVs, and AVs. Again, as discussed by Sanguinetti et al (2019) "shared" is taken to include behaviors that may be distinguished as shared vs. pooled. The distinction is whether a given user expects to exert control over whether anyone else gets in the vehicle in the course of the trip. An SV is commonly taken to be a vehicle used serially, by one user who must first relinquish control over the vehicle before another user may access it. A pooled vehicle is one in which any given user may (or must) expect that other users may be granted access to the vehicle, interrupting the course of the original user's trip. The acronym SV will be used to refer to vehicles operated within an operational model in which for any given trip, the user may expect to share with another rider previously unknown to the initial user, i.e., pooled use. Vehicle sharing means a shift from private vehicle ownership toward mobility as a service (MaaS), implying new institutional actors. For now, private firms serve as conduits between drivers and passengers via mobile apps. The most relevant level of automation for this review is "fully automated driving." Though SAE has attempted to excise such terminology from its definitions, this level of automation is sometimes referred to as "driverless cars" and "autonomous vehicles." The acronym AV will be used to refer to systems of vehicles capable of "fully automated driving." However, studies that examine relevant safety and security concepts that may be apparent in lower levels of automation are also reviewed here. Finally, EVs include those that store energy in batteries (plug-in electric vehicles, PEVs) and those that store energy as hydrogen (fuel cell electric vehicles, FCEVs). The extant literature on consumer response to electric vehicles and their "problems," e.g., high initial purchase cost (PEVs and FCEVs), short driving range per charge (PEVs), and limited charging infrastructure (PEVs and FCEVs), may be less useful to this review.

Organization of the Rest of this Review

Most of the material presented here is from the academic research literature, with additional materials from insurance, consultant, automotive manufacturers, transportation network companies, and government sources. The initial plan to formally interview representatives of these potential actors in e-SAV development, deployment, and governance was abandoned after several interactions with prospective interviewees. The primary reason was the novelty of the idea of user constellations of safety and security. The author attended multiple events soliciting possible interviewees. These included a University of California Institutes of Transportation Studies' workshop on e-SAVs in Sacramento in November 2018, the 2019 Annual meeting of the National Transportation Research Board in Washington, DC in January 2019, the UC Davis Three Revolutions Future Mobility Research Workshop in Davis, CA in March 2019, and the 2019 Biennial Asilomar Conference on Transportation and Energy in Asilomar, CA in July 2019. The conversations provided cues to some references, a few follow up phone calls, and references to other contacts. Ultimately though, the author made the decision it would further the goals of this white paper to shift effort to reviewing the literature—including leads from these contacts—rather than conduct formal interviews.

The outline for the rest of this white paper is:

- Concepts of safety and security as well as related topics of risk and uncertainty
- Are potential user groups concerned about the safety and security of e-SAVs and their constituent technologies?
    - Topical by socio-technical systems

    - A few works looking at e-SAVS or which are syntheses of works on the constituent systems: Electrification; Automation; Sharing.
    - Partially integrated systems such as e-SVs and the individual systems of EVs, SVs, and AVs.
    - This list provides examples of possible safety and security concerns in different categories. Others will be added as they are discovered in the literature.)
- Incipient Institutional Frameworks
- Summary and Conclusions: Research Agenda

The opening sentence of this white paper alludes to the many different topical, conceptual, and methodological perspectives that have already been brought to bear on subjects discussed in this white paper. Little information on user perspectives was found in the few plans and scant legislation specific to e-SAVs that were identified. Therefore, the bulk of the discussion focuses on research. There is a brief discussion of incipient institutional arrangements that have formed to guide planning and governance following the discussion of research. As these will ultimately vary not only by state but by region and city, these notes focus on California as an example.

Concepts of Safety and Security

A general distinction between safety and security based on accidental vs. intentional harm was offered to open this paper: "safety" refers to the absence of or protection from accidental harm while "security" refers to the absence of or protection from intentional harm. Along these lines, Waldrop (2006) argues against "security as [merely] safety," adding among other ideas that of security as liberty. In this expanded idea of security, to be secure is to be free from threat by individual, corporate, and state actors in a way we don't speak of being "free" from accidents and mistakes. In this section, a brief review is presented of conceptual bases for distinguishing safety from security. Types of safety and security concerns are described as prelude to the next section in which research into those types is summarized.

As noted in the introductory discussion much of the work reviewed here was written from or for the designer-provider-regulator's perspective and much of it focused on one of the three constituent technologies of e-SAVs: vehicle electrification, automation, and sharing/pooling. Writing about vehicle automation, Pype et al (2017) call "for a holistic development view on security, safety, and privacy…as they are all interacting, and cannot be seen completely independent." However, the view Pype et al take is from the perspective of system designers, e.g., safety is "the correct system functioning of the car and the protection of the people in the car, mainly to ensure avoidance of car and/or traffic accidents," and "security is seen to be a system-property spanning from components to cloud solutions." In addition to using safety and security to distinguish between accidental and intentional harm, this white paper proposes to explicitly extend the boundaries of the "system" to include the people who use it—and those who make, operate, regulate, defend, and attack it. In this way, systems of e-SAVs may analyzed via any of several "social" models. Axsen and Kurani (2012) review socio-technical systems (STS) approaches (Geels, 2010) which include social construction of technology (SCOT)

(Pinch and Bijker, 1984) and actor-network theory (ANT) (Law and Hassard, 1999). Another social framework, Giddens' (1984, 1991) structuration approach, is discussed further.

Ontological Security and the Risk Society

According to Giddens (1991), ontological security is a feeling that carries "the individual through the transitions, crises, and circumstances of high risk." While variously summarized by different authors, we can take a need for ontological security to be a need to be able to trust the social-physical milieu in which one exists. "High risk" in this context is not a statement about the probability or magnitude of consequences, but describes a general social order characterized by risk, i.e., modern society. The bases for ontological security are emotional and cognitive. While ontological security is oft described as a defense of the continuity and stability of a sense of self (e.g., Wikipedia, https://en.wikipedia.org/wiki/Ontological_security), Giddens argues that creativity is essential to ontological security as it relates to trust:

> *"Creativity, which means the capability to act or think innovatively in relation to pre-established modes of activity, is closely tied to basic trust. Trust itself…is in a certain sense creative, because it entails a commitment that is a 'leap into the unknown,' …however, to trust is also (unconsciously or otherwise) to face the possibility of loss…"*

Thus, more than the sense of self surviving as a static construction, ontological security allows this sense of self to grow in the context of Beck's (1986) "risk society."

Giddens (1999) further argues that Beck's risk society is "a society where we increasingly live on a high technological frontier which absolutely no one completely understands, and which generates a diversity of possible futures." Giddens (1999) goes on to argue, "The origins of risk society can be traced to two fundamental transformations…the end of nature; and…the end of tradition":

> *"The end of nature…means that there are now few if any aspects of the physical world untouched by human intervention...For hundreds of years, people worried about what nature could do to us – earthquakes, floods, plagues, bad harvests and so on. At a certain point, somewhere over the past fifty years or so, we stopped worrying so much about what nature could do to us, and we started worrying more about what we have done to nature…."*

and,

> *"To live after the end of tradition is essentially to be in a world where life is no longer lived as fate."*

Risk society is not any more hazardous than nature or traditional society; the concept of risk simply doesn't exist in traditional society while hazards, natural or otherwise, certainly do.

The importance of these concepts to a question of whether potential users of e-SAVs perceive personal risk constellations arises first in demonstrating the relevance of this, and by example, other, social theories to the existence of such constellations and second in the task of linking personal to societal risk constellations. An example of the first is presented next; the second is discussed in the later section on incipient institutional frameworks.

Drawing from this work by Giddens, Hiscock et al (2002) argue that elements of ontological security are "feelings of protection, autonomy, and prestige": people need to feel protected, that such a feeling allows autonomy ("enough invulnerability for a person to exercise autonomy"), and that:

> *"sustaining feelings of pride has effects which go further than simply protecting or enhancing self-identity, because of the intrinsic relations between the coherence of the self, its relations to others, and the sense of ontological security more generally."*

Hiscock et al (2002) use this tripartite definition of ontological security to examine use and ownership of private cars vs. transit use and whether one of the benefits of cars is to provide car owners (via prestige) and users (via autonomy and protection) greater ontological security than transit provides to its users. In doing so, they elaborate several forms of protection (from intentional violence by other people, from accidents, as comfort (see the section on cocooning below)), autonomy (convenience, choice or agency, and reliability), and prestige (income, lifestyle, masculinity, and respect).

Safety

In Pype et al (2017) we see the most common interpretation of "safety" across vehicle electrification, sharing and automation literatures—a concept that might be more familiar as "traffic safety" or "road safety." These definitions routinely privilege motor vehicles: road safety is taken to mean the reduction of the incidence and severity of accidental collisions between motor vehicles; between motor vehicles and other road users whether as occupants of other vehicles, cyclists, or pedestrians; between motor vehicles and roadway elements such as barriers, abutments, and lighting; and, between motor vehicles and other constructions such as buildings, as well as natural elements bordering the operating environment (such as vegetation) or entering the operating environment (such as wildlife crossing roadways). The narrow interpretation of safety as road safety or motor vehicle accident prevention appears in most work on vehicle automation. Such works may be comprehensive within this narrow category. For example, Li et al (2018) develop estimates of safety benefits of connected AVs (assuming complete market penetration of a wide variety of AV sub-systems) across 37 categories of pre-crash conditions in the National Highway Traffic Safety Administration's General Estimates System (GES).

Metrics of road safety include injuries and deaths from accidents, i.e., collisions between vehicles and of vehicles with infrastructure or other objects near roadways. Typically, counts of accidents and accidental injuries and deaths have been pro-rated per vehicle- or person-mile. More recently programs and proposals have been made to push roadway deaths to zero, essentially eschewing weighting by how much travel is occurring (see as examples the National Safety Council's plan (Ecola et al 2018), Vision Zero (https://visionzeronetwork.org), and the Federal Highway Administration's Safety Strategic Plan (FHWA, undated)).

