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Dashboard design and the 'datafied' driving experience

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Abstract

In this article, I consider how the redesign of vehicle dashboards has restructured car-related data processes. I do so by charting the emergence of two such processes enabled by the redesign of vehicle dashboards: firstly, the transformation of 'geodata' into 'navigational data' with the integration of voice-activated navigation systems into vehicle dashboards, and secondly, the transformation of 'vehicle data' into 'driving data' in the convergence, and customization, of dashboard features and functionality. Both transformations are enabled through strategic design decisions, persuading drivers to participate in novel practices they might otherwise not. Firstly, in that voice-activation is depicted as a seamless, unmediated interface between the normal, natural speech of a driver, and the vehicle itself. Secondly, through the strategy of control, the driver is persuaded to believe they have full(er) customizable power within, and of, the vehicle. The systems discussed here – a voice-activated navigation system built on the What3words platform, and a 'widescreen' dashboard in a range of Mercedes-Benz vehicles – are representative of broader efforts within the automotive industry to cultivate a newly 'datafied' driving experience.

Keywords

Datafication, automobility, dashboards, navigation, driving, experience

Introduction

In this article, I consider how the redesign of vehicle dashboards has restructured car-related data processes. I do so by charting the emergence of two such processes enabled by the redesign of vehicle dashboards. Firstly, with the integration of voice-activated navigation systems into vehicle dashboards, 'geodata' becomes 'navigational data'. Here, this transformation is enabled through the implementation of new addressing and speech protocols that radically change the relationship between driver and vehicle, when performing navigational tasks. Secondly, 'vehicle data' becomes 'driving data' in the convergence, and customization, of dashboard features and functionality. Here, this transformation is enabled through the spatial, aesthetic and operational integration of typically separate aspects of the driving experience (instrument cluster, navigation and entertainment), re-presenting vehicle-related data in new, and novel, ways. In evaluating these concomitant 'datafication' processes, I use Mejias and Couldry's (2019: 3) definition, in which datafication involves 'the transformation of human life into data through processes of quantification, and the generation of different kinds of value from data'.

Both transformations are enabled through strategic design decisions, persuading drivers to participate in novel practices they might otherwise not. Firstly, through the strategy of 'representational transparency' (Agre, 1995: 186), voice activation is depicted as a seamless, unmediated interface (Bolter and Grusin, 1998) between the normal, natural speech of a driver and the vehicle itself. Here, a voice activation system, a novel addressing system and an infotainment system combine to reorganize the navigational activities of a typical driver. By imposing a new 'grammar of action' (Agre, 1994: 107), these technologies work to capture automotive navigation in new 'datafied' ways. A significant component of this new navigational grammar, in which drivers not only issue 'vocalized instructions' (Hind and Seitz, 2021: 24) as opposed to using physical dials or interfaces, is that localized place names (neighbourhoods, streets and buildings) are replaced with 'unique, three word strings' (Hind and Seitz, 2021: 24). The result is what Agre refers to as 'semantic colonization' (Agre, 1995: 186), as these new

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grammars impose themselves on the established navigational practices of drivers.

Secondly, through the strategy of control, the driver is persuaded to believe they have full(er) customizable power within, and critically *of*, the vehicle – an example of what Mattern (2015) refers to as 'dashboard drama'. It is through this aesthetic allure that the driver is subject to an 'empowerment and measurement regime' (Agre, 1995: 176), in which their driving experience is made manageable by the vehicle manufacturer. While offering greater, and deeper, aspects of customizable control – from the reorganization of apps on the vehicle's infotainment system to the selection of different instrument cluster styles – automotive actors are afforded new ways to cultivate the driving experience. Increasingly, this is leading to the use of artificial intelligence to 'anticipate' and 'pre-empt' driver actions based on contextual information (location and time of day) and past user behaviour.

Here, I interrogate how such systems transform car-related data from one state (geodata and vehicle data) into another (navigational data and driving data). The systems discussed here are representative of broader efforts within the automotive industry to transform the vehicle itself into 'mobile spatial media' (Alvarez Leon, 2019a) or wholesale into a 'platform', through which the use of data is integral (Alvarez Leon, 2019b; Wilken and Thomas, 2019).

While the automotive industry is not alone in making use of data streams produced as by-products (Pridmore and Mols, 2020; Thatcher, 2014), there are nonetheless unique challenges to be found in this application, such as interpreting spoken destinations or disambiguating common street names. These provide the possibility of articulating distinct aspects of datafication (Sadowski, 2019; Van Dijk, 2014) within vehicles, and beyond other spaces such as the home (Maalsen and Sadowski, 2019; Pridmore et al., 2019). The effect is manifold: the cultivation of new kinds or streams of data (touchscreen interfaces augmented with voice activation, mirrors replaced by recordable cameras), new ways of representing established kinds of data (vehicle speed or fuel levels) and altered practices in relation to both (entering destinations, accelerating).

The aim of the article is thus threefold: firstly, to map where and how datafication takes place within the car; secondly, to establish the role of vehicle dashboards in enabling this datafication; and thirdly, to identify the strategies that come to shape the nascent datafied driving experience.

In the next two sections, I consider how geodata is (and is not) transformed into navigational data, and how vehicle data is transformed into driving data. In the former, I discuss how some kinds of geographical information escape datafication, while others are subject to a practice I call 're-datafication'. In the latter, I discuss how vehicle data is 'surfaced' as driving data, generating alternative kinds of value in the process (Mejias and Couldry, 2019), connected, for instance, to the development of electric vehicles. In the subsequent section, I explore how dashboard 'convergence' (Hind and Gekker, 2019; Jenkins, 2006) enables these transformations. In the final two sections I discuss two cases: a voice-activated navigation system built on the What3words platform, and a 'widescreen' dashboard in a range of Mercedes-Benz vehicles.

Navigational data: 'Turn-by-turn'

Geodata is data with a geographical, locational or spatial component (Lauriault, 2017; Leszczynski, 2017). Typical examples include coordinates, a house address or a postcode. Geodata may be relatively precise (GPS location) or represent a general geographic area (a state or municipality), with scholars attentive to the spatialities of data, more broadly (Crampton et al., 2013; Shelton, 2017). Furthermore, geodata can be used for various kinds of navigational tasks: to orientate oneself on a hike, to enable the delivery of consumer goods or to arrange a meeting with friends. In this section, I consider first how some kinds of geographical information are *not* transformed into data in the act of navigating a vehicle. Then, how geodata *stays* as geodata while being enrolled into navigational practice, before discussing how geodata *is* transformed into navigational data in the act of navigating a vehicle. In other words, how navigational data is 'activated' through various associated practices, which to varying degrees satisfies a general definition of datafication, as offered by Mejias and Couldry (2019) involving both (a) quantification and (b) generation of different kinds of value.

Navigational data is dependent on geodata. Geodata might be *added* to other kinds of (geo)data such that its use, or operational, value is enhanced. Geodata might also be *replaced* by more useful geodata that usurps the original geodata's low utility. Both enable a navigational task to be completed. Thus, navigational data is always composed out of geodata but may be combined with other contextual data that aids the completion of the navigational task. If there is no navigational task to perform, the geodata remains as geodata.[1] Even then, geodata may be enrolled into navigation without being transformed into navigational data. In any case, navigational data does not exist a priori but is transformed into navigational data through the act of navigation. It is, therefore, 'ontogenetic', emergent in the practice of navigating (Hind, 2020; Kitchin and Dodge, 2007).

