Understanding Constructive Technology Assessments from an IMP Perspective: The Case of Autonomous Vehicles

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Abstract
Autonomous vehicles are expected to have a significant impact in shaping how future transport systems will evolve. Developing possible future vision on this AV's will impact society is necessary if government policy is to influence future transport ecosystem development. The purpose of this paper is to outline a methodological approach for investigating future technological visions that incorporate IMP approaches of how visions can possibly be spread throughout the network. We include a particular focus on cases where power relations between stakeholders influence technology development processes.

Introduction
Autonomous machines underpinned by artificial intelligence (AI) are expected to become a general purpose technology, embedded in many aspects of our daily lives. These machines will possess the capability to respond to changes in the local environment without human intervention, thereby creating numerous new network interactions. This research focuses on the socio-technical development of autonomous vehicles (AV) and their integration into existing freight and passenger transport systems. The AV revolution will be a major disruption within the transportation industry (Fagnant & Kockelman 2015; Sun, Olaru, Smith, Greaves & Collins 2017). Anticipated impacts from AVs vary, with some indicating that human driving will be forbidden or restricted, while others believe obstacles around human machine interaction (e.g. pedestrian behaviour) will present an insurmountable barrier to diffusion (Makridakis 2017). A future with all vehicles being fully autonomous (driverless) will no longer require the services of truck drivers, taxi/ Uber drivers, auto crash repairers etc. (Makridakis 2017).

The mapping of technology futures is based on either foresight or forecasting. Whereas, forecasting aims to predict the future, foresight considers more than one possible future visions with the aim to allow decision makers to analyse robust policies or strategies in the now. As a forecasting technique, *technological roadmapping* projects current trends forward into a future whereby the impact of uncertain but anticipated events are given probability weights to arrive at a most likely future, a prediction. On the other hand *scenario planning*, being a foresight method, identifies two (or possible more) influential societal, technological or institutional drivers that will lead to very different futures. The influence of drivers is determined by their impact on shaping the future but also their level of uncertainty; without uncertainty the scenarios would collapse to a prediction. *Constructive technology assessment* (CTA) is a foresight approach in that multiple futures are accepted, but it differs from scenario planning in that examines the interaction of decision makers and institutions that will shape the development and adaptation of new technologies.

This paper compares these three main methodologies and will discuss a research project that shows how CTA can be used to investigate stakeholder visions on the future use of autonomous vehicles. CTA is particularly relevant for Industrial Marketing and Purchasing (IMP) researchers as it focuses on possible technology emergence within a socio-technical network where the interaction between actors strongly influences the shape of technology trajectories.

Autonomous Vehicle Context

AV technology is still at an emergent stage with most activity being conducted in R&D arms of large technology and car manufacturing firms in partnership with universities and government. There is however, little doubt that AVs will be a disruptive and transformative technology within the transport sector (Sun et al., 2017). Even at this early stage, opinions are being formed and gaps are opening up on the societal impact of AVs. The practitioner literature tends to focus on the extensive changes and mostly positive consequences of AV technology use (e.g. McKinsey & Company, 2016; Giffi et al., 2017). In contrast, the academic literature has highlighted potential negative effects, some of which are unforeseen given current uncertainty (Wadud et al., 2016; Mervis, 2017; Milakis, 2017). Examples of negative possibilities include: greater obesity; a loss of driving competencies and skills (Bazilinksy et al., 2015); a lack of trust (Fraedrich & Lenz, 2014); hacking connected vehicle systems (Fagnant & Kockelman, 2015); privacy concerns about data transfer to third parties and the deprivation of the joy of driving (Fagnant & Kockelman, 2015; Kyriakidis et al., 2015).

In these projected future scenarios where shared AVs dominate, there may be less traffic congestion, fewer accidents and lower demands on mass transport, however these benefits may be offset by a much smaller vehicle market including auto-parts, servicing and repairs (job losses); and changes to government revenue streams for road funding (capital flow through the economy). To this end it is possible that industry may promote a vehicle ownership future that accelerates urban sprawl and furthers the problem of congestion in large cities; thus negating our previous positive benefit of less traffic congestion (Sun et al., 2017). While neither scenario may emerge, due to unforeseen possibilities, freight and logistics firms will adapt AV technology along with broader ICT applications to drive their own competitive advantage. The combination of positive and negative consequences and how private strategy, public policy and society adjust to these interacting forces needs to be considered holistically.

