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Introduction

Autonomous driving is often depicted as a ‘disruptive’ technology with a potential for having a prominent ‘impact’ on society. For example, the Scientific Foresight Unit of the European Parliament lists autonomous vehicles as the first of ten technologies “which could change our lives” (van Woensel et al. 2015). Autonomous driving promises that motorized vehicles can be fully automated. That is, driverless cars are expected to be able to navigate through messy everyday traffic without human supervision.

Germany’s Federal Government expects autonomous driving to enhance traffic safety and reduce emissions (The Federal Government 2015, p. 8–11). By optimizing traffic flow, it is assumed to make room for more motorized traffic on the existing roads. As a technological fix, autonomous driving is expected to remedy some of automobility’s issues, such as, congestions and accidents. What appears desirable for the Federal Government seems threatening to others. For example, some German automotive and technology journalists draw on dystopian science-fiction narratives to locate autonomous driving within a frame of loss of control and robot uprising (Berscheid 2014, p. 28).

The driverless car is a vision. It exists only in the form of expectations and promises that have shaped their potentials. However, there are other technologies related to autonomous driving which have entered everyday traffic. Today’s cars are equipped with a multitude of driver-assistance systems, which range from the anti-blocking system to the latest advanced driver-assistance systems (ADAS), such as Tesla’s “Autopilot”. The “Autopilot” enables a “car to steer, accelerate and brake automatically within its lane.” (Tesla 2019) Nevertheless, “Autopilot features require active driver supervision and do not make the vehicle autonomous.” (ibid.) ADAS do not fully substitute for drivers. All ADAS require a driver to be present and conscious behind the wheel (Broggi et al. 2016, p. 1630). Neglecting to monitor ADAS can lead to lethal accidents (see Stilgoe 2018).

Autonomous driving is not a novel phenomenon; it is a long-standing modernist dream of control that has yet to be realized. For instance, roboticist Raúl Rojas refers to a 1918 cover of *Scientific American* depicting a futuristic automobile. Its caption reads “The motorist’s dream: a car that is controlled by a set of push buttons” (Rojas 2013). According to Rojas, this exemplifies the promise that drivers could use their driving-time for activities other than operating their vehicle within traffic.

During the past 100 years, driverless cars and autonomous driving have been imagined under various labels, such as automated highway systems (hereafter: AHS). Expectations and promises have remained stable over time (Wetmore 2003). Advocates of automated driving promise driverless cars that are supposed to be safer, more efficient, and more comfortable than manually driven cars. Autonomous driving is expected to be feasible and its realization is promised to be within reach. Enthusiasts of driverless cars continually cite technological improvements as reasons for the feasibility of these cars. With each technological advance, enthusiasts claim that their dream can be turned into reality.

Technological progress and its related technological imperative are the ideologically resources that underpin visions of autonomous driving. Technology demonstrations (Smith 2009; Simakova 2010; Rosental 2013) are crucial practices in sustaining autonomous driving. In technology demonstrations sociotechnical assemblages are presented in action as evidence for their worth. Companies and university projects use technology demonstrations to convince external audiences by providing visual 'proof' of the feasibility and of the usefulness of an envisioned technology. It is through the agencies' of these demonstrations, that visions acquire substance as these presentations enact links between concrete technological artifacts and more encompassing visions.

The vision of AHS has been popularized by General Motors, who sold AHS to the U.S. public through a large-scale marketing effort. The company's "Highways and Horizons" pavilion at 1939's World Trade Fair in New York City featured a vision of the city of 1960, which it called "Futurama" (Norton 2011). Inside the pavilion, visitors sat on armchairs mounted on a conveyor and were moved over a 3000 m^2 model landscape. Visitors took on the bird's-eye view of a modernist city planner as they looked down on "10,000 animated model cars, dashing along a fourteen-lane highway, [which, GB] embodied the automatic traffic of tomorrow, kept in lane by radio waves" (Kröger 2016, p. 48). Futurama was envisioned as a city dominated by cars but without the usual gridlock and messiness. GM's vision was more about reconstructing the city to accommodate 1940s cars than presenting the car of the future (Norton 2011, p. 593).