Navigational data is *not* always activated in the driving of a car. Firstly, geographical information may be embedded within the wider environment, both inside and outside the car, that remains as geographical information but is still integral to navigational practice. This may include visible buildings or landmarks and temporary road signs that issue text-based instructions, but also trusty road atlases or 'occasion maps' scribbled on the rough pieces of paper (Singh et al., 2019; Thielmann, 2019). Although there may well be a change in value as these phenomena are enrolled into specific navigational tasks, they are not turned into (geo)data in the process, and as such do not undergo datafication.

This is not, however, to say that such geographical information has not been datafied already in other contexts, or that there have not been attempts to 'datafy' them in an automotive setting either. The Google Streetview and Google Earth projects have long enabled the capture of buildings, landmarks and street scenes in a visual format, enabling various kinds of datafied experiences, from 'Dionysian adventures' (Kingsbury and Jones III, 2009: 502) to geo-based forms of evidencing and intervention (Parks, 2009). Moreover, within the automotive industry, there have been numerous attempts to capture the aspects of the built environment for the purposes of autonomous driving. HERE's HD Live Map (HERE, 2021), Mobileye's Road Experience Management (REM) (Mobileye, 2021) and Waymo's 3D maps (Waymo, 2020) all collect localized, topographic data 'from the height of the curb' to the 'width of an intersection' (Waymo, 2016). A recent patent filing by Ford details a system capable of reading advertising hoardings to be transmitted into the vehicle itself (Rose, 2021). However, at present, none of these systems constitute a lived driving experience, or are embedded within everyday automotive navigation.

Secondly, geodata may become enrolled into navigational practices, but stubbornly remain as geodata. Typically, such geodata might be found in fixed road signs with place names and numerical distances, or in traffic lights, in which geographical information has already been extracted, coded and displayed. Yet, while enrolled into navigational practices (think of how many times a road sign has been interpreted by a passing driver), this geodata is not transformed into navigational data, as no further quantification has taken place, even though different kinds of value are arguably being generated through its enrolment in many specific, unique navigational tasks each day. Thus, it cannot be said that additional datafication happens in such a case.

As before, however, this has not prevented attempts to turn this kind of geodata into navigational data. The aforementioned mapping systems developed for autonomous vehicles do not only typically capture localized topographic data (curb heights and intersection widths) but also intend to extract geodata displayed in directional signs and traffic lights. In a demonstration of Mobileye's REM system on the roads of Munich, Germany, one is able to see a real-time representation of approaching traffic lights (Mobileye, 2020); data that is collected by vehicles equipped with Mobileye technology. However, once again, this is not a universal driving experience at present. As a result, this geodata, while very much enrolled into automotive navigation, is not typically 're-datafied'.

Thirdly, geodata may be enrolled into navigational practices that transform it into navigational data. Ordinarily, this activation occurs through digital devices such as integrated sat-navs, standalone sat-navs, generic or single-purpose map apps (Brown and Laurier, 2012; Chesher, 2012; Hind, 2019; Hind and Gekker, 2014). With each, geodata undergoes a second round of datafication, as pre-existing datapoints (house numbers, postcodes, etc.) are transformed into 'turn-by-turn' datapoints in the act of navigating via a digital device, or what Singh et al. (2019: 287) refer to as a 'turn-taking machine', thus generating immediate navigational value to the driver. Rather than datafication, per se, this 're-datafication' instead further transforms one kind of data into another. These transformations are necessarily performed in part (or whole) through specific technical relations between devices, apps, platforms and infrastructures, which differ between the examples given above.[2]

This final category is of particular interest because of how it usurps these other modes. When geodata is transformed into navigational data, it captures and codifies the navigational experience, 'turn-by-turn'. Here, this re-datafication is enabled by the imposition of these new infrastructures, which seek to re-route navigational activities through them instead. This is what Couldry refers to as a 'general project of social re-construction' (Couldry, 2020: 1140), as 'life actions previously performed elsewhere' (Mejias and Couldry, 2019: 3) are carried out through a digital device. However, complicating the abstractive power that datafication offers, these other sources of navigational information are also rather stubborn: they stand in the way – sometimes quite literally – of datafication, limiting the extent to which users might require, or interact with, navigational devices. It is this contestation between reliable, appropriate, and accurate sources of navigational information that I will turn to in the first case study.

In summary, while in the first category (geographical information in navigation) value generation might occur, this is not through datafication. In the second category (geodata as geodata), datafication has already occurred, and value generation does take place, but not through the transformation of geodata into navigational data. In the final category (geodata into navigational data), re-datafication can be said to occur, through which both quantification and value generation take place in the act of navigation. What is important to mention about all three categories is the transformation (or not) of geodata is dependent on certain operational conditions being met. Some sources of geographical information remain untouched by datafication, others have already been extracted and codified, while others still have become more recently exposed to emergent, recurring and persistent re-datafication efforts.

In the next section, I discuss the transformation of another car-related datafication process, the 'surfacing' of vehicle data as driving data.

Driving data: Indicator-by-indicator

Vehicle data is data that is generated by the car for the technical operation of the vehicle itself. Ordinarily, the transmission of vehicle data is enabled through a centralized communication system, referred to as a 'vehicle bus'. Various protocols have been developed over the years to standardize communication procedures, ensuring that components can safely and effectively speak to each other. 'Electronic control units' (ECUs) that control a suite of functions within the car are dependent on vehicle data, as well as the vehicle bus that sends such data throughout the vehicle. Examples include the engine control unit (for controlling the engine), the transmission control unit (for controlling gear transmission) or the control unit for anti-lock braking systems. Luxury cars now have between 100 and 150 ECUs (Stoltzfus, 2017; Winning, 2019), despite attempts to consolidate them into multi-functional systems (Intel, 2018).

As vehicle data facilitates machine-to-machine communication, it does not need to be seen by, or made interpretable for, the driver. However, much like geodata is transformed into navigational data, so vehicle data can be transformed into driving data, surfaced through representation in indicators, dials, lights or some other visual (or audio) form.[3] Driving data is vehicle data that is activated in the process of driving a vehicle. While vehicle data lies under the bonnet, (usually) quietly ensuring the vehicle is operating properly, driving data is presented to the driver to aid decision-making. Like navigational data, driving data is brought into being through the various stages or moments in the driving experience.

Vehicle data is surfaced as driving data in multiple ways. Firstly, data can be *proximally* surfaced. While the manual use of external indicators and headlights (Brown and Laurier, 2017) are examples of proximal communication, these do not typically require ECUs and thus do not generate data at all. As visual signs, they are analogous to the (first) geographical information category discussed previously. While such instances may well generate value, as these phenomena are enrolled into specific driving actions, they are not turned into (driving) data in the process, and as such do not undergo datafication. However, the development of 'adaptive' or 'intelligent' sensor-activated headlights that dynamically adjust to different conditions (fog, night) or situations (an urban environment, a sharp corner) does require ECUs and as such undergo datafication. Here, driving data is not only made available for other road users to aid safety and ensure appropriate driving etiquette, but is also dynamically enrolled into driver decision-making.

Secondly, such data can be *internally* surfaced. Here, data is surfaced through instruments, dials, lights and screens on a vehicle dashboard. Such data is principally surfaced for the driver, to ensure they can perform driving activities, such as deciding when to refuel or change gear. In the USA, 44 separate indicators are standardized by law (Federal Motor Vehicle Safety Standards, 2020). In 2020, Honda recalled 608,000 vehicles in the USA (O'Kane, 2020) after discovering faulty software that could 'cause the instrument panel to not display critical information' (National Highway Traffic Safety Administration, 2020: 1). As vehicle data has already undergone a process of datafication (quantification and value generation), the transformation into driving data can be considered re-datafication, through which new safety-critical forms of value are generated.

