# A Brief History of Smart Transportation Infrastructure

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## Introduction

This paper examines intersections of communication and transportation technology in the U.S. across a number of cases to argue that smart infrastructure has long been manifested in what Urry (2007) has described as *nexus systems*, or those which require many elements to be working synchronously. Understanding smart infrastructure as those which align with 21st century sensibilities concerning technology, convenience, and safety/security, this paper looks more specifically at the layering of information technologies to achieve desired ends. Not surprisingly, convergences of communication and transportation infrastructure to facilitate control are nothing new. Revisiting these cases through the lens of informationalization proves valuable in understanding exactly what we mean by "smart."

To that end, this paper makes a series of stops through the history of U.S. transportation to examine the relationship between communication and transportation technology. I begin with the railroad and telegraph as discussed in Carey's "Technology and Ideology: The Case of the Telegraph" (1989), which he argued "freed communication from the constraints of geography" (Carey, p. 204). He discusses the impact of the telegraph/train combination in two areas highly relevant to smart infrastructure and connected mobility: first, in the impact that the telegraph had on commodity markets, and second, the creation of railway time, later to be adopted as standard time in the U.S. In this first case, informationalization occurs through the synchronization of the train with the telegraph and standard time as enabling technologies.

I next explore the rocky transition from a nexus mobility system (trains and electric streetcars) in urban areas to an unsafe series system driven by gasoline: bus and automobility. In the early 1900s, pedestrians, roller-skaters, police, and streetcar companies struggled with the introduction of the automobile. As individual transportation was previously limited to the speed of the pedestrian or animal (horse, carriage, cart, wagon), lower speeds meant that synchronization was less important. As transportation at high speeds goes off the rails, urban planners had to find ways to manage an auto-mobile public. I briefly trace a history from the 1910s through the 1930s to examine what smart solutions were developed to make modern automobility possible.

With these historical perspectives on smart transportation infrastructure, I want to think about the present mobility system in terms of our information-rich and connected automobility. Rethinking something as new-seeming as "smart infrastructure" through past examples should reveal an existing rather than a new tendency to manage movement via communication technologies.

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**What is Smart Transportation Infrastructure?**

No consistent definition for "smart" in the ways that it is currently being leveraged to promote radical changes in essential infrastructure and services currently exists. What present uses suggest include real-time data collection and processing (See IBM's "Smarter Planet campaign), instant visibility and real-time remote control, as is the case with smart electric grids and smart metering, more healthful and environmentally aware solutions, or simply the addition of information and communication technology to make government, business, and daily life "better."

It is with this in mind that I want to suggest that, at least beginning with electronic communication technology (the telegraph), communication has been integrated with transportation in a manner that falls in line with the present articulation of smart. Seeing "smart transportation" as a set of tendencies that works to integrate additional layers of information resulting in safer and more efficient management of flows (in this case, traffic) places the real-time management of trains via telegraph technology and the development of time zones as well as traffic signs and lights as part of a long trajectory that leads up to our current visions of autonomous vehicles. Rather than see "smart" as some kind of brand new technological epoch, I suggest it is rather part of a longer trajectory of managing movement via communication technology.

**Synchronizing Trains by Fixing Time**

While I might start this conversation from a place where humans first recorded the changing of the seasons to indicate when it was time to migrate from one place to another, or when it was time to plant and harvest crops, I begin with electronic communication. Carey (1989) explains that it was then that, for the first time, communication was able to move across vast distances faster than any transportation technology could carry a message (with a few exceptions, including the semaphore telegraph).

The widespread adoption of the telegraph had a number of important effects on culture, commerce, and transportation as Carey famously discusses in "Technology and Ideology: The Case of the Telegraph" (1989). The telegraph changed journalism in terms of the speed and reach of news, the perspectives that stories were written from, and the style in which it was written (See Blondheim, 1994 for an extensive history of the telegraph and news, including the creation of the Associated Press). Instant communication with far flung colonies increased the reach of empire, and the separation of information from cargo opened up possibilities for commodity trading and futures markets.