Given the metrics of deaths and injuries from traffic or road accidents, the safety validation of EVs and AVs has to a great extent been a matter of comparison to conventionally fueled vehicles driven by human drivers. (Deviations from this for EVs, AVs, and SVs will be discussed below in the sections on these vehicle types.) As such, questions such as how to validate claims of reduced accidents and injuries, primarily for AVs, elicit responses from researchers such as Kalra and Paddock (2016) who estimate the number of miles (and thus indirectly, the number of years) AVs would have to be driven to substantiate claims of reduced deaths and injuries. To cite their result regarding validating an improvement in fatalities per 100 million miles—never mind zero fatalities—of AVs compared to human drivers:

> *"to demonstrate with 95% confidence and 80% power that [AVs'] failure rate is 20% better than the human driver failure rate of 1.09 fatalities per 100 million miles [AVs would have to be driven] 11 billion miles (500 years) [for a fleet of 100 AVs driven 365 days per year, 24 hours per day]."*

Based on estimates such as this, Kalra and Paddock (2016) conclude,

> *"it may not be possible to establish the safety of autonomous vehicles prior to making them available for public use. Uncertainty will remain."*

Security

Security here relates to both e-SAV users and information about those users, i.e., their virtual representations, as well as people who, while not users of e-SAVs, will be affected by them. The latter group would include any other "road users," whether those are travelers by other modes, e.g., non-motorized modes, non-automotive motorized modes, and transit, as well as people using the road space and its edges for non-travel purposes.

The distinction just offered is a more specific statement regarding security than concepts offered by, for example Elmaghraby and Losavio (2014) who state security is, "an assurance that a person may go about his or her life without injury to life, property or rights." Threats to physical security may be experienced in the act of accessing, traveling in, or egressing an e-SAV but may also be experienced outside the act of travel due to breaches of information about travelers or unauthorized "sharing" by e-SAV system operators. Breaches of information may carry risks of subsequent direct physical harm as well as, for examples, harms to reputation, financial well-being, and rights of association. Risk to e-SAV travelers and their virtual representations may be further linked through location data—a breach of the virtual self that reveals the location of the physical self also reveals where the physical self is not. If a person is known to be in a vehicle, other locations such as their homes, may be exposed to increased risk of burglary, for example.

From a narrow system design perspective, i.e., one that does not include potential users, the view of the security of data, for example, is exemplified by this case:

> *"Hackers are able to use these communications channels to gain direct control of cars and as a result wreak potential havoc on the roadways and even create mass*

accidents… It is therefore critical that vehicles are able to detect malicious data such as viruses or intrusions and authenticate incoming messages." (Pype et al, 2017, p. 20)

These threats to security may come from attacks upon the e-SAV system from outside or inside, i.e., through the (mis)use by system operators or regulators. An incipient example of the latter has already been taken up by the American justice system in United States v. Jones (2012) in which the U.S. Supreme Court concluded the placement of a GPS tracker on a vehicle constituted an unreasonable search absent prior information the vehicle had been used in the course of criminal activity. However, the larger point is not that a particular security concern has been adjudicated, but that "a clear theory of law and rights to define what can and should be done" to balance systems operation and governance with security of persons and their information does not exist as it regards new systems of pervasive data collection and communication.

Elmhaghraby and Losavio (2014) primarily focus on instances in which automobiles remain privately-owned but inform discussion of the case considered here where the traveler does not own the vehicle (SVs, SAVs, and e-SAVs). If data from federally-mandated On-Board Diagnostic systems, event data recorders, and increasingly pervasive on-board telematics systems and integration of smartphones with vehicles (and thus GPS data) are judged to be within control of the vehicle owner, this would raise the question of who controls the data about the vehicle when the traveler does not own the vehicle, but it is the traveler, not the vehicle per se, that is being targeted or surveilled.

Cybersecurity: Data Safety and Security

Transportation network companies (TNCs) claim to not be transportation companies, but to be intermediaries between willing providers of rides and willing people wanting rides. The merits of this argument are beyond scope of this white paper. What is relevant to e-SAVS is TNC's provide an example of leveraging a widely available system of wireless communication and the concomitant growth of a population of people habituated to e-commerce facilitated by smartphones. These information and computer technology (ICT) enabled consumers have largely been willing to exchange access to data about themselves—names, real time location, credit card data including associated data such as home addresses—as part of the "currency" with which they pay for services—rides, in the case of their use of TNCs.

Blyth (2019) identifies "safety as function of big data" as part of one of three major "transcripts" in the arguments for systems of AVs, namely "safety of the driver." Other technology-focused and more technology-optimistic accounts tend not to see the possible conflict between greater private (or social) benefit at the cost of the potential exposure of data, for example, Shladover (2018),

> *"Automation overcomes one of the major impediments to transportation system performance and safety, which are the limitations of human driver performance and behavior. The really powerful synergy between [connected vehicle] CV and AV systems comes with the additional data that CV technology can provide to AV systems to improve their performance and safety."*

Cisco Systems (undated) defines cybersecurity as,

> *"the practice of protecting systems, networks, and programs from digital attacks. These cyberattacks are usually aimed at accessing, changing, or destroying sensitive information; extorting money from users; or interrupting normal business processes."*

The relative risk of internal (to an operating entity) vs. external threats to the quality or sanctity of data has been reported in Verizon's Data Breach Investigations Report for the past several years. While the majority of data breaches are perpetrated as attacks from outside organizations, accidental or intentional harm caused by such attacks coming from within organizations are not rare. The 2019 report shows that of the data breaches across several public and private sectors analyzed for these reports for the years 2010 to 2018, between 20 and 40 percent of breaches were due to "internal threat actors" (Verizon, 2019).

Data breaches attributed to errors by insiders might be characterized as "safety" from the perspective of the breached entity (users or other institutions necessary to operate and regulate the system) as the insiders did not intend to release or misuse information—any resulting harm would from their perspective be accidental. According to the Verizon report most breaches attributable to internal actors are "most often in the form of errors." These errors may directly expose data or leave openings that outside attackers eventually find. However, to users of e-SAVs, whether the e-SAV system operator accidentally left a door open or intentionally exposed (or allowed exposure of) user data, any harm to users may be perceived as intended by someone and thus a security risk, rather than safety, risk.

Security and Trust

Additional examples of ICT-enabled commerce may be instructive in defining if not solving cybersecurity issues for e-SAVs. Etzioni's (2017) uses the framing of trust to describe the relationships in several "sharing economy" and e-commerce examples: TNCs, similar businesses for lodging rentals e.g., AirBnB, on-line marketplaces, e.g., eBay and Amazon. Trust is defined by Etzione (2017) as "a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behaviors of another." If for much of our past, trust has depended on face-to-face interaction, "the internet has posed major new challenges to trust …by providing a very high level of anonymity" (Etzione, 2017). Relying greatly on the work of Bart et al (2005), the examples Etzione provides are described according to the mechanisms intended to enhance trust, in particular "community features" such as mutual reviews by vendors and users and user forums. In the end though, Etzione (2017) concludes regarding all these e-commerce examples,

> *"The most anyone can say with assurance based on the indirect evidence is that the level of distrust is not high…."*

What he means by indirect evidence is that the sheer (and mere) growth of ICT-enabled user bases must mean large numbers of people trust the systems. This ignores the systemic changes that ICT-enabled commerce has wrought, e.g., the decline in brick-and-mortar bookstores may not mean readers trust Amazon more than they did their local bookstore. Future visitors to a city may not trust e-SAVs more than they would have trusted traditional taxis. To be fair, Etizone (2017) does offer the observation that there has been little "systematic social science studies" of the platforms he reviews, studies that would allow the formulation and testing of hypotheses to provide more direct evidence of the role between trust, ICT-enabled commerce, and by extension, systems of e-SAVs.

Lee and See (2004) provide a more general overview of trust in the context of automation. Their review concludes there are some shared elements of definitions of trust but also some important differences. As Etzione (2017) stated, vulnerability is widely associated with concepts of trust. Lee and See (2004) summarize several definitions saying,

> *"For trust to be an important part of a relationship, individuals must willingly put themselves at risk or in vulnerable positions by delegating responsibility for actions to another party."*

Lee and See (2004) go on to characterize trust as relevant in situations in which explicit goals are to be achieved: "Trust describes a relationship that depends on the characteristics of the trustee, the trustor, and the goal-related context of the interaction." This foreshadows their discussion of "appropriate reliance" on automation: how much should the trustor trust the trustee to achieve the trustor's goal? How much should a traveler trust a system of e-SAVs to deliver them safely and securely to their destination? To the point of this paper, whether or not there are objective reasons to do so, will there be identifiable groups of people who exhibit different levels of trust in e-SAVs? As a question of transition to e-SAVs, will people have to trust those systems more than they trust either the present regime or whatever regime in which they accomplish their travel at the time e-SAVs become a real option?

Traversing Risky Spaces

Citing Hiscock (2012), Wells and Xenias (2015) argue, "The cultural position of the car has changed to being a protected personal space within which to traverse an implicitly hostile urban environment." They contend this "cultural position" is exemplified and supported by a variety of in-vehicle technologies ranging from the prosaic, e.g., door locks that activate automatically, to the extreme, e.g., armor plating. These increasingly include communications and telematic systems allowing remote sensing by intended and assumed beneficent observers but opening another point of entry to unintended observers of unknown intent.

Cocooning

Cocooning is an elaboration on security in the sense of creating a private space, i.e., keeping out unwanted "others." The term seems to come from studies of automotive acoustics and the development of audio and sound systems in automobiles. If at first car radios were aftermarket add-ons to provide news and entertainment to drivers, audio-visual technologies now create audio-visual micro-environments within a vehicle and, sometimes customizable, sound environments for different drivers' tastes (Bijsterveld, 2010; Walsh, 2010). Wells and Xenias (2015) extend the list of cocooning technologies to a wide variety of comfort and convenience features—"electric operation of windows, seat adjustments and in-seat heating and cooling, self-closing doors and boots, sunroofs, etc. all act to heighten the sense of individual control or power over the immediate environment." One of the arguments, at least for privately owned AVs capable of SAE levels 4 and 5 automation, is the extending of cocooning to include the ability of the driver to increasingly retreat even from the task of driving.