Thirdly, data can be *remotely* surfaced. Here driving data is extracted for the use of remote parties such as car rental companies, haulage firms or insurance providers (Meyers and Van Hoyweghen, 2020). 'On-board diagnostics' (OBDs) are typically used to track vehicles, with simple devices plugged into OBDs transforming vehicle data into driving data. For fleet operators, external surfacing enables 'smarter decisions, powered by data' (US Fleet Tracking, 2020), through which vehicle assets can be managed. Increasingly, however, this type of extraction is being enabled to both obtain ever-more granular driving data, as well as to expand such efforts to everyday vehicle owners (Gekker and Hind, 2019). In this case, vehicle data is transformed into driving data through a re-datafication process that yields greater opportunity for the aggregation, combination and comparison (i.e. quantification) of, and between, such data. This results in a more intensive and persistent generation of (operational, asset, environmental and social) value, mostly for the parties above, but also potentially for other drivers as insights gained from the re-datafication process inform the redesign of vehicle dashboards and associated technologies (Sadowski, 2019).

In summary, in the first category (proximal surfacing) datafication occurs under certain circumstances, with recurring, and familiar, forms of value generated between drivers in the process. This is dependent upon the extent to which the vehicle contains components that at least possess the *capacity* for such proximal surfacing, of which many older or entry-level models do not. In the second category (internal surfacing), datafication has also already occurred, with secondary re-datafication processes seeking to cultivate new forms of value, principally for drivers. This internal surfacing is legally mandated in all vehicles, and hence is common, but has considerable scope to be redesigned, rearranged and ultimately re-datafied according to relevant vehicle safety standards. In the final category (remote surfacing), re-datafication results in more aggressive forms of data use for third parties, through which a multitude of different forms of value might be generated. Remote surfacing is ordinarily made possible by wider technological infrastructures (fleet management/tracking platforms) and devices (GPS trackers) increasingly available to ordinary drivers. Some of these final forms of value – generated mainly through internal and remote surfacing – find their way (back) to the driver in the redesign of vehicle dashboards. The following section will thus consider the role of the dashboard in the datafication process.

Dashboard convergence: From spatial to operational integration

Originally a physical board to prevent material from 'dashing up' onto the exposed driver (Mattern, 2015), dashboards in contemporary vehicles display an array of phenomena from operation-critical processes (gear, engine temperature) to multimedia options (radio station, Bluetooth connectivity). While the talk of urban and smart city dashboards is now common (Kitchin et al., 2016; Zook, 2017), the discussion of the evolution of vehicle dashboards is less so. Yet over the years, the dashboard has developed from a device made to prevent any physical hindrances to driving, to a multifunctional aid designed to enhance the driving experience.

In this section, I contend that dashboard 'convergence' facilitates datafication, in which the otherwise separate interfaces housed within a vehicle dashboard – typically the instrument cluster, navigational assistance and multimedia – are becoming operationally dependent. In this, I go beyond Alvarez Leon's (2019a: 370) suggestion that cars have become 'integrated media spaces', arguing that it is through this convergence that the datafication of wholesale vehicle operations is occurring. More specifically, the generation, and (re-)presentation, of both navigational data and driving data is being enabled through the convergence of dashboard functions.

Dashboard convergence is not necessarily a new phenomenon, with innovation in vehicle dashboard design being a constant since the early 20th century. Yet, as Mattern (2015) discusses, the 'standard package' of a Ford Model T in 1908 'consisted solely of an ammeter, an instrument that measured electrical current'. While early computers only made use of displays to check for 'errors' rather than for 'complex data output or input' (Thielmann, 2018: 47), early motor vehicles had more immediate ways to inform users of a problem: '[w]ater gushing from the radiator, an indicator you hoped *not* to see, was your "engine temperature warning system"' (Mattern, 2015; authors' emphasis). Yet dashboards had already became symbolic representations of vehicle state, rather than strictly indexical representations, 'progressively simplify[ing] the information relayed to the driver, as much of the hard intellectual and physical labour of driving was now done by the car itself' (Mattern, 2015).

Following Mattern, then the principle of dashboard design from the 1950s onwards exhibits a kind of rationalizing design tendency, 'driven primarily by aesthetics' (Mattern, 2015), with fewer vehicle operations needing to be represented (either indexically or symbolically) to the driver. However, this aesthetic desire has given way to a developmental reality in which additional controls, features and options have increasingly become 'bolted on' to existing dashboard layouts. Rather than serving to filter and selectively surface critical performance metrics, vehicle dashboards have evolved to 'expose' much more of the vehicle's seeming limitless functionality. This dashboard 'complexity' (Everdell, 2015) or 'clutter' (Thrift, 2004: 56) has been driven by this counter-tendency, desiring to offer a better driving experience, ordinarily at the expense of driving safety or simplicity.

Thus, the dashboard has become an important space for innovation in recent years as new driving features and data flows are represented to enhance this driving experience. Dashboard convergence is a logical effect of the 'platformization' of the car, which has made it connectable, modular and interfaceable (Helmond, 2015). Dashboard convergence presents itself as a fix for 'clumsy' (Everdell, 2015) dashboard design, offering to resolve these related aesthetic, experiential and safety questions at once. While urban dashboards provide an illusion that cities can be singularly knowable and measurable through an 'instrumental rationality' (Kitchin et al., 2016: 94), vehicle dashboards have typically offered an instrumental plurality driven, in part, by the automotive manufacturer's (increasing) reliance on selling optional add-ons, vehicle configurations and soft/hardware updates (Krings et al., 2017; PWC, 2018).

This dashboard convergence is twofold. Firstly, there is a *spatial* convergence in which previously separate modules are placed within the same part of the vehicle dashboard. A typical example is the integration of navigational capabilities within a multimedia system embedded within the central console of a vehicle (Alvarez Leon, 2019a). Here, an external navigational device (sat-nav, road atlas, occasion map, etc.) is replaced with an in-built feature, selectable by the driver in the same way as they turn on the radio or adjust the air conditioning. In this, multimedia and navigation functions exist on the same ontological plane – as 'apps' – embedded within such a system, accessible via buttons or a touchscreen.

Secondly, there is *operational* convergence involving the integration of previously separate systems. In this form of convergence, different systems are 'vertically' integrated, such that either one is dependent on the other. Arguably, this operational convergence is newer, a required step in the platformization of the car, in which different systems are made interoperable, in a 'plug-and-play' approach, similar to how web platforms offer access via APIs (Plantin et al., 2016). A novel example, to be discussed in the next section, is the integration of voice activation systems with navigational capabilities. Here, a voice activation system, a unique addressing system and an infotainment system work together, with commands issued through one (voice activation), triggering a response in another (addressing), to be presented in another (infotainment).

These two types of convergence – spatial and operational – are integral to re-datafication: the transformation of geodata and vehicle data into navigational data and driving data. This horizontal (spatial) and vertical (operational) integration enables the activation, surfacing and/or extraction of these data types, in ways that were either previously unimaginable, technically impossible, difficult to implement or otherwise 'siloed'. Through re-datafication, the navigational and driving data streams are made more valuable, both for the driver of the vehicle and – just as critically – for the manufacturer. Through this 'interoperability' (Wilmott, 2016) previously separate systems (and their accompanying data types) are made to work with each other.

This push towards greater interoperability, crystallized in the convergence of dashboard functionality, is driven in large part either by the 'full-stack' capabilities of big tech companies entering the automotive market, or in their emulation by automotive manufacturers in partnership with 'tier one' chip, component and system suppliers. In both cases, access to, and control over, the entirety of data streams generated by, and in, a vehicle is regarded as important for the extraction of value in an industry typically burdened by high production costs. As a result, vehicle manufacturers and their parent groups have typically had to be alert to new profit maximization possibilities, whether through mergers and acquisitions, 'strategic in-sourcing', vehicle platform consolidation, labour flexibilization or moving production facilities (Pavlínek, 2008, 2020). Capturing and streamlining navigational and driving data streams have enabled vehicle manufacturers to *optimize* the production and maintenance of vehicles, to *control* how this data is used, to *build* new features and services and to *grow* the value of their operations (Sadowski, 2019).

