Resilient Cartography: Using Interactive Online Mapping to Represent Corridor Mobilities

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Introduction

If we are to build and maintain a resilient transportation system we must also communicate the truths of its landscape. To do otherwise tempts misuse or abuse of the system by its users, or of its users by the system. Actors who govern the network — its planners, engineers, and policymakers — have established methods for disseminating information about the system to those who use it. These methods include passive communication via objects such as roadway signage, or active methods, such as instantly updateable variable message signs (VMS) and in-vehicle advisories. Other sets of actors, including radio stations and GPS providers, supplement these by providing enroute updates to drivers. Overlapping sets of these and other modes of communication help a range of users to navigate the system, whether as cyclists or pilots, truck drivers or railroad engineers. Maps and mapping are among the most common techniques for understanding the complex sociospatial relations produced by our transportation systems.

As makers and users of transportation system maps, we need to survey and develop mapping practices that allow us to untangle not only the braided spatial forms of transportation systems but also their correlative mesh of social processes. These mappings (Dodge et al., 2011) must allow us to decode on one hand the forms by which transportation systems arrange people and objects, and on the other, the process by which such arrangements produce corresponding economic, political, and cultural content (Castells, 1977; 15). The capacity of transportation system actors to prevent network failure — or to contain failure’s fallout — requires a better understanding of how the "flows and interconnections" that produce network space embed within broader patterns of social life, more particularly, of how "different social groups and different individuals are placed in very distinct ways in relation to these flows and interconnections" (Massey, 1993; 61).

The public — especially those among it who make regular use of the system — also benefits from having a better understanding of the relational dynamics of transportation systems, particularly of how their experience of the system negatively affects, or is negatively affected by, the experience of the system by others (who may not necessarily use the system in the first place). An everyday example of this occurs during rush hour, as radio programs narrate congestion patterns for the benefit of commuters participating in same congestion patterns. These updates may be thought of as maps (orally transferred, as in "I-95 is congested south of the Beltway until you get to Woodbridge...") that helps driver determine how their presence on the roadway relates to that of other drivers.

The Resilient Cartography project described in this report suggests a technique for developing interactive travel-duration maps to work in conjunction with static maps of socioeconomic data from across a city-region. Such maps may help to call attention to the spatial distribution of network capital and the capacity of marginalized groups to access certain areas of the city within reasonable amounts of time. The remainder of the report proceeds in three parts. The following section addresses the relationship
between mobility with inequality, and discusses the concept of motility in the context of travel-duration. This section is followed by one which discusses how cartographers and others have used the temporal dimension to illustrate uneven spatial landscapes. The third and final section describes the development of interactive travel-duration maps for Baltimore and Boston, as well as the issues encountered.

Mobility and inequality

The spatial forms of transportation systems are in constant dialogue with the activities of those who dwell-in-motion (Sheller and Urry, 2006), but also of those who happen to dwell in motion's path. This is a crucial dimension of the "corresponding economic, political, and cultural content" described above: the interactions between people and transportation systems reflect broader cultural and ideological contexts, which they also (simultaneously) recast. Inequalities in the contemporary city-region increasingly derive from the ways mobility infrastructure and practices have been deployed, administered, and consumed, thus prompting new modes of struggle against, and inquiry into, cities "as sociotechnological complexes of infrastructural power and mobility" (Graham, 2001; 340). Mappings that enable our understanding of the sociospatial relations of our transportation-system therefore enable our opposition to the inequalities these relations produce.

Nineteenth-century Londoners experienced particularly stark forms of transportation-produced inequality during its "time of great tearing down": a period beginning with the advent of rail travel in the 1830s and its wholesale renovation of London over the next two or three decades. The novel forms of mobility developed during this period produced novel forms of urban spatiality (Hesse, 1992; 53).