Why Different Users May Perceive Different Personal Risk Constellations

Körber and Bengler (2014) summarize several potential "individual differences" that affect response to automation in general and by extension, vehicle automation in particular: "stable traits, operator states, attitudes and demographics." Much of their specific discussion of traits such as "propensity to daydream" (Antrobus et al 1967), "task-focused coping, emotion-focused coping and avoidance" (Matthews and Campbell 1998), proneness to boredom (Farmer and Sundberg, 1986), and "active task-related fatigue, passive task-related fatigue and sleep-related fatigue" (May and Baldwin, 2009) is in reference to partial automation and may be obviated by this review's focus on Level 5 automation. Still, their work stands as an example of integrating a variety of psychosocial measures into understanding differences across people. Sarriera et al's (2017) list from their work on willingness to share vehicles contains many similar constructs, but provides additional specific examples: "personality types, attitudes, and motivations with respect to ride-sharing…extroversion, disposition toward diversity, convenience, reliability, comfort, safety, environmentalism, and constraints on autonomy."

Körber and Bengler (2014) say that to their knowledge, "there is no naturalistic driving study published about how much individuals can really free themselves from monitoring the automation even in a highly automated drive." This poses the question of whether, at least as a transitional matter, there may be an as yet unresearched difference in the extent to which people can emotionally and cognitively let go of monitoring their travel in an e-SAV that would affect when (in a longer term sense of shifting a large portion of the population travel in e-SAVs) different people will become e-SAV users.

Without attempting to describe all the reasons and all the ways in which users of systems of e-SAVs may perceive different personal risk constellations that could affect their willingness to use such systems, the plausibility of such differences will merely be established here. A longer discussion of gender is presented below, recognizing there is additional conceptual and empirical work supporting reasons to believe that age, class, race and other reasons may also affect personal risk constellations of e-SAV use. For example, existing users of pooled services on TNCs have been characterized as younger, lower income, and less likely to be married than TNC users who have not used pooled services (Sarriera, 2017).

Summarizing three dozen studies on associations between individual characteristics and response to vehicle automation, Nordhoff et al (2016) argue there is consistent evidence,

> *"men have shown a higher interest in automated driving than do women, more positive attitudes toward automated driving, and a higher willingness to use and buy the technology."*

Associations are found between responses to the prospects of vehicle automation and research respondents' age (Kockelman et al 2016). While associations with income have also been reported for AVs, e.g., Kyriakidis et al (2015), SVs, e.g., Sarriera et al (2017), and EVs, e.g., Axsen et al (2016), these associations indicate that all associations between personal characteristics and AVs, SVs, and EVs suggest reasons to expect such with e-SAVs—but not to expect necessarily the same associations. In the case of income, many of the associations to AVs are based on sales of vehicles to private owners not on use of AVs by people who do not own the vehicles. Still, as an example of work to date, Casley et al (2014) report that respondents who believed Level 5 AVs would be safer than the average human driver were likely to report they would pay more, on average, for such an AV and would be willing to buy such an AV sooner than people who were less sanguine about AV safety.

In addition to the socio-economic and demographic measures often used for market segmentation, research has also addressed the effects of mobility, psychological traits, individual and household contexts, as well as the social, land use, infrastructure, and e-SAV system design details will segment demand in ways that potentially cross-cut issues of safety and security.

Gendered Security

Hiscock et al's (2002) identification of a "masculine" prestige with automobile ownership and use (display) may vary across cultures and makes and models of vehicles. If men may be more likely than women to derive prestige from some vehicles it does not have to follow that women cannot do so too. What matters is simply that access to different meanings of automobiles is gendered. If those meanings are part of creating ontological security by women and men, then we expect different personal risk constellations for existing systems of automobility and have more reason to hypothesize gendered differences in personal risk constellations of socio-technical systems of e-SAVs.

Linking gendered personal risk constellations to societal risk constellations raises the question of the genderedness of the social constellations—who is responsible for creating risks, who pays, who benefits, who is responsible to address the different safety and security experiences of e-SAVs (in this case) of users (and citizens)? Caprioli (2004) notes while "notions of security are often presumed to be gender neutral," several researchers conclude "women's security is systematically violated in both public and private spheres, and that legal equality in the public sphere cannot lead to women's security in the private sphere." With specific relevance to access to and use of systems of mobility, such as e-SAVs, Caprioli (citing Bunch, 1995) notes,

> *"Fear of violence in the private sphere leads to women's insecurity, as exemplified by the avoidance by women of certain places at certain times of the day lest they experience violence and subsequently be deemed culpable in attacks upon themselves…"*

Empirical evidence for differences between female and male users of TNCs comes from Sarriera et al (2017). Their survey of TNC users reported safety was a greater issue for female than male users. Their work also provides support for the importance of social context in concepts of security and trust. Women are reported to be more likely than men to carpool. Carpooling differs from TNC use in that carpools are typically made up of stable groups of people who—even if strangers to start—come to know each other and share, if nothing else, the routine of daily travel to and from work. In contrast, Sarriera et al (2017) found that in the context of pooled TNC services, while overall few respondents viewed such services as an opportunity to meet new people, women were much less likely (12%) than men (23%) to agree this was a reason to use a pooled TNC. Women were more likely than men to report negative experiences with other riders on pooled rides; again, while few people reported these negative experiences, women were more than three times as likely as men to do so. In response, women were more likely than men to indicate they would like more information about who else might be or get into a pooled vehicle.

Are Potential Users Concerned About the Safety and Security of e-SAVs?

The concerns of potential users of e-SAVs and the constituent socio-technical systems have been ascertained by numerous studies ranging methodologically from simple polling to elaborate stated preference experiments and topically from a single constituent technology to (imagined) systems of e-SAVs. The general conclusion of this discussion is that conclusions to be drawn from work to date about whether users perceive personal risk constellations with respect to e-SAVs remains conjectural and further research is required. Some of this literature is reviewed in this section, starting with the most comprehensive in the sense of covering systems of e-SAVs then moving to the individual constituent technologies: automation, sharing, and electrification.

e-SAV Safety and Security Perceptions from Users' Perspectives

A small number of recent studies address fully- or nearly-fully formed ideas or deployments of e-SAVs. Recently, a journal issued a special edition synthesizing research spanning user studies across all three constituent technologies. These are reviewed first before moving on to the individual constituent technologies of vehicle sharing, automation, and electrification.

A recent special edition of Transportation Research Part D is titled: *The roles of users in low-carbon transport innovations: Electrified, automated, and shared mobility* (Axsen and Sovacool, 2019a). The nineteen collected articles plus the editors' introductory review make a compelling case for treating systems of e-SAVs as socio-technical systems that can and should be studied from a wide variety of social science perspectives. As relevant as the special edition's title sounds and for all the richness of the individual articles, coverage of issues of user safety and security is fragmented and few of these works stipulate meanings of concepts of safety, security, risk, uncertainty, or trust, as called for in the opening of this white paper. Further, none deal with the integration of electric-drive, sharing, and automation into systems of e-SAVs.

Axsen and Sovacool (2019b) provide the opening review of the special edition. As part of organizing the collected results, they categorize user perceptions of e-SAVS (a term they do not use) into a two-by-two matrix taken from Axsen and Kurani (2012b). The two dimensions are private-societal and functional-symbolic. Axsen and Sovacool's (2019b) only explicit recognition of "safety" is as a functional attribute, though both private and societal:

> *"…the category is meant to encompass all of the functional attributes that a vehicle, or a form of mobility, provides for the consumer, such as its ability to travel over distances (km driven or travelled) in a manner that is affordable, convenient, or safe for the consumer (owner, driver or passenger)"…*
>
> *"The societal-functional category includes the innovation's direct societal impacts, including environmental impacts and energy usage, land-use impacts, and safety impacts to society more broadly…."*

Leaving aside the question of whether safety (and security) have symbolic dimensions, i.e., what they represent and to whom do they represent those things, Axsen and Sovacool (2019b) usefully distinguish between private safety of individual users and society at large. However, what they mean by safety (or security) is not entirely clear. They conclude the works assembled in the special issue display an,

> *"array of symbolic perceptions, relating to identity, belongingness, changing societal expectations, trust and anxiety."*

By placing personal risk constellations within a framework of risk society, structuration, and ontological security we can tie safety and security to symbolic representation through trust. The mention here of anxiety foreshadows the linking of anxiety to security by Kester (2019) that will be discussed in the section below on EVs.

Axsen and Sovacool (2019b) identify no articles in Axsen and Sovacool (2019a) addressing safety or security issues related to EVs (see their Table 5), three articles that address private-functional safety aspects and none that address societal-functional safety or security aspects of SVs (see their Table 6), and three that address private-functional safety and security aspects of AVs, one of which also addresses cybersecurity and two of which address societal-functional aspects (see their Table 7). Relevant conclusions from the three AV references are presented next.

Whittle et al (2019) rely on an expansive literature review and few highly selected expert interviews to explore their titular topic, *"User decision-making in transitions to electrified, autonomous, shared, or reduced mobility."* Safety is discussed in terms of specific measures of road safety, e.g., reduced crash risks (citing Bansal et al 2016). While raising the specter of "concerns about cybersecurity…willingness to share data…and concerns relating to the adequacy of [connected automated vehicle] laws and liability…" from their literature review, they down play these based on their expert interviews, quoting one of them: "It is perhaps the security of the vehicles that is the key issue there rather than the cyber security of the systems, the privacy aspect of it." Whittle et al (2019) are among the few sources to address concepts of trust, noting trust in "existing technology (i.e., human-driven vehicles) is much higher than in new technology." Spurlock et al (2019) survey respondents in the San Francisco Bay Area regarding their use and interest in EVs, SVs, and AVs (or component capabilities of AVs such as adaptive cruise control). They find ratings of the importance of "vehicle safety" are not statistically significantly related to interest in any of them.