Methodological approaches for researching future technologies

There are multiple different approaches used in researching possible futures for new technologies. This paper examines three of the main approaches relative to each other, placing added attention on CTA and its parallels with IMP thinking.

Technology Roadmapping

Technology roadmapping is a support tool used within organisations to consider how they need to develop strategies linked to new product development processes with the main results inputted into planning processes (de Alcantara & Martens 2019). In particular, it focuses on linking resource allocations, organisational strategy and changes in the environment to developing new technologies through time (Phaal, Farrukh & Probert 2004). This approach uses standard processes to develop subjective probabilities and simulations to generate the future roadmap. Often short term in focus, there have been few long term roadmaps used for the purpose of detecting identify possible disruptions (Phaal et al 2004, p. 12). As roadmapping is internally focused, it doesn’t usually incorporate external actors from the broader ecosystem. The roadmap is often a single scenario and becomes less useful in high uncertainty environments or for disruptive technologies, as expected with the impact AV technology (de Alcantara & Martens 2019; Hussain, Tapinos & Knight 2017). It has been suggested to incorporate aspects of scenario planning into this approach in an attempt to broaden and include greater focus on dynamics, flexibility and environmental focus (Hussain et al 2017; Cheng, Wong, Cheung & Leung 2016).

Scenario Planning

Scenario planning is an approach that considers possible future states and develops milestones that organisations use to assess managerial decisions (Hussain et al 2017; Schoemaker, Day & Snyder 2013; Amer, Daim & Jetter 2013). While there are multiple approaches to scenario planning, they all develop tools to enhance organisational decision making given uncertain and complex futures (Amer et al 2013). Scenario planning focuses on uncertainty and influence as the main criteria for analysis and can use either quantitative or qualitative methods.

Amer et al. (2013) describes three principal methodologies: Intuitive logics; La prospective; and Probabilistic modified trends. The wide variety in methodologies allows for flexibility to adapt to the purpose of the planning activity. While probabilistic modified trends methods focus on trying to quantitatively determine whether certain events are likely to occur and is used for prediction purposes, La prospective considers that "the future can be deliberately creased and modelled; while intuitive logics methods are more subjective and try to use the process of scenario planning for developing strategy and as a learning exercise (Amer et al 2013, p. 27). The strengths of scenario planning include its ability to consider multiple possible outcomes and incorporate dynamic environments suitable for assessing new technologies. The process is limited by focusing on uncertainties which are difficult to foresee into the longer term future, particularly for technologies where no current market / or use has been developed and doesn't strongly incorporate the social dimension. This makes it difficult to determine which uncertainties should be incorporated into the analysis given the complex processes surrounding AV use.

Constructive Technology Assessment

CTA is an approach that strongly embeds social aspects, mapped in the context of technological developments. The development agenda is therefore led by a "societal agenda" (Schot & Rip 1996, p. 255), also described as the "social shaping of technology" (Genus 2006, p. 14). This is achieved through incorporating a wide variety of different stakeholder visions, beliefs and values, where the construction of stakeholder visions are more important than facts as visions have a performative influence on future behaviour (Versteeg et al 2017). Franks and Cohen (2012) highlight that by incorporating social values and ideas that may not be considered within narrowly focused technology approaches, technological trajectories will be shaped in response to societal values.

The ability to incorporate dynamics within actor interactions allows CTA to be appropriate during the early stages of technology development when the product is still malleable to changes from policy and social influences (Versteeg et al 2017). Thus, allowing technology trajectories to avoid lock-in influences that may result in negative consequences for either the technology or society. Other benefits in the CTA approach include analysis of reflexivity within the interactions (Fisher 2007; Genus 2006) and the importance of considering dynamics which is particularly important during the early phases of development (Schot & Rip 1996; Fisher 2007).