In the following two sections: I analyse two innovative vehicle dashboard designs: firstly, a voice-activated navigation system based on the unique addressing platform What3words. This can be seen to have transformed geodata into new forms of navigational data. Secondly, a self-styled 'widescreen cockpit' designed by Mercedes-Benz, which has arguably surfaced vehicle data as novel forms of driving data. The result of both is an emerging datafied driving experience. I contend that their comparative successes – as examples of dashboard convergence in which data is transformed within the vehicle – rest on two strategies: representational transparency and customizable control. While reflective of broader developments in the digital economy, these strategies take on specific qualities in an automotive context.

Voice-activated navigation as representational transparency

What3words is a proprietary geocode system that divides the world into $3m^2$ grids, identifiable by a unique three-word string. In doing so, it algorithmically converts underlying geographic coordinates, enabling users to remember locations such as 'thread.strollers.bumble' (somewhere in Germany). What3words claim it is superior to established postal systems, with the $3m^2$ grids enabling users 'to specify a precise entrance, unlike a street address which identifies an entire building' (Macgregor, 2020a), and that 'unlike street addresses which are often duplicated', What3words locations are 'all unique', available in 'over 40 languages' (Macgregor, 2020a) (Figure 1).

In 2018, Daimler integrated What3words into its new infotainment system, 'Mercedes-Benz User Experience' (MBUX), aboard the new Mercedes-Benz A-Class (Daimler, 2018a). In doing so, they suggested they had 'moved one big step closer to [their] goal of making the vehicle into a mobile assistant' such that '[i]nputting locations…makes life easier for our customers and ensures a special experience' (Daimler, 2018a). In this, What3words could be activated through a touchscreen interface, but also via voice control.

As a promotional video demonstrates (Mercedes-Benz, 2018a),[4] the combination of What3words and LINGUATRONIC (MBUX's voice control system) (Daimler, 2018b) is seen as integral to the navigational experience within the A-Class. Rather than the driver using clunky search boxes, unresponsive knobs and buttons, or external apps or sat-navs, the owner merely issues instructions to the vehicle, with What3words deemed 'the simplest way to talk about location' (Mercedes-Benz, 2018a). In this, typical (local) addressing systems are rendered confusing and frustrating. As the manufacturer reminds us, street names are rarely unique (Mercedes-Benz, 2018b), street numbers are difficult to differentiate between, and some towns are entirely unpronounceable to unfamiliar users (What3words, 2019). In short, the integration of What3words into the A-Class is set up to provide an improved navigational experience.

However, rather than simplifying vehicle navigation, the convergence of a novel addressing system, a voice control system and a navigational system yields significant 'praxeological changes' (Thielmann, 2018: 50) between driver and vehicle. This operational convergence demands drivers follow, very carefully, a set of new conversational protocols to activate the navigational experience. Rather than offering a 'transparent' interface, in which the 'illusion of representational transparency' (Agre, 1995: 186) between the driver and vehicle is maintainable, What3words 'remediates' (Bolter and Grusin, 1998) this navigational experience, inserting a number of new rules drivers must follow.

As a promotional video shows, 'Sophie' receives a message on her smartphone: 'let's meet at hello.page.brand for brunch' (Mercedes-Benz, 2018a). As she gets into the car, she utters the words 'hey Mercedes', before asking the vehicle to 'take [her] to What3words hello.page.brand' (Mercedes-Benz, 2018a). Yet rather than instantly generating a route, Sophie is instead given three choices: her intended destination, but also 'hello.page.brands' and 'hello.page.barn'

Figure 1. An illustration of how the What3word grid system works.
Source: What3words (2021a).

(Mercedes-Benz, 2018a). While What3words is designed to remove ambiguity, only a plural form of one word distinguishes two results (brand to brand*s*). Furthermore, despite their claim that 'What3words addresses are spaced as far apart as possible to avoid confusion' (Macgregor, 2020b), all three options are within a 23-mile (37 km) radius of Sophie's current location. Likewise, upon changing plans, a second set of results yields three locations in barely a 30-mile (48 km) radius. Again, the three-word addresses are not readily distinguishable, with 'lanes.larger.daring' returned alongside 'lands.larger.daring' and 'ages.larger.daring' (Mercedes-Benz, 2018a); an issue corroborated by security researcher Andrew Tierney, who similarly found a 'large numbers of plurals and homophones' in close proximity while testing the platform (Wakefield, 2021) (Figure 2).

The activation of navigational data in the use of a voice-activated navigation system results in a peculiar, if not altogether dangerous, experience. According to the company, What3words is accepted by over 80% of the UK's emergency services, often dependent upon reaching individuals in remote locations, quickly (What3words, 2020). Yet, in the examples above, geodata in the form of a familiar, localized address is rendered mute. In its place is reference to a general geographic area (Bayswater, Cranleigh or Send) and a number of either similar sounding (lanes, lands), or singular/plural forms (brand, brands), of proximally located What3words strings.

This erasure – of localized names and places, idiosyncratic, ambiguous or unpronounceable to outsiders – is common to (digital) capitalism (Nicas, 2018; Rose-Redwood et al., 2019; Sotoudehnia, 2018).[5] The automatic translation, or 'toponymic reconfiguration' (Rose-Redwood et al., 2010: 454), of established place names into trivial three-word locations, is the key to the reorganization of navigational practice within the vehicle. With this, the driver is expected to change their navigational habits on two counts: firstly, to shift from using touchscreens/knobs to voice control; secondly, to shift from using postcodes and addresses to using randomized three-word strings.

Regarding the former, it alters how geodata is transformed into navigational data. Rather than street names, whole addresses or postcodes being selected from within an addressing database[6] by the user via a touchscreen or dials, three-word strings are spoken and 'matched' to the What3words database by LINGUATRONIC. Thus, entirely *new* kinds of vocal data are created – and captured – in every command issued, and every destination uttered. Geodata is literally called into being at the beginning of a navigational task, undergoing a transformation into navigational data as each desired destination or datapoint is enrolled by the 'turn-taking machine'.

Regarding the latter, it constitutes, what Agre (1995: 186) refers to as 'semantic colonization', in which new

Figure 2. The 'frustration' of inputting addresses by touch.
Source: What3words (2021b).

semantic terms usurp others. Not only is one kind of geodata (postcodes) bypassed, but another kind altogether (three-word strings) created, even acting parasitically on the other to 'convert' postcodes into What3word locations. This re-datafication process generates an altogether more problematic form of value rendered not from local road names or through a standardized (and nationalized) postcode system, but from randomized three-word strings. While it is a strategy that purports to offer representational transparency, it only succeeds in adding further layers, as new navigational 'procedures' are designed (Garfinkel, 1996; Thielmann, 2019). This semantic colonization is made possible through the proprietary nature of the system itself, under which What3words data (i.e. vocalized search requests), and the conversion software code, is protected by copyright owned, or licensed, by What3words (What3words, 2021c).

The new conversational protocols also arguably remove the noted 'interpretative flexibility' (Pridmore and Mols, 2020: 2) of typical household voice-activated devices, considering their specificity of use within an automotive context, and for strictly navigational tasks. Although LINGUATRONIC bears some similarities with generic, or all-encompassing devices that allow users to access information (weather, news, entertainment, etc.) or control a suite of secondary appliances (lights, heating, music systems, etc.), its integration with What3words establishes a far clearer use case: automotive navigation. Unlike users of other household voice-activated devices, drivers of vehicles equipped with both do not necessarily 'struggle…to determine what these devices are really for' (Pridmore and Mols, 2020: 3). Instead, the obvious hurdle becomes re-learning established ways of automotive route-planning and wayfinding, from entering postcodes to using a touchscreen sat-nav.