Moving on from Axsen and Sovacool (2019a), Blyth (2019) provides an encompassing discussion of safety and cybersecurity by juxtaposing "dominating technological transcripts of agency" and "hidden transcripts of social context." Briefly, conflicts between these two transcripts are the conflict between arguments widely given for AVs ("transcripts of agency" taken to mean the freedom to act of people imagined to be drivers of private vehicles) with other transport users, e.g., riders in now-driverless vehicles, and users of heretofore public roads and space, e.g., cyclists and pedestrians. Thus, achieving the promises of increased safety by expanding the agency of "former drivers" to accomplish non-driving activities while they travel may argue for the removal of other humans who may pose a "problem," e.g., erratic (from the e-SAV system's perspective) cyclists and pedestrians. This raises the prospect that all mobile "actors" whether users of the e-SAVs system or not would have to be capable of communicating with the e-SAV system to aid tracking and projecting their movements.

Zoellick et al (2019) examines the responses of riders on electric, shared, and automated "pods" on roads, however over proscribed routes on campuses. The perceptions and responses they measure of riders included perceived safety, trust, fear, and surprise, defined as (in all four cases drawing on other sources cited in the original):

- Perceived safety: "A subjective evaluation of the hazard for the physical condition of the passenger both generally and with consideration of attention/distraction."
- Trust: "The belief that allows users to willingly become vulnerable to automated vehicles after having considered its characteristics."
- Fear: "The conscious experience of negative valence and high arousal related to but more activating than distress with a high potential to trigger behavioural responses of 'fight or flight'."
- Surprise: "The conscious experience of high arousal triggered by misexpected (positive or negative) stimuli resulting in a short-lasting impetus for behavior."

Despite Zoellick et al's (2019) call for and claim to "transparency of definitions," the meaning of their offered definition of safety must be inferred by reference to the specific items used to build its measurement scale (see their Table 5) and careful reading of the text of both the main article and supplementary materials. Ultimately, their construct of perceived safety is operationalized as a factor made up of the loadings for four items, three of which are statements about general beliefs about whether using an AV is "dangerous," feelings of safety (both general and specific to the ride taken in the AV "pod" as part of their research), and belief that AVs generally reduce accident risk. In short, their measure only specifically references accident risk, leaving any other aspects of danger and safety open to the interpretation of their respondents.

Zoellick et al (2019) do not propose a multivariate model—conceptual or mathematical—to test possible relationships between their measures of acceptance, perceived safety, emotions, and intention to use AVs. Based on their efforts to construct response measurement scales of each of these general constructs and the empirical results from their respondents' "test rides" in a Level 4 automated pod they offer this conclusion:

> *"Our main results include positive evaluations of electric AVs by 125 participants evident in high ratings for acceptance, perceived safety, trust, and intention to use. Participants were amused, surprised, and not afraid after their experience."*

Regarding the emotion of fear, they go on to say,

> *"Fear might be too drastic to describe the experience of riding an AV supervised by an operator with 12km/h maximum speed on private land adequately."*

As a final note the original study was in German, so all interpretation here relies on the English-language article and translations of the questionnaire and other materials. In making these accessible, Zoellick et al (2019) are to be commended for heeding their call for "availability of all data and questionnaires…rigorous reporting of data structure, reliability, and statistical properties…critically evaluating [one's] own approach…."

Shared and Pooled Vehicles

Before proceeding, the following nomenclature is reviewed. *Ridesharing* is sharing time and space in a vehicle with another passenger. It is distinguished from *single passenger ride-hailing* and *car-sharing*, including single passenger shared vehicles (SVs) and single passenger shared autonomous vehicles (SAVs). While ridesharing occurs in SVs and SAVs, both can operate without ridesharing. We refer to ridesharing in SVs and SAVs as *pooling*, and thus *pooled SVs* and *pooled SAVs.*

Concepts and conclusions regarding the use of shared and pooled vehicles are reviewed here. The first example, by implication, opens the discussion of safety to topics other than road safety and safety concerns of others than the rider in an SV. (Feeney, 2015) argues TNCs are safer than traditional taxi services:

> *"Ridesharing safety worries relate to the well-being of drivers, passengers, and third parties. In each of these cases there is little evidence that the sharing economy services are more dangerous than traditional taxis. In fact, the ridesharing business model offers big safety advantages as far as drivers are concerned. In particular, ridesharing's cash-free transactions and self-identified customers substantially mitigate one of the worst risks associated with traditional taxis: the risk of violent crime."*

While Feeney's (2015) foregrounding of crime against drivers is a useful addition to the discussion of SV safety, the relevance to a future system of e-SAVs is limited as the point of the "automation" in e-SAV is to eliminate the driver. Still, Feeney's (2015) discussion remains relevant as, "the emergence of a new industry that puts people into strangers' cars does give rise to legitimate safety concerns." Though written in the context of TNC's business model, "the stranger" can be extended to whatever public, private, or public-private entities operate future systems of e-SAVs. The potential for such institutional strangers to pose a safety and security concern to users—as those terms are understood in this report to mean accidental and intentional harm—is exemplified by instances of TNCs publicly displaying data allowing riders to be tracked and executives of a TNC using the company's access to real-time location data to track known people. Feeney (2019) characterizes these as "privacy worries." The examples seem important because—in the case of executives of the entity operating the TNC—they highlight that it doesn't take an attack or hack from outside the system to expose users' data. While the TNC in question claims to have sanctioned the executive and strengthened its own privacy policy, such policies are likely opaque to users and only as strong as their enforcement.

Lavieri and Bhat (2019) frame the willingness of a traveler to share a trip with a stranger in terms of a difference in the monetized value of the option of taking the ride alone or with a stranger, including a travel time penalty to pick up the stranger. However, the effect of the stranger was framed in terms of "levels of discomfort and privacy concerns when sharing a vehicle with a stranger" rather than safety or security. Privacy might be interpreted to include security but may also be related to other personal traits such as introversion-extroversion. Regardless, Lavieri and Bhat (2019) highlight potentially important contextual matters affecting sharing a vehicle with a stranger. Commuters are estimated to be less averse to sharing for a commute trip than for a social-recreational trip. (The existing distribution of commute modes in their sample is heavily weighted toward solo drivers: 87% solo driver, 9% non-solo car, and the balance non-car). Given the general impression that "commute travel" may be more structured in terms of the time constraint for workplace arrival in particular, they go on to conclude that travel time to serve the additional passenger may be a greater barrier than sharing the vehicle with that person.

Citing a number of safety and security concerns regarding sharing vehicles with strangers, Sanguinetti et al (2019) draw on Sommer's (2007) concept of personal space to sketch designs of vehicle interiors to allow/emphasize either social interaction among strangers or privacy between strangers. In developing their suggested research agenda, they highlight the incipient nature of any possible conclusions: too few people have too little experience of pooled ride-hailing. Their examples of vehicle designs demonstrate that even under such fluid conditions, design and testing of SAVs (and e-SAVS by extension) can be informed by both grounded and theoretically informed research.

Another analysis of "driver" data from TNCs describes successful attempts on over 20 different TNCs to learn the identity of driver by exploiting the "nearby vehicle" feature of all TNC's apps (Zhao et al 2019). The exposed data included drivers name, home address, driving patterns, real-time locations of specific drivers—and of interest even if vehicle automation succeeds in eliminating drivers—allowed the "attackers" to discover aggregate data about the functioning of the TNC itself, such as number of rides, vehicle utilization, and vehicle presence in a given territory. Of interest to the question of ongoing defense against such attacks—assuming this one has subsequently been blocked—and user trust in future e-SAV service providers, Zhao et al (2019) report they launched their successful attacks against these TNCs after extensive media coverage of two large data breaches at TNCs.

Questions of data security related to SVs have been explored more systematically than for EVs and AVs—EVs because they likely pose similar safety and security *data* risks as conventional vehicles and AVs simply because there are few Level 5 AVs in limited demonstration and development projects. Pham et al (2017) organize their discussion of "privacy concerns" (as a subset of data safety and security) in TNCs around a taxonomy that accounts for TNC riders, drivers, service providers and outsiders. Seven bilateral relations between these four groups are classified as to who may be trying to expose or exploit whose personally identifiable information (PII) or location. Their "threat classification" of these seven privacy threats is qualitative and, as with Feeney (2019), based on the relative threat posed by TNCs and conventional taxis. This comparison may limit direct extension of Pham et al's (2019) results to e-SAVs as the vast majority of people who would use a future system of e-SAVs would not be coming from taxis: in most U.S. cities they would be coming from private automobiles. Still, for purposes of this review, the two "high risk" threats to privacy, i.e., safety and security of PII and location data, are from 1) what service providers know about riders and drivers and 2) outsiders' access to those data—whether by prior agreement with service providers or not. Pham et al (2019) propose to reduce these risks by anonymizing users, cloaking pickup and drop-off locations, and producing only partial trip traces. Notably, they do not address the reduced economic value (from sales of data to third-parties) to the service provider of these reductions in data fidelity nor that a "trusted anonymizer" is required which may simply move the target of an "outsiders" attack on the system and adds another actor that all other actors including users must trust. Redrawing the system boundaries or changing the number and types of actors inside and outside the boundaries doesn't change the fundamental dynamic of PII and location data of users being collected, transmitted, and stored by some set of "insiders" and protected from disclosure by either "insiders" or "outsiders."

TNC riders and the question of riding with strangers

One study is selected to highlight some of the methods, insights, and pitfalls in conducting research on user perceptions of safety and security of future systems of e-SAVs. Sarriera et al (2017) polled users of TNCs on their use of or willingness to used pooled services, i.e., the willingness of User A to share a ride with an unknown stranger, User B, who may already be in the car when User A is first picked up, or whose pick up occurs during User A's ride—possibly after some deviation from the shortest route to User A's destination. The sample is not representative of the general traveling public nor is it likely to have been representative of TNC users at the time (mid-2106). While three-fourths of the sample had used the pooled service of either Uber (UberPool) or Lyft (LyftLine), a contemporaneous announcement by Uber stated, "20 percent of all of its rides globally" are on UberPool (TechCrunch, 2016), i.e., it seems the sample likely overrepresents people who have already used pooled ride hailing. Still, at a minimum the results provide insights into why some users of TNCs exposed themselves to the possibility they would share a vehicle with a stranger and the study is an example examination of the behavior of people traveling within the context of at least one of the three socio-technological systems that are themselves sub-systems of e-SAVs.

