Driven to Congestion: How the Planning, Engineering and Politics of Transportation Established, Preserves and Perpetuates the Automobile City

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Abstract

The last eight decades of urban transportation planning and engineering in the United States have been dominated by the hegemony of the automobile. Auto-oriented planning of the transportation and land use system has had a profound impact on the built environment both in greenfield developments and neighborhoods that predated the auto. The pedestrian quality of cities has been eroded by the automobile, and urban renewal in the United States erased many neighborhoods strongly oriented around walking and transit use. Equally pervasive as the auto itself is the place for the car in the institutional cultures and practices involved in shaping the city.

The shortcomings of mobility-oriented transportation planning have been well critiqued, even from the very early days of Interstate building. In recent decades there has been a flurry of interest in articulating sustainable transportation policies to provide multi-modal accessibility and to consider the interactions between transportation, land use, and other policy realms such as health, energy, environment and equity. The current impending crisis of aging and ailing highway structures in the United States presents a momentous opportunity to reassess the need and purpose of such infrastructure, and to rebuild, reconceptualize, or remove it in a matter more consistent with current policy goals and planning processes – rather than the ones in place when initially built.

Despite the interest, need and opportunity to reconceptualize aging infrastructure in America to support a more sustainable reshaping of land use and activity patterns, the potential to do so is heavily impaired by a transportation planning process that is still dominated by the tools, methods and assumptions, political biases, procedural failures, and instilled human behaviors of the first highway-building era. The McGrath Highway in Somerville, MA is used as a case study to discuss how persistence of 1950s technical, procedural and political dysfunctions threaten to undermine this opportunity. Short-term actions and strategies to avoid this impending fate are suggested for McGrath Highway with applicability to a wider national context of similar opportunities.

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Introduction

> “We can’t solve problems by using the same kind of thinking we used when we created them”
> – Albert Einstein

The last eight decades of urban transportation planning and engineering in the United States have been dominated by the hegemony of the automobile. Auto-oriented planning of the transportation and land use system has had a profound impact on shaping the built environment. The effects of the automobile can be observed all across the metropolitan landscape, with its strong influence not only in shaping suburban built forms but also in altering the integrity and function of inner city neighborhoods that were built in the eras when walking, the horse car, and the streetcar were the dominant transportation technologies.

The form and function of these inner city areas in the United States have since been eroded by the automobile and the infrastructure built for it, and together with urban renewal these planning actions succeeded in erasing many neighborhoods strongly oriented around walking and transit use. In particular, elevated freeways that were forced into the center of cities became a pervasive and destructive influence on the city. Equally pervasive as the auto itself is the place for accommodating the car in the political will of the country’s decision-makers, as well as in the institutional cultures and practices involved in shaping the city: namely, those of transportation planning and engineering, and land use planning.

In the 1920s auto oriented zoning requirements began to create neighborhoods which were designed to accommodate the auto and of inadequate density to support transit access. In a frenzy of building after the Federal-Aid Highway Act of 1956 authorized $25 billion over twelve years to accelerate construction of the national system of Interstate highways, many cities laid waste to huge swaths of downtown cores to build high-capacity, high-speed freeways. Some of these structures, such as McGrath Highway in Somerville, were built before the Interstate program using local funding. However, the offer of 90% federal funding for Interstate projects did not improve the quality of highway projects despite the opportunity to increase spending on better design and impact mitigation. Most of these structures were built hastily, with little or no meaningful public consultation and before the passing of planning process legislation such as 1962 planning requirements, Section 4(f), and the National Environmental Policy Act of 1970. However, in some cities the tide turned on the concept of total reliance on the automobile. City government and citizen support began to increase for investment in public transits systems. Anti-highway protest movements led by citizens sprouted across the nation from Boston to Baltimore to Memphis and San Francisco, in a period referred to as the ‘highway revolt.’ Although some planned urban expressways through cities were successfully stopped, many communities live still today with the legacy of hulking highway relics.

The shortcomings of freeways in cities and mobility-oriented transportation planning focused on the car have been extensively critiqued, almost as soon as cars began to emerge in cities. However, in recent decades there has been a flurry of interest in articulating sustainable transportation policies to provide multi-modal accessibility and to consider the interactions between transportation, land use, and other policy realms such as health, energy, environment and equity. Although these policy changes have yet to have a substantial impact on the shape of cities, an impending infrastructure crisis presents the opportunity to reset the path.

"The beautiful thing about concrete is that it eventually crumbles. Pound it with ice, salt, and relentless traffic for a few decades, and it falls to pieces."[1] America's highway infrastructure, the bulk of which was built with federal grants since the 1950s and 60s and inadequately maintained, is now ailing. The Federal Highway Authority has rated one in nine bridges in cities "structurally deficient," and estimates that an investment of $70.9 billion will be needed to rehabilitate these structures.[2] This presents a momentous opportunity to reassess the need and purpose of such infrastructure, and to rebuild, reconceptualize, or remove it in a matter more consistent with current policy goals and planning processes – rather than the ones in place when initial construction occurred.

Furthermore, infrastructure in cities impacts not only the function of a local transportation system, but it can also affect the value of adjacent property and shape surrounding land uses. Regional transportation infrastructures, which focus on providing movement and throughput rather than access to land parcels, tend to be locally undesirable features on the landscape due to traffic, pollution, and the interruptions in the urban fabric that these facilities create. As such, derelict land parcels, low-density and low-intensity uses, and locally undesirable activities (such as scrap yards and waste management plants) tend to be spatially co-located along and near these corridors.[3] Therefore, reconceptualizing or removing highway infrastructure may often hold the potential to serve as a catalyst for much more widespread neighborhood regeneration and revitalization.

Of course not every aging highway is necessarily a candidate for removal and replacement with a boulevard. A thoughtful evaluation, including consideration of how to mitigate traffic disruptions during construction with increased transit and redirecting traffic, will still likely show that it may be appropriate to rebuild or rehabilitate many structures in place. However, in other cases where neighborhood impacts of highways are not tolerable and adjacent land use redevelopment potential

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1 McMorrow (2012)

2 Transportation for America (2011), 3-6

3 The nature of the relationship between infrastructure and the quality of surrounding neighborhoods is likely cyclical. Although infrastructure might have been initially built though areas of the city perceived as having lower-value, the externalities generated by the infrastructure undoubtedly reinforces such patterns (if not initially establishing them in entirety).

is high, elevated facilities should be replaced with reconceptualized transportation corridors that include the use of new transit facilities and even tunnels if traffic is particularly intense. But in many cases, careful consideration of revisions to the transport network required during construction in any case, and of the land reuse potential of the area, will reveal that it is a better idea to redevelop a corridor with urban streets. Because of the constructions costs involved, the opportunity to address the negative impacts of highways on surrounding neighborhoods, and the potential redevelopment value of urban land, infrastructure rebuilding warrants careful evaluation and consideration under the principles of the National Environmental Policy Act.

Purpose

Despite the interest, need and opportunity to reconceptualize aging highway infrastructure in the United States, there is a serious risk that the potential to do so will be heavily impaired by a transportation and land use planning process still dominated by the tools, methods and assumptions, political biases, procedural failures, and instilled human behaviors of the first highway-building era. This thesis attempts to explore and reveal those biases, which are often seemingly innocuous and rooted in basic assumptions about the dynamics of the transportation and land use system and the nature of travel demand. Without recognizing the technical, procedural and political dysfunctions ingrained in the societal process of planning for and building infrastructure and developing urban land, the status quo approach threatens to usher in a second era of thoughtless national highway (re)building. Short-term actions and alternative strategies to avoid this impending fate are explored in the context of a case study of the McGrath Highway in Somerville, Massachusetts.

Prior work

There have been a number of tear-down projects of elevated highways in cities already executed, including: the West Side Highway (7.6km) in New York City, Central Artery (2.9km) in Boston, Cheonggyecheon Expressway (9.4km) in Seoul, Harbor Drive in Portland (4.8km), Central Freeway (1km) and Embarcadero Freeway (2.6km) in San Francisco, Park East Freeway (1.6km) in Milwaukee, Alaskan Way in Seattle (4.5km) and Cypress Expressway (2 km) in Oakland.[4] These projects have generated a small amount of research examining both the technical and political factors underlying the planning and execution of highway removal, as well as studies attempting to monitor and analyze the post-implementation impacts of these interventions.

Cervero (2006) examines the effects of the reconceptualization of the Central Freeway and Cheonggyecheon Expressway on adjacent land values, neighborhood development, traffic congestion and roadway safety; he concludes that while much of the evidence remains anecdotal, on balance the effects to date seem to be positive. The optimism around the transformative potential of demolishing elevated freeways in cities has spurred efforts such as the annual *Freeways Without Futures* ranking which lists the top opportunities in North America for replace aging urban highways with boulevards according to the Congress for New Urbanism, and a recent report by EMBARQ and ITDP, "The Life and Death of Urban Highways," which documents the impacts of five tear-down case studies. Interest in the topic continues to grow and there exist ongoing planning studies or proposals for the possible tear-down of elevated segments of the Sheridan Expressway in New York City, Route 34 in New Haven, I-64 in Louisville, I-81 in Syracuse, the Clairborne Expressway in New Orleans, and the Gardiner Expressway in Toronto.[5]

Nevertheless, there is a shortcoming of literature on the topic of freeway removal in cities, especially given that efforts to reduce or reprioritize highway capacity are by and large niche interests in the practice of traffic engineering. The most notable change in this paradigm is work in the area of Context Sensitive Solutions (CSS): a line of research sponsored by the Federal Highway Authority that aims to support the development of both engineering practices and design solutions to better balance rather rigid roadway design guidelines (such as those in the AASHTO Green Book[6]) with community concerns and sustainable planning goals. However, this area of research and literature is focused on the physical roadway (e.g. "resurfacing, restoration, rehabilitation"), with little emphasis on the engineering and planning processes through which freeway removal projects are subject to before reaching the final design stage.

4 EMBARQ, ITDP (2012); Spicer 2011

5 EMBARQ, ITDP (2012); Spicer 2011

6 The *Policy on the Geometric Design of Highways and Streets* is produced by the American Association of State Highway Transportation Officials (AASHTO) and often referred to as the "Green Book." Although the FHWA describes the Green Book as a series of guidelines, roads in the National Highway System must conform to its standards by law.

Napolitan (2007) makes an important contribution in analyzing the circumstances underlying the successful demolition of and replacement with an at-grade boulevard of the Central Freeway in San Francisco and the Park East Freeway in Milwaukee, in contrast to the decision to leave elevated and repair the Whitehurst Freeway in Washington DC. Based on these cases, she proposes a theory of freeway removal that identifies four factors supporting a decision for de-elevation: "(1) the condition of the freeway must be such that there is concern over its integrity and structural safety, (2) a window of opportunity exists; the window may be the precondition itself or another event that enables a freeway removal alternative to gain serious consideration and legitimacy, (3) the value of mobility must be lower than other objectives such as economic development, quality of life, etc., and (4) those in power must value other benefits more than they value the benefits associated with freeway infrastructure for the alternative of freeway removal to be selected over other alternatives."[7]

Spicer (2011) explores the freeway as a roadway typology in American cities, and also focuses on the case of the McGrath Highway. Based on evidence of neighborhood change from three removal precedents in the U.S. (Central Freeway, Cyprus Freeway, West Side Highway), she proposes an at-grade boulevard and a parkway (in combination with a new transit extension) as urban design strategies for de-elevating the McGrath Highway that are likely to be successful and create favorable outcomes.