Incorporating a wide variety of stakeholders offers strengths in being able to access visions from peripheral stakeholders that might become more prominent in future (Schoemaker et al

2013); evaluate alignment between diverse groups, and incorporate strong democratic aspects (Genus 2006). Stakeholders can include institutions, organisations, consumers, resources, scientific actors and legislators (Schot & Rip 1996). The weakness of a democratic approach is the difficulty of incorporating “societal” stakeholder feedback into the process over time. Encouraging interaction and building collective sensemaking for alignment between “society” and “technical” stakeholders is important within CTA approaches. The inability to facilitate collective sensemaking relates to societal actors not responding to results, incorporating very diverse visions where little alignment occurs and technical actors not placing emphasis on social feedback over the time of technical development process (Schot & Rip 1996).

The above discussion outlines the three major approaches used to analyse technology futures. All of these approaches have been used by industry for different purposes. Each approach has inherent strengths and weaknesses and the choice of approach needs to suit how results will be incorporated within decision making or strategy planning processes. Table 1 compares and summarises the different approaches.

Table 1 Comparison of Major Approaches to Investigating Technology Futures

Methodology	**CTA**	**Scenario Planning**	**Technological Roadmapping**
	Aimed at foresight	Aimed at either foresight or forecasting	Aimed at forecasting
Time frame	Long term	Medium - Long term 3-5 Multiple possible futures	Short term Single future considered
Process	Dynamic	Dynamic	Linear
Flexibility of approach	Non-standard approach varies according to technology	Multiple approaches that vary via context	Standardised tools & approaches
Level focus	Ecosystem focus	Organisation focus with occasionally national level	Product focus within organisations
Stakeholder Input	Broad, including society	Internal organisational experts; external technology and market experts; often lead by consultant	Internal organisational experts; external technology experts
Strengths:	Incorporates power relations Democratic process Incorporates reflexivity Focuses on interactions between actors	Enhances vision Facilitates strategic discussions	Detailed planning Clear decision making lines Linking market & technology
Weaknesses:	Difficulty in incorporating social feedback into the process	Difficulty in which uncertainties to select for analysis Limited to number of scenarios Doesn’t deal well with external analysis of periphery or non-dominate conditions Assumptions place boundaries around the analysis	Normative results Linear results Limited input from external sources Doesn’t deal with highly dynamic environments well

How CTA Aligns with IMP Approaches
Based on this comparison, we believe that CTA best aligns will with IMP approaches. CTA refers to *emerging irreversibilities* which enable or constrain certain actions and interactions as (van Merkek & van Lente 2005), similar to lock-in events (Purchase et al 2014). As technologies progress from conception, to development and eventual market diffusion, they become increasingly entrenched in a particular direction due to the investments, lock-ins and path dependencies (Schot & Rip 1997; Araujo & Harrison, 2002; Olaru & Purchase 2015). As resource distribution decisions are made, alternative options often become comparably less viable and it is therefore relevant to understand the stakeholder beliefs and sensemaking which underpin such decisions (Versteeg et al 2017; Möller 2010).

When technological development is uncertain, stakeholder *expectations,* cognition and sensemaking play an important role in decision making and therefore form another concern for both CTA and IMP perspectives (van Lente 2012; Möller 2010). Serving to build learning culture & capacity; legitimize risky investments; offer heuristic guidance in situations with multiple subjective paths; and through their influence help to coordinate between actors (van Lente 2012). Much of the impact of expectations and cognition of emerging technologies depend on the degree they are shared between actors and actor capability (Versteeg et al 2017; Möller 2010).

Within the context of emerging technologies, distinct and stable roles are not yet considered to exist and instead are continuously shaped and altered through interactions with a view to eventually finding their place (Versteeg et al 2017). This highlights the importance of network dynamics in technology development (Chou & Zolkiewski 2012). CTA also seeks to understand actors' perceptions of others through the concept of *positionings* (van Merkerk & van Lente 2012; Lowe, Ellis & Purchase 2008) and is used to capture expectations of roles which actors attribute to themselves and to others, as well as the expected roles which others may place on them. Considering expectations are shaped through engagement with others, CTA uses the concept of *spaces for interaction* to describe the various mechanisms which provide opportunities for interactions (Versteeg et al 2017). When structural channels are established for interactions, actors are able to discuss and negotiate issues around emergent technologies (Versteeg et al 2017). These spaces however, often do not exist for new technologies and actors therefore respond to this absence by creating new spaces or engaging through existing, unspecialised spaces (van Merkerk & van Lente 2008).