Of greater import to the task of putting this example into the context of this report, Sarriera et al (2017) never state a definition of safety but their use of it in context conveys they mean something like “safe from intentional harm from the ‘other’ in the vehicle,” i.e., what they mean by safety is one aspect of what this paper treats as security. (Sarriera et al (2017) use the word “security” only once and in a way that implies the same meaning as their use of “safety.”)

Respondents who had used either Uber or Lyft’s pooled-SV service were asked to rate their agreement with a series of statements describing possible motivations to use pooled service rather than any other mode, i.e., respondent were not asked to compare pooled SVs specifically to single passenger ride-hailing. Those who had not used the pooled service were asked to speculate on what their motives might be, i.e., the statements were put into the context of “If you were to use pooled SVs…,” rather than “When you use….” Of the 14 proffered motivations, one expressly addresses issues about people other than the driver in the car: “I feel safer having another person in the car other than the driver.” Another statement doesn’t describe a motivation so much as an expectation about whether they are likely to share the vehicle: “There is a chance I do not get paired with another passenger.” In the case of reasons to not choose to use a pooled SVs service either more often (if the respondent uses them) or at all (if they don’t), six of the eight proffered motivations are plausibly related to fear of intentional harm from a stranger. Sarriera et al’s results for motivations related to their concept of safety are excerpted from their Tables 3 and 4 are rearranged and combined in Table 1 below to emphasize differences between respondents who have and have not used the pooled services.

There are several questions about how to interpret the results—one general, one specific, and one related to measurement and the interpretation of numerical results. In general, each statement from Sarriera et al (2017) is an agreement rating with whether that statement is a reason the respondent does (would) or doesn’t (wouldn’t) choose to use a pooled SVs service. For all items, the context is not clear—are respondents being asked to consider a specific trip or travel more generally? Specifically, for the statement, “*I feel safer having another person in the car other than the driver,”* nothing is stipulated about the third “another” person, including whether this third party might already be known to the respondent. From this follows the possibility that the respondent is more willing to agree to the statement if they are already traveling with a friend or partner, so that the “another person” would be the third, not second, person in the car (other than the driver). Finally, interpreting means of scales and in particular judging differences between groups based on comparing means on scales is potentially misleading as means can mask differences in distributions. This is illustrated in the motivation to use pooled SVs: “*There is a chance I do not get paired with another passenger.”* (All items are scored from 1 = strongly disagree to 7 = strongly agree, a mean of 4.0 indicates that, on average, respondents are neutral.)

The first motivation statement in favor of using a pooled SV in Table 1 provides an example of both what is concealed by the overall meaning of averages and what comparisons tell us about the two groups. TNC users—whether they have used pooled SVs or not—are, on average, slightly in agreement that they use (or would use) a pooled SV because there is a chance they will not be paired with another user. But the aggregated percentages of agree, neutral, and disagree provided by Sarriera et al (2017) indicate the two groups are different. The most frequent response category for pooled SV users is agreement; the modal category for people without experience using UberPool or LyftLine is neutral. A similar problem arises for the statement regarding the motivation to use a pooled SV because it is (or, would be) safer to have another person other than the driver in the vehicle. While the means are nearly identical and the same percentage of pooled SV users and non-users agree this is a reason they do (would) use pooled SVs, the neutral and disagree percentages are different. The clear modal response for people with pooled SV experience is disagree. In the case of people without pooled SV experience, essentially identical percentages of people agree as disagree and more (than those with experience) are neutral.

Based on a closer look at the distributions, one would not conclude that experience with pooled SVs makes no difference—as one might be tempted to do if only the means of the first two items in Table 1 were compared between the two groups. Rather, it seems as if people who have used the pooled SV services of Uber and Lyft are more likely than non-users to 1) use the pooled services because they believe they won't actually be required to pool *and* 2) are more likely to disagree their motivation to use the pooled service is because they would feel safer if they did share the ride with a stranger. Together, these reveal the possibility that users of pooled SVs do not like or at least are not yet habituated to sharing a vehicle with a stranger; each pooled ride may be a wager they won't have to share.

The first motivation against using a pooled SV further illustrates how averages affect the interpretation of results. The mean rating for people without experience of pooled SVs to the statement, "*I am afraid to be paired with an unpleasant passenger*," is 4.5. Despite being the highest average score in Table 1, it signals on average only slight agreement. However, the distribution by aggregated categories reveals the portion of respondents registering some agreement approaches two-thirds. The mean is lowered because few respondents are neutral while one-third register some disagreement. Rather than modest agreement suggested by the mean, the aggregated distribution shows a divided response; a large majority agree they wouldn't use a pooled SV, at least in part, because of their perceived reluctance of spending time in a vehicle with an "unpleasant passenger."

Users of the pooled SVs in Sarriera et al (2017) also revealed a gender difference in agreement with motivations for and against using the services. Female users of pooled SVs operated by Uber and Lyft were much more likely than male users to agree they don't use the services more because "I am afraid to be paired with an unpleasant passenger" (61% to 47%) and "I feel safer having another person in the car other than the driver" (50% to 26%).

Table 1. Possible motivations to use and not use pooled SVs services.

Motivation to use pooled ride-hailing, e.g., UberPool or LyftLine	Mean	Agree	Neutral	Disagree
There is a chance I do not get paired with another passenger.				
With pooled SV experience	4.1	42%	28%	30%
Without pooled SV experience	4.0	33%	39%	27%
I feel safer having another person in the car other than the driver.				
With pooled SV experience	3.8	36%	21%	43%
Without pooled SV experience	3.9	36%	27%	37%
Motivation to NOT use pooled ride-hailing, e.g., UberPool or LyftLine				
I am afraid to be paired with an unpleasant passenger.				
With pooled SV experience	4.2	53%	13%	33%
Without pooled SV experience	4.5	62%	9%	30%
There are no clear norms of interaction.				
With pooled SV experience	3.6	33%	21%	46%
Without pooled SV experience	3.6	32%	22%	45%
I cannot indicate a preference not to interact with the other passenger.				
With pooled SV experience	3.5	30%	24%	45%
Without pooled SV experience	3.7	36%	19%	45%
I cannot see the name, gender, and age of the other passenger.				
With pooled SV experience	3.5	34%	16%	51%
Without pooled SV experience	3.5	33%	16%	51%
I cannot rate and see ratings of other passengers.				
With pooled SV experience	3.5	30%	20%	50%
Without pooled SV experience	3.6	33%	20%	47%
I cannot see a picture of the other passenger.				
With pooled SV experience	3.3	27%	18%	55%
Without pooled SV experience	3.3	26%	17%	57%

Source: Sarriera et al (2017).

Note: All items originally measured on a 1–7 scale from strongly disagree to strongly agree, thus a score of 4.0 indicates, on average, neither agreement nor disagreement, i.e., “neutral”. Sarriera et al (2017) also presented data in aggregate categories shown here. Percentages may not add to 100 because of rounding.

Sample sizes: TNC users with experience using pooled services = 752; TNC users without experience using pooled services = 245

Automated Vehicles

Much of the discussion about AVs related to the topic of this paper is about road or traffic safety, i.e., the expected relative incidence of accidental collisions of vehicles in systems of AVs compared to the present system of humanly-piloted vehicles. There has been some extension of this topic to include collisions between AVs and non-vehicular road users, e.g., cyclists and pedestrians. Marchant and Lindor (2012) bluntly state, “Cars crash. So too will autonomous vehicles….” Lin (2013) reminds us that any *net* reduction in deaths and injuries from motor vehicle accidents will be accompanied by a redistribution of who is at risk of being killed or hurt.

Motivated by the starkness of these observations, Hevelke and Nida-Rümelin (2015) develop a set of ethical questions about responsibility for crashes of AVs. Their questions largely revolve around the relative responsibility of AV manufactures (such future manufacturers may include more than “car companies,” including also providers and integrators of systems of sensors, communications, software, etc. required to produce systems of SAE level 5 AVs) and users of AVs. While this paper deals with personal risk constellations, the introduction of that concept through Grunwald’s (2016) societal risk constellations and the earlier reference to the social construction of technology open the door to at least mentioning other actors’ risk constellations. Ultimately, the following discussion will be brought back to users’ perceptions of safety and security.

The first question Hevelke and Nida-Rümelin (2015) address is under what conditions it would be ethical to develop “tort liability for car manufacturers in a way that will help along the development and improvement of autonomous vehicles.” Their answer—which may or may not be the same as that reached by any real-world process of legislation-regulation-litigation—is it is morally defensible if the result is a reduction in the probabilities of accidents resulting in deaths and accidents. They do diminish an essential element of their argument by relegating it to a footnote:

> *“…ethical problems of this sort might still play an important role in other questions surrounding autonomous cars. Certain pre-programmed reactions of an autonomous car in case of accidents might, for example, use some groups as means to an end.”*

In short, Hevelke and Nida-Rümelin’s (2015) response to Lin (2013) and to the “trolley problem” as it is framed for AVs, is to reject any specific instance of an AV’s operational logic dictating an action that protects the AV occupant(s) to the risk of people outside the vehicle. They argue that so long as the new system of AVs reduces the probability of collisions between AVs and between AVs and other road-users, e.g., pedestrians and cyclists, then an ethical basis is established for creating a system of tort liability to allow the development of systems of AVs.

However, it seems Lin’s (2013) point about systems of AVs producing net decreases in deaths and injuries from road accidents may put some people—who presently face lesser risk under the existing regime of human-piloted vehicles—at greater risk and Hevelke and Nida-Rümelin’s (2015) footnote cited above still looms. To the extent a realized accident risk distribution (of any system) is the sum of individual events, what are the rules that result in many AVs across many actual or avoided collisions that *don't* produce a new class of more-at-risk people? The question speaks to the developmental phase Hevelke and Nida-Rümelin's (2015) seek to allow because different responses across people to the prospects of different results of AV collisions depending on whether the respondent is asked to imagine they are in the AV or not. As cited in the introduction, Bonnefon et al (2016) report survey respondents routinely want AVs designed to,

> *"(…sacrifice their passenger for the greater good) and would like others to buy them, but they would themselves prefer to ride in AVs that protect their passengers at all costs."*

Such findings may be confounded by or may confound two subsequent questions raised by Hevelke and Nida-Rümelin's (2015) about assigning responsibility for crashes and their consequences to AV users—even in the case when the user has no opportunity or means to control the AV.