There was a considerable discrepancy between what was envisioned and demonstrated in the form of models and what was technologically feasible (Wetmore 2003). Wetmore argues that GM benefitted from this dream—despite its not being realized—because "by selling the future GM was also selling the present" (ibid.). General Motors' concern in this technological demonstration was to promote automobility (Urry 2004; Böhm et al. 2006) and to secure its future rather than to implement large-scale efforts of automation. Wetmore points out that, at the time of the exhibition, it was uncertain whether cars would remain a dominant form of transportation. It was only after World War II, with the construction of the U.S. national highway system and the emergence of suburban sprawl, that automobility's hegemony solidified (Seiler 2007).

AHS contributed to making already existing cars more appealing by providing imaginary solutions to automobility's pressing problems and thereby contributing to the hope that automobiles could be further improved. Wetmore argues that the continued appeal of these visions stems from the seductiveness of the technological demonstrations. AHS was never realized outside of carefully staged presentations, whereas other forms of car automation became working systems and achieved mass production. The grand vision of AHS was reduced and individualized into cruise control in the mid-1950s (Kröger 2016, p. 55).

In the new millennium, autonomous driving has become a hot topic in AI and robotics primarily due to the ever-growing civilian market for ADAS and the demand for uncrewed military ground vehicles (Broggi et al. 2016). In 2000, the U.S. Congress passed a mandate (U.S. Government 2000) that by 2015 one-third of the operational ground combat vehicles of the U.S. military were to be uncrewed ("unmanned"). In response to this, the Defense Advanced Research Projects Agency (DARPA) organized a series of *Grand Challenges* in 2004, 2005, and 2007. DARPA and its predecessor agencies have been a key driver and supporter of AI and robotics since the 1960s (Edwards 1996, pp. 64–65). Prizes and competitions are a well-known method to support technological research and innovation (Maibaum 2018).

DARPA sees military potential in autonomous driving in so far as it promises to increase the security of U.S.-American soldiers. During the opening of the DARPA Urban Challenge 2007, Tony Tether, the director of DARPA from 2001 to 2009, promised "that this technology will save a lot of lives—on the battlefield."[1] DARPA succeeded in enrolling many influential researchers and thus enlarged a research community that was marginal prior to the Grand Challenges (Broggi et al. 2016, S. 1630). During these events, in which research vehicles were required to solve tasks such as completing an autonomous drive through the desert or through simulated suburban traffic, university projects competed with each other for a cash prize.

Researchers are often motivated by the belief that autonomous driving can be compartmentalized into tasks or subproblems to be solved, such as "path-planning in structured areas" (Wang 2012, pp. 103–124). For roboticists in the field of autonomous driving, driverless cars in everyday city traffic are more than a seductive future; today, university projects and automotive companies conduct street trials (Marres 10/21/2016). In street trials, companies and university projects monitor their research vehicles' performance in in everyday city traffic. Research vehicles are computationally enhanced

1 https://youtu.be/-xibwwNVLgg?t=17 [Checked on 03/04/20]

automobiles that can serve two purposes at once. First, they serve as research instruments in the process of solving subproblems, which involves testing, evaluating, and improving approaches from artificial intelligence (AI) and robotics. The objective is to determine the feasibility of a specific approach, for example, that of a certain sensor configuration paired with a specific algorithm. Second, since solving specific subproblems often materializes in visible movements of the research vehicle or visualizations of the algorithm's output, the research vehicle can also be used for technology demonstrations. Streets trials can serve the two objectives simultaneously.

Sustaining autonomous driving

So far social science has mostly been concerned with possible implications of driverless cars (Bissell et al. 2018; Büscher et al. 2012; Laurier and Dant 2012) rather than in analysis of empirical materials. These speculatively oriented studies are complemented by empirical studies on acceptance (e.g. Fraedrich and Lenz 2016), which take for granted the feasibility of driverless cars and the future widespread diffusion of autonomous driving. All of these studies tend to reproduce uncritically the rhetoric of governments, private companies, and research projects that are rallying for autonomous driving. The above studies misconstrue contemporary innovation. The proliferation of hyperbolic expectations and visions can be seen as a necessary part of strategic science and technology innovation (Borup et al. 2006, pp. 286–287). The claims of inevitability of autonomous driving are acts of persuasion (Stilgoe 2020, pp. 8–9). Governments are inclined to stimulate hype in order to justify present spending on irreducibly uncertain 'technologies of the future'. Private companies and publicly funded research project are incentivized to claim that driverless cars are within reach; these actors compete for attention and financial resources (Stilgoe 2020, pp. 40–41). With regard to autonomous driving, "the gap between baby steps and giant leaps, between concept cars and transport systems, is filled with promise and speculation." (Stilgoe 2018, p. 33). Given that we are dealing with a vision, the only certainty is that there is no certainty concerning if, when, under which conditions, and for whose benefit autonomous driving will be realized.

Studies that investigate autonomous driving empirically are still rare (Brown and Laurier 2017), but this seems to be changing. For example, Stilgoe reconstructs the competing definitions of problems, solutions, and concerns within the public debate of autonomous driving (2018). What remains missing, however, is an analysis of the lived relations between technological artifacts, researchers, and visions. This study seeks to contribute to an understanding of autonomous driving by engaging with technological artifacts and with the practitioners who actually try to realize visions of autonomous driving.

This book is not about if, when, how, and to whose benefit autonomous driving will emerge. Science and Technology Studies consider technological research and innovation to be contingent and heterogeneous (Bijker and Law 1992). The emergence of a particular technology depends on the stabilization of a sociotechnical network of heterogeneous elements; its elements are human and nonhuman. Thus, technological research and innovation is never only 'technological'. Furthermore, technologies are not 'born' feasible. Technologies only seem inevitable in retrospect. This study investigates a technological project in a situation where very little is certain but expectations are high. It analyzes how relations between technological artefacts, visions, and researchers are sustained both symbolically and materially.

This book is not about 'the future'. Rather, it is about how certain visions of the future are kept alive in the observable present. In particular, this study examines research in autonomous driving by engaging with a pioneering project in computer science. Autonomous driving is investigated through the lenses of narrative, care, and gender-technology relations.

Narrative forms are a primary element of autonomous driving. To endow their artefacts with meanings that are recognized by laypersons, researchers in autonomous driving need to construct frames of meaning (Carlson 1992, p. 177) in which autonomous driving makes sense. As autonomous driving is controversial, researchers need to craft persuasive and compelling narratives. These narratives are enacted through texts and speech, but they also enacted through staged performances, including video demonstrations. Visionary storytelling reduces the complexities of research in autonomous driving by concealing its contingencies and uncertainties. Innovation communication is not what comes 'after' technological research but is rather integral to the very processes of innovation (Horst et al. 2017, pp. 892–893).

In the hands of the computer scientists doing research in autonomous driving, these visions are transformed into a variety of enactments, including street trials and video demonstrations. It is through these translations that visions are sustained and acquire substance. Unlike carefully staged video demonstrations, street trials are risky. During Uber's street trials a pedestrian was killed in 2018 (Stilgoe 2020, p. 1). Sociotechnical assemblages of autonomous driving demand care to be held stable in the messy and contingent world of everyday city traffic.

This study is situated within a recent re-orientation in the social studies of technology (Both and Cohn 2017; Cohn 2013; Denis and Pontille 2015; Jackson 2014; Singleton 2010) towards relations of care in sociotechnical assemblages, which connects to earlier studies of repair and maintenance (Orr 1996;