Although the structurally deficient condition of many bridges across the nation may help satisfy the first and second preconditions theorized by Napolitan, this thesis examines how the window of opportunity for freeway removal may be threatened by the political will to respond to a perceived crisis of crumbling infrastructure with special "fix it first" legislative acts that seek to rapidly repair ailing structures rather than engage in the planning process that may elucidate the potential for their reconceptualization. Furthermore, the third and fourth preconditions proposed by Napolitan may also not be realized since the perceived myth of expanding automobile mobility beyond finite capacity constraints is perpetuated by the misuse of transportation forecasting and modeling processes, which thereby undermines potential political will to remove freeways and repurpose the urban land.

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7 Napolitan (2007)

Organization

The remainder of this thesis is organized into the following six sections:

• Chapter 1: Building the automobile city – lock in and path dependence
This section explores the initial period of road expansion in US cities. The effects of road infrastructure on the built-form of cities, individual demand responses to a changing urban landscape, and political responses to automobile growth, are linked in a systems model to understand the growth of the automobile city.

• Chapter 2: Case study – McGrath Highway
This section examines the history of the McGrath Highway as an example of the broader narrative of lock-in to the automobile described in chapter 1. The current physical, planning, and political conditions that may be aligning to support the reconceptualization of McGrath Highway and surrounding areas are discussed.

• Chapter 3: Transportation planning & engineering – the status quo machine
This section discusses the assumptions and biases embedded in transportation forecasting and modeling approaches that hinder sustainability policy objectives by violating real-world capacity constraints and by pre-determining auto-oriented outcomes through projecting existing behaviors far into the future.

• Chapter 4: A perfect storm – for or against change?
This section describes how planning processes, infrastructure funding programs, and the proclivity of governments to respond swiftly to perceived crisis, demonstrate systemic distortions in how benefits and costs are considered, thereby working to generate anti-environmental outcomes that undermine the reconceptualization potential of McGrath Highway and hinder the implementation of the Green Line Extension as a public transit alternative.

• Chapter 5: An opportunity to rethink automobile infrastructure
This chapter examines how inevitable construction disruptions and taking mitigation actions for them, as well as making spot improvements to improve pedestrian and motorist safety can be used to create an incremental implementation strategy that moves toward an at-grade McGrath Highway as the new normal.

• Chapter 6: Summary and conclusions
This chapter summarizes the findings of this thesis. Based on the general policy, procedural and political shortcomings identified in the thesis, and building upon the strategy to achieve a better outcome in the McGrath Highway case, I infer approaches that can be encouraged nationally to facilitate more sustainable outcomes in dealing with the infrastructure crisis.

1. Building the automobile city – lock in and path dependence

This section explores the initial period of road expansion in US cities, focusing on the Boston area as an example. The effects of road infrastructure on the built-form of cities, individual demand responses to a changing urban landscape, and political responses to automobile growth are linked in a systems model to understand the growth of the automobile city.

1.1 Street, highway and city form

> "When the American people, through their Congress, voted a little while ago for a $26 billion highway program, the most charitable thing to assume about this action is that they hadn't the faintest notion of what they were doing."[8]
> – Lewis Mumford (1957)

Even before the sweeping national changes of the Interstate program occurred, the automobile had already come to have a profound effect on changing the role, function and design of the right-of-way in American cities. The initial growth of the automobile in cities was largely an unplanned phenomenon; it seemed to just happen. Although much of the core urban street network in cities like Boston was planned and built before the first automobiles hit the road, these networks appeared to have held a latent capacity to absorb the movement of the motorcar within their existing curb lines – for the early automobile could be considered just a horseless replacement to the carriage.There was concern about the absorptive potential of the automobile in the city from the very first introduction of automobiles, but the excitement of elite owners of automobiles overcame early attempts at regulation and promoted concepts like the parkway to introduce higher speed auto traffic into park paths.

The initial influx of cars into the urban environment rapidly became a deluge. The number of motor vehicles registered in the nation grew from 8,000 in 1900, to 108,000 in 1906, to 944,000 in 1912, to approximately 8 million by 1920. The automobile was in full control of the transportation scene by 1930 with 23 million vehicles on the road: one car for every 5 citizens, and more than half of American families owning a car.[9] This initial growth of the automobile dramatically altered the character of the street and the urban environment, and in doing so, sparked a broad discourse of how to manage and plan for the car in the city. (**figure 1**)

Modernist theory about the city, which began to emerge in the late 1920s focused on the role of infrastructure and urban street systems as machines and instruments to the functioning of the city – rather than places of activity in their own right. Modernists did not recognize the street as providing the fundamental spatial structure for the city

8 Mumford (1957), 244
9 Southworth and Ben-Joseph (1997), 56; Gordon (1991), 9; Lewis (1997)

Figure 1: Washington St looking north to the Orpheum Theatre in 1921 (top); Washington St looking south to the Orpheum Theatre in 1932 (bottom)

through the relationships of building massing and street widths.[10] The automobile, and the thinking it spurred about urbanism, challenged the very function of the street itself as a realm for "life between buildings." [11] (**figure 2**)

A notable advocate of this thinking in this line was Le Corbusier: "the little fish are the pedestrians in our cities, the big fish are the cars… the result will be a massacre, the complete destruction of all the fish, large and small, because the aquarium is too small for such high speeds."[12] Corbusier, who was admittedly concerned with the negative impacts of the car's machine-ear speed on the biological speed of pedestrians, chose to embrace the car as victor and chastise the street as villain in his vision of the Radiant City: "Our streets no longer work. Streets are an obsolete notion. There ought not to be such things as streets."[13]

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10 Southworth and Ben-Joseph (1997), 72

11 The concept of life between buildings has been popularized by Gehl (2010) and includes "all of the very different activities people engage in when they use common city space: purposeful walks…promenades, short stops, longer stays, window shopping, conversations and meetings…"

12 Corbusier (1935), 121

13 Corbusier (1935), 121

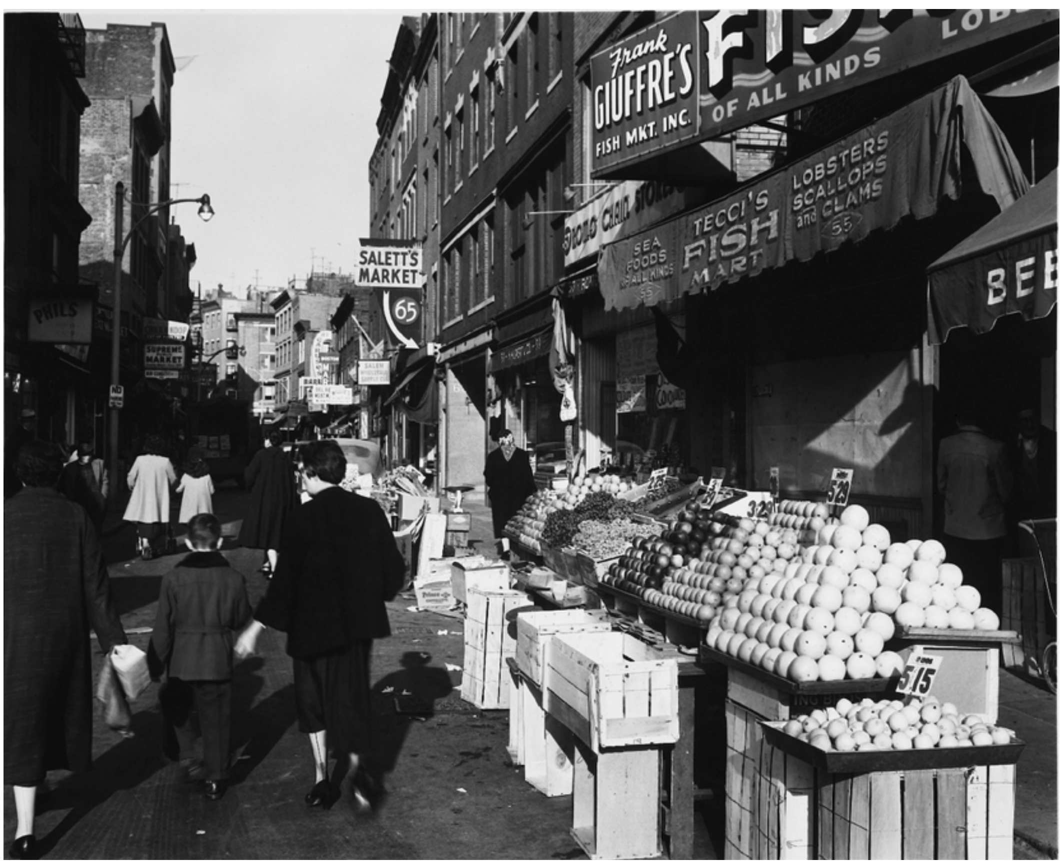

Figure 2: Salem St in Boston's North End, photographed here in 1954, illustrates the concept of life between buildings.

Instead, the street was to be redefined as "*a machine for traffic, an apparatus for its circulation*, a new organ, a construction in itself and of the utmost importance."[14]

Discussion of the destructive effects of automobiles on city life was not just a niche concern among city planning professionals, but it pervaded into the popular culture of the country. In May 1939, the American cultural icon, Superman, declares war against the car (**figure 3**):

> "Attention, citizens of the city! A warning from Superman - Pay close heed! The auto accident death rate of this community is one that should shame us all! It's constantly rising and due entirely to reckless driving and inefficiency!"
> – *Action Comics*: Vol 1 # 12