Perhaps concepts of trust will mediate these questions of liability, though trust and systemic outcomes have not been reported so far. Rather, to date trust has been tested within the limited context of whether individual respondents trust (an implied, single) AV. Whether people do or don't trust AVs or "self-driving cars" has been shown to affect their acceptance (e.g., Zhang et al 2019) and resistance (e.g., Konig and Neumayr (2017). Choi and Ji (2015) argue that a three-part definition of trust in automated systems (functionality-helpfulness-predictability) can be mapped into a three-part definition of trust in people (competence-benevolence-integrity):

> *"…functionality refers to the belief that the system has the capability, functions, or features to perform essential functions. Helpfulness refers to the belief that a system will provide adequate and responsive aid, whereas predictability refers to the belief that the system acts consistently and its behavior can be forecast. Functionality is similar to interpersonal trust's competence belief. Predictability construct is similar to interpersonal trust's integrity belief. Helpfulness is similar to interpersonal trust's benevolence belief."*

They conclude that in their sample of drivers, trust in the hypothetical system of fully automated vehicles was positively correlated with respondents' stated intention to use such a system. Further, trust in AVs mitigated perceptions of riskiness of AVs.

Choi and Ji (2015) discuss locus of control. They had hypothesized that people with an external locus of control, i.e., those who tend to believe that events are subject to control by others and events outside themselves would be more accepting of AVs. However, they drew no conclusions based on their survey data and modeling. In contrast, Hegner et al (2019) claim "trust in the technology and the concern about handing over control to a machine go hand in hand as respondents' cognitive and affective perception of [AVs]".

Still, evidence of the effects of trust in perceptions of safety and security of e-SAVs and their constituent socio-technical systems seems incomplete on the one hand and mixed on the other. On the one hand, little work seems to have been done on the issue of trust related to the electric and shared components of e-SAVs, especially as trust may mediate expectations of strangers. On the other hand, in presenting their results on trust and acceptance of AVs, Zhang et al (2019) cite several studies with varying results:

> *"…this is the first time that trust was identified as the most critical antecedent in determining AV attitude. Previous related studies have either reported that the role of trust in AV acceptance was insignificant (Kaur and Rampersad, 2018), supplementary (Buckley et al., 2018) or mediated by other factors such as [perceived usefulness] PU (Choi and Ji, 2015), probably due to limitations in the proposed models or the survey population. This finding suggests that trust not only influences human monitoring or operating behaviors when riding an AV (Körber et al., 2018; Payre et al., 2017), but also determines whether people in the first place would ride [in] AVs or not.*

Further, König and Neumayr (2017) were far more measured in their discussion of the role of trust, highlighting a lack of trust as an element of resistance to AVs. They caution against both "over-trust" as it may lead to inappropriate use as well as "under-trust" which may stymie growth in user bases and under-performance on social goals. Their results based on a sample containing non-drivers, drivers of vehicles without any automation features, and drivers of vehicles with some automation features with respect to "self-driving cars" include a "prevalent lack of trust across all sub-groups in the functioning of the technology." Further, their respondents were,

> *"…reluctant to hand over control over their cars to technology, the most distinct objections stemming from safety concerns caused by the fear of potential attacks by hackers and system malfunction."*

This conclusion would seem to address both security (cybersecurity vis-à-vis "hackers") and safety (as implied by "malfunction") as security and safety are defined in this paper.

Polling on Automated Vehicles

As was done in the section above on SVs, a few studies on responses to AVs are reviewed in more detail. Schoettle, B. and M. Sivak (2014) authored an early review of polling data on "autonomous and self-driving vehicles." The Advocates for Highway and Auto Safety released two brief "bullet point" summaries (2018a, 2018b) of 20 polls between 2016 and early 2018, both under the title "Public Opinion Polls show Skepticism about Autonomous Vehicles." Such polls have so far addressed general samples of households rather than users of any vehicles equipped with subsets of AV technologies, e.g., lane keeping, adaptive cruise control, and parking assistance. More sophisticated studies of such users are summarized in the next section.

Polling samples are often based on phone contacts—the better ones using landlines and cellular phones. In at least one case, the population of registered voters was sampled. Varying definitions of safety, security, and even AVs are used across the reviewed polls. Safety is generally limited to road safety. The only comment on "security" among the cited results was two-thirds of registered voters were "somewhat or very concerned about cyber threats to driverless cars." However, across these varied populations and definitions of safety and security, evidence from polls of samples intended to describe Americans generally find broad based skepticism of AVs.

Two of these polls are discussed at greater length, in part because their associated reports are more expansive than others and because they illustrate some of the issues just discussed. The two are from the Pew Research Center (Smith and Anderson, 2017) and J.D. Power (2019). Selected results from the Pew Research Center poll are shown in Table 2.

The Pew Research Center (Smith and Anderson, 2017) stated, "Americans express more worry than enthusiasm about coming developments in automation—from driverless vehicles to a world in which machines perform many jobs currently done by humans." Their report is based on a sample of over 4,000 Americans, weighted to be representative of the population, i.e., not intended to represent any likely early user groups. A dichotomy between "enthusiasm" and "worry" about automation across four areas is explored, with more attention to matters of economic outcomes and social equity. Concepts of safety are limited to road safety and designs of systems of AVs (including roadway infrastructure). Further some questions leave undefined whether the respondents are being asked to consider their reactions to AVs from the perspective of driving themselves in their own car or from that of a rider in an AV. Concepts of security were not asked at all. Pew's results indicate a split decision so far on expectations of the effects of AVs on road safety:

> *"And although a plurality (39%) expects that the number of people killed or injured in traffic accidents will decrease if driverless vehicles become widespread, another 30% thinks that autonomous vehicles will make the roads less safe for humans."*

In the limited contexts presented by Pew's survey questions, a sample of respondents weighted to be representative of the adult population of Americans is at best ambivalent about the road safety of AVs. As many say they would not feel safe ("not too safe" or "not safe at all") as would feel safe ("very safe" or "somewhat safe") sharing the road with "a driverless vehicle." Note how the singular article, "a," does not put the respondent in the mind of considering most or all (other) passenger vehicles on the road being AVs. The Pew report states a plurality of respondents think deaths from traffic accidents will go down, but it is a small plurality and over 60 percent of respondents think deaths from accidents will be unchanged or increase. Respondents are not ambivalent about their safety perceptions of sharing the road with "a driverless freight truck": nearly two-thirds say they would not feel safe.

Given this early public "worry" about AVs, strong majorities of respondents favor design and regulatory restrictions on AVs: requiring them to travel in dedicated lanes, restricting where they can travel (using the example of schools), and—in direct contradiction of the economic argument for automation in shared use vehicles (and freight)—requiring a "person in the driver's seat who could take control in an emergency situation." Based on all these, if willingness to ride in a driverless vehicle is the ultimate summary of prospective enthusiasm or worry about AVs, 44 percent reply they would, "personally, want to ride in a driverless vehicle…."

Table 2. Questions regarding automated vehicle safety, Pew Research Center (Smith and Anderson, 2017)[1]

Question	Answer Categories	Percent
How safe would you feel sharing the road with a driverless passenger vehicle?	Very safe	11
	Somewhat safe	37
	Not too safe	35
	Not safe at all	17
	No answer	0
How safe would you feel sharing the road with a driverless freight truck?	Very safe	8
	Somewhat safe	26
	Not too safe	33
	Not safe at all	32
	No answer	0
If driverless vehicles become widespread, do you think that the number of people killed or injured in traffic accidents will increase, decrease, or stay about the same?	Increase	30
	Decrease	39
	Stay about the same	31
	No answer	0
Would you strongly favor, favor, oppose, or strongly oppose the following rules and regulations for driverless vehicles?	Sum of “strongly favor” and “favor”	
• Requiring them to travel in dedicated lanes		83
• Restricting them from traveling near certain areas, such as schools		69
• Requiring them to have a person in the driver’s seat who could take control in an emergency situation		87

[1] Randomization of question and answer options used in the conduct of the survey are not shown in this table.

Polling by J.D. Power (2019) indicates greater skepticism possibly stemming from a different definition of vehicle automation. After stipulating that “a ‘fully automated vehicle’ [is] a car in which the occupants have no control,” the J.D. Power poll continues to a set of questions about safety without stipulating a definition of that word. Taken at face meaning, nearly half of respondents (45%) would require AVs as defined to be “100% safe—0% error” before they would ride in one. Nearly as many (38%) indicate they simply would not ride in an AV. This is one of a few polls to use the word “trust”: it does so within the context of who would respondents trust “to perform reliable safety testing.” A plurality (40%) would trust no one, of the other options (vehicle manufacturer, federal government, state governments, Insurance Institute for Highway Safety, Highway Loss Data Institute, Other) the only one to get even double-digit percentage response was the vehicle’s manufacturer (12%). Whether with regard to themselves, family members, or other people such as pedestrians, the highest level of risk of injury or death respondents say they would “be comfortable with” is a 100% reduction compared to a “normal car.” Again, taken at face value the latter indicates most people would not ride in an AV unless the risk of injury or death was entirely eliminated.

Whatever the progress in technology and systems research, development, and testing, those few polls that have been repeated over time do not indicate contemporaneous increases in public "comfort," "confidence," or "enthusiasm" among their samples. Two insurance companies, State Farm and AAA, are implementing multi-year studies to track response to AVs. In their 2016 press release, State Farm states, "Despite increased awareness, respondents in 2016 are no more likely to express interest in purchasing a fully autonomous vehicle than respondents in 2013." This is more skeptical than it seems as the press release goes on to say that in addition to increased awareness, "[2016] respondents are slightly more confident in the ability of self-driving vehicles to safely navigate on their own than respondents in 2013." In their more recent press release, AAA (2019) states, "Seven in ten (71 percent) U.S. drivers would be afraid to ride in a fully self-driving vehicle, similar to levels of fear in April 2018 following high-profile incidents involving fatalities."