Everywhere one looked, the old was giving way to the new as roads scythed through the rookeries and slums of Dickens's London, the Underground infrastructure (beginning with the Metropolitan and District lines) hollowed out the streets and squares, Bazalgette was sorting out the sewage, and the great stations of Victoria, Euston, Paddington and Charing Cross demanded ever more land for platforms, lines and depots (Hunt, 2008).

The transformation of urban space produces corresponding transformations to urban social relations, as new spatial forms enable some groups, often at the expense of other groups disabled by the new urban spatiality. The upheaval wrought by London's six massive railway terminals (constructed on its periphery beginning in the late-1830s through the early-1850s), its sewerage system (begun in the mid-1850s), and its Underground system (begun in 1860) widened the rift between England's two nations: a politically impotent working-class and a powerful capitalist elite (Disraeli, 1845). In his Condition of the Working Class in England (1844), Friedrich Engels relates England's deepening social inequalities with the capacity of the elite to control how and when the new spatial forms may be employed, and by whom:

the Government determined during the session of 1844 to force the all monopolising railways to make travelling possible for the workers by means
of charges proportionate to their means...and proposed therefore to introduce such a third class train upon every railway daily, the "Reverend Father in God", the Bishop of London, proposed that Sunday, the only day upon which working-men in work can travel, be exempted from this rule, and travelling thus be left open to the rich and shut off from the poor (214).

With apologies to Dickens, it was indeed the best of times (for some groups) and the worst of times (for others).

The French artist Gustave Dore documented and dramatized the environments produced by 'the great tearing-down,' often from the vantage of the transportation system itself. In Over London by Rail (1872), for example, Dore depicts the desperate living conditions of London slum-dwellers who have crowded themselves out of economic necessity into the soot-blackened crannies beneath a railway viaduct (cf. In Our Time, 2010; and Nichols, nd).

![Figure 1. Gustave Dore's Over London by Rail (1872)](image)

In this illustration, we do not see the locomotive as author of Victorian England's transportation revolution — indeed, we do not see the locomotive at all — but rather we
see the costs its use incurs for those largely unable to afford such use. Thus, transportation innovations that, for some groups, emblematize speed and access, for other groups mean nothing little more than pollution, noise, and social exclusion.

**Motility and travel-time**

Kaufman (2002) uses the term *motility* to describe one's potential capacity for mobility. He argues that motility should be considered a unique form of capital, subject not only to uneven distribution among people but also to dynamic relationships of constraint and enablement within particular spatial contexts (Kaufman et al., 2004). Transportation projects that expand the motility options of one group, for instance, often narrow or eliminate those of another.

At present, transportation planners often account for environmental costs but rarely for the social impacts of transportation systems, whose most damaging effects are experienced by low-income and socially-excluded groups, often in the form of constrained motility (Uteng, 2007; see also Jeon and Amekudzi, 2005). A lack of adequate motility options for people can lead to their exclusion from basic and necessary levels of participation within society, including access to jobs, schools, and medical facilities (see Percy-Smith, 2000, or Room, 1995, 6). Socially excluded people may suffer from numerous “linked and mutually reinforcing” problems, including lack of adequate education or employment, poor health or nutrition, crime and recidivism, and unstable family or housing situations (Social Exclusion Unit, 2001; 10). Though social exclusion may correlate with poverty, the two are not necessarily mutually inclusive; poverty refers to a distributional inequality, social exclusion to one of relations — a lack of income is but one of several factors potentially constraining societal participation by those who are socially excluded (Putnam, 1995; 321–322; Kenyon et al., 2002).

An extensive body of research has found that social exclusion may also contribute to or be caused by disparities in mobility and motility among people and groups (Church et al., 2000; Kenyon et al., 2002; Lyons, 2003; Social Exclusion Unit, 2003; Cass et al., 2005). This mutual relationship is closely related to an over-reliance by transportation planners on quantitative measures and techniques. Conventional modeling methods and cost-benefit analyses informing transportation infrastructure decisions are “driven by distributive principles that serve highly mobile groups, most notably car users, at the expense of weaker groups in society” (Martens, 2006; 14). Transportation planners and networks of elite decision-makers are thus able to perpetuate the accumulation of mobility capital — motility — by the already highly motile. Moreover, biases inherent within transportation modeling and cost-benefit analyses may contribute to or help sustain conditions of social exclusion for people whose mobility needs are either passively ignored or actively frustrated by the existing order (Grieco, 1995; Martens, 2006; Uteng, 2007).