Most relevant to the discussion at hand is the ways in which the electric telegraph (also referred to as the magnetic telegraph: see Taylor, 1966) provided for the more effective management of trains. The time – "right now" – was the same for both parties despite the many number of local times that existed city to city. Schivelbusch (1994) explains that while the first practical application of the technology for rail was in tunnels where other methods proved inadequate to communicate about oncoming trains or identify hazards, it soon proved essential in the management of train transportation (p.30). It was not until after the U.S. Civil War that the telegraph was used more widely in rail operations (Taylor, 1966, p. 152).

While the use of communication technology to coordinate trains constitutes one element of smart transportation, the development of railroad time – essential to the expanded use of trains and foundational to the ways that we coordinate activities at a distance even today – is perhaps one of the most important information layers to come out of the railroad/telegraph couplet. Carey explains: "Our sense of time and our activities in time are coordinated through a grid of time zones, a grid so fixed in our consciousness that it seems to be the natural form of time" except for when we "fall back" and "spring forward" (p. 223).

A number of points become clear when considering the train/telegraph alongside contemporary usage of *smart.* First, though elements of data collection and processing were not yet an automatic feature of this development, the technology led to the expansion of goods as commodities and futures markets as well as time zones, essentially creating new data layers. Instant visibility, another element of smart transportation was a central motivation for the integration of the technology, hence the first application in a tunnel. The telegraph (and later, time zones) made the train a safer mode of transportation for people and goods. Finally, the solution was just… better. The telegraph's apparent invisibility "made electricity and the telegraph powerful impetuses to idealist thought both in religious and philosophical terms" (Carey, p. 206). Leo Marx's notion of the technological sublime (2000) and Carey and Quirk's discussion of the electrical sublime (in *Communication as Culture*, 1989) are important dimensions to consider when examining "smart" technology, but are outside the scope of this paper.

**Managing Mass Motordom: Synchronizing Automobility**

In *Mobilities* (2007) mobility scholar John Urry makes a distinction between *series* and *nexus* systems, the former being those systems where parts function independently, and the latter which require many different parts working together of the whole system to work (with rail being the first of these for mobility). But I want to argue here that *even as a series system*, automobility as it exists in the US could be understood also as operating as a nexus system. Though drivers and passengers depart and arrive on a schedule of their own choosing, a great many information systems coordinate movement across space. Aside from roads themselves which limit the areas that are passable, traffic lights that regulate the flow of movement, codified traffic laws and unwritten "rules of the road" govern simultaneous movement of automobiles so effectively that my past 100,000 miles have been without incident. That is not to say that automobility is not without risk. The U.S. National Highway Traffic Safety Administration estimates that 32,850 people died in U.S. motor vehicle accidents in 2013 at an average of 1.11 for every 100 million vehicle miles of travel (U.S. NHTSA, 2014). But it used to be much worse.

In the mid-1910s, the *Electric Railway Journal* featured numerous stories on automobile accidents, with titles such as "The Vehicular Traffic Menace" and "Motor Vehicle Accidents and Traffic Regulation" (No Author, 1916; Windsor, 1916). Windsor's 1916 article suggested that material features in the road that would force drivers to slow down as well as prohibitions on street play as two measures to decrease injury risk for the non-automobile public. By the 1920s, articles supplementing streetcar service with buses began to appear, and by 1930s the journal featured more ads for buses and rubber tires than supplies and services for traditional streetcars. Through the 1920s, articles in *The Electric Railway*

*Journal* demonstrate a shift from seeing bus transportation as a threat in the form of dangerous and unregulated jitney service to an important adjunct to electric streetcar transportation (when run by the streetcar companies, of course). As challenging economic conditions combined with a need to replace aging infrastructure, the bus became an attractive public transportation solution. By 1923, Executive Secretary J. W. Welsh of the American Electric Railway Association writes: “The members of the committee are convinced that the motor bus has come to stay. It is a business proposition, not a theory” (p.620). The mid 1920s is also the time frame identified as the period in which automobility became organized and made important steps to solidify the future of automobile transport.

The development of urban automobility in the U.S. is well documented in Peter Norton’s *Fighting Traffic* (2008), which traces traffic management from the beginnings of the automobile in the city up through the late 1930s. Norton examines the move to “the motor age” through focus on three separate technological frames that align with key groups involved in the transition: *justice* from the perspective of traditional street users, *efficiency* from the perspective of traffic engineers and those interested in reducing congestion, and *freedom* that was leveraged by motordom to argue for the right to the street, for better roads, and for a future for automobility (p. 17-18).