14 Corbusier (1929), 123

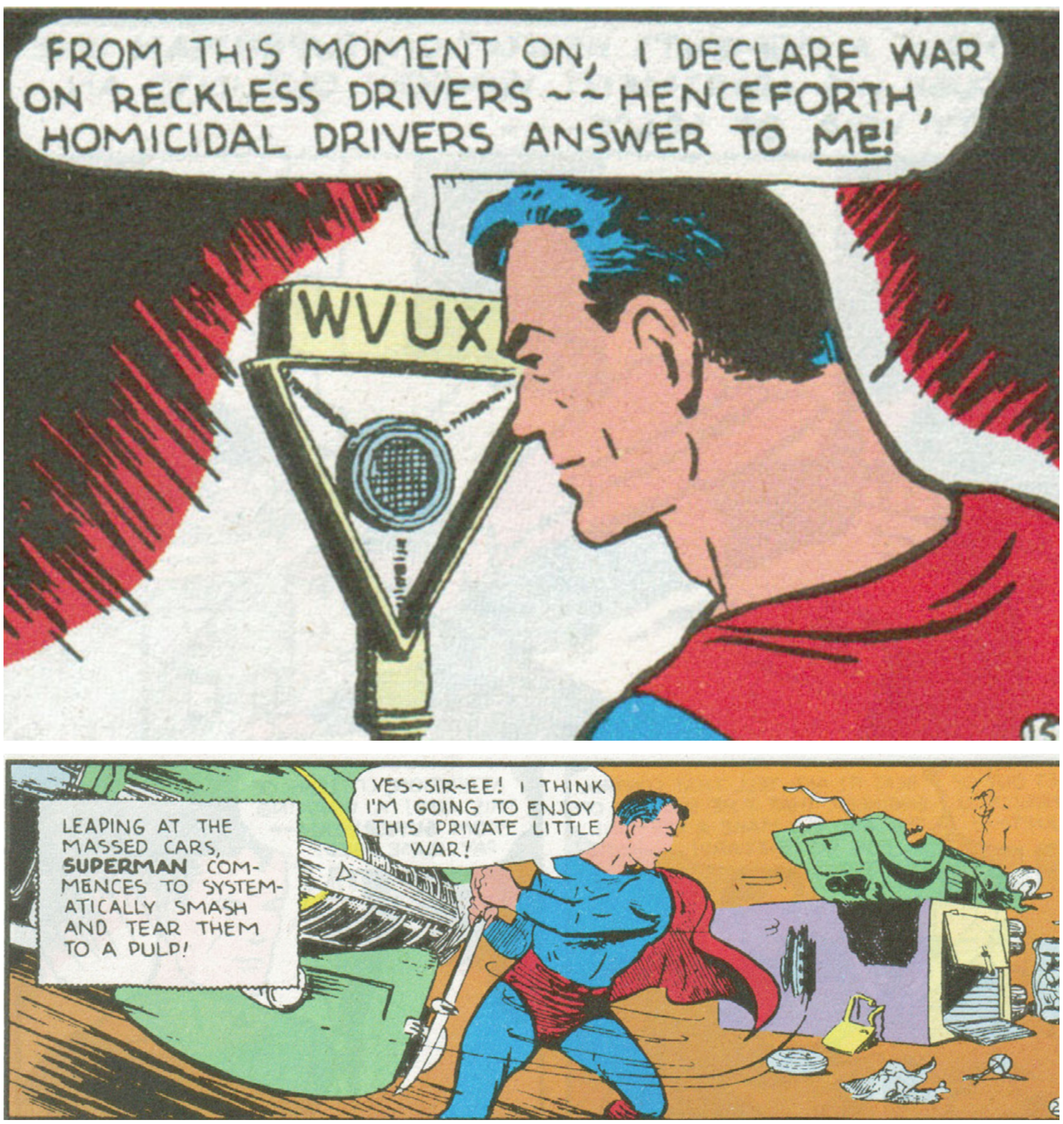

Figure 3: Action Comics, Vol 1 # 12 (panel 15, 20)

In the same year that Superman was thrashing cars, five million visitors passed through the "Futurama" exhibit at the New York World's Fair, which depicted the American landscape in 1960 as envisioned by Norman Bel Geddes (and funded by General Motors). According to Geddes, the Futurama responded to the problems of motorists who are "harassed by…the nuisances of intersectional jams, narrow, congested bottlenecks…irritating traffic regulations…[and] appalled by the daily toll of highway accidents and deaths," by showing "how a motorway system may be laid down over the entire country – across mountains, over rivers and lakes, through cities and past towns – never deviating from a direct course and always adhering to the four basic principles of highway design: safety, comfort, speed and economy."[15]

It is equally important to recognize that ideas in land use planning and architecture also expressed design concepts that worked to set and reinforce the path toward a city organized around the car. The viability of the very concept of urbanism came into question soon as it was observed how automobiles and the space they consumed for circulation and parking overwhelmed dense city environments. In the *Disappearing City* (1932), Frank Lloyd Wright identifies the automobile as underlying the rationale for his Broadacre City: an anti-city concept where population is dispersed in a landscape where each household is sited on one acre of land. "The fundamental unit of space-measurement has so radically changed that the man now bulks ten to one and in speed a thousand to one as he is seated in his motor car. This circumstance would render the city obsolete… The traffic problem is not a symptom of urban success but evidence of urban failure."[16] Wright even dismisses highways in cities as a remedy, in favor of complete abandonment of the core: "Why deck or double deck or triple deck city-streets at a cost of billions of dollars only to invite further increase and eventually meet inevitable defeat? Why not allow citizenship to keep the billions it would have to pay for "decking" to buy more motor cars and get out and get more out of living in a more natural and fruitful life.[17]"

> "We will solve the problem of the city by leaving the city"
> – Henry Ford

At the urbanizing fringe, the walkable city was becoming an outmoded typology and burgeoning automobile ownership exerted an important influence on new designs. In 1927 on two square miles of farmland in Bergen County, New Jersey, Clarence Stein built Radburn. Some scholars have incorrectly interpreted Radburn's influence, arguing that it was the predecessor of conventional, low-density suburban sprawl.[18] This debate notwithstanding, Stein's vision for Radburn was clear: "a town

15 Geddes (1940), 4

16 Wright (1932), 20-21, 35

17 Wright (1932), 32

18 Vander Ryn and Calthorpe (1986) argue: "Levittown inherited many of the planning ideas of Radburn." While Lee and Ahn (2003) demonstrate that privatized gardens and monotonous parallel rows of houses at Levittown bear no similarity to Radburn's focus on shared open space and walkways, Radburn helped popularized the superblock and cul-de-sac forms that now typify suburban America.

Figure 4: Cambridge Street looking south near Scollay Square in 1925 (top) and looking north from Scollay Square during road widening in 1930 (bottom)

in which people could live peacefully with the automobile – or rather in spite of it."[19] Stein held that the "automobile was a disrupting menace to city life in the U.S.A."[20] However, rather than designing Radburn as a rejection to this "flood of motors,"[21] he too embraced the car and also viewed the city as the problem. Stein critiqued the gridiron street pattern as "obsolete as a fortified town wall," and derided contemporary urban cores as outmoded "dinosaur cities."[22] Stein argued that cities like New York had reached the "limits of efficiency,"[23] and lobbied President Roosevelt for policies to hasten decentralization since cities were "fundamentally antagonistic to out needs."[24]

The prescriptions about reforming the street from Corbusier and other contemporaries were more than the mere musings of futurists, and the transition from street as urban landscape to a servicing infrastructure soon became built into the city. The Institute of Transportation Engineers (ITE) was founded in 1930, defining a new profession of highway engineering as "a branch of engineering which is devoted to the study and improvement of the traffic performance of road networks and terminals. Its purpose is to achieve efficient, free, and rapid flow of traffic…yet at the same time, to prevent traffic accidents and casualties."[25]

Within the core of Boston, early erosions of the city's walkable fabric came in the form of spot improvements and flyovers at intersections. The *Report on a Thoroughfare Plan for Boston* (1930) focused on improving "the chief source of congestion and delay which results from the crossing at grade."[26](**figure 4**) More dramatic alterations came in the form of linear, limited-access parkways such as Storrow Drive. Constructed in 1950, Storrow Drive replaced a two-lane, tree-lined, frontage road to the city's waterfront Esplanade with a six-lane, high-speed parkway that displaced much of the original Esplanade and created a noisy and polluting barrier of traffic that cut-off the city from its riverfront.[27] Parkland taken for the construction of Storrow Drive was replaced by shifting the park outward and reclaiming land from the Charles River, however, the quality and desirability of the space was fundamentally altered by the presence of the new roadway. (**figure 5**)

Critics such as Lewis Mumford bemoaned such trespasses: "the motorway has repeatedly taken possession of the most valuable recreation space the city possesses, not merely by thieving land once dedicated to park uses, but by cutting off easy access to the water front parks, and lowering their value for refreshment and repose…

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19 Stein (1957), 37
20 Stein (1957), 41
21 Stein (1957), 41
22 Parsons (1998), 24
23 Clarence Stein in essay, March 18, 1949. (in Parsons, 470)
24 Clarence Stein to President Roosevelt, march 23, 1931. (in Parsons, 200)
25 Southworth and Ben-Joseph (1997), 75
26 Report on a Thoroughfare Plan for Boston (1930), 15
27 The Esplanade Association (2012), 37

Figure 5: The Charles River Esplanade frontage road ca.1940 (top) was replaced by Storrow Drive 1954 (bottom)

witness the shocking spoilage of the Charles River basin parks in Boston."[28] Whereas the era of intersection spot improvements and parkways modified the street system for the automobile, but more or less within the existing urban structure and right-of-way patterns, the intrusion of elevated freeways in cities would be far more destructive to urban fabric and further degrade urban living and walking conditions.

Elevated structures were not a novel invention of the highway engineer. Leonardo Da Vinci speculated about a multi-level city, stratified based on social class, with upper levels for the gentry and lower stages for services, carts and tradesmen.[29] Elevated transport viaducts in cities emerged as early as the 1860s in New York City and in 1901 in Boston, as a strategy to increase space for and improve the speed of rail transit systems in dense urban environments where right of way space was constrained. However, the noise and visual impacts of elevated transportation on the urban quality were so unsatisfactory that they were replaced in cities around the world with subway tunnels that were not only more costly to construct, but arguably also more unpleasant to travel in.[30](**figure 6**) Despite that correction of course, the West Side Highway, constructed in Manhattan in 1927, was one of the first elevated highway structures built in the country, and a concept for an elevated Central Artery through downtown Boston appears as early as 1930.[31](**figure 7**) Both of these ideas well pre-dated the national Interstate program.

The devastating path that many freeways cut through urban neighborhoods and blocks was a deliberate quality of the Interstate program. Thomas MacDonald, chief of the national Bureau of Public Roads, argued in favor of road expansion to solve transportation problems within major cities, and the enacted Interstate legislation included plans to bring highways right into the downtowns of cities.[32] Freeways into cities, alongside massive urban renewal schemes, were ironically advanced as a form of social and economic therapy to rescue cities by providing access to downtown jobs for a rapidly suburbanizing workforce and to alleviate traffic congestion where it was perceived to be the worst.[33]

Elevated highways may have initially seemed less intrusive than accommodating traffic at grade by leaving the ground level free for local streets to cross and to provide parking. However, elevated highway structures proved to be tremendously more detrimental than earlier elevated rail transit lines. Freeways through cities are the ultimate expression of the anti-street, with no relationship to the rest of the built form. Freeways were conceptualized as mobility conduits for vehicles, which allowed drastically more vehicles to flow into urban areas than would have otherwise occurred owing to the constraints of a city's historic surface-level street network (even with

28 Mumford (1957), 251
29 Shelton (2010), 163
30 Mumford (1957), 251
31 Report on a Thoroughfare Plan for Boston (1930)
32 Reid (2006), 39
33 Rose (1990), 5