From a methodological perspective, the lack of consistent populations of study, means of sampling even when study populations are the same, and differences in questions and concepts of safety—and the near absence of the concept of security—across questionnaires limit comparability across polls and the applicability of much polling to the topic of e-SAV user safety and security constellations. However, the relative consistency of the overall conclusions despite these differences suggests that broad-based consumer reticence about AVs is robust across all these differences: no matter who is asked or how they are asked, so far and over time more people claim to be aware of AVs but no more are looking forward to being in AVs.

Electric Vehicles

For systems of e-SAVs, for which it is stipulated there is no driver in the vehicle, many of the usually cited problems of electric vehicles are difficult to assess, notably those that may pertain to safety and security. A few possible areas of concern are discussed briefly: so-called "range anxiety" and the sound levels of electric-drive vehicles as this may affect cyclists and pedestrians.

"Range anxiety" is typically defined as, "the everyday fear of drivers to run out of fuel and/or electricity before they reach their destination or a refueling or recharging station" (Kester, 2019). It has rarely been defined or evaluated explicitly in terms of safety or security. Kester (2019) introduces a novel conceptualization of stress [stemming from anxiety] as an embodied instance of insecurity. Still, it is difficult to locate this concept of (in)security within the "safe from intentional harm" conceptualization of security used in this white paper. Noel et al's (2019) exploration of the "reactionary rhetoric of range anxiety" does touch on safety issues caused by the potential to be stranded by the roadside. They map this into Hirschman's (1991) category of "jeopardy." No work was found exploring whether potential users of future systems of e-SAVs will be concerned that a vehicle in which they are riding will be delayed in reaching a destination because it requires charging.

The quiet of electric-drive vehicles has been characterized as problematic for other travelers, particularly people such as cyclists and pedestrians who rely on auditory cues to help judge the approach of motorized vehicles. Wogalter et al (2001) noted their survey respondents favored hybrid and electric drive vehicles—when the only characterization offered was these would be "quieter than gasoline engine-powered vehicles." However, asked to consider this from the perspective of a pedestrian, "respondents expressed concern over the reduced auditory cues to the presence of a moving vehicle." Emerson, et al (2011) document the difficulty visually impaired pedestrians had in hearing passing hybrid electric vehicles. While cautious about offering conclusions, the authors indicated that the increased difficulty of participants in hearing quieter vehicles warranted further investigation. As a transitional issue for e-SAVs—at least in the U.S.—the quiet of EVs is presently the subject of rulemaking by NHTSA (49 CFR, Parts 571 and 585: Minimum Sound Requirements for Hybrid and Electric Vehicles).

Other Road Users: Cyclists and Pedestrians

Continuing from the discussion of the quiet of EVs, Merat et al (2017) review research into other motor vehicle interactions with pedestrians. It appears pedestrians use different cues to judge whether it is safe to cross in front of a vehicle depending on vehicle speed: at faster vehicle speeds, pedestrians seem to rely more on cues from the movement of the vehicle while at slower speeds, pedestrians seem to rely more on cues from the driver (Schneemann and Gohl, 2016). The implication for Level 5 AVs is of course there is no driver in the vehicle. Merat et al (2017) go on to describe several efforts by automakers, AV system developers, and others to address, "how to replicate these implicit and explicit communication strategies in the absence of person-to-person communication."

Evidence from Other Travel Systems

Air Travel

While searches for studies at the intersections of safety and security on the one hand and vehicle electrification, sharing, and automation were intended to produce the most relevant literature, supporting evidence is found in other literatures. Air travel presents another option to learn from travelers in a system that shares at least one pertinent feature with Level 5 automation: the airplane is entirely out of the control of any given "user" (counting the airline crew as part of the provider system). Koo et al (2018) study the effect of safety information on air travelers (hypothetical) flight choices. While the study, as with so many others, fails to define "safety" (the closest offering is to rate different flight options by an undefined "safety record" or by the number of or chance of "incidents"), several results suggest hypotheses for study with respect to e-SAVs.

First, the statistical model that best fit the experimental data accounted for threshold effects, i.e., not all respondents trade off safety levels (or service levels) over the entire range of attributes and even among those who do, there are distinct groups of people with low or high estimated willingness to pay for higher safety. The classes of respondents who did not trade-off safety and service over their entire ranges fell largely into two groups previously identified in the context of car commute choice (Hess et al 2012): one eliminates all options but the safest, if there are ties on the safest, then they choose among the remaining options based on service levels; the other eliminates the worst safety option, then chooses based on service levels. (The choice among service levels may itself be based on either these sorts of thresholds or on a tradeoff among service attributes.)

Second, the distribution of choice making styles across a population is subject to the form in which safety information is presented. While at least a plurality of respondents appeared to choose flights based on a “fully compensatory” strategy of weighing all attributes across their full range of values, across all non-compensatory strategies, at least a fourth and up to just more than half of respondents did not. Presenting safety information as the number of incidents a specific type of aircraft had been involved in over the past three years (presumably across all airlines flying that type of aircraft) invoked the highest percentage of people to choose a non-compensatory decision strategy of simply eliminating all options but the safest.

Third, and generalizing the first and second, there are distributions of perceptions of airline flight safety, decision strategies regarding choosing flights in the presence of safety information, and thresholds of acceptable safety across the population. The latter indicates that safety is not perceived by nearly all the population as a linear variable.

Informal Carpooling

Though not widespread, the practice of informal carpooling that developed around high occupancy vehicle (HOV) lane access provides insights into sharing cars with what Millgram (1977) described as “familiar strangers.” The example is of greater relevance to the case of e-SAVs than carpooling which generally is practiced by people who are at least acquaintances, fellow students, or co-workers prior to their carpool relationship. The practice of single occupancy vehicle drivers picking up riders so as to provide the driver with the time savings afforded by HOV lane access and the rider with the option of commuting to work by car rather than transit came to be known as “slugging.” Mote and Whitestone (2011) use Giddens’ (1984) structuration approach and the role of routines in creating the ontological security required for the practice of strangers to travel together in informal carpools. Mote and Whitestone (2011) describe that elements of the structuration of slugging included the relative balance of power between drivers and riders—drivers need riders to access HOV lanes; drivers owned the vehicle—and the development of norms to guide both in-car and queueing behavior for riders. In-car behaviors were largely normalized to maintain personal space within the possibly cramped (for strangers) confines of a car, e.g., riders were not to initiate conversation. While waiting for a ride, etiquette imposed a “first-come, first-served” definition of equity modified by a norm that the last person standing in line should not be a woman left to wait alone.

Incipient Institutional Frameworks

This note highlights some of the institutional actors in creating any transition to e-SAVs. It is meant to acknowledge the creation of some fora to address users’ safety and security perceptions of e-SAVs while suggesting others that may be desirable This starts with an introduction to relationships between system/service providers and legislators/regulators, but the important questions suggested by this white paper are 1) who is perceived to be responsible by (potential) e-SAV users and other affected actors for safety and security and 2) what are users' responsibilities, or perhaps again, what do they perceive their responsibilities to be?

The roles of governments and technology and service suppliers is being negotiated at and across multiple levels of governance. The integration and deployment of the constituent technologies of e-SAVs bring some participants from government and industry who do not play a large or any role in a model of privately-owned and operated, petroleum-fueled vehicles that dominated a century of automobility. Electrification of vehicles brought new suppliers, e.g., battery manufacturers, electric utilities, electric vehicle service equipment manufacturers, and new market entrants to automotive production and sales. It also involved new regulators and new roles for regulators. The California Air Resources Board created a role for itself in demanding "zero emission vehicles"; the California Public Utilities Commission added vehicle electrification to its transportation docket (which of some relevance to vehicle sharing and automation, also includes regulating the taxi and limousine industries).

Vehicle sharing and automation may greatly increase the number and variety of actors from government and product and service providers in discussions of the safe and secure operation of systems of e-SAVs. While sometimes created to finance, construct, and/or operate and manage infrastructure and development projects, public-private partnerships can serve to, more or less formally, inform and negotiate new rules, regulations, and relationships between responsible parties. In this capacity, such partnerships may also call themselves working groups, steering committees, or by a variety of other names.

In the case of e-SAVs, an example of such a steering committee is California's Autonomous Vehicle Steering Committee (though this example presently does not include suppliers). This steering committee includes representatives of state and federal agencies who have traditionally been responsible for roads and road safety: Caltrans, California Highway Patrol, Department of Motor Vehicles, Office of Traffic Safety, Department of Insurance, State Transportation Agency, and the National Highway Traffic Safety Administration. This steering committee informs the process of creating regulations in California, first for testing AVs with a driver in the vehicle and now for AV testing without drivers. The Steering Committee and its activities are described further in Soriano (2018). Similar committees exist within other states and across multiple jurisdictions, e.g., the American Association of Motor Vehicle Administrators' Autonomous Vehicle Working Group (https://www.aamva.org/Autonomous-Vehicle-Best-Practices-Working-Group/) and the Association of Metropolitan Planning Organizations AV Working Group (http://www.ampo.org/resources-publications/ampo-work-groups/connected-and-autonomous-vehicles-working-group/).

Notable for this discussion, the regulations promulgated by the State of California for testing of AVs without drivers include the requirement that any passenger in such a vehicle who is not an employee or contractor permitted to run the test be notified what personal information, if any, may be collected and how it will be used (Soriano, 2018).

Conclusions: A Research Framework and Agenda

The central hypothesis of this white paper is that users and potential users of socio-technical systems of e-SAVs will perceive personal risk constellations, i.e., perceived sets of more or less uncertain safety and security costs and benefits, that will shape who may be among the first users (of an e-SAV system of a particular design), why they will be at least willing and possibly eager to use it, as well as whose personal risk constellations will have to be reconciled with e-SAVs design and operation before they become users. The importance of such differences in framing is seen in specific results presented in the paper, e.g., the approximately 50% increase in the number of people who state a willingness to use a "self-driving vehicle" when the vehicle is described as being as good a driver as the respondent.