An astounding number of pedestrian deaths that accompanied the rise of the automobile in the 1920s: motorists were framed as reckless speeders, usurping the street at the cost of everyone else, and were also contributing to unhealthy levels of noise in the urban soundscape (Norton, 2008; Bijsterveld, 2008). Public safety movements were powered by public outrage, anger, and grief as citizens focused on the casualties of the automobile—mainly children— in public safety posters, events, and monuments (Norton, 2008, pp. 38-49). As police worked to restore order on the streets, a range of solutions were tried: cornermen synchronized by traffic towers, silent policemen that kept drivers from cutting corners, and the Milwaukee mushroom, which was an improvement on the latter. (pp. 54-63). The introduction of “jaywalking” reframed pedestrian rights to the street as limited, providing more safely at the expense of hundreds of years of pedestrians’ right to the street (Norton, 2008).

Traffic engineers approached the traffic problem by reframing it “as a technical matter for experts” (Norton, 2008, p. 105). On the success of public water and sewer decades before, there was wide support for viewing streets as public utilities and to redesign them for efficiency (McShane, 1999; Norton, 2008). McShane’s history of attempts to control traffic shows that while a variety of approaches and solutions to managing traffic were tested in the 1910s, consensus over best practices (including automatic traffic lights and staggered systems) was coming together by the 1930s. As engineering approaches to traffic management came to dominate industry-led, experimental, and police traffic control efforts through the 1920s, responsibility for managing traffic was informed by a “large, self-reinforcing, international, professional community” that came together in the 1930s – the Institute of Traffic Engineers in the United States in 1931 (p. 389) The solidification of the profession resulted also in the solidification of established systems. In line with what Hughes calls *momentum* (1983) and others have referred to as *lock-in* and *path-dependency* (referenced in Dennis and Urry, 2009), deviation from standard practice often failed despite noted flaws. One such example is the use of red and green for traffic signals (colors originally used for rail signals) despite the significant portion of the driving population that was red-green color blind (McShane, 1999, p. 396).

New methods of managing traffic had other positive outcomes, including for those interested in the reduction of noise. In addition to public education campaigns concerning excessive noise, the new signs and visual signals made the streets quieter (Bijsterveld, 2008, p. 118). She presents a review of suggestions for reducing urban traffic noise at two anti-noise conferences hosted by the Dutch Sound Foundation in the 1930s, including moves to visual signaling to eliminate unnecessary horn blowing and better street visibility to reduce accidents and their related noise (p. 125). She explains, however, that prevailing attitudes saw “the production of orderly town plans and, above all, orderly behavior” as central to the noise problem (p.125). While only the first of these indicates something similar to the current prevailing notion of “smart” suggests, what the movements have in common is the promise that quieter (or more wired) cities would be better, safer, more efficient and civilized places than they were before… isn’t that the promise of smart?

While engineers long argued that they could continue to maximize efficiency of existing roads to accommodate more traffic without building new ones, eventually they couldn’t be maximized any more – what was referred to as a limitation on “floor space” (Norton, 2008, p. 153). While additional measures were taken to further relieve traffic congestion, it became clear at a point that more roads would need to be built. Norton’s history shows that the auto industry successfully redefined the efficiency problem as one of a shortage of street space (rather than an excess of automobiles) by shifting the conception of the street as a public utility to that of a commodity linked with demand through gas taxes, registration, and licensing (p. 176). The auto industry worked hard to divorce the accidents from “speed” and “the motor” and to rather associate accidents with reckless and careless behavior on the part of both drivers and pedestrians. In order to keep pedestrians from being killed (or more accurately, getting in the way of the fast-moving automobile), “motor highways” were proposed (p. 238-241).