What is also important to note is that while partnerships with external suppliers are typical within the automotive industry, the integration of third-party digital services such as What3words into the in-car experience is less so. This represents a significant development in the automotive industry, as vehicle manufacturers begin to involve companies with expertise in 'datafying' user experiences, such as with Polestar's use of Android Automotive OS

(Polestar, 2021) and Ford's partnership agreement with Google from 2023 (Korosec, 2021). One can only expect the type, mode, intensity, and granularity of navigational (re-)datafication to therefore increase in subsequent years as the value of such data is realized.

The widescreen cockpit as customizable control

The 2018 A-Class not only integrates both voice control and a unique address system into the navigational experience, but also showcases a new dashboard design referred to as a 'widescreen cockpit' (Mercedes-Benz, 2018c). In this new dashboard, previously separate screens for the instrument cluster and the infotainment system (MBUX) are combined into a single entity operated either via touch or voice. The housing for the instrument cluster now extends towards the centre of the dashboard, with the infotainment system stretching across to the driver. In 2021, Mercedes-Benz launched the 'Hyperscreen', a 56-inch display stretching the full width of the interior (Hawkins, 2021), enabling even deeper forms of customizable control (Figure 3).

In another promotional video, we see a YouTuber explain the features of the widescreen cockpit (Mercedes-Benz, 2018c). As it begins, he guides viewers through the 'three screen set-ups available' to the driver (Mercedes-Benz, 2018c): two 7-inch displays, one 7-inch display and one 10.25-inch display, and two 10.25-inch displays, meaning 'drivers can now customize their display screens' (Mercedes-Benz, 2018c). In this, there is a double spatial convergence: firstly, the integration of both instrument cluster and infotainment system into a single entity: the widescreen cockpit; secondly, a variable spatial convergence (the 'three screen set-up') in which the new systems embedded within the interface can be resized. Either users can select two smaller screens (less intrusive), enlarge the media screen (for scrolling through songs, etc.) or choose the full, 'widescreen' experience.

Next, he describes how drivers can perform this customization:

> For example, if you wanted to rearrange the order of these apps [on the infotainment system], you just press and hold on one of the apps, in this case the navigation app, slide it across to where you want it, and then tick confirm and it locks it nicely in place. (Mercedes-Benz, 2018c)

Here, the media display works akin to the homescreen of a mobile device, in which app icons are presented in a grid-like fashion, movable at the user's discretion. However, as he continues, he also highlights the possibility of customizing the instrument cluster, opting for an 'understated' style option (Mercedes-Benz, 2018c). In the 2021

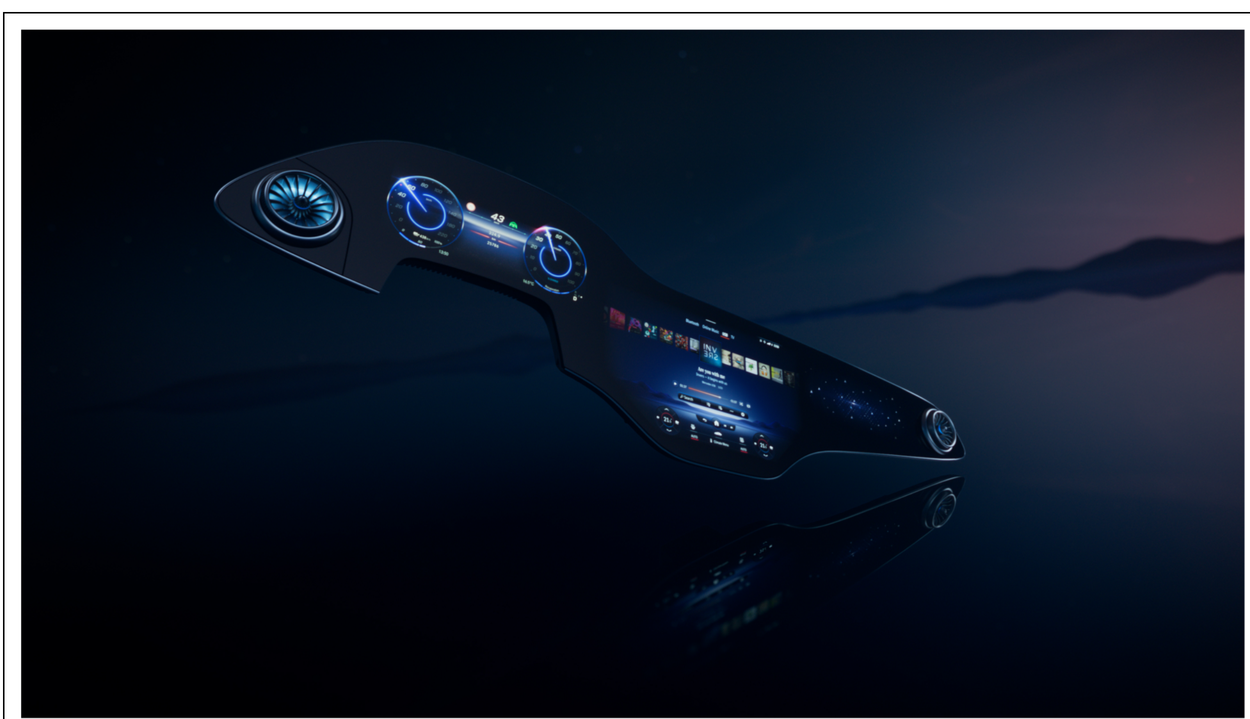

Figure 3. The new MBUX 'Hyperscreen' with three visible screen areas, wider than the widescreen cockpit.
Source: Daimler (2021).

version, the MBUX system includes a 'zero layers' feature in which apps appear 'in a situational and contextual way', meaning drivers do not 'have to scroll through submenus or [even] give voice commands' (Daimler, 2021). In this, the already strange 'order of apps' (Morris and Murray, 2018: 12) is disrupted.

While the claim of a 'zero layer' display is certainly another example of the strategy of representational transparency, I argue it represents another, novel, tendency in vehicle dashboard design. While media functions within cars have been 'appified' (Morris and Murray, 2018) for a while, instrument clusters and driving-related features have typically remained off-limits. Here, app-ecosystems manifesting as 'permanent excess: excessive downloads, excessive connections…and excessive amounts of information' (Mellamphy et al., 2015: 2) have been constrained by vehicle safety standards that govern the style, size, illumination and appropriate abbreviations (ABS, ESC, etc.) for display icons. However, as the above, and another later video suggests, there are now 'many ways to customize your digital dashboard' (Mercedes-Benz, 2019) that increasingly extend beyond media screens and the integration of apps (Goggin, 2021), and into the representation of vehicle states. That is, to how vehicle data is internally surfaced and transformed into driving data.

This, I argue, constitutes a novel application of Phil Agre's 'empowerment and measurement regime' (Agre, 1995: 176), in which drivers are 'empowered' to customize their digital dashboards, 'personalizing' their own driving experience. This is akin to how Tanya Kant (2015: 34) describes Facebook apps as 'tools for self performance', framing and staging the construction of identities. Yet through novel measurement techniques – datafication by another name – vehicle manufacturers can further 'manage' the driving experience.

In the 2021 update, this regime is made even clearer and increasingly proactive, as app presentation is 'supported by artificial intelligence' through a 'context-sensitive awareness [that] is constantly optimized by changes in the surroundings and user behaviour' (Daimler, 2021). Here, the 'MBUX Hyperscreen continually gets to know the customer better and delivers a tailored, personalized infotainment and operating offering before the occupant even has to click or scroll anywhere' (Daimler, 2021). What display to show when, and for what purpose, is therefore a kind of situated surfacing in which the MBUX system offers a greater level of customizable control without the need for direct user interaction. What becomes clearer, then, is how the Hyperscreen is intended to function like a recommendation engine, hooking, looping or 'trapping' (Seaver, 2018) the driver into certain kinds of driverly

Figure 4. The Hyperscreen visualizing new kinds of driving data (electric vehicle energy 'boost' and 'recuperation') using a novel 'clasp'-style display.
Source: Daimler (2021).

attention not dissimilar to those found on other cultural, digital platforms (Bucher, 2012; Pederson et al., 2021; Siles et al., 2020).

The new 'clasp'-style display also renders the driving experience anew. Designed for forthcoming electric models, it internally surfaces new driving data streams. Rather than a combination of speedometer and tachometer common to petrol/diesel vehicles, the Hyperscreen uses a 'spatially moving clasp' to represent the 'boost' and 'recuperation' stages of electric motor use (Daimler, 2021). Here we witness a re-datafication process, as outlined previously, that generates new data, from a new data source, using novel data metrics (motor 'boost' not engine revolutions per minute). In this, the redesign of a critical dashboard indicator is intended to cultivate a sensitive, mindful driver, embodying the fluid, regenerative qualities of the electric motor powering the vehicle (Figure 4).

With these technologies, spatial convergence (both fixed and customizable) leads to an operational convergence, in which both the media display (with app content) and the driving display (with driving data) are presented on the same ontological plane. In this, both are made customizable, not only to the driver's interests, tastes, feelings and passions (Sheller, 2004), but also to their driving *situations* (i.e. going on a family holiday, or driving home from work). Although, as Mattern (2015) explains, instrument clusters have always enabled additional functionality, for a price, this has typically only concerned *what* can be displayed, not necessarily *how* or indeed *when*. With MBUX all three occur: interchangeable displays that not only show current speed, but also electric motor 'recuperation', refuelling limits, or the distance to a desired destination; different styles or 'skins' for the displays themselves; and context-specificity enabled by artificial intelligence according to who the driver is, and what they are likely to be doing.

Conclusions

Vehicle dashboards are being radically redesigned to represent data differently within the car. With this, vehicle manufacturers are moving beyond the representation of typical features such as fuel levels and speed, or simply the digitization of previously mechanical indicators such as fingers and dials. As vehicles are becoming platformized, new data streams are being generated, sometimes derived from entirely novel operational states. New techniques are being employed to represent this data, and new strategies to convince drivers of their utility.

In this article, I have considered how the redesign of vehicle dashboards has restructured both navigation and driving through two datafication processes: firstly, in the transformation of geodata into navigational data, and secondly, in the surfacing of vehicle data as driving data. The spatial and operational convergence of navigation, entertainment and driving features within the car has been a critical enabler of these processes. To convince the drivers of the value of these design changes, two strategies have been deployed by manufacturers. Firstly, 'representational transparency' (Agre, 1995: 186) in which new vehicle interfaces are sold as fixes to existing systems deemed annoying, confusing or complicated to use. Secondly, 'customizable control' in which drivers are afforded greater ability to personalize vehicle displays. These strategies, I have argued, are specifically enabled by re-datafication, in which existing forms of data are transformed into others, actively shaping the experience of driving a car.

To evidence the transformation of geodata into navigational data, I discussed the integration of What3words – a unique addressing system – into a Mercedes-Benz navigation system. Constituting a rather complex operational convergence of multiple systems and functions, navigational capabilities become primarily enabled through voice activation. Here, geodata is activated as a very particular kind of navigational data, posing both novel practical issues for the driver, as well as constituting a kind of 'semantic colonization' (Agre, 1995: 186) in which placenames (i.e. geodata) are rendered as randomized three-word strings for the purposes of navigation.

To elucidate the transformation of vehicle data into driving data, I turned to Mercedes-Benz's MBUX system. Here there is an obvious spatial convergence as driving, navigational, and entertainment features are fitted into a single 'widescreen' dashboard, or 'Hyperscreen'. However, the MBUX system also demonstrates another more subtle convergence, in which the different display screens of the vehicle dashboard can be customized, enabling driving data to reflect a driver's interests, tastes or personality. As an imminent new version of the MBUX system demonstrates, this customizable control is to be further enhanced through artificial intelligence, enabling a 'situated surfacing' of context-relevant functions. These customizable forms, far from being additional elements or features, subtly yet substantially reconfigure the experience of driving. Indeed, rather than a curious side effect, they constitute intended design effects: techniques to transform the driver and their ways of driving.

Thus, this article has sought to add to emerging work on data and platforms, considering how automobiles are being subjected to datafication processes. In the process of transforming both geodata and vehicle data into navigational data and driving data, respectively, new datafied driving experiences are emerging. These, I argue, are worthy of ongoing investigation, as they generate unique effects that help to better understand how datafication is shaping the world-at-large and on the road.

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Notes

1. While it is beyond the scope of this article, it is also possible for geodata to be transformed into other kinds of data, besides navigational data. For example, in how a postcode may be used to validate an administrative request (council tax, energy bill amendment, etc.), verify identity (picking-up a parcel, etc.) or map thematic data (educational attainment, health, employment, etc.). In each case, geodata is not being used navigationally, but for other purposes. In doing so, it undergoes a similar transformation through these varied acts.
2. For instance, in how the capacities of map apps lend themselves to more seamless and continuous modes of datafication than integrated sat-navs.
3. Vehicle data can also be transformed into other kinds of data, besides driving data. For example, in the process of diagnosing a technical fault with a component, vehicle data may be extracted by a mechanic or engineer. The point, once again, is that this transformation occurs once enrolled into the new activity. In this case, of diagnosing a fault or of maintaining or replacing a component.
4. The original video has since been removed; however the page is still accessible via an archive link. A similar example can be found here: https://what3words.tumblr.com/post/179683783794/all-you-need-to-know-about-mercedes-benz-gps-voice
5. Thanks to Aikaterini Mniestri for originally alerting me to this, and especially to the colonial practice of place renaming.
6. Such as the UK Royal Mail's Postcode Address File (PAF).

References

Agre P (1994) Surveillance and capture: Two models of privacy. *The Information Society: An International Journal* 10(2): 101–127.

Agre P (1995) From high tech to human tech: Empowerment, measurement, and social studies of computing. *Computer Supported Cooperative Work* 3(1): 167–195.

Alvarez Leon LF (2019a) How cars became mobile spatial media: A geographical political economy of On-board navigation. *Mobile Media & Communication* 7(3): 362–279.

Alvarez Leon LF (2019b) Eyes on the road: Surveillance logics in the autonomous vehicle economy. *Surveillance & Society* 17(1/2): 198–204.

Bolter JD and Grusin R (1998) *Remediation: Understanding New Media*. Cambridge, MA: MIT Press.

Brown B and Laurier E (2012) The normal, natural troubles of driving with GPS. In: *CHI '12: Proceedings of the SIGCHI conference on human factors in computing systems, pp. 1621–1630*.

Brown B and Laurier E (2017) The trouble with autopilots: Assisted and autonomous driving on the social road. In: CHI '17: Proceedings of the 2017 *CHI conference on human factors in computing systems, pp. 416–429*.

Bucher T (2012) A technicity of attention: How software 'makes sense'. *Culture Machine* 13: 1–23.

Chesher C (2012) Navigating sociotechnical spaces: Comparing computer games and sat navs as digital spatial media. *Convergence* 18(3): 315–330.

Couldry N (2020) Recovering critique in an age of datafication. *New Media & Society* 22(7): 1135–1151.

Crampton JW, Graham M, Poorthuis A, et al. (2013) Beyond the geotag: Situating 'big data' and leveraging the potential of the geoweb. *Cartography and Geographical Information Science* 40(2): 130–139.

Daimler (2018a) New infotainment system with innovative address system: Daimler invests in What3words. Available at: https://media.daimler.com/marsMediaSite/en/instance/ko/New-infotainment-system-with-innovative-address-system-Daimler-invests-in-what3words.xhtml?oid=32742799 (accessed 25 May 2021).

Daimler (2018b) Under the microscope: LINGUATRONIC Voice Control: 'Hey Mercedes'. Available at: https://media.daimler.com/marsMediaSite/en/instance/ko/Under-the-microscope-LINGUATRONIC-voice-control-Hey-Mercedes.xhtml?oid=32997867 (accessed 25 May 2021).

Daimler (2021) MBUX Hyperscreen: The big in-car cinema. Available at: https://www.daimler.com/innovation/digitalisation/connectivity/mbux-hyperscreen.html (accessed 25 May 2021).

Everdell C (2015) Why the car industry needs to rethink the dashboard user interface design. Available at: https://techcrunch.com/2015/10/08/why-the-car-industry-needs-to-rethink-the-dashboard-user-interface-design (accessed 25 May 2021).

Federal Motor Vehicle Safety Standards (2020) Standard no. 101; controls and displays. Available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=7d443eb75ceba033fed91e90f816b574&node=se49.6.571_1101&rgn=div8 (accessed 25 May 2021).

Garfinkel H (1996) *Notes Comparing Two Analytic Formats of Occasion Maps of Way Finding Journeys: 'Documentary' and 'Essentially Procedural'*. Los Angeles, CA: University of California.

Gekker A and Hind S (2019) Infrastructural surveillance. *New Media & Society* 22(8): 1414–1436.

Goggin G (2021) *Apps: From Mobile Phones to Digital Lives*. Cambridge: Polity.

Hawkins AJ (2021) Mercedes-Benz unveils its absolutely massive 56-inch 'Hyperscreen' display. Available at: https://www.theverge.com/2021/1/7/22217267/mercedes-benz-hyperscreen-size-specs-eqs-ces-2021 (accessed 25 May 2021).

Helmond A (2015) The platformization of the web: Making web data platform ready. *Social Media + Society* 1(2): 1–11.

HERE (2021) HERE HD Live Map. Available at: https://www.here.com/platform/automotive-services/hd-maps (accessed 25 May 2021).

Hind S (2019) Digital navigation and the driving-machine: Supervision, calculation, optimization, and recognition. *Mobilities* 14(4): 401–417.

Hind S (2020) Between capture and addition: The ontogenesis of cartographic calculation. *Political Geography* 78(April): 1–9.

Hind S and Gekker A (2014) 'Outsmarting traffic, together': Driving as social navigation. *Exchanges* 1(2): 165–180.

Hind S and Gekker A (2019) On autopilot: Towards a flat ontology of vehicular navigation. In: Lukinbeal C, Sharp L, Sommerlad E and Escher A (eds) *Media's Mapping Impulse*. Stuttgart: Franz Steiner Verlag, 141–160.

Hind S and Seitz T (2021) Agre's interactionism. *SFB1187 Media of Cooperation Working Paper Series* 18: 22–25.

Intel (2018) Automotive ECU consolidation. Available at: https://www.intel.com/content/dam/www/public/us/en/documents/white-papers/ecu-consolidation-white-paper.pdf (accessed 25 May 2021).

Jenkins H (2006) *Convergence Culture: Where Old and New Media Collide*. New York: New York University Press.

Kant T (2015) Spotify has added an event to your past: (Re)writing the self through Facebook's autoposting apps. *The Fibreculture Journal* 25: 30–61.

Kingsbury P and Jones III JP (2009) Walter Benjamin's Dionysian adventures on Google Earth. *Geoforum* 40(4): 502–513.

Kitchin R and Dodge M (2007) Rethinking maps. *Progress in Human Geography* 31(3): 331–344.

Kitchin R, Maalsen S and McArdle G (2016) The praxis and politics of building urban dashboards. *Geoforum* 77: 93–101.

Korosec K (2021) Ford vehicles will be powered by Google's Android Operating System. Available at: https://techcrunch.com/2021/02/01/ford-vehicles-will-be-powered-by-googles-android-operating-system (accessed 18 August 2021).

Krings J, Bakker J and Hoppe S (2017) Auto industry growth strategies: Fasten your seatbelts. Available at: https://www.strategyand.pwc.com/de/en/industries/automotive/auto-industry-growth-strategies/auto-industry-growth-strategies.pdf (accessed 18 August 2021).

Lauriault TP (2017) Open spatial data. In: Kitchin R, Lauriault TP and Wilson MW (eds) *Understanding Spatial Media*. Los Angeles, CA: Sage, 95–109.

Leszczynski A (2017) Geoprivacy. In: Kitchin R, Lauriault TP and Wilson MW (eds) *Understanding Spatial Media*. Los Angeles, CA: Sage, 235–244.

Maalsen S and Sadowski J (2019) The smart home on FIRE: Amplifying and accelerating domestic surveillance. *Surveillance & Society* 17(1/2): 118–124.

Macgregor M (2020a) How are What3words addresses better than regular street addresses? Available at: https://support.what3words.com/en/articles/3577580-how-are-what3words-addresses-better-than-regular-street-addresses (accessed 25 May 2021).

Macgregor M (2020b) How are the words assigned? Available at: https://intercom.help/what3words/en/articles/3577589-how-are-the-words-assigned (accessed 25 May 2021).

Mattern S (2015) Mission control: A history of the urban dashboard. Available at: https://placesjournal.org/article/mission-control-a-history-of-the-urban-dashboard (accessed 25 May 2021).

Mejias UA and Couldry N (2019) Datafication. *Internet Policy Review* 8(4): 1–10.

Mellamphy NB, Dyer-Witheford N, Hearn A, et al. (2015) Apps and affect: Editorial. *The Fibreculture Journal* 25: 1–9.

Mercedes-Benz (2018a) What3words voice navigation: MBUX in the A-Class. Available at: https://web.archive.org/web/20200813053637/https://www.mercedes-benz.com/en/vehicles/passenger-cars/a-class/what3words-voice-navigation-mbux-in-the-a-class-2018/ (accessed 25 May 2021).

Mercedes-Benz (2018b) What3words voice navigation – First to Mercedes-Benz. Available at: https://www.mercedes-benz.com/en/innovation/connected/what3words-voice-navigation-first-to-mercedes-benz/ (accessed 25 May 2021).

Mercedes-Benz (2018c) MrJWW presents the A-Class (Part 1): The widescreen cockpit. Available at: https://www.mercedes-benz.com/en/vehicles/passenger-cars/a-class/mrjww-presents-the-a-class-2018-part-1-the-widescreen-cockpit/ (accessed 25 May 2021).

Mercedes-Benz (2019) Mercedes-Benz A-Class (2019): How to personalise the displays. Available at: https://www.youtube.com/watch?v=pdRTv_LtlWM (accessed 25 May 2021).

Meyers G and Van Hoyweghen I (2020) 'Happy failures': Experimentation with behaviour-based personalisation in car insurance. *Big Data & Society* 7(1): 1–14.

Mobileye (2020) Unedited 1-hour Mobileye autonomous vehicle ride in Munich. Available at: https://www.youtube.com/watch?v=A1qNdHPyHu4&t (accessed 25 May 2021).

Mobileye (2021) Road Experience Management (REM). Available at: https://www.mobileye.com/our-technology/rem/ https://www.mobileye.com/our-technology/rem/ (accessed 25 May 2021).

Morris JW and Murray S (2018) *Appified: Culture in the Age of Apps*. Ann Arbor, MI: University of Michigan Press.

National Highway Traffic Safety Administration (2020) Instrument panel software incorrect/FMVSS 101/111. Available at: https://static.nhtsa.gov/odi/rcl/2020/RCAK-20V439-3598.pdf (accessed 25 May 2021).

Nicas J (2018) As Google Maps renames Neighborhoods, Residents Fume. Available at: https://www.nytimes.com/2018/08/02/technology/google-maps-neighborhood-names.html (accessed 25 May 2021).

O'Kane S (2020) Honda recalls 608,000 vehicles for faulty software. Available at: https://www.theverge.com/2020/8/4/21354314/honda-recall-software-odyssey-pilot-passport-back up-camera-reboot (accessed 25 May 2021).

Parks L (2009) Digging into Google Earth: An analysis of 'crisis in dafur'. *Geoforum* 40(4): 535–545.

Pavlínek P (2008) *A Successful Transformation? Restructuring of the Czech Automobile Industry*. Heidelberg: Physica-Verlag.

Pavlínek P (2020) Restructuring and internationalization of the European automotive industry. *Journal of Economic Geography* 20(2): 509–541.

Pederson MA, Albris K and Seaver N (2021) The political economy of attention. *Annual Review of Anthropology* 50: 1–17.

Plantin J-C, Lagoze C, Edwards PN, et al. (2016) Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media & Society* 20(1): 293–310.

Polestar (2021) Polestar 2: First car with Google built in. Available at: https://www.polestar.com/uk/firstcarwithgooglebuiltin/ (accessed 18 August 2021).

Pridmore J and Mols A (2020) Personal choices and situated data: Privacy negotiations and the acceptance of household intelligent personal assistants. *Big Data & Society* 7(1): 1–13.

Pridmore J, Zimmer M, Vitak J, et al. (2019) Intelligent personal assistants and the intercultural negotiations of dataveillance in platformed households. *Surveillance & Society* 17(1/2): 125–131.

PWC (2018) Five trends transforming the automotive industry. Available at: https://www.pwc.com/gx/en/industries/automotive/assets/pwc-five-trends-transforming-the-automotive-industry.pdf (accessed 18 August 2021).

Rose J (2021) Ford wants billboards to beam distracting ads to screens inside your car. Available at: https://www.vice.com/en/article/n7bnz7/ford-wants-billboards-to-beam-distracting-ads-to-screens-inside-your-car (accessed 25 May 2021).

Rose-Redwood R, Alderman D and Azaryahu M (2010) Geographies of toponymic inscription: New directions in critical place-name studies. *Progress in Human Geography* 34(4): 453–470.

Rose-Redwood R, Vuolteenaho J, Young C, et al. (2019) Naming rights, place branding, and the tumultuous cultural landscapes of neoliberal urbanism. *Urban Geography* 40(6): 747–761.

Sadowski J (2019) When data is capital: Datafication, accumulation, and extraction. *Big Data & Society* 6(1): 1–12.

Seaver N (2018) Captivating algorithms: Recommender systems as traps. *Journal of Material Culture* 24(4): 421–436.

Sheller M (2004) Automotive emotions: Feeling the Car. *Theory, Culture & Society* 21(4/5): 221–242.

Shelton T (2017) Spatialities of data: Mapping social Media ‘beyond the geotag’. *GeoJournal* 82(4): 721–734.

Siles I, Segura-Castillo A, Solís R, et al. (2020) Folk theories of algorithmic recommendations on spotify: Enacting data assemblages in the global south. *Big Data & Society* 7(1): 1–15.

Singh R, Hesselbein C, Price J, et al. (2019) Getting ‘there’ from the ever-changing ‘here’: Following digital directions. In: Vertesi J and Ribes D (eds) *digitalSTS: A Field Guide for Science & Technology Studies*. Princeton, NJ: Princeton University Press, 280–299.

Sotoudehnia M (2018) Toponymic checksum or flotsam? Recalculating Dubai’s grid with makani, ‘the smartest map in the world’. In: Rose-Redwood R, Alderman D and Azaryahu M (eds) *The Political Life of Urban Streetscapes: Naming, Politics, and Place*. London: Routledge, 290–308.

Stoltzfus J (2017) Your car, your computer: ECUs and the controller area network. Available at: https://www.techopedia.com/your-car-your-computer-ecus-and-the-controller-area-network/2/32218 (accessed 25 May 2021).

Thatcher J (2014) Living on fumes: Digital footprints, data fumes, and the limitations of spatial big data. *International Journal of Communication* 8: 1765–1783.

Thielmann T (2018) Early digital images: A praxeology of the display. In: Feiersinger L, Friedrich K and Queisner M (eds) *Image – Action – Space: Situating the Screen in Visual Practice*. Berlin: De Gruyter, 41–54.

Thielmann T (2019) Sensormedien: Eine medien-und praxistheoretische annäherung. *SFB1187 Media of Cooperation Working Paper Series* 9: 1–10.

Thrift N (2004) *Driving* in the city. *Theory, Culture & Society* 21(4/5): 41–59.

US Fleet Tracking (2020) The GPS tracking service for managing your assets. Available at: https://www.usfleettracking.com/fleet-tracking/ (accessed 25 May 2021).

Van Dijk J (2014) Datafication, dataism and dataveillance: Big data between scientific paradigm and ideology. *Surveillance and Society* 12(2): 197–208.

Wakefield J (2021) App used by emergency services under scrutiny. Available at: https://www.bbc.com/news/technology-56901363 (accessed 19 August 2021).

Waymo (2016) Building maps for a self-driving car. Available at: https://blog.waymo.com/2019/09/building-maps-for-self-driving-car.html (accessed 25 May 2021).

Waymo (2020) Waymo safety report. Available at: https://storage.googleapis.com/sdc-prod/v1/safety-report/2020-09-waymo-safety-report.pdf (accessed 25 May 2021).

What3words (2019) All you need to know about Mercedes-Benz GPS voice navigation using What3words. Available at: https://what3words.com/news/automotive/all-you-need-to-know-about-mercedes-benz-gps-voice-navigation-using-what3words/ (accessed 25 May 2021).

What3words (2020) Over 80% of UK emergency services are using What3words. Available at: https://twitter.com/what3words/status/1287815238742609922 (accessed 19 August 2021).

What3words (2021a) Delivery Germany. Available at: https://drive.google.com/file/d/1GYpvn5LtOAzRKU0e1XmttiOsUp0wu2sn/view (accessed 28 September 2021).

What3words (2021b) Input frustration: Automotive navigation. Available at: https://drive.google.com/file/d/1jUHW8ohwPI55or1yuxxIK_iY4Ivigu4z/view (accessed 28 September 2021).

What3words (2021c) What3words terms and conditions. Available at: https://what3words.com/terms (accessed 19 August 2021).

Wilken R and Thomas J (2019) Maps and the autonomous vehicle as a communication platform. *International Journal of Communication* 13: 2703–2727.

Wilmott C (2016) Small moments in spatial big data: Calculability, authority and interoperability in everyday mobile mapping. *Big Data & Society* 3(2): 1–16.

Winning A (2019) Number of automotive ECUs continues to rise. Available at: https://www.eenewsautomotive.com/news/number-automotive-ecus-continues-rise (accessed 25 May 2021).

Zook M (2017) Crowd-sourcing the smart city: Using big geosocial media metrics in urban governance. *Big Data & Society* 4(1): 1–13.