That we may expect different people to see the same system of e-SAVs represent different personal risk constellations is evidenced by work to date on the users of the constituent technologies (EVs, SVs, and AVs), their combinations, and even other modes. Differences have been observed between demographic groups in the uptake and use of EVs, SVs, and AVs. The specific case for how women and men can be expected to have different concerns for safety and security has been used as an example to illustrate the existence of groups of people who may systematically differ in their personal risk constellations. Such differences as these overlay other reasons why we expect differences in personal risk constellations: from individuals' psychological traits, to household location and mobility contexts, to land use patterns and regional transport infrastructure systems, as well as the responsiveness of e-SAV system designers, operators, and regulators to attend to a multitude of safety and security constellations.

This paper started with the definitions of safety and security, as well as risk, uncertainty, and trust. The decision to start with definitions is a response to one of the most important conclusions of this paper: concepts of safety and security are defined differently or not defined at all across literatures from researchers, government agencies, industries, and consultants. The definitions used here rest on a distinction between whether any actual, anticipated, or unexpected harm to a person (or institution) or their virtual representation was accidental or intentional (by some other actor). In this way, "safety" is taken to be a category of accidental harm that contains many types of harm identified as the consequence of, as examples, accidental collisions, unexpected (by the user) braking, acceleration or turns, or accidental release of personally identifiable information. Similarly, "security" is a category of intentional harms. Redrawing safety and security this way places other "topical" definitions such as road safety and cybersecurity, into either or both the safety and security categories depending on whether any anticipated or actual harm (or harm reduction) is accidental or intentional. Thus, crime is cast as a security issue rather than a safety issue as it was characterized in Feeney's (2015) comparison of SVs and conventional taxis.

Notions of safety and security were grounded in an approach to "risk society" (Beck, 1992). The argument is not that hazards did not exist in prior social eras, but that the idea the future is risky and uncertain is new and gives people and institutions a focus on the future that differs from pre-modern eras. This pervasive risk must be countered by ontological security—a feeling (even more than a belief) that people and institutions can be trusted to be who they appear to be and to act as they are expected to act (Giddens, 1991). Widespread acceptance of e-SAVs requires that all the actors involved—system and service providers, regulators, and users—can be trusted. To trust a system of e-SAVs requires users to feel they can make themselves vulnerable with the expectation that the actions of all the other actors involved are at least non-threatening and at best beneficent to the interest of the user. Giddens's (1984, 1991) structuration approach provides a framework to organize the concepts of safety, security, trust, risk, and uncertainty.

It could be argued that in offering a distinction between safety and security based on intention, this paper further confounds a discussion that is already confusing because of multiple or missing definitions of the same terms. However, the disparate definitions of safety and security provide at least indirect evidence to support the central hypothesis of this paper: depending on a researcher's interest, a decision maker's purview, whether someone is a designer, producer, operator, regulator, or potential user—they may see different aspects of things they call "safety" and "security."

For now, the multiplicity of definitions seems far less problematic than the failure to define terms. It has been noted several times throughout this paper that authors did not offer definitions; in some cases, their meaning could be inferred, in others they could not. Addressing this is part of the call for better comparability across studies of e-SAVs offered by Zoellick al (2019):

> *"(1) transparency of definitions and operationalisations, (2) availability of all data and questionnaires, (3) rigorous reporting of data structure, reliability, and statistical properties, (4) critically evaluating the own approach, and (5) positioning the findings within the corpus of existing research."*

With modification, these might be adopted as principles for not only research, but also development, deployment, operation, and governance. The call for "availability of all data" might be most problematic as it must be reconciled with the safety and security of users, data about and from the e-SAV system that can be tied to users, and data about the e-SAV system that even if it can't be used to target a specific user can be used to put "users" more generally at increased risk of harm.

Regarding the central hypothesis of the existence of personal risk constellations, the conclusion drawn here is it remains largely unaddressed in the literature reviewed here. As such these questions laid out in the Introduction remain unanswered and thus form elements of a research agenda to guide transitions:

1) Do different users and potential users of e-SAVs perceive different risk constellations?
    i) If so, what are those constellations?
    ii) How does the integration of electrification, automation, and sharing or pooling affect those constellations?
2) Do these constellations vary systematically by characteristics of users?

3) As a matter of how to create and sustain transitions, how do answers to questions such as these affect societal risk constellations?

The question of framing raised earlier relates to the relevance of several of the specific results presented. As this white paper stipulates Level 5 automation, does work on present users of SVs—which have a driver—help us understand possible future personal risk constellations of e-SAVs? Unless future e-SAVs alert their riders to impending exhaustion of battery charge, what is the import of present research on “range anxiety” among EV drivers (or perhaps more importantly, those who are not yet EV drivers)? The relevance is whatever experience of vehicle electrification, sharing and pooling, and automation people may have are likely to shape their perceptions of e-SAVs. That is, if people will have personal risk constellations for e-SAVs, then they already have such constellations for the systems of travel modes they use now.

Putting this into context with the research topics just stated, examples of more specific research questions would include:

- Do people have personal risk constellations of presently available modes whether they use them or not?
    - If so, what are the elements of those constellations and how are they interpreted?
        - For example, if an SV user has a perception that they are secure from harm from a crime committed by the “stranger” who is their SV driver because they know the driver is registered with a company that required a background check on the driver, will some SV users want all users of e-SAVs to be similarly screened?
            - Are these hypothetical SV users distinguishable as a group from other SV users?
        - How do these present SV users’ personal risk constellations affect their imagined constellations for e-SAVS?

Regarding this example, research presented here addresses how much and by what means some people want access to information about the stranger who may enter “their” SAV (Etzione, 2019). In this way, research on extant personal risk constellations may reveal what those constellations are but more importantly how they affect present travel choices whether or not it provides specific solutions to future risk constellations associated with e-SAVs.

This white paper is a call for clarity not consensus on terminology, theory, and methods. This call extends to research on perceptions of users of the constituent socio-technological sub-systems—vehicle electrification, sharing or pooling, and automation—of e-SAVs and their incipient combinations into systems of e-SAVs. Axsen and Sovacool (2019b) describe the variety of representations of users and potential users in a recent special journal edition on the role of users on electrified, automated and shared mobility as a “rich mosaic of frameworks… each framework is better equipped to observe different aspects of the user.” For all the richness in that special journal edition (Axsen and Sovacool, 2019a), even it does not span the possibilities. Sanguinetti et al (2019) used Sommer’s (2007) exploration of personal space as the behavioral basis of design. Several authors rely on, or comment on the reliance on, various forms of models of individual decision making that attempt to relate attitudes, norms, values, and beliefs to intentions and behaviors. These models include the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), the Theory of Planned Behavior (TPB) (Ajzen and Fishbein, 1980), the Technology Acceptance Model (TAM) (Davis, 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al, 2003), as well as less cognitive and more emotional frameworks such as pleasure-arousal-dominance cited in Nordhoff et al (2016).

All these approaches focus on the individual user who should be recognized as living in and responding to the larger social-political-economic world in which any system of e-SAVs would be realized. Viewing e-SAVs as socio-technical systems in which users are but one set of actors, Axsen and Sovacool's (2019) offer:

> *"a socio-technical systems or transition approach will consider the broader social system, with numerous types of users (including stakeholders and non-users), a broad range of perceptions, and representation of dynamic processes such as the formation and negotiation of those perceptions and meanings amidst changes in systems, infrastructure and social structure.*

The variety of questions, answers, and insights into how users and potential users of the constituent systems of e-SAVs reviewed in this white paper echo calls from authors such as Axsen and Sovacool (2019b), Zoellick et al (2019) and Sanguinetti et al (2019) to continue to work across a spectrum of social science approaches, theories, and methods. Jackson (2005) provides an accessible review of the potential scope of behavioral theories and approaches that could be brought to bear. Further, doing so in conjunction with hardware and software designers, system integrators, mobility service providers, legislators and regulators would mean we are taking a self-aware approach—a reflexive approach (Giddens, 1984, 1991)—to socio-technical systems of e-SAVs.

This socio-technical framing hearkens back to Grunwald's (2016) definition of societal risk constellations that serves as the source of the notion of personal risk constellations. Continuing efforts to hear alternative perspectives, promote multi-disciplinary research, and incorporate direct user participation in imagining e-SAVs may best resolve personal risk constellations of e-SAVs to assure their design, deployment, and operation in ways that assures the user behaviors, i.e., widespread uptake and a willingness (and even desire) to share rides, that at present are believed to be required to achieve goals such as improved safety and security, reduced emissions of regulated pollutants and climate forcing gases, and improved transportation equity.

Glossary

This glossary presents definitions of terms as they are used in this white paper. Terms are listed in the order they first appear in the main text.

Safety—being secure from accidental harm.

Security—being safe from intentional harm.

Risk—describes situations in which an action may lead to more than one outcome.

Uncertainty—the extent to which possible outcomes and their probabilities are unknown.

Trust—willingness to make oneself vulnerable to the actions of others.

Electric-powered vehicles (EVs)—vehicles powered by electric motors including plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and hydrogen fuel cell electric vehicles (FCEVs) though there is an assumption of a transition to all-electric BEVs and FCEVs.

Vehicle automation—SAE's (2016) Level 5: vehicle systems capable of "fully automated driving" are the focus of this white paper though research on lower levels of automation are reviewed, too.

Shared (and pooled) vehicles (SVs)—allow or require users to contemporaneously share a vehicle with users. The term "pooled ridesharing" is used to refer to the specific case of strangers making contemporaneous use of a vehicle. The discussion of SVs will allow for solo and pooled use but look toward systems in which pooling is the pervasive use.

e-SAVs—the acronym to name systems that integrate electric-drive, high levels of vehicle automation in services that provide shared and pooled mobility services. Without stipulating what other supporting information and communication systems are required for any specific implementation of e-SAVs, the implied product and service providers are included as possible "points" in personal and societal risk constellations.

Societal risk constellations—relationships between the risks perceived, managed, insured or otherwise experienced and managed by "the relationship between groups of people such as decision-makers, regulators, stakeholders, affected parties, advisors, politicians and beneficiaries" (Grunwald, 2016).

Personal risk constellations—personal risk constellations are hypothesized to be perceived sets of more or less uncertain safety and security costs and benefits, that will shape who may be among the first users (of an e-SAV system of a particular design), why they will be at least willing and possibly eager to use it, as well as whose personal risk constellations will have to be reconciled with e-SAVs design and operation before they become users.

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