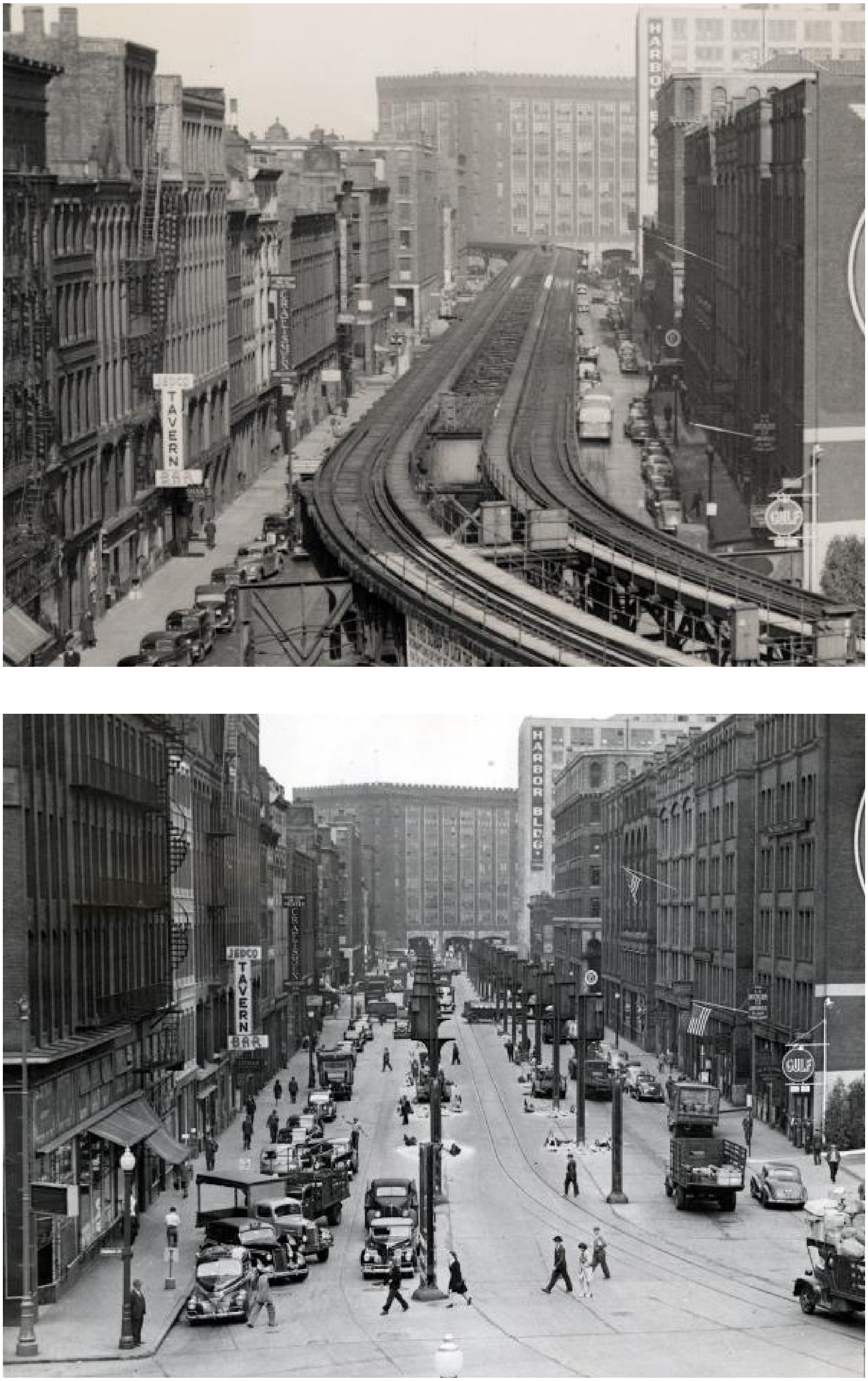

Figure 6: Atlantic Avenue Elevated before (top) and after demolition in 1942 (bottom)

spot improvements). Moreover, whereas streets provide access to land and define development parcels, urban freeway alignments completely defied existing built form and block patterns in their alignments. Freeways not only divided the fabric of the city physically and psychologically, but they also fractured the logic of urban space by creating vacancies and voids, and left-over parcels whose shape was defined by the turning radius of the automobile at 55-miles per hour. (**figure 8**) Each mile of freeway took approximately twenty-four acres of land and each interchange another eight acres.[34] Indeed Robert Moses, the "master builder" of freeways in New York City is quoted: "when you operate in an overbuilt metropolis, you have to hack your way with a meat axe."[35] Demolition and land clearance for freeway construction was also often drastically increased in scale than that needed to accommodate the right of way by plans for broader neighbourhood urban renewal schemes that were developed in tandem. A 1975 review of the elevated segment of I-93 though Somerville, commissioned by the Federal Highway Authority and Massachusetts Department of Public Works, concluded that the structure is "completely out of scale with the urban zone through which it passes" and "there is a great deal of wasteland associated with the right-of-way, and extensive visual voids."[36] These outcomes underneath and around elevated highways through cities were in stark contrast from the rosy pictures painted by highway departments in their feasibility studies and planning reports, which showed public spaces with high amenity value and animated with people and children playing. (**figure 9**)

34 Lewis (1997), 153
35 Lewis (1997), 193
36 Lewis (1997), 236

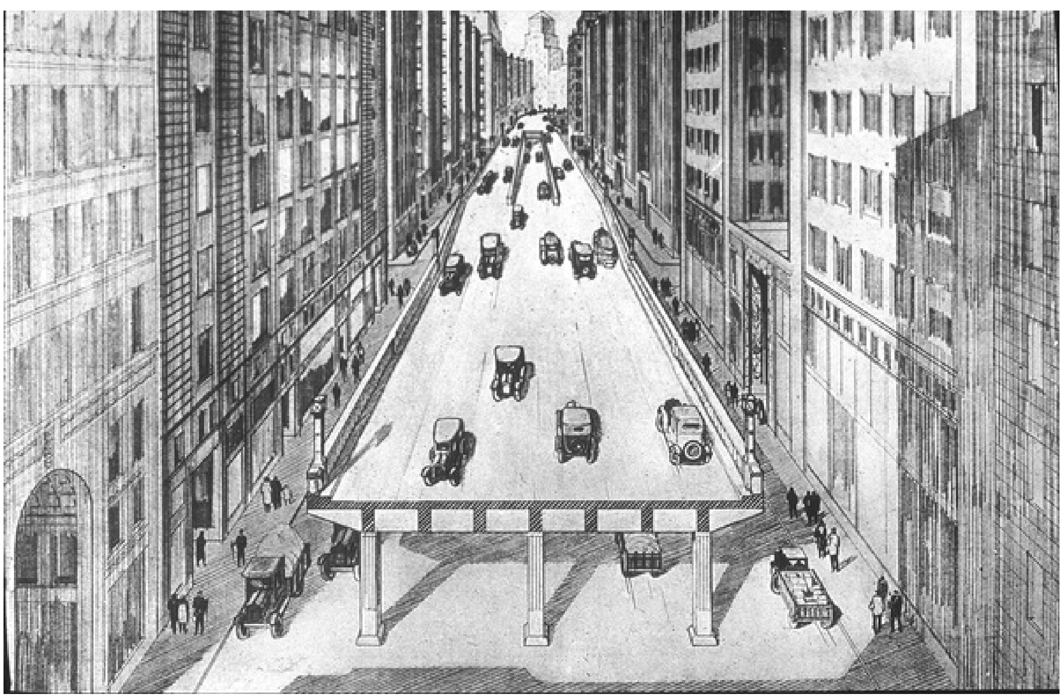

Figure 7: Conceptual drawing of elevated central artery through downtown Boston (1930)

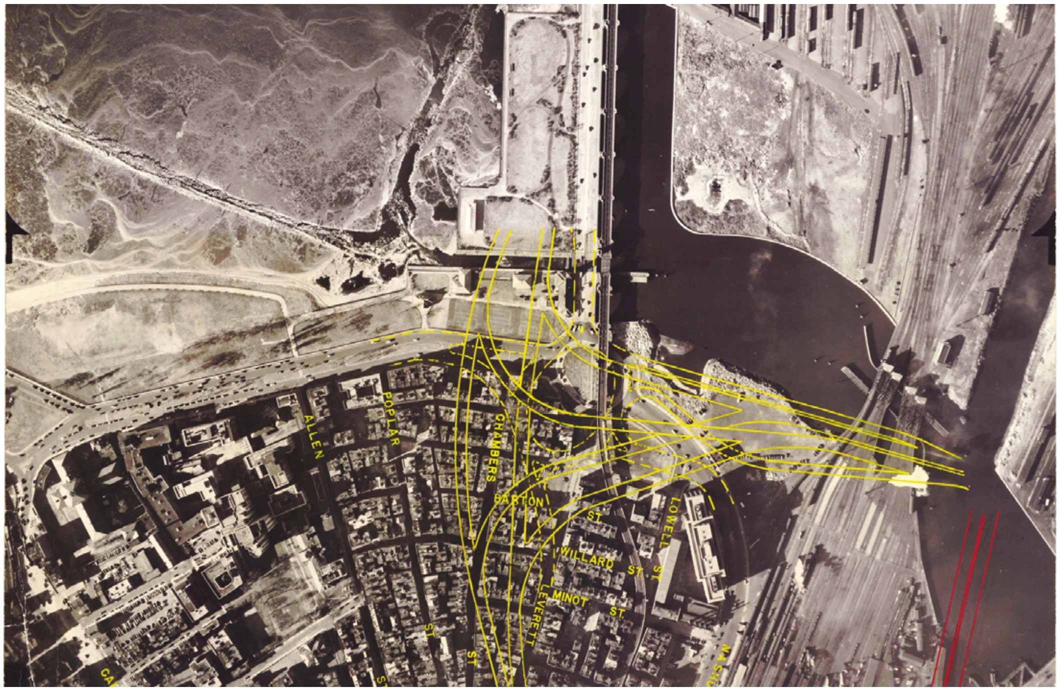

Figure 8: Proposed alignments to connect the Central Artery to the Inner Belt Highway demonstrate Figure how Interstate freeway planning completely defied established block and street patterns. Although the West End neighborhood shown here was demolished for urban renewal, the Belt Highway was never constructed.