Finally, as a way to map out the network, CTA highlights the importance in including a diversity of network actors (Genus 2006) due to their interdependence and interactions, similar to IMP approaches (e.g. Håkansson 1982). While CTA considers two categories of actors: *Enactors and Selectors*, in relation to the development of technology. Enactors are the actors which work to realise new technology by constructing progress scenarios and identifying challenges to overcome. These technology-centric actors are typically the developers, manufacturers, researchers and government agencies associated with a particular technology (Versteeg et al 2017). Selectors on the other hand, are the societal groups and government agencies that will become the end users of the technology. They are involved in deciding between multiple technological options and development pathways available, often leading to conflicting viewpoints to Enactors (Versteeg et al 2017). The binary categorisation of actors is not consistent with IMP approaches that acknowledge multiple overlapping actors roles in different context and over time.

Conducting CTA

There is no set CTA process as it "has a diffuse and emerging character", allowing for individualisation of the research design to meet the expectations of the research project (Schot & Rip 1996, p. 252).

CTA makes use of secondary data, such as government reports, organisational white papers, patent data etc, allowing the researcher to begin to report technology perceptions and expectations of the main actors. While this material may be sanitised, it has been used to: guide development of future approaches such as interviews (Versteeg et al 2017; Fisher 2007; Douma et al 2007); and develop 'information packs' that are distributed to participants that may have limited background knowledge such as users (Versteeg et al 2017).

There are a wide range of tools used to collect primary data. These techniques are aimed at one or more of the following: evaluating socio-technical dynamics; considering the potential relevant of possible obstacles and influences; and construction of stakeholders' visions, expectations and frameworks (Versteeg et al 2017; Fisher 2007; Franks & Cohen 2012). Table 2 outlines examples of various tools used:

Table 2 Summary of approaches for primary data collection

Technique/ Approach	Examples	Description
Interviews (unstructured or semi-structured)	Versteeg et al 2017; Fisher 2007; Frank & Cohen 2012; Douma et al 2007	Data on stakeholder constructions around technology development processes and their perceptions of dynamics and interactions
Participant Observation	Fisher 2007; Douma et al 2007	Data on interactions between various actors
Action Research Feedback Techniques	Fisher 2007; Schot & Rip 1996; Douma et al 2007	Breaking down differences in stakeholders' expectations and assumptions; encourages interactions between different stakeholders; change use behaviours if technology implemented; improving effectiveness of technology implementation
Scenario Methods	Douma et al 2007	Data on microanalysis of technology use (e.g. cost effectiveness; user friendliness, etc)
Survey Methods	Versteeg et al 2017	Data collection can encompass a wider number of different stakeholders' perceptions

This project will develop a robust empirical foundation for understanding the role of multiple stakeholder interactions in AV technology use to help decision-makers explore potential futures. Using a constructive technology assessment (CTA) methodology this project studies the expectations of different stakeholders regarding the development of AV technology for various applications including: public transport; freight and logistics; private vehicle use and taxi services. Data will be collected based on the U.K and Australian AV contexts. Interviews will allow the researcher to delve into not only constructions of their future visions but also elicit information around power relations between important actors and the socio-technical forces that impact future possibilities. As Genus (2006) explains, it is the difference and ongoing disagreement between stakeholders that is important and interviews will allow the research to consider these "differences" is greater depth during the data analysis.

Discourse analysis will be undertaken on the qualitative interview data, and consider possible different stakeholder visions (Potter & Wetherell, 1987). Data analysis will also highlight trade-offs and paradoxes that arise within the data, as these will be points at which policy implications are important for "shaping" future technology paths.

Conclusion

This paper proposes a methodological approach for investigating future vision on the implementation and use of technology. It incorporates IMP principals through considering interaction at different levels: social to social; material to material and social to material. In our case the material component has some decision making capability through the AI embedded in the vehicle. Therefore, while power relations between social actors are still an important component, we must now consider situations where the material has the overriding decision making in certain situations. With AI expected to greatly influence our daily lives, including our working lives, discussion on how IMP may be able to incorporate this material aspect with decision making capabilities is important for growing our methodological approaches given the future trends that are likely to occur.

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