In the 1930s as more cars were on the roads “the definition of the noise problem could change from a chaos of sounds coming from individual noise sources to levels of sound produced by a collective source” (Bijsterveld, 2008 p. 135). Technologies such as traffic lights and signals, police, driver signaling (the horn, flashing of lights at night, and eventually turn signals), speed restrictions, and driver education worked to make movement operate as the collectively as they sounded. Organizations including automobile associations, dealerships, and the auto industry are but some of the elements that work to organize “people who drive cars” into an “automobile public.” One key lesson of Peter Norton’s *Fighting Traffic* (2008) is that it was this level of organization that led to the change in thinking about the use to the street as a place for cars and not for everyone. When considering these many layers of cooperation, it seems that the distinction between *series systems* where parts function independently and *nexus systems* where parts must function in concert should serve less as a strict division and more as extremes on a continuum.

**Horizons of Smart Transportation: Driverless Cars**

> "The imagined future of the automobile has a long history and it is dominated by one feature. Automobiles will be made to drive themselves. Drivers will be freed to conduct all forms of business and leisure from the seat of their automobile; not having to concern themselves with the tedium of paying attention…" (Packer, 2008, p. 41).

Visions of cars that are remote controlled or that drive themselves date back to at least the 1920s (Packer, 2008, p. 51). While the car has long been the site of communication interventions, the present intensification of technology in the automobile has them outfitted with increasing numbers of wires and CPUs, wireless networks, sensors, gauges, software, services, and screens (Packer and Oswald, 2010). Trends in the U.S. indicate that an increasing number of teens and young adults are delaying or forgoing obtaining a driver's license: in 1983, driver's licenses peaked at 92.2% of the 20-24 population, falling to 79.7% in 2011 (Lavelle, 2013). Reports and popular press articles agree that while cost is a factor, young drivers are also using alternate options (riding with others, public transportation) or are simply "too busy" to have gotten around to it yet. With the technology available (and much of it already in the car, including automatic transmission, drive-by-wire steering, lane assist and remote start/stop capabilities) and a potentially mobile public opting out of driving (or piloting a car?) the conditions for a cheaper, more flexible and less time-consuming technology to succeed are present. Freedom – the freedom to drive – was important in establishing the automobile as inheritor of the road. Freedom is now being used to free the driver from the drudgery of driving, and perhaps even learning *how* to drive.

Fertile soil or not, what are the chances that the automobility system as we know it will turn on its head? Dennis and Urry (2009) observe two moments when systems are open for the highest degree of change: first, at the early stage of system development where initial decisions tend to have effects that endure (lock in) over time: *path dependence* (p. 56-57). Second, systems can exist in a state of "self-organized criticality" in which *black swans* – small and unexpected changes from the fringes – have the capacity to significantly disrupt the order of a system (p. 58). It is in this state that Dennis and Urry place the automobility system. They identify "smart vehicles" reliant on Intelligent Transportation Systems (ITS) as having the potential to have a large impact on automobility. ITS relies on *telematics,* "which includes wireless technology, vehicle tracking, navigation assistance and car-to-car communications," all elements of contemporary smart automobile transportation (p. 81).

Suggesting that such advances could move the car from a *series system* to a *nexus system*, they point to ways that a variety of concepts and initiatives to make these visions actualities with goals of making traffic more safe, more secure, more productive, more environmentally friendly, and less private (81-86). Digitization, they argue, could enable *social sorting* akin to tiered internet service; it could also enable remote stopping, a feature that a leaked 2014 European Network of Law Enforcement Technologies document proves EU Police are interested in (p. 86-90).

Such features are of interest in an environment where attention has been refocused on security. In my research on critical infrastructure, I have noticed a tendency for the State to be more concerned that someone will attack a bridge than that it will fail structurally (with the latter being more likely). Packer argues that in the present permanent War on Terror where every vehicle is a potential bomb, interest in controlling the automobile is of critical concern to the state (p. 48). Packer argues that technologies of communication, command, and control (C3) have been associated with automobility since the 1920s when they were used to coordinate police, and the integration of communication technology with automobility has long been presented as a means to make automobility safer and more efficient (p. 48).