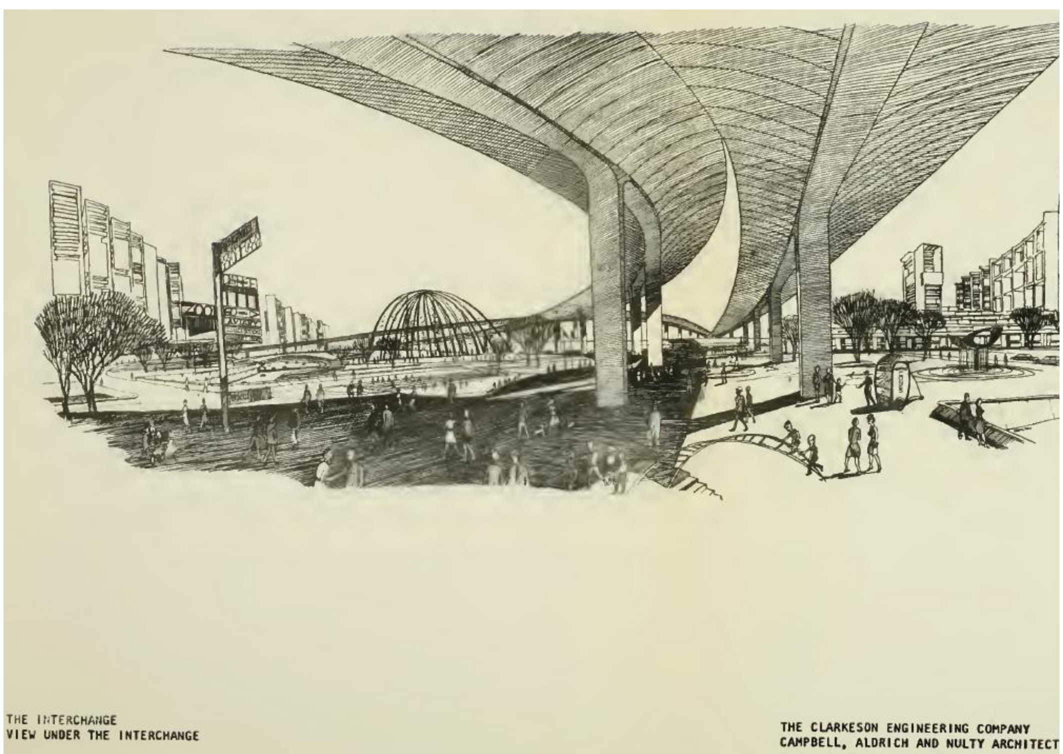

Figure 9: Artist's conception of the "veiw under the interchange" from the preliminary draft of the Basic Design Report - Interstate Route 95 and 695: Boston, Masssachusetts (1965)

Similar impacts on the surrounding neighborhood land use were felt across the nation. Fairfield (2010) describes the devastation in Oakland, where: "Construction leveled large parts of West Oakland, isolating neighborhoods from one another and cordoning others off behind a mass of concrete... Construction scars, ugly structures, and accumulating refuse blighted poor neighborhoods and lessened property values. Repair shops and car washes, muffler and spray paint services, and used car lots and parking garages arose disproportionately."[37] These results were the massive amplifications of the same basic phenomenon noted by Clarence Stein in 1929: "frontage on the through highway has very limited value…people no longer want to live at such places."[38]

The continuity and quality of inner city urban environments was further degraded by the provision of parking lots as a solution to both perceived traffic and land use problems of the inner city. In 1923 The National Conference of City Planning encouraged cities to allocate sites for off-street parking facilities, and the first municipal parking lot was provided in Boston in 1930.[39] During the 1920s and 1930s the process of clearing old buildings was used systematically to remove unwanted uses from the central city. Parking lots were viewed as the best solution to provide short-term economic revenue to property owners since they generated good rents without much investment. (**figure 10**) By mid century the rapid suburbanization of jobs and housing fuelled this destructive cycle onward as buildings in declining central business districts were torn down and replaced with parking lots, reducing property tax revenues but justified by the hope of attracting suburbanites back to the city.[40] Yet these lots further extended the linear impact of roadways and highways in the city into broader neighborhood area impacts that again undermined the viability and fabric of the walking and transit-oriented city.

Beyond the direct impacts on the form and function of adjacent urban places, the Interstate highway program through cities has been cited as the single-most influential measure contributing to the demise of urban living and to the creation of the automobile-dependent metropolis.[41] Although urban renewal programs physically destroyed the urban fabric of the inner city, freeway capacity in cities and the mobility it provided greatly accelerated the trend of metropolitan decentralization that was already underway in US cities since the era of the streetcar suburbs. Freeways enabled the spatial extent of the city to spread out into vast new areas of undeveloped land, and within new developments mass-motorization enabled the construction of suburban landscapes characterized by low densities, the ample provision of parking, and the separation of land uses and activities into large mono-functional zones as dictated by the contemporary ideologies of zoning codes. These patterns of development were enabled by the automobile, and also therefore necessitated using

37 Fairfield (2010), 255
38 Clarence Stein letter to Benton MacKaye, Oct 12, 1929. (in Parsons, 154)
39 Ben-Joseph (2012) ,69
40 Ben-Joseph (2012), 73
41 Fishman (1999)

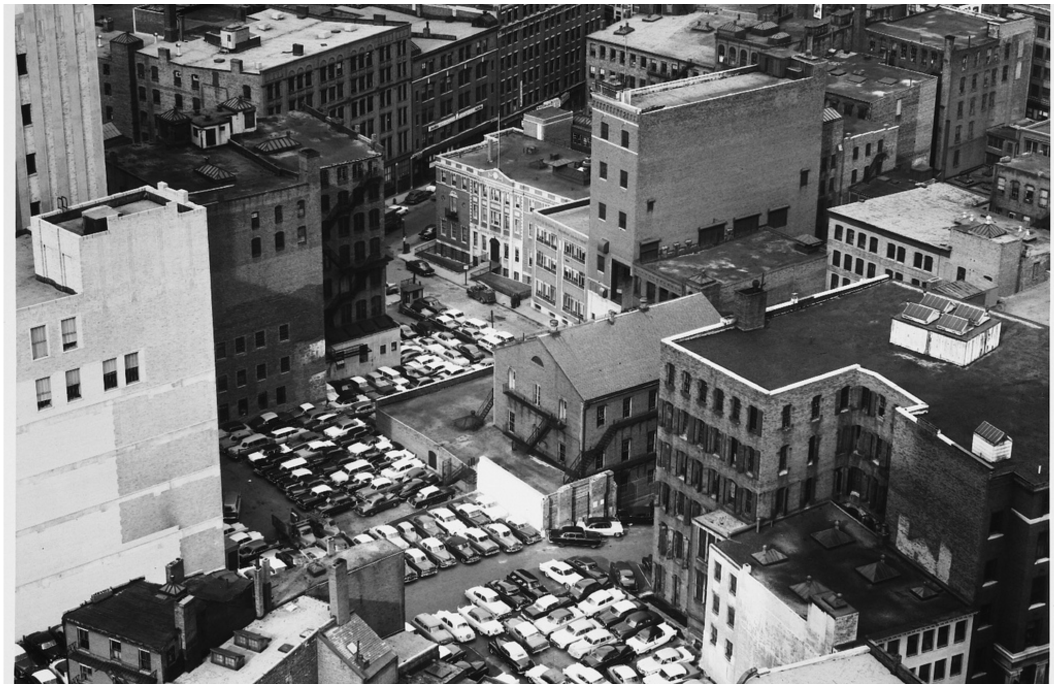

Figure 10: Parking Lots Near New England Telephone Building (1954)

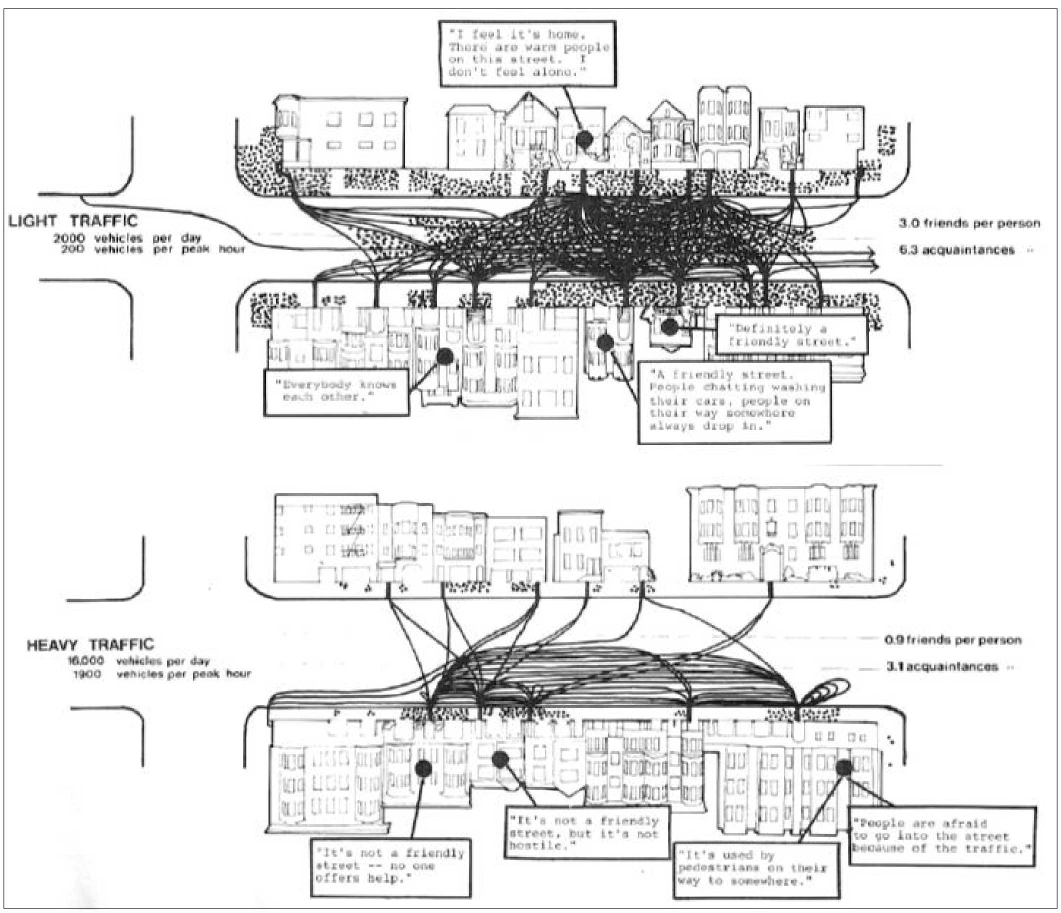

Figure 11: The quantity and pattern of social relationship changes dramatically from a quiet street with 2000 vehicles per day (top) to a heavy traffic artery with 15,000 vehicles per day (bottom)

the automobile. The development of these vast suburban areas exacerbated lock-in to the automobile not only in these neighborhoods but also at the metropolitan scale. For, trips with either origin or destination in these new places would be made by automobile no matter how transit-oriented or incapable to accommodate car traffic the city form at the other end.

Although the visual and neighborhood effects are hard to measure, the impact of vehicle traffic and its infrastructure on pedestrian movement, social relationships and the neighborhood fabric has been documented. In the seminal work *The Image of the City* (1960), Kevin Lynch, a professor of urban planning at MIT, documents individuals' perception of city form based on interviews and sketches of their mental maps. Lynch's work recognizes the increasing impact on the city from spot widening to parkway to highway. "Cambridge Street divides two regions sharply but keeps them in some visual relation. Storrow Drive is clearly related to the Charles River, and is thus tied to the general pattern of the city. The Central Artery on the other hand, winds inexplicably through the center…[it] seems to divide absolutely, to isolate.[42] Appleyard (1981) illustrates the negative correlation between traffic volume on a street and the number of relationships between neighbors. As traffic increases, the number of neighborly acquaintances not only drops drastically, but the pattern of relationships becomes strongly aligned only along one side of a street with few relations crossing busy arteries.[43] (**figure 11**) Not only do the number of activities change as the quality of space declines, but Gehl (2010) argues that so too do the nature of activities: necessary activities may persist, but social and optional activities decline or disappear. (**figure 12**) Likewise, in cities that have attempted to improve the pedestrian quality of space, such as Copenhagen where the amount of pedestrian-only zones was increased from 15,000m^2 in 1962 to 100,000m^2 by 2005, the conclusion has been "unequivocal: if people rather than cars are invited into the city, pedestrian traffic and city life increase correspondingly."[44]

In summary, the growth of automobile travel, the infrastructure to support it, and the changes in metropolitan structure and development patterns it enabled created a pattern of lock-in to the car. The physical effects of auto-oriented infrastructure have dramatically undermined the viability or existence of other modes of travel in cities and the fabric that hitherto supported them. Walking became unpleasant, undesirable, and at times impossible. And with the decline of walking, the ability to access public transportation was also eroded, further consolidating the role of the car. In new (sub)urbanizing landscapes opened up by freeway connectivity, development patterns were oriented wholly around the auto, contributing to metropolitan-scale lock-in to automobile travel.

42 Lynch (1960), 23, 63-64
43 Appleyard *et al.*(1981)
44 Gehl (2010), 12

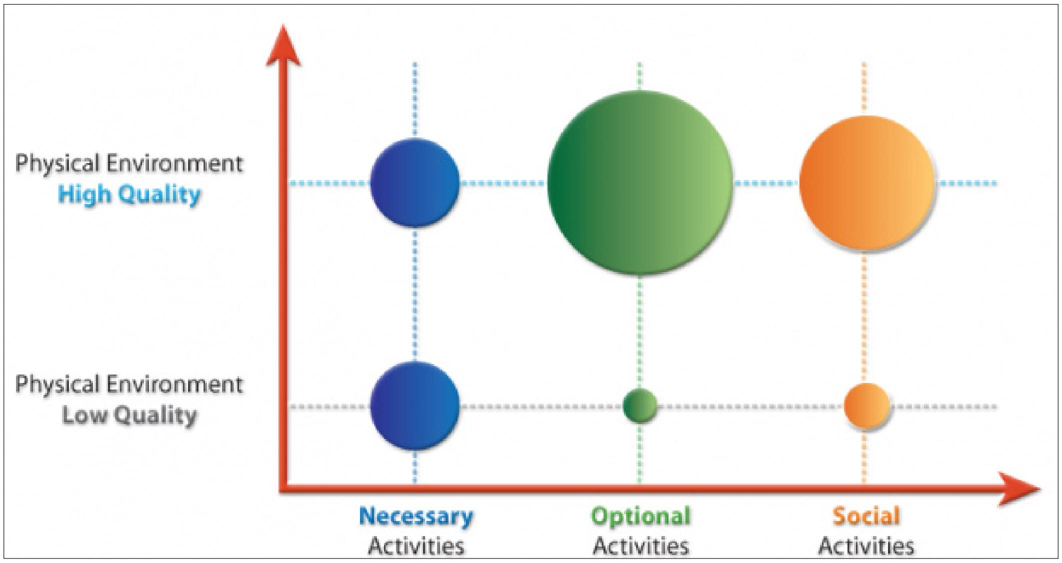

Figure 12: Conceptual relationship between quality of the physical environment and the type and amount of pedestrian activity.

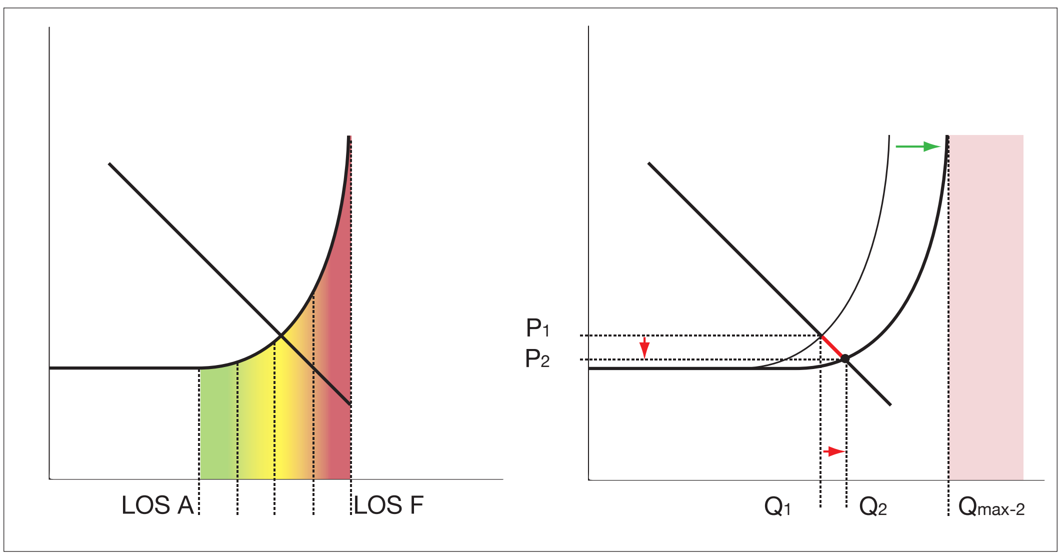

Figure 13 (left), *Figure 15 (right)*

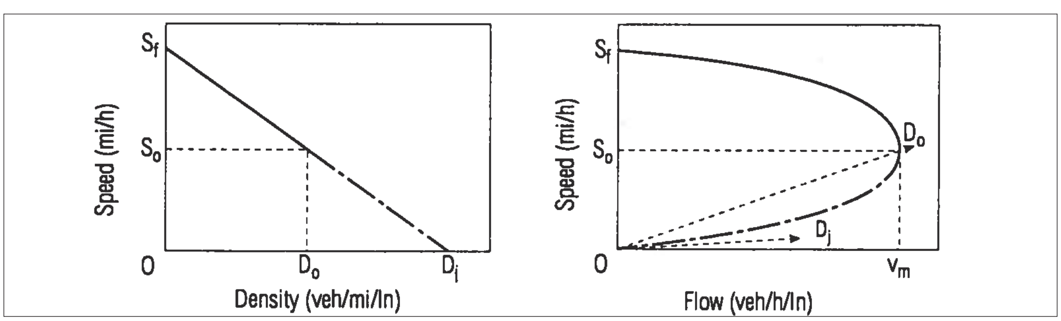

Figure 14: Diagrams from the Highway Capacity Manual (2000) showing the conceptual relationship between traffic speed, flow and density, and how capacity (flow) drops as a roadway beceomes overloaded

1.2 Disaggregate demand response

The phenomena of lock-in and path dependence can also be understood in terms of a system dynamics micro-economic model of individual demand responses to a motorizing city. The initial growth of the car in the city (demand), and the road building that followed (supply), triggered a feedback loop to perpetuate the demand for auto travel.

1.2.1 Theoretical model

A series of simple supply and demand curves, each illustrating a principle, will be used to model the effect of transportation supply on shaping demand.

Transportation systems are governed by capacity constraint

The amount of transportation supply available in a system at a given time is finite,[45] and the supply is completely inelastic in the short-run. Although this may seems self-evident, it is important to emphasize that demand cannot in practice exceed supply (**figure 13**).

Finite capacity constraint creates congestion effects

For a given supply constraint, the quantity consumed impacts the quality of the service. This principle of congestion stems from the fundamental relationship between speed and traffic flow, whereby traffic speed declines as the number of users approaches saturation capacity (V_m) of the roadway. In other words, level of service experienced by an individual user degrades as more people use the system, and as too many people use the system capacity drops. (**figure 13, 14**)

Supply expansion and movement along the demand curve

The demand function represents the willingness to pay for transportation. The willingness to pay reflects a whole host of factors including the utility (or benefit) derived from travel, but also many background factors such as the availability of alternatives. If the finite constraint on supply is loosened, for example by widening a road to increase the *quantity* of capacity from Q_{max-1} to Q_{max-2}, a new equilibrium point on the existing demand curve is realized. The *quantity* of consumption increases from Q_1 to Q_2, and price decreases from P_1 to P_2. Due to existence of congestion effects, expanding the *quantity* of road capacity from Q_{max-1} to Q_{max-2} results also in improving the *quality* of supply. For any given number of people now using the road, everyone experiences a better level of service. (**figure 15**) This improvement leads to the following effect.

45 Supply is defined as the maximum throughput in a network for a given piece of infrastructure and technology with which to manage it.

Supply expansion and shifts in the demand curve – induced demand

Increasing quantity supplied, and therefore reducing the level of congestion experienced at a given amount of consumption, increases the marginal benefit of consumption because it reduces the time taken to complete a given task.[46] Therefore, it is hypothesized that initial congestion reduction will increase demand (that is change the demand curve), until demand reaches the point Q_3 which restores the initial level of congestion in the system and the initial price point P_1. There are now more people using the system, but it is just as congested and the level of service is no better than before the road capacity expansion. This erosion of initial congestion relief to demand growth is referred to in the literature as *induced demand*. (**figure 16**)

Downs (1992) explains this phenomenon as a principle of "triple convergence" which makes it "almost impossible to eradicate peak-hour traffic congestion on limited-access roads" unless a road can simultaneously carry every commuter at the moment of peak demand. The congestion relief from road capacity expansions are ultimately offset by drivers who formerly (1) used alternative routes, (2) traveled at other times, or (3) used public transit. These three forces will cause traffic volumes to rise until vehicles again experience the same level of congestion as before an expansion.[47]
The notion that accommodating automobile travel begets further car use is neither recent nor an argument advanced only by anti-car critics. Traffic engineers have been well aware of the phenomenon since the origins of the profession and continued to acknowledge it the Interstate era:

46 Gibson (2003)
47 Downs (1992), 29, 145

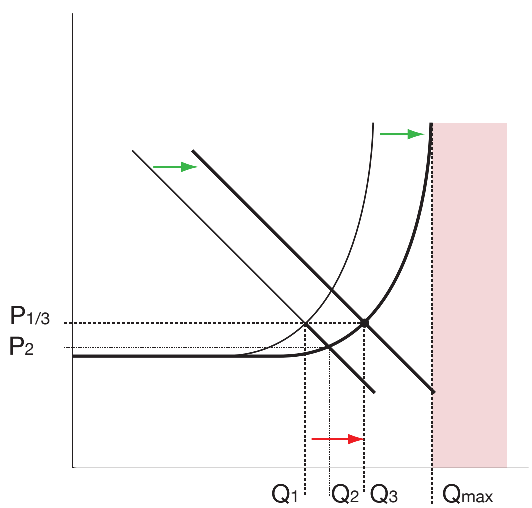

Figure 16 (left)

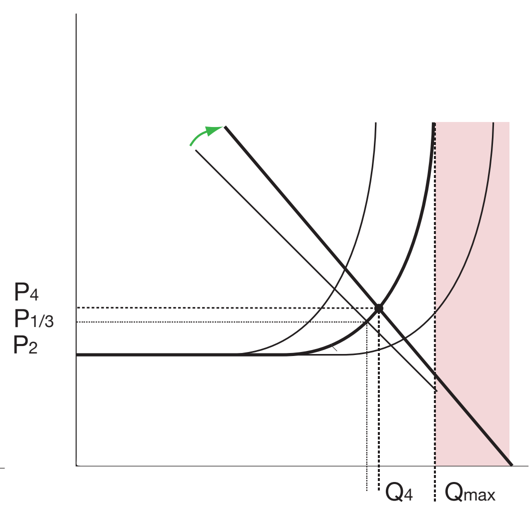

Figure 17(right)

"It is sometimes said that it is useless to increase street capacities in central areas as any additional capacity provided will be immediately taxed to the saturation point…there are undoubtedly a considerable number of persons who now use the automobile for trips that could be made just as conveniently and more economically by railroad or rapid transit line. A further slowing up of the traffic movement would stop some of these ill-advised trips."
– Report on a Thoroughfare Plan for Boston, (1930)

"Another function of the [inner] belt, not wholly desirable, yet inevitable, is that of an interval bypass of the city core. For generations, the congested city streets have served as an effective barrier to motor vehicle travel from north to south or vice versa. The belt highway will break this down and cause a flow of induced traffic not revealed by any surveys based on past conditions."
– Study of the Belt Expressway Through Cambridge, (1957)

Supply expansion and shifts in the demand curve – lock in
Capacity expansion and the phenomenon of induced demand suggests that changes in supply alone can bring about changes not only in the quantity demanded, but also the nature of the demand curve itself. In addition to inducing demand, loosening capacity constraints and building more transportation supply increases the size of the road network and may produce lock-in. In chapter 1.1, I articulated arguments based in urban design thinking for how expanding automobile infrastructure produced lock-in to the car by eroding the quality of the urban environment. This effect of expanding the supply of automobile capacity in the transportation system can also be modeled, first as a further upward shift in the demand curve (from Q_3 to Q_4), and second as a pivoting of the demand curve that represents movement to a more inelastic demand function due to the disappearance of alternatives to the car.[48] Therefore, a road capacity expansion that results in an increased transportation network size may ultimately increase the amount of travel (from Q_1 to Q_4) *increase* the price (from P_1 to P_4) and *increase* the level of congestion.[49](**figure 17**)

These models demonstrate how supply-side responses (i.e. road building) to initial traffic demand can work to amplify demand and shape consumer preferences for automobile travel. They also provide a theoretical link between the form-based critiques of auto infrastructure and neoclassical models of decision-making.

48 This includes declining transit performance and competitiveness, reduced transit service, and the erosion of walkability.
49 Gibson (2003)

1.2.2 Empirical validation

There have been several attempts in the past decade quantify the extent to which road capacity expansions produce induced demand. Developing a robust study design to answer this question is challenging, due to the reliance on observing natural experiments, the procedural difficulty of monitoring traffic changes through time, and the conceptual challenge of developing an adequate framework to distinguish various sources of traffic growth. However, the research reviewed supports that some portion of the anticipated congestion relief from projects that increase supply is lost to increased travel and mode shift from transit to the automobile.

Duranton and Turner (2011) examine the relationship between highway lane kilometers and highway vehicle-kilometers travelled in American cities over several decades. They find that VKT increases proportionately to highways, and that therefore, "supply is unlikely to relieve congestion, and current roadway supply exceeds the optimum." The study estimates a roadway elasticity of VKT between 0.67 and 0.89 and suggests four sources for this new traffic growth, of which changes to individual behavior and changes in commercial driving are the most important. Cervero (2003) examines road expansion projects in California between 1980 and 1994, and estimates a long-term elasticity of VMT with respect to traffic speed of 0.64. His results suggest that about 80% of expanded roadway space becomes used by new peak-period travel, and that nearly half of this 80% is due to capacity expansion itself (as opposed to other factors such as changes in land use patterns caused by road building).

1.3 The political tragedy of expanding the concrete commons

> "…the followers of a new cult which, instead of the golden calf, has chosen as its goddess the private automobile. The cult of the autocrats, which I will name 'autocrazity,' is perfectly willing to sacrifice our cities on the altar of the new goddess."
> – Victor Gruen (1960)

In his seminal article, *The Tragedy of the Commons*, Hardin (1968) argues that an open access pasture with a finite capacity to support a herd of grazing animals is destined to be overused and degraded:

> "the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another…. But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush…"

Hardin prescribes the need for "mutually agreed upon coercion" to regulate the use of such common access resources, since there are "no technical solutions" to inherent natural scarcities. If we fail to recognize these constraints and take action, he forewarns that society will "greatly increase human misery."

The transportation system can be considered a concrete version of Hardin's commons, governed by a finite capacity constraint and prone to overuse and congestion as every self-interested driver seeks to use the system to their benefit without regard for the damaging impact of every additional user on the overall quality of system performance. However, unlike the pasture, fishery, or forest that cannot be recreated, building a bigger transport commons holds the allure of a technical solution to the finite capacity constraint. Yet, therein lies the political tragedy of the concrete commons and the source of misery: expanding it.

Congestion in the concrete commons is a curiously self-limiting problem. Based on the principle that actual demand cannot exceed supply (and that capacity drops as demand strains supply), the amount of road space in a city imposes a finite limit on the amount of vehicle traffic that can be accommodated. Therefore the observed performance level of a road can be considered an expression of a user equilibrium point between the demand for travel (willingness to pay) and the availability and cost of using the road (supply curve). J.G. Wardrop (1952) articulates this as his first principle of traffic equilibrium: "the journey times on all the routes actually used are equal, and less than those which would be experienced by a single vehicle on any unused route."[50]

Absent a regulatory scheme on its use, a road will be just as slow or congested as drivers are willing to tolerate, but the condition of the system can get no worse than crawling speeds, the loss of throughput capacity, and complete gridlock at the extreme – beyond this point there is no where else to go and no physical capacity to accommodate growth. Gehl (2010) reiterates the point: "The volume of car traffic almost everywhere is more or less arbitrary, depending on the available transportation infrastructure… every city got precisely as much traffic as space would allow… in the effort to cope with the rising tide of car traffic, all available city space was simply filled with moving and parked vehicles."[51]

The key observation is that traffic growth beyond capacity limits cannot simply just happen as it must be invited or at least physically encouraged. Whereas congestion is a self-limiting condition in the physical sense, the rise of cars in cities alongside efforts to build our way out of it triggered a third feedback loop in the automobile growth story: the political will to build infrastructure. As described previously, the early rise of automobile travel in cities was a non-decision by government that could be accommodated by the latent capacity of existing street networks to absorb some traffic. The initial growth of the car in cities to the point where existing streets became congested can be considered an expression of inherent consumer preferences for personal mobility. However, the continued growth of auto-mobility was more than preference accommodating; government intervention in the form of road building, alongside the failure to maintain transit or an alternative transforming opportunity, created lock-in and was preference-shaping.

50 Wardrop (1952), 345
51 Gehl (2010), 9

> "The city's street system should be adapted to the requirements of a motor age. The art of street design and construction has lagged far behind the art of vehicle design and construction."
> – Report on a Thoroughfare Plan for Boston (1930)

However, Wardrop's user-optimal traffic equilibrium is by no means an ideal outcome. Although users stuck in traffic and congestion provide de facto evidence of a willingness to pay the cost, the aggregate disutility for all travelers is not at its minimum. Furthermore, congestion is a cost in wasted time and inherently different than payment in dollars that the transportation supplier could use to improve service. Whereas the cost (in terms of time and congestion) of using the auto rises with usage as demand approaches capacity and level of service drops, the cost of transit tends to decline as ridership grows, since higher passenger densities enable better service, shorter headways, and spread large fixed operating costs over more riders. If the personal costs of road congestion were invested collectively in public transit and some automobile trips are consequently diverted on to transit, congestion could be reduced and overall travel times would improve and move toward a social optimal. (**figure 18**) Indeed, such an investment in transit service may be the only promise of a technical solution to this commons problem. However, in the political tragedy of the concrete commons this alternative vision of more sustainable growth supported by transit is overwhelmed by the majority status of the auto and its supporting interests.

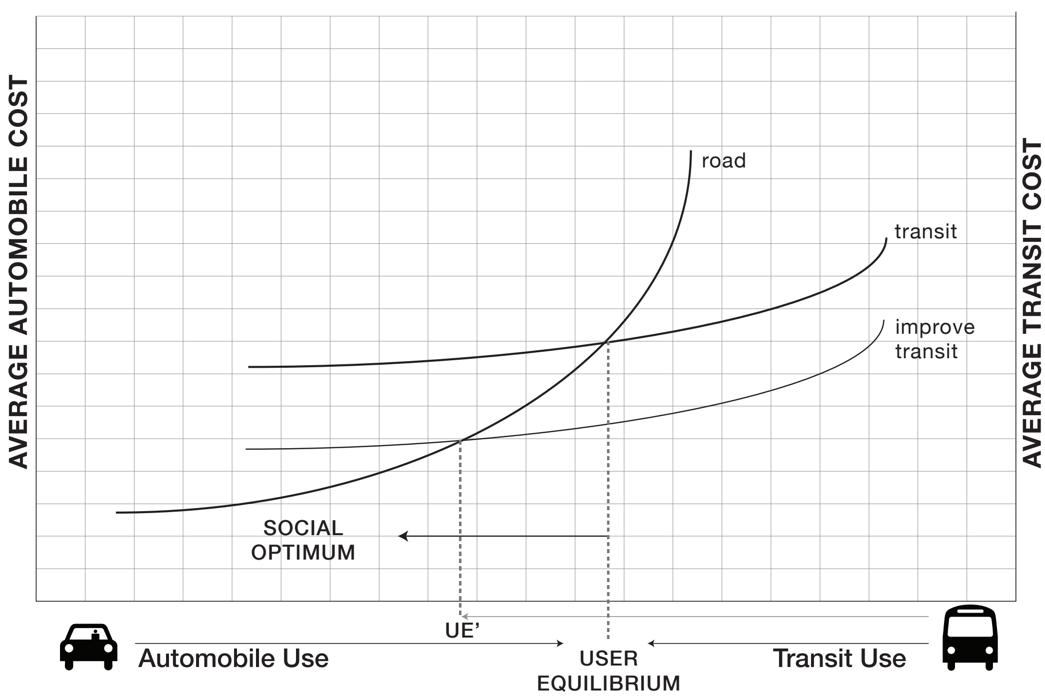

Figure 18: Transit investment as a potential technological solution to expanding the concrete commons

Despite the conceptual attractiveness of public transit, governments expended both huge sums of money and summoned enormous political will to cater for the car. In 1916 congress authorized $75 million[52] over five-years for road construction.[53] By 1929 every state in the country had enacted gasoline sales taxes (usually three to four cents per gallon) to finance road construction, and collectively all levels of government invested $34.6 billion on road construction between 1921 and 1940.[54] Whereas urban citizens accessed a fair degree of mobility from public transportation systems and the walkability of dense urban environments, the automobile provided a great leap forward for mobility in rural areas. As such, early road expenditure programs focused on farm-market roads motivated to help get traffic "out of the mud." This landscape, coupled with the rural representation bias of the US Senate system, likely helped build the political will for federal support of state and local road building.

Works Progress Administration (WPA) projects of the 1930s spent ten-times as much money on road building projects as on public transportation.[55] This funding bias for roads over transit may have been driven in part by the institutional structure of transit. Public transit service in the United States was primarily developed and operated by for-profit enterprises with some degree of public oversight to award route concessions and also regulate fares. As such, it may have been politically difficult to justify channeling depression-era stimulus funds for investment in privately held public transit systems,[56] rather than in a state sponsored and publicly executed road-building scheme.

Public expenditure on road building was just the tip of the iceberg. Whereas investment in public transit usually provides a complete system (track, vehicle, maintenance and driver), in the automobile system the costs of vehicle ownership, operation and parking are private. Kothari (2007) estimates that in Boston, the ratio of private spending on the automobile outweighed public spending by a factor of over 14. By investing in roads, the state stimulated massive consumer spending in the auto industry and petroleum sector, thereby creating two very strong and increasingly powerful political interests in favor of perpetuating the automobile growth machine.

By the end of the 30s a proposal for an $8-billion, 30,000-mile national network of tolled super highways was being debated in Congress but ultimately blocked in Senate in 1938 by the successful lobbying efforts of state and federal road builders

52 1.6 billion in 2012 dollars

53 Rose (1990), 8

54 Gordon (1991), 11; Rose (1990), 4

55 Gordon (1991), 11

56 Although some transit facilities were transferred from private to public ownership rather early in Boston (the Cambridge subway was sold to the Commonwealth in 1920 as a form of public subsidy to the private operator), rail systems in New York and Chicago were purchased by the state in 1940 and 1947, respectively.

Figure 19: Downtown Boston before (top) and after the construction of the elevated Central Artery in 1954 which demolished approximately 1000 buildings (bottom)

who advocated for a toll-free system.[57] By 1954, President Eisenhower directed his administration to devise a "dramatic plan to get 50 billion dollars worth of self-liquidating highways under construction": expenditure greater than the recently ended Korean War.[58] These projects increased the behavioral lock-in to the car (as described in chapter 1.1 & 1.2), thereby creating an ever-growing political constituency in favor of the car, and in turn further fuelling the political will to expand the concrete commons.

From early intersection spot improvements, to the trespasses of the parkways on parklands, and ultimately the dramatic intrusion of freeways into cities, government summoned enormous political will to destroy the fabric of the city and displace citizens in the path of the road. These were not only side effects of highway building, but also articulated policy objectives. In the report, *Toll Roads and Free Roads* (1939), the Bureau of Public Roads articulates the link between freeways and urban renewal by suggesting: "the whole interior of the city is ripe for…major change." The National Interregional Highway Committee created by president Roosevelt recommended in the report *Interregional Highways* (1941) that a new system of national highways should enter into the core of metropolitan areas and integrate with "the future development of the city." [59] However, the scale of the changes brought by highways and the detriment to the already declining city was enormous. Construction of the Central Artery through Boston (which predated the Interstate program) required demolishing 1,000 buildings and displacing 20,000 people. (**figure 19**) With the Interstate program mayors of cities further invited these highway projects, both for the temporary boost to the economy that Interstate highway construction funds brought to the local economy, as well as out of desperation to remain connected to the growing suburban reaches of the metropolis. According to the U.S. House Committee on Public Works by the late 1960s federal highway building was demolishing over 62,000 housing units annually with an impact on as many 200,000 people per year.[60] The provision of parking also fuelled the destruction of the city, and in 1946 the American Society of Civil Engineers reported that fifteen states had laws enabling the use of condemned properties for parking lots.[61]

In addition to spending money on roads, an entire bureaucracy was created around the enterprise. For example, more people worked for the Bureau of Public roads in the Philippines in 1952 than in the entire Bureau in 1919.[62] Political will was also summoned to further entrench the dominance of the automobile on land use by codifying auto-oriented designs through engineering design standards and land-use planning law. The requirements of the Federal Housing Administration (FHA),

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57 Rose (1990), 5
58 Lewis (1997), 98-99
59 Mohl (2004), 677
60 Mohl (2004), 680
61 Ben-Joseph (2012), 81
62 Lewis (1997), 91

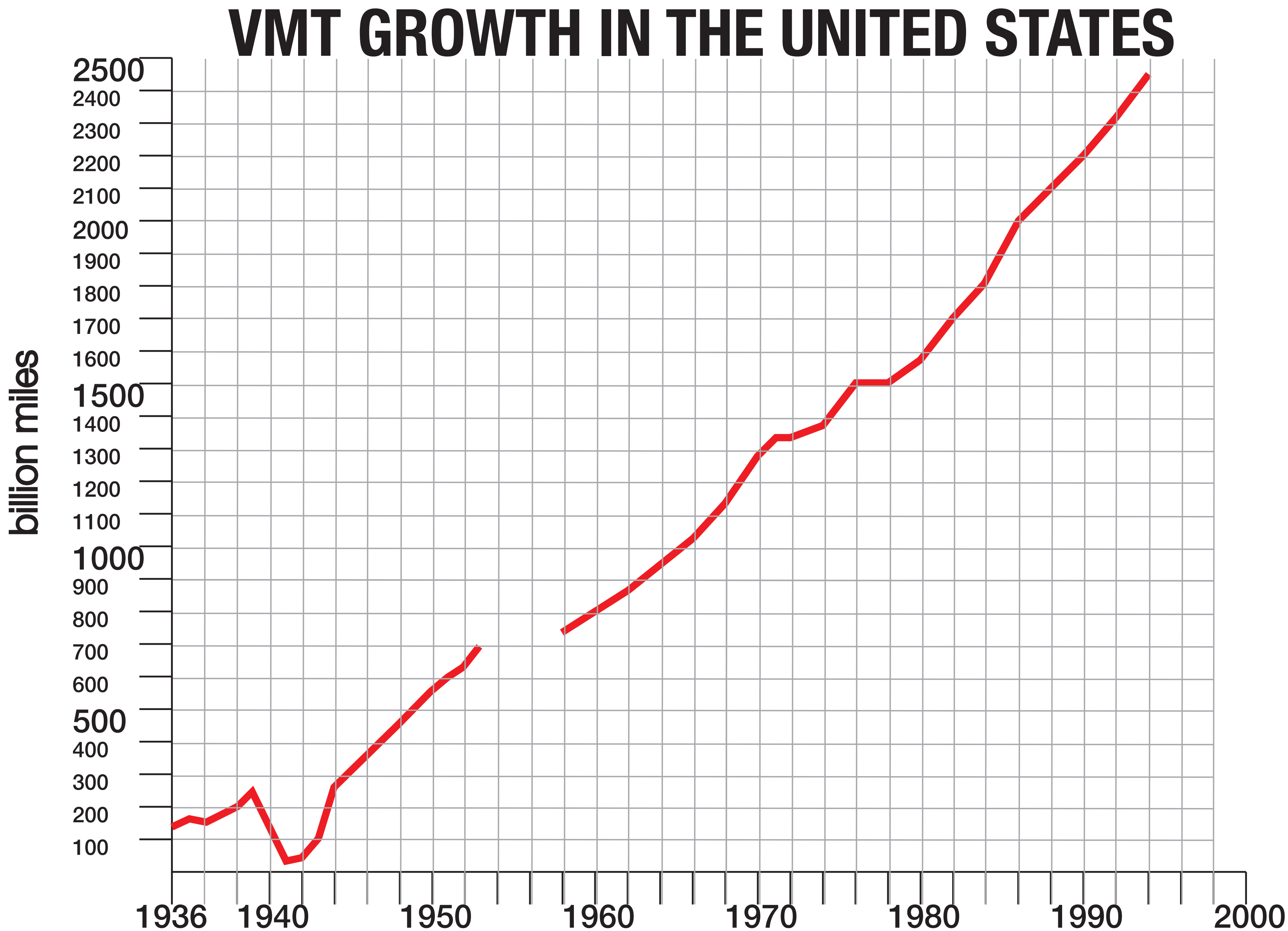

Figure 20: Vehicles Miles Travel growth in the United States from 1936 to 1998

which provided financial assistance and mortgage insurance, had a profound impact on building a decentralized and auto-oriented metropolis. In its 1935 circular, *Subdivision Development,* the Administration "insist[s] upon the observance of rational principles of development in those areas in which insured mortgages are desired" such as a minimum 10 foot lane width for traffic lanes and 50 foot frontage for dwelling lots. The following year, an FHA bulletin proclaimed: "the gridiron plan which has been so universally adopted in most of our cities has several very decided disadvantages."[63] Parking provision was also entrenched systemically, and according to a 1947 report by the ENO Foundation 70 cities in the country had included parking standards as part of their zoning requirements. The ENO report concludes: "the parking problem can be effectively tackled through zoning requirements."[64] Despite legal challenges from some property owners, courts upheld parking requirements as part of zoning codes. In Massachusetts, the Supreme Judicial Court ruled in 1966: "the reasonable premise of requirement for off-street parking spaces for new buildings is that parking automobiles nearby is an established function of the use of any building."

Such sweeping changes and regulations could not have been advanced if the interests of the auto were not also aligned with the perceptions of the majority of Americans: Americans who now overwhelmingly traveled (and had to travel) by car. These perceptions were also shaped and reinforced by multi-media marketing by the hegemony of petroleum, automobile and road-building lobbyists, who helped sell the vision that the auto was central to the American way of life. Unfortunately, those displaced to build freeways into cities were usually the poorest members of society and a politically weak minority who lived in the walkable core of the city: they often could not afford the auto, but neither did they need it by virtue of the urban environment in which they lived. Ignoring the socioeconomic damage of the urban freeway and urban renewal was intrinsic to the ruthless efficiency of driving the automobile city forward.

Although heavy-handed highway projects would be unthinkable today, the tragedy still continues. Whereas complete gridlock or crawling travel speeds could be considered the very "human misery" that Hardin forewarns, in the concrete commons the "mutually agreed upon coercion" in the form of taxation and spending to expand the commons have actually worsened misery over the decades. Vehicle Miles Traveled (VMT) has grown dramatically over the last six decades, reaching a national total of approximately 3 trillion miles per year in 2010. (**figure 20**) And with this growth in VMT, mobility and access to opportunity have become inextricably linked with a dependence on unsustainable and insecure fossil fuel energy. Every year the *Urban Mobility Report* published by the Texas Transportation Institute (TTI) issues its highly publicized Travel Time Index measure, which invariably warns that congestion and delay in the nation's transport system is getting worse. In 2011, the report estimates national congestion costs exceeding $100 billion

63 Ben-Joseph (2012), 83-84
64 Ben-Joseph (2012), 76

and that the average annual delay experienced by each commuter has increased to 34 hours from only 14 in 1982. These startling figures are often cited as evidence of a worsening congestion crisis in the nation, and used to summon the political will for more capacity based interventions and the expansion of both road and transit systems. However, misleading political interpretation of mobility-based measures in the TTI report also continues to erroneously support the notion that more highways can be part of the solution, rather than the source of misery in the first place. The TTI report relies on the ratio of congested travel time during the peak to the free flowing time off-peak to define delay, therefore implicitly assuming that uncongested travel is not only desirable but also achievable (a notion dispelled by Downs' principle of triple-convergence). Instead, in the report *Driven Apart* (2010) published by CEOs for Cities, congestion is measured based on trip distance and total travel time. *Driven Apart* reports that the most hours spent in traffic are in places like Indianapolis, Louisville and Memphis (where densities are low and destinations are far apart), and not in the traditional targets of criticism like New York and Chicago (where peak-period congestion levels may be high but locations are closer together