Mapmakers who privilege merely spatial depictions of transportation systems often ignore many of the less visible ways these spatial forms produce differentiated experiences among groups. Moreover, the ways in which many groups access the
transportation system not only shapes their experience of urban space but can also affect the way others experience it, reinforcing “structures and hierarchies of power and position by race, gender, age and class, ranging from the local to the global” (Tesfahuney, 1998; 501; quoted in Hannam et al., 2006; 3).

I want to explore the use of time, particularly travel-time, as a cartographic element for making explicit the splintering landscapes produced by contemporary transportation systems. Maps of travel-time may help broaden conversations between the public and its transportation planners regarding the cause and effect interactions between sociospatial fragmentation and the resilience (or not) of transportation systems. Visualizing the abstract, ever-shifting relationship between time and space may provide planners, policymakers, and the public a solid foundation from which to make the total system less susceptible to failure, the consequences of failure, and the difficulties recovering from it (Bruneau et al., 2003).

The following pages consider how mapmakers and others have used time as an element for depicting the construction of two uneven landscapes by urban transportation systems and their users. I have labeled these landscapes of control and landscapes of modal dominance. This report concludes with a brief discussion of my efforts to create an interactive online mapping application for representing corridor mobilities.

### Landscapes of control

Using time as a cartographic element can help us to read transportation landscapes as reproductive of particular regimes of power and control.

Technology critic Langdon Winner cites New York City’s master builder Robert Moses, who in the mid-20th-century demanded roadway overpasses on roads between the city and its nearby beaches be built high enough to allow passage for predominantly white automobile-owners, yet low enough to restrict passage for twelve-foot-tall buses and their predominantly black, low-income ridership (Winner, 1986). Moses intended for the overpasses to function as passive border checkpoints, producing a racialized space that allowed "whites privileged access to opportunities for social inclusion and upward mobility [while at the same time imposing] unfair and unjust forms of exploitation and exclusion on aggrieved communities of color" (Lipsitz, 2011; 6). But presence of intent is seldom the rule:

> the most important examples of technologies that have political consequences are those that transcend the simple categories “intended” and “unintended” altogether. These are instances in which the very process of technical development is so thoroughly biased in a particular direction that it regularly produces results heralded as wonderful breakthroughs by some social interests and crushing setbacks by others. (Winner, 1986; TK)

Travel and mobility have become instrumental to the performance of the contemporary global order (Urry, 2009; 30). As with the landscapes imposed at the local scale by
Moses's overpasses, mobility governance regimes have constructed “(relatively) secluded space across the world along the connecting lines of the space of flows” (Castells, 1996, 417). Movement through, or occupation of, this secluded space by a 'kinetic elite' (Graham and Marvin, 2001) enhances their capacity to reconfigure space to suit their interests "of a restless, shifting capital flow" (Harvey, 2001; 338; who cites Harvey, 1978; 1982; ch. 13).

Those users (or nonusers) of the transportation system, who cannot accept time fragmentation, the speeding up of daily tasks or the use of the predominant technologies are finding that their opportunities and social life are weakened. In the words of Southerton (2003: 23), ‘that people are increasingly mobile, together with a general loosening of the rigidity of institutional temporalities, suggests that coordinating movement in time and space has become increasingly problematic’. Meanwhile, those who can use these resources and skills without constraints find themselves in a city that is organized to give their practices even greater comfort and speed. And all this happens while the unequal links described in studies on gender and transport (Whipp and Grieco, 1989; Rosenbloom, 1993; Grieco, 1995; Pickup, 1988; Law, 1999) persist. The Hurricane Katrina disaster in New Orleans showed the tragic consequences of these unequal relations. While some people were able to escape from the city, others had no alternative but to stay behind with their only possessions and face the catastrophe. (Camerero and Oliva, 2008)

Innovations in transportation technologies have therefore enabled sociospatially-expansive, mobile forms of urban life for some groups and created correspondingly isolating, oppressive forms for others. These innovations often lead to types of urban development that produce differentiated access to transportation systems based upon a number of factors, including class, gender, and race. An increasingly common example of this are programs which allow a select group of passengers (able to afford it) to bypass airport security, while another select group of passengers remain subject to increased security based upon their gender, race, or ethnic origin. In her work on social transport policy, Grieco (1995) describes how low-income and unreliable bus transit combine to prevent low-income families from establishing effective routines:

For instance, where an off-peak discount ticket was used and a scheduled bus failed to arrive within the discount period, the non-discount charge fare was operable. For those on low incomes, this frequently meant remaining in the original destination until such time as the discount period recommenced. Effectively, due to the inability to pay the higher peak period fare, these individuals became ‘time prisoners’. (Kindle DX highlight location 110-115)

Disparities of access such as these produce a fragmented transportation system, enhancing the economic and environmental security of those able (and authorized) to make use of full capacity, while at the same time heightening uncertainties among those who experience the system as plodding, dangerous, and — quite often — altogether prohibited.
Travel-time as a cartographic element has the potential for revealing areas of the transportation system whose access and use is subject to intentional or unintentional control by a hyperconnected, 'kinetic elite.' Mappings in this vein might, for example, depict the mobility footprints of households and individuals within the system, revealing, on the one hand, mobility-disabled groups who must by necessity pursue localized, place-based strategies and, on the other hand, mobility-abled groups who are free to pursue a wider range of strategies across a broader space of places (Harvey, 1993; 24).

Landscapes of modal dominance

Our word "mode" arrives to us from the Latin *modus*, meaning "measure," which itself has a more distant root in the proto-Indo-European ancestor *-med*, meaning also "(to) measure." From this much earlier root we get words like *medical* (from Latin *mederi*, originally "know the best course for"), *meditation* (from Latin *meditari*, "to think over, reflect, consider"), *mediate* (from *mediari*, "to intervene"), and a host of others, including *median*, *medium*, and *media*. How does this etymology resonate with how we understand modes of travel or mobility?

First, each mode performs particular rhythms — distinctive divisions of time (and space) — during our use of it. These rhythms derive from interactions between objects in the landscape and our being-in-motion. French director Michel Gondry's video for the Chemical Brother's *Star Guitar* (video available to view at [http://vimeo.com/7469697](http://vimeo.com/7469697)) is playfully built around the visual rhythms produced as a high-speed train drifts through a deliriously syncopated infrastructural landscape.

Second, each mode of travel prescribes limits on the everyday extent of its users' spatiotemporal experience, and therefore on the opportunities available to those users (Sager, 2006; Scott and Horner, 2008). Modes of travel that "know the best course for" (*mederi*) travel from A to B also impose the conditions of this course upon us (*mediari*). The spatiotemporal extent afforded us by each mode is conditional upon its network footprint, usage fees, operating schedule, and all its assorted vagaries. Sidewalks end. Trains overcrowd. Planes delay. Roads congest. Bicycle lanes pothole.

Modes of travel, then, modify not only how we experience spatial relations — as time and rhythm — but also how we experience social relations — as interactive participant or as marginalized outsider. Just as some modes transform landscapes of discrete structures into a single, unifying blur or place entire cities into an inconvenient window, some modes allow us to resist forms of oppression or access a wider range of employment opportunities. They are not simply modes but modifiers — of our spatial experience and, crucially, of our social participation. (Yes: "modify" comes to us from the Latin *modifacere*, meaning "to limit, measure off, restrain." And, yes, *modifacere* contains the root *modus*.)

Modes of transit, then, can be accurately judged not only for their contributions to efficiency and productivity and their positive and negative environmental side effects, but
also for the ways in which they can embody specific forms of power and authority. (Winner, 1986; 19)

Travel-time as a cartographic element can reveal urban situations in which certain modes of transit (as certain modes of power and authority) mediate the mobile life of a community in ways that are at odds with the aims and goals of the community itself. For example, roadway infrastructure within a community may permit motorists with rapid travel-times through the community though the residents of the community itself may experience relatively longer travel-times due to low levels of automobile ownership.

![Diagram of travel-time through a community]

**Figure 2. The Detroit Geographical Expedition & Institute's Where commuters run over black children on the Pointes-Downtown Track**

In 1971, Bill Bunge and the Detroit Geographical Expedition & Institute produced a map titled *Where commuters run over black children on the Pointes-Downtown Track*. Though not explicitly a map of travel-time, it nonetheless counterposes two modes of travel. Specifically, the map calls attention to the racism of Detroit's transportation system, which privileges the interests of (white) motorists over those of (black) pedestrians.

Mappings that disclose how a particular mode either maintains undue dominance or limits the use of alternative modes within particular communities may allow us to build...
resilience within the transportation system. Such mappings might identify users and areas that rely upon alternative (counterdominant) modes but are underserved by them. Comparing modes as politics may enable planners and policymakers to improve system resilience through policies and practices designed to more appropriately distribute access.

Visualization and Play

The uneven spatial distribution of most forms of capital is easily apprehended merely by taking a drive from one end to the other of any town or city. Kaufman’s notion of motility, however, is a form of capital, which — because it is driven by process (not form) and manifests over time (not space) — cannot be readily illustrated through the techniques of conventional, static mapping.

A policy-maker, researcher, or member of the public should be able to see the shape and quality of her surrounding urban region by interacting with a number of variables describing network capital, especially those which suggest the exclusion or marginalization of some groups from full & effective participation within local, regional, and transregional networks.

The purpose of this mapping project is to reinforce and demonstrate to the public and policy-makers the idea that travel-duration within urban areas is highly contingent on mode & location.

Project description

The project proceeded in three phases: a software and data-source survey phase, a data collection and refinement phase, and a proof-of-concept development phase.

During phase one, I surveyed software and existing online platforms for travel-time maps. My search uncovered a variety of recent maps, most of which took advantage of the interactive graphics capabilities of Adobe Flash and other rich internet applications (RIAs). There were four platforms most similar to the one under development for this project (see Table 1). These included Stefan Wehrmeyer’s Mapnificent (mapnificent.net), mySociety’s Mapumental (mapumental.com), various other mySociety mapping projects (mysociety.org), and Nederland van Boven (the site has been repurposed). For each of these, I identified several dimensions common to many online maps, and compared the four platforms with regard to each of these.
Table 1. A selection of online platforms featuring interactive travel-time maps.

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<th>Platform</th>
<th>Spatial coverage</th>
<th>Interactivity</th>
<th>Data sources</th>
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First, the maps depict a range of spatial extents. Only Mapnificent depicts cities in the United States. The other three depict locations in the United Kingdom (Mapumental and mySociety), and the Netherlands (Nederlands van Boven). Nederlands van Boven is the only platform to offer data at the scale of the nation. The other three only map public transit within a discretely bounded city, not in relation with other cities.

Second, the ability of users to interact with the maps varies across platforms. For instance, users can specify the start point of trips from any location (within the spatial extent) for both Mapnificent and Mapumental. Users of the other two, however, are limited to specifying only general postcode start points (Nederlands van Boven) or none at all (mySociety). With regard to modal coverage, all four include data for public transit; Nederlands van Boven offers additional data for trips by automobile. Users for all but the mySociety maps have the ability to set their maximum desired travel-duration and, in the case of only Mapnificent and Nederlands van Boven, their desired minimum travel-duration. MySociety is the only of the four platforms to integrate housing prices as part of its interactive package. Users can find areas of cities that meet their travel-duration criteria, which might prove useful during a housing search.

Finally, each of the platforms differs with regard to their data sources. Mapnificent uses data from the General Transit Feed Specification data exchange, which acts as a one-stop shop for transit data from over 720 transit agencies around the world (gtfs-data-exchange.com). Both Mapumental and mySociety use data from the UK.
government, including the National Public Data Repository (data.gov.uk/dataset/nptdr) and the Department for Transport. Nederland van Boven is the only platform to use privately-collected data (specifically, from 9292.nl/zakelijk#).

During the second phase, I surveyed available data sources and initiated data-collection efforts regarding both travel-time data for a selection of cities, as well as determinants of network capital (e.g., median household income level). I narrowed my focus on travel from certain points within several cities along the I-95 corridor, specifically Boston and Baltimore. This data is useful as a proxy for more granularized data, which in some cases may be broken-down by income or education level of individuals or groups, gender, age, race, mode of travel, and level of service (e.g., Amtrak versus commuter rail). This project opted for the simplicity of general travel-duration data over the costs and difficulty of obtaining increased detail.

In the third phase, I began development of a platform similar to the four surveyed for phase one. I relied upon the Processing programming language (processing.org), which offers a unique set of visualization tools, making it a sort of code-driven sketch book for designers and scientists whose work is primarily visual, or is otherwise enhanced by playing around with visually-projected data (such as statisticians or cartographers). I began with two basemaps: one for Boston and one for Baltimore (Figures 3 and 4). Each basemap depicted Census block-group data for median household income. I then overlaid this static basemap with a dynamic, interactive layer depicting GTFS travel-time data published by the various public transit agencies in each of the two cities.

![Figure 3: An interactive map of travel-times from Logan International Airport, in Boston, at 30-, 60-, and 120-minute duration intervals. The basemap depicts census block-groups shaded according to median household income level.](image)

Users were able to interact with the temporal data by designating one among a set of thirty-minute intervals. When adjusted, the travel-shed for each of these interval selections grew to reveal the block-groups accessible from the start-point within the designated temporal range. The shading of each block-group (according to median household income level) suggested to users how the economic characteristics of certain areas might relate with the network capital available to those who dwell within it.
Figure 4: An interactive map of travel-times from Baltimore-Washington Thurgood Marshall International Airport at 30-, 60-, and 120-minute duration intervals.

Issues with Project Execution

I was not able to successfully output the data contained within each of the travel-sheds into a table allowing users to compare quintile cross-sections for each duration interval from the starting point. This would have made the maps far more useful than as mere visualizations. The problem arises from the nature of the basemaps: I was only able to make the interactive layer work when the basemaps were reduced to images (as opposed to, say, data-rich GIS-produced maps). If the basemaps were able to somehow output a value for each block-group, I would be able to ask Processing to take the block-groups within each travel-shed and output these values into quintile tables such as those from Figure 5.

Figure 5: A possible output table for block-group level data cross-referenced with the travel-sheds for specified duration intervals. The shading intensity denotes the number of block groups within each quintile within a given duration interval.

Such a table might allow users to compare the “shape” of network capital (or, at least a proxy measure for it) within travel-sheds for a number of duration intervals, either from two starting points within the same city, or between starting points in different cities.
Moreover, the method of using Processing employed within this project will not easily scale to a larger spatial extent, nor to multiple points within the same city. I began collecting data city-wide but quickly realized that collecting at multiple points would require more time than was available to me. Similarly, I realized that the computations necessary for “playing” with that much data would quickly tax the computing resources available on my personal computer, let alone as a standalone online-based application.

Conclusion

The proofs-of-concept described in this report demonstrate that Processing-based mapping techniques carry some potential for helping cartographers to illustrate the relation between travel-duration and network capital (and its proxy measures). Though the techniques do not scale as well as I intended, they do have potential applications in limited and narrowly-defined visualizations, particularly those less likely to demand significant processing power.

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References

Travel-time references