Packer suggests that we must look to ways that "safety" has been leveraged "as a means for altering or maintaining asymmetric relations of power" (p. 44). In terms of the actualization of a fully automated automobility system, we should closely interrogate claims that such a system would be "safer" (or in this case "smarter") as the invested industries say, or if such claims are being made in order to re-organize a system to the benefit of a relative few. Companies producing necessary components for the traffic management system itself—software companies, network security firms, equipment manufacturers, map and navigation services, and internet service providers, for example – would clearly benefit from such a system. Organizations involved in shipping would be able to do more than just track drivers in real time: a new and improved automobility system that greatly diminishes the potential for damage to trucks, and that can do more to ensure on-time delivery. Law enforcement and the armed forces would have the ability to monitor, inspect, and stop cars at a distance. While fire and ambulatory services would greatly benefit from cars that get out of the way automatically, it would likely be just as often that someone paying for a "fast lane" would be barreling past most of us resigned to slow mobile units.

While the term "C3" was not in the parlance of early twentieth century city planners and traffic engineers, the assemblage of communication technologies coupled with early automobility constitute a kind of proto-C3 system, as Packer suggests in the use of the radio by police in the 1920s (and later two way radio, and CB) as a mechanism for coordinating police activity (Packer, 2008). Considering this alongside the development of the automatic traffic signal in 1922 (McShane, 1999), the first centrally controlled signal system in Chicago in 1926 (Norton, 2008, p. 135), and the addition of more visual signage including standardized traffic signs and street names (Bijsterveld, 2008, p. 118) demonstrates that an array of communication technologies were instrumental in making automobility safer, quieter, faster, and more efficient.

**Conclusion**

> "Our major obligation is to not mistake slogans for solutions" – Edward R. Murrow

American newscaster Edward R. Murrow warned the public to look beyond the quips made in political campaigns and toward the actual plans to solve problems. We should be equally cautious about "smart transportation." What does that even mean? Is it something new, or just an intensification of the coordination of movement through space and time? Whether we reckon location by natural landmarks, star charts or GPS coordinates – by seasons, minutes, or picoseconds – we have long been mastering our environment with information layers. Does "smart" mean the addition of electronic communication technology, and we have been smart since the telegraph? Any time we work to include elements of C3? Or it has to be computers. When is a change in degree a change in kind?

We need to ask ourselves what we mean when we use this word – smart – when discussing the relationship between communication and transportation technology. If it points to the real time manipulation of flows based on instant visibility across a network via ICTs, then in many cases it constitutes something unique. I am reminded to be cautious about this word, however, when it used as a marketing buzzword that stands in for all the reasons that something is better without telling us why. In the case of IBM's Smarter Planet campaign, it can be a call to build a better future with machines. It can mean a more nuanced management of power generation, transmission and distribution that prevents cascading system failure and extends the life of our aging grid. Smart can mean approaches to warfare that promise less collateral damage, even when the reality may be that the effects are simply displaced in time. It can mean "your phone has the internet now" or "we want you to think we have somehow managed to make water itself better."

We might consider whether smart solutions being marketed as safe, environmentally friendly, convenient forms of personal transport are mainly (as is the case with smart metering in electric utilities) a way to continue to extend the life and capacity of aging infrastructure. While such maximum utilization of existing resources is "smart," it is by no means the primary way that such solutions are sold to the public. In the same vein, the advantages for law enforcement and domestic surveillance in the security state are left out of the utopian visions of the smart future. As Packer has demonstrated is the case with "safety" (2008) and Norton (2008) with "freedom," smart appears to serve as an effective legitimating discourse for proposed changes that have much broader implications for automobility and a host of other systems that constitute the substrate of 21$^{st}$ Century life. We might consider the impact that smart transportation solutions impact freedom of mobility at the personal, sovereignal, and civic levels as Sheller (2008) suggests - who can go where, how is motility for some increased at the expense of others, and how are users more or less able to participate actively in both their governance and the shape of their mobility systems? (pp. 27-30).

I hope this brief history demonstrates that on the whole, we have always been reaching for something more fitting, more freeing – better overall – that is just out of reach. To say that the telegraph and train combination, time zones, or centrally controlled traffic signals were not equally as smart as a car that "drives itself" (which is possible only because of those developments) does a disservice to the long history of innovation in communication and transportation technology. It draws us into the myth that "things are about to get a whole lot better like never before… so hang in there!"

I don't have a better term to describe what are now being called smart technologies, but hope that my questions lead us to think more carefully about using such terms as scholars of mobility, transportation, and communication. Let us reveal the intentions hiding behind the marketing buzzwords to reveal the real promise of the transportation + communication technologies of tomorrow.

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