Markus Edelmann (markus.edelmann@kit.edu)
Silke Zimmer (silke.zimmer@kit.edu)
Karlsruhe Institute of Technology (KIT)
Institute for Technology Assessment and Systems Analysis (ITAS)

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Autonomous driving from the perspective of history and technology assessment

– working report

Abstract

In recent years, the media as well as vehicle manufacturers presented a vision for autonomous driving (AD) as a smart mobility future: as safe and convenient as possible and completely connected with the environment, the autonomous car would bring its passengers to their destination. The self-driving car would thereby reduce environmental impacts and provide more personal and private spare time for the passengers, to be enjoyed during their stress-free trip. Meanwhile, it is not clear whether the rollout of such a technology might have impacts on society – and if so, which ones. These and other issues are part of the activities of technology assessment (TA). TA in general evaluates scientific and technological developments with a focus on socio-technical impacts and possible systemic and unintended effects.

Working in the field of TA as a historian, parallels and links to historical topics and scientific historiography – normally unconsidered by TA – attract ones attention. Hence, we want to examine them in this contribution and highlight possible intersections between TA and (academic) history. For this purpose, AD serves as an appropriate case study to investigate the possible linkages between history and TA from an interdisciplinary perspective. It will be shown how TA could deal with AD and at which point history might join in.

The overall aim of the following contribution is to outline where linkages between both disciplines can be found and to sketch how a possible convergence of them could look like. To this end, a generalized overview on TA, its historical origins and basic concepts will be given. This will be followed by a short introduction to AD and its state of the art as well as TA research questions related to it. We will then give thought to these questions from a historical perspective and will also address visions and expectations. This will lead to a reflection about interdisciplinarity in TA and the possible role of history in this.

Technology assessment – a brief introduction to what it is and where it comes from

TA was developed between the 1960s and 1970s as a research-based discipline for policy advice. This led to the foundation of the Office of Technology Assessment (OTA) in the USA in 1972[1] according to the Technology Assessment Act (Congress of the United States 1972. The Technology Assessment Act: Public Law 92-484):

> *"The basic function of the Office shall be to provide early indications of the probable beneficial and adverse impacts of the applications of technology and to develop other coordinate information which may assist the Congress."*

Today this scientific and analytical methodology developed by OTA is known as *'classic TA'* approach. Grunwald (2010, 89) summarized this approach as "*value-free, state-oriented, systemic, expert-orientated, scientistic and technological deterministic […]"*. Shortly after the idea of TA was born, it began to spread out over the world. Soon, in the mid-80s, fourteen European TA facilities joined the European Parliamentary Technology Assessment (EPTA) network[2] (Grunwald et al. 2014, 18f.).

Outlining the following and ongoing research discussions about definitions, concepts, and methods of TA would go beyond the scope of this contribution. Nevertheless it should be mentioned that conceptual discussions on the subject split it into two main branches in the 1970s. Policy analysis is an instrumental approach, while public deliberation follows a discursive approach (Grunwald et al 2014, 19f.). Grunwald pointed out that:

> *"The history of TA can be recounted as a history of experimenting with concepts and of learning by testing or deducing from relevant conceptual debates." (Grunwald 2009, 1142)*[3]

The question *what TA might be* is still controversially discussed as there are different interpretations of its self-understanding and there is *no consensual definition* (ibid. 1104).

Nevertheless, Decker and Ladikas proposed a definition that is widely accepted:

> *"Technology assessment (TA) is a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology."* (Decker & Ladikas 2004, 14)

This was taken up by Grunwald to explain the limits of TA as following:

[1] For more detailed information on the history of TA see Vig and Paschen (1999) quoted by Grunwald (2009), Grunwald (2010); Saretzki (2014), and Grunwald et al. (2014).

[2] Cf. European Parliamentary Technology Assessment, http://eptanetwork.org/index.php.

[3] In Germany, the first step of historical analysis of TA was made by the thesis of Brinckmann (2006). She analyzed the history of the Study Group for Systems Research (SfS) in Heidelberg in a historical perspective. See also Brinckmann (2006b).

> *"This definition stresses that TA contributes to problem-solving, but does not pretend to provide actual solutions. TA provides knowledge, orientation, or procedures on how to cope with certain problems at the interface between technology and society but it is neither able nor legitimized to solve these problems. Only society can do this, through its institutions and its decision-making processes*." (Grunwald 2009 1113)

According to him, some general characteristics of TA can be defined: it takes into account (foreseeable or presumable) side effects of new and emerging technologies with regard to uncertainty and risks. Its work is value-related and analyzes normative positions. Its approach is systemic with a broad understanding of innovation and it encourages reflections on alternatives. TA research is done on an interdisciplinary and transdisciplinary basis (Grunwald 2009 1111f.).

In this contribution we will focus on the technology-induced approach of TA to highlight possible side effects of AD by providing a state of the art overview related to the existing socio-technological system. In the following paragraphs we will frame questions on how new and emerging innovative technologies are linked to autonomous driving from the perspective of TA. The first step is to draw a sketchy image of expectations and visions regarding this technology and its linkages to the socio-technological system into which this new technology aims to fit in. This will be based on broad desktop research, including all kinds of media sources from scientific articles to press releases and existing studies. In a next step this will be presented from a TA perspective to investigate crosscutting relations to other fields, like culture, ecology, economy, society, and politics, in order to detect intended and unintended systemic effects.

Autonomous driving – state of the art

While the dream of autonomous cars (cf. Kröger 2014) or flying cars (cf. Meyer-Soylu et al. 2014) is very old, the usage of autonomous systems, like autopilots in aviation, did not spread before the mid-80s. The trends towards automatized transportation vehicles (e.g. trucks, ships, and rail bound vehicles) and an increased level of automatization up to full autonomous systems are still unbroken, as the proliferation of drones illustrates.[4] These developments are based on further improvements of existing driver assistance systems (e.g. anti-lock braking system or speed control) and sensor technology as well as computer-based interfaces between these systems and the environment. Most of these inventions are general efforts to make car driving safer and more convenient, especially in situations in which human reaction may be too slow. Along with the

[4] Cf. successful landing operation of autonomous drone on aircraft carrier in 2013: Cf. Weber (2013).

progress of miniaturization, the increase of computer capacity, and wide-scale production of such components, many major car manufacturers are involved in research projects on AD.[5]

Today the basic idea is to imitate human senses by using different sensors as basic equipment of AD systems, as the following explanation shows: Depending on manufacturers and technical requirements, an AD system basically consists of redundant sensor packages (e.g. optical and infrared sensors, near and far radar, ultrasonic), as well as GPS navigation or car-to-car external communication systems (cf. Litmann 2014, 5). The heart of AD is the interaction, controlling, and steering of the processes between the sensors, the executing Advanced Driver Assistance System (ADAS) as well as the human-machine interfaces (HMI). Huge amounts of data have to be handled simultaneously by a computer, which has to steer all relevant components. Here, algorithms and software play a key role, too (cf. Dettmer & Tietz 2014). During the last few years remarkable developments in research could be recognized, especially the technical feasibility of part and full AD of personal cars, which Google demonstrated with its research project. Both the media (e.g. technology blogs)[6] and vehicle manufacturers (e.g. IAA 2013; CES in Las Vegas 2014) now hype and present visions for AD as a smart multi-connected mobility future.

Technology assessment of autonomous driving

Observing the broad discussion about AD, one could assume that the technology is ready for use and the real challenge lies within some regulative aspects. A classification of autonomous cars and regulation aspects was carried out by the responsible National Highway Traffic Safety Administration (NHTSA 2013 and cf. Smith 2014) for the US[7] for Germany. The legal basis was laid down in the Vienna 'Convention on Road Traffic' (1968). The great challenge is to find clear common positions on the interpretation of the driver itself and his intended 'ability to control his vehicle all the time' which is defined under the terms of the Vienna agreement. The issue of how to deal with this question is widely discussed (cf. Smith 2014 and Lutz 2014). Do the regulations have to be adapted to the technical possibilities or, vice versa, the technical possibilities to existing regulations? How much R&D and technological progress are necessary to identify or close the gap in the human-machine interaction? These are key challenges which have to be addressed. The above-mentioned debate about regulative aspects due to the introduction of new

[5] Recent examples are two projects from the 1990s – VaMoRs and VaMP – which were developed within the European research project Eureka Prometheus, joined by several car manufacturers and universities. According to Vanderbilt the engineer Dickmanns initiated this series of projects "that eventually earned him the sobriquet 'the pioneer of the autonomous car'", quoted from Vanderbilt (2012); cf. Diekmanns (2007); http://www.dyna-vision.de/.

[6] Cf. http://www.theverge.com/; http://www.wired.com/; http://arstechnica.com/; http://www.heise.de/.

[7] For classification of AD in Germany see the Federal Highway Research Institute (BASt 2012).

technologies touched an unsolvable problem of technology assessment in general, the so-called Collingridge dilemma (cf. Collingridge 1980):

- Because of high uncertainty possible effects cannot be envisaged, especially during the research and development stage at the moment of transition into the mass market.
- If a technology is then once used and adapted, it will be difficult – if not impossible – to enforce modifications to prevent possible unintended effects, especially in the moment of transition.[8]

This dilemma describes the above implied question related to legal aspects: would it be better to set some regulations before the introduction of a technology (*ex ante*), or, once it is introduced, observe the developments and readjust the regulations based on experience *(ex post)*?[9]

The focus on regulative aspects is a first sketch to show the difficulties and challenges that come with AD. But TA takes many more aspects into account. Some examples of possible TA research questions are:

- *Legal aspects:* Who will be responsible in incidents of damage or loss? Who will be the owner of and responsible for the data collected by the AD car? Will it be the driver, the owner or companies? Who will be the person responsible in case of hacking or spoofing attacks?[10]
- *Environmental potentials:* Will potential environmental benefits (e.g. expected CO2 reduction) be offset by 'more' traffic and a more intense use of the existing infrastructures? Will availability and comfort lead to more traffic demand (changing travel behaviors)?[11]
- *Human-machine interaction:* Will further technology developments really be able to solve the key problem of 'in or out of the loop'?[12] Will in some cases an alternative approach like highway platooning with specially trained drivers not be sufficient at the stage of technology introduction? How could a communication between other non-AD traffic participants look like in a mixed traffic situation (predictable AD systems and ad hoc decisions by non-AD systems)?
- *Market-related aspects:* Does AD really have the potential to attract end consumers while depriving them of the emotions linked with driving such as liberty, fun, and power? Will AD be a promoter for alternative propulsion systems? Will AD open up the 'automotive

[8] This transition could be described by the transition theory of Geels (2005).

[9] Here, the limits as well as the aims of TA will become more precise and visible. TA may provide knowledge, but does not solve technology problems itself; eventually the decision will be referred to the society.

[10] For examples see: Horchert (2014) and Shepard, Humphreys & Fansler (2012).

[11] See the example of Smith (2012).

[12] On the problem of 'in or out of the loop' see Parasuraman & Riley (1997) and Bainbridge (1983).

market' for other companies (e.g. Google) and alternative business models like car sharing?

- *Social aspects – jobs:* Which kind of implications will a wide usage of AD systems have on transport-related jobs? [13]
- *Social aspects – travel behaviors:* What kind of rebound effects induced by changing travel behaviors may be possible?
- *Cultural aspects:* If there exist some linkages between technical cultures (technical positivism vs. skepticism/constructivism), how could they be described and assessed regarding this technology?[14]

From a broader perspective, this leads to the question if AD will be a 'disruptive technology' and be able to trigger a 'radical' innovation process in the transportation system? And what will this change in the transport system mean for business regimes, like car manufacturers and their suppliers (cf. Christensen 1997)?

History and technology assessment – common objects of research

In order to show how the daily work of TA could be affected by historical points of view, we will concentrate on two of the above-mentioned aspects TA is investigating concerning AD: the legal debate and the issue of user expectations and visions.

As already shown, the legal aspect of AD is an important and much discussed topic. Closely connected to this regulation is an ethical and moral discussion. Therefore it is essential to see this not as a new and unprecedented case: There have already been debates on automated and autonomous systems – and there are already rules and regulations for them. Histories of the legal regulations of autonomous or automatic machines[15] like, for example, industry robots, automatic pilots, or even the lately discussed drones could help to understand contemporary regulations, their limits, and where they need elaboration. Historical science could provide insights into the handling of specific situations in the past, as for example the problem of operators 'in and out of the loop' (like pilots flying on autopilot) and how this situation has to be treated in legal terms.

Also the controversy about the responsibility of chauffeurs in the very beginning of the automobile era (and even before with horse-drawn carriages) can serve as an example for the

[13] Cf. the controversy over mobility applications: Hägler (2014) or Zacharakis (2014).

[14] See further Davies (2014) and Gleich (2014).

[15] See e.g. on the history of industrial automation: Fraunholz (2012), Noble (1984) and Steiner (1988).

debate on AD vehicles today.[16] Back then it was discussed who should be in charge if an accident occurs: The owner of the carriage? The driver? In which cases was the owner to be held responsible? In which cases the driver? How could owners make sure that the drivers were not negligent? And how could drivers be assured that their employer provided the means to maintain the vehicle in good condition? Of course the solutions to the difficulties of that time cannot be simply transferred to AD today, but being aware of these discourses can help a lot in identifying and understanding positions and actors in the debate as well as envisioning trends and characteristics of the upcoming (or already ongoing) discourse.

Historical contribution on visions, expectations, and scenarios

Many ideas and visions of laypeople as well as engineers are related to autonomous locomotion – be it driving or even flying (cf. Kröger 2012). These visions are likely to play a role in the development of AD today, but they are not new and the historical point of view can help to explain and understand them in this field. How, why, and in which contexts imagined people self-driving cars or self-flying aircraft and which hopes were related to that? Have these desires been satisfied in the meanwhile or are they still the same? At this point the interrelation to social sciences is very obvious as the subject matter is located in the present. These and many other questions may lead to a better understanding of the expectations regarding AD.

As far as visions and expectations can be explained by historians, the results may contribute to the generation of future scenarios that are often used in technology-induced or technology-related TA. These scenarios may in general terms be described as a device to think about possible futures and how they could look like, "if …". In the context of AD, scenarios will be helpful to summarize the discourse about it, to structure the various arguments and options related to possible AD futures, and to support a broad debate in society between different groups of interests.[17] The scenarios thereby often have a narrative form and are told like stories. So in both disciplines, history as well as TA, consistent narratives occur and similarities can be found: the sources and data used have to be analyzed, contextualized, and interpreted; the facts have to be connected coherently, the text has to follow a reasoned structure, so that the underlying sense will become clear.

[16] On this controversy from an actor-network point of view, see Wetmore (2004).

[17] In recent years a number of studies were published on the subject of AD. Several of these studies like Silberg (2012; 2013) are working with different scenario methods. For examples for the usage of scenarios in TA Projects see: Meyer-Soylu et al. (2014); Schippl et al (2012); and for scenario methodology in more detail see Kosow el al. (2008) and Steinmüller (2010).

Conclusion and outlook: An approach to interdisciplinarity

For generating possible future scenarios, TA relies on knowledge supplied by other disciplines. Usually these are natural science, engineering, sociology, philosophy, geography, and environmental science – just to name some of them. History is normally not represented – at least not in person. Even though TA is a downright inter- and transdisciplinary attempt, historians are usually not part of the team.[18] If historiographical knowledge is taken into account (often sociologists bear that perspective in mind), it is done in an unstructured, coincidental, and intuitive manner. For a historian – rather accidentally working on TA – this approach appears slightly unhistorical, given the fact that the historic dimension of many aspects of TA work is so obvious and strong. Therefore it is hard to understand why it is not included more intentionally. But there will also be challenges for historians who are part of a TA workgroup: they will not only have to work on topics of interest for TA studies (as e.g. in the form of preliminary studies), but they will also have to present the outcomes of the historical activity in a way that is compatible with and comprehensible for other disciplines. This could be realized by the use of common methods, theories, and approaches. There is already common ground with other researchers in TA from the humanities and social sciences. Methods to catch up with TA may for example be discourse analysis (as substantially defined by Foucault 1972), actor-network theory (e.g. Latour 1987) or the theory of the social construction of technology (SCOT; Bijker/Pinch/Hughes 2012). These all are quite well-known and (at least time and again) applied in historiography – as well as in TA.[19]

In any case it is crucial that the historical knowledge is provided by scientific historiography to make sure that it does not only provide contingent and fragmentary or even misleading insights into past circumstances. Preparation, compilation, and appraisal of the historical data should thus be conducted by professional historians – also to guarantee that if history is more taken into account, no imprudent "learning" out of simple analogies occurs. [20]

Using the example of TA on AD, this contribution intended to give some leads on how the fields of history and TA interrelate and where possible starting points for cooperation could be. Anyway there is a lot of work left to be done on this issue – and many practical experiments to be conducted.

[18] Cf. Grunwald (2010) p.134f. and p. 203ff. on the disciplines in TA and their contribution to TA studies.

[19] Science and Technology Studies (STS) that are partially engaged in similar topics as TA may be seen as a link between history and TA since they intentionally work with (academic) history, especially history of technology. STS publications are received by historians as well as TA researchers.

[20] Reinhard Koselleck showed this elaborately in his work on *futures past* (2004). His thoughts on the relationship of "future" and "past" can be fruitful also for TA considerations.

References

Bainbridge, L. (1983). Ironies of automation. Automatica, 19(6), 775–779

BASt: Cooperative Traffic and Driver Assistance Systems: Part 1: Basics, technical design and requirements. Gasser et. al. Rechtsfolgen zunehmender Fahrzeugautomatisierung, Bergisch Gladbach, Bundesanstalt für Straßenwesen, 2012 (Berichte der Bundesanstalt für Straßenwesen, Unterreihe „Fahrzeugsicherheit“, Heft F 83, Januar 2012), Retrieved July 30, 2014, from BASt: http://www.bast.de/DE/Publikationen/Foko/Downloads/2012-11.pdf?__blob=publicationFile&v=1.

Bijker, W. E., Hughes, T. P., & Pinch, T. (Eds.) (2012). The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology (anniversary edition). Cambridge, Mass.: The MIT Press.

Brinckmann, A. (2006a). Wissenschaftliche Politikberatung in den 60er Jahren: Die Studiengruppe für Systemforschung, 1958 bis 1975. Gesellschaft - Technik - Umwelt: Vol. 9. Berlin: Edition Sigma.

Brinckmann, A. (2006b). The Studiengruppe für Systemforschung: Systems Research and Policy Advice in the Federal Republic of Germany, 1958–1975. Minerva, 44(2), 149–166.

Christensen, C. (1997). The Innovator’s Dilemma. When technologies cause great firms to fail. Boston, Massachusetts: Harvard Business School Press.

Collingridge, D. (1980). The Social Control of Technology. New York, 1980.

Congress of the United States (1972). The Technology Assessment Act: Public Law 92-484. Retrieved July 24, 2014, from U.S. Congress, Office of Technology Assessment, The OTA Legacy: 1972-1995 (Washington, DC: April 1996): http://www.princeton.edu/~ota.

Convention on Road Traffic (See article 8, paragraphs 3 and 5 and article 13, paragraph 1, p.1) Retrieved July 30, 2014, from http://www.unece.org/fileadmin/DAM/trans/conventn/crt1968e.pdf

Davies, A. (2014). This Startup Says It Can Make Any Car Autonomous for $10,000: Autopia. Retrieved July 04, 2014, from http://www.wired.com/2014/06/cruise-self-driving-car-startup/

Decker, M.; Ladikas, M. (2004). Bridges between Science, Society and Policy. Technology Assessment – Methods and Impacts. Springer, 2004.

Dettmer, M., & Tietz, J. (2014). Der Sieg der Algorithmen: Die Digitale Revolution. Der Spiegel, 17, 68–75.

Dickmanns, Ernst Dieter (2007) Dynamic Vision for Perception and Control of Motion.

FAS - Federation of American Scientists. Office of Technology Assessment Archive: Blog. Retrieved July 24, 2014, from http://ota.fas.org/.

Fraunholz, Uwe (2012), „Revolutionäres Ringen für den gesellschaftlichen Fortschritt“. Automatisierungsvisionen in der DDR; in: Uwe Fraunholz, Anke Woschech (Ed.), Technology Fiction. Technische Visionen und Utopien in der Hochmoderne, Bielefeld: trancript Verlag.

Fraunholz, Uwe; Woschech, Anke (Eds.) (2012), Technology Fiction. Technische Visionen und Utopien in der Hochmoderne, Bielefeld: trancript Verlag.

Geels, Frank (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technological Forecasting and Social Change, 72(6), 681–696.

Gleich, C. (2014). Die Ethikbremse schleift: Wir Deutsche wissen, was nicht geht. Amis bauen es trotzdem. Retrieved July 04, 2014, from Heise Zeitschriften Verlag: http://heise.de/-2243299.

Grunwald, A. (2002): Technikfolgenabschätzung – Eine Einführung. Berlin.

Grunwald, A. (2009). Technology assessment - Concepts and methods. In A. Meijers (Ed.), Handbook of the philosophy of science: Vol. 9. Philosophy of technology and engineering sciences (pp. 1103–1146). Amsterdam, London, Boston: Elsevier/North Holland.

Grunwald, A. (2010). Technikfolgenabschätzung: Eine Einführung (Zweite, grundlegend überarbeitete und wesentlich erweiterte Auflage.). Gesellschaft--Technik--Umwelt: Vol. 1. Berlin: Edition Sigma.

Grunwald. A., Hennen, L., & Sauter, A.: Parlamentarische Technikfolgenabschätzung in Deutschland und Europa, in: APuZ - Aus Politik und Zeitgeschichte, Jg. 64, H. 6-7/2014, S. 17-24 Bundeszentrale für politische Bildung (bpb) (Ed.) (2014).

Hägler, M. (2014). Leichter ans Ziel - egal womit: Mobilitäts-App Moovel. Retrieved August 14, 2014, from http://sz.de/1.1993415.

Handbuch Fahrerassistenzsysteme - Grundlagen, Komponenten und Systeme für aktive Sicherheit und Komfort, Vieweg+Teubner Verlag Wiesbaden, 2012, Seite 24-32.

Horchert, J. (2014). "Im Visier der Hacker": TV-Reportage zeigt Cyber-Angriffe. Retrieved July 15, 2014, from http://www.spiegel.de/netzwelt/web/im-visier-der-hacker-tv-reportage-zeigt-cyber-angriffe-a-980942.html.

Koselleck, Reinhard (2004). Futures Past. On the Semantics of Historical Time. New York: Columbia University Press.

Kosow, H., Gaßner, R., Erdmann, L., & Luber, B.-J. (2008). Methods of Future and Scenario Analysis: Overview, assessment, and selection criteria. Retrieved July 25, 2014, from http://www.die-gdi.de/uploads/media/Studies_39.2008.pdf.

Kröger, Fabian (2012). Fahrerlos und unfallfrei. Eine frühe automobile Technikutopie und ihre populärkulturelle Bildgeschichte, in: Uwe Fraunholz, Anke Woschech (Ed.), Technology Fiction. Technische Visionen und Utopien in der Hochmoderne, Bielefeld: trancript Verlag.

Kröger, Fabian (2014). Die Zukunft, die nie eintrat: Über die Nützlichkeit filmischer Zukunftsbilder des autonomen Fahrens für die Prospektive. In: Technikfolgenabschätzung - Theorie und Praxis: 1/2014. Schwerpunkt Verkehrszukünfte. Visionen jenseits aktueller öffentlicher Aufmerksamkeit. 23. Jahrgang (pp. 9–12).

Latour, Bruno (1987). Science in Action. How to Follow Scientists and Engineers through Society. Milton Keynes: Open University Press.

Litman, T. (2014). Autonomous Vehicle Implementation Predictions: Implications for Transport Planning. Retrieved July 30, 2014, from http://www.vtpi.org/avip.pdf.

Lutz, L. S. (2014). Rechtliche Hürden auf dem Weg zu autonomen Fahrzeugen. Retrieved July 03, 2014, from http://www.heise.de/tp/artikel/41/41393/1.html.

Meyer-Soylu, Sarah et al.: Zur Arbeit fliegen? In Technikfolgenabschätzung - Theorie und Praxis: 1/2014. Schwerpunkt Verkehrszukünfte. Visionen jenseits aktueller öffentlicher Aufmerksamkeit. 23. Jahrgang (pp. 13–21).

NHTSA (2013). Preliminary Statement of Policy Concerning Automated Vehicles. Retrieved July 30, 2014, from http://www.nhtsa.gov/search?q=autonomous%20driving&spell=1&site=nhthqnlas187_Pages&client=default_frontend&output=xml_no_dtd&ie=UTF-8&access=p.

Noble, David (1984), Forces of Production. A Social History of Industrial Automation. New York: Oxford University Press.

Parasuraman, R.; Riley, V. (1997). Humans and Automation: Use, Misuse, Disuse, Abuse. Human Factors, vol. 39 (2), 230-253.

Saretzki, Thomas: Entstehung und Status der Technikfolgenabschätzung, in: APuZ - Aus Politik und Zeitgeschichte, Jg. 64, H. 6-7/2014, S. 11-16 Bundeszentrale für politische Bildung (bpb) (Ed.) (2014).

Schippl, J., Edelmann, M., Puhe, M.(2012). Eco-Efficient-Transport Interim report on scenarios for eco-efficient transport, Deliverable No.3. Brussels: Science and Technology Options Assessment.

Shepard, D. P., Humphreys, T. E., & Fansler, A. A. (2012). Evaluation of the vulnerability of phasor measurement units to GPS spoofing attacks. International Journal of Critical Infrastructure Protection, 5(3-4), 146–153.

Silberg, G. (2013). Self-Driving Cars: Are We Ready? Retrieved April 29, 2014, from https://www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/self-driving-cars-are-we-ready.pdf.

Smith, B. W. (2012). *Managing Autonomous Transportation Demand.* Retrieved July 30, 2014, from http://cyberlaw.stanford.edu/files/publication/files/BWS-2012-ManagingAutonomousTransportationDemand.pdf.

Smith, B. W. (2014) Automated Vehicles Are Probably Legal in the United States. 1 Tex. A&M L. Rev. 411 (2014). Available at SSRN: http://ssrn.com/abstract=2303904 or http://dx.doi.org/10.2139/ssrn.2303904

Steiner, André (1988), Die Einzweckautomatisierung im Maschinen- und Fahrzeugbau der DDR vom Beginn der 50er bis zur Mitte der 70er Jahre. Ergebnisse und Grenzen; in Dresdener Beiträge zur Geschichte der Technikwissenschaften (DBGT) 16, p. 82–84.

Steinmüller, K. (2010). Science Fiction: eine Quelle von Leitbildern für Innovationsprozesse und ein Impulsgeber für Foresight, in S. e. a. Hornbostel (Ed.), Foresight - Between Sience and Fiction. iFO-Working Paper No. 1 (pp. 19–31).

Technikfolgenabschätzung - Theorie und Praxis (TATuP), Available at: http://www.tatup-journal.de/

Vanderbilt, T. (2012). Autonomous Cars Through the Ages: Autopia. Retrieved July 08, 2014, from http://www.wired.com/2012/02/autonomous-vehicle-history/?viewall=true.

Vig, N.; Paschen, J. eds. Parliaments and Technology Assessment. The Development of Technology Assessment in Europe. Albany, USA, 1999.

Weber, N.(2013):Kampfdrohne glückt Landung auf Flugzeugträger. Retrieved July 08, 2014, from http://www.spiegel.de/wissenschaft/technik/x-47b-drohne-gluecckt-landung-auf-flugzeugtraeger-a-910546.html.

Wetmore, Jameson M. (2004). Redefining Risks and Redistributing Responsibilities: Building Networks to Increase Automobile Safety, in: Science Technology & Human Values, Summer 2004 vol. 29 no. 3, p. 377-405.

Zacharakis, Z. (2014). Tausende Taxifahrer in Europa wollen gegen Uber demonstrieren: Taxi - App Uber. Retrieved August 14, 2014, from http://www.zeit.de/wirtschaft/2014-06/uber-demonstration-taxi-fahrer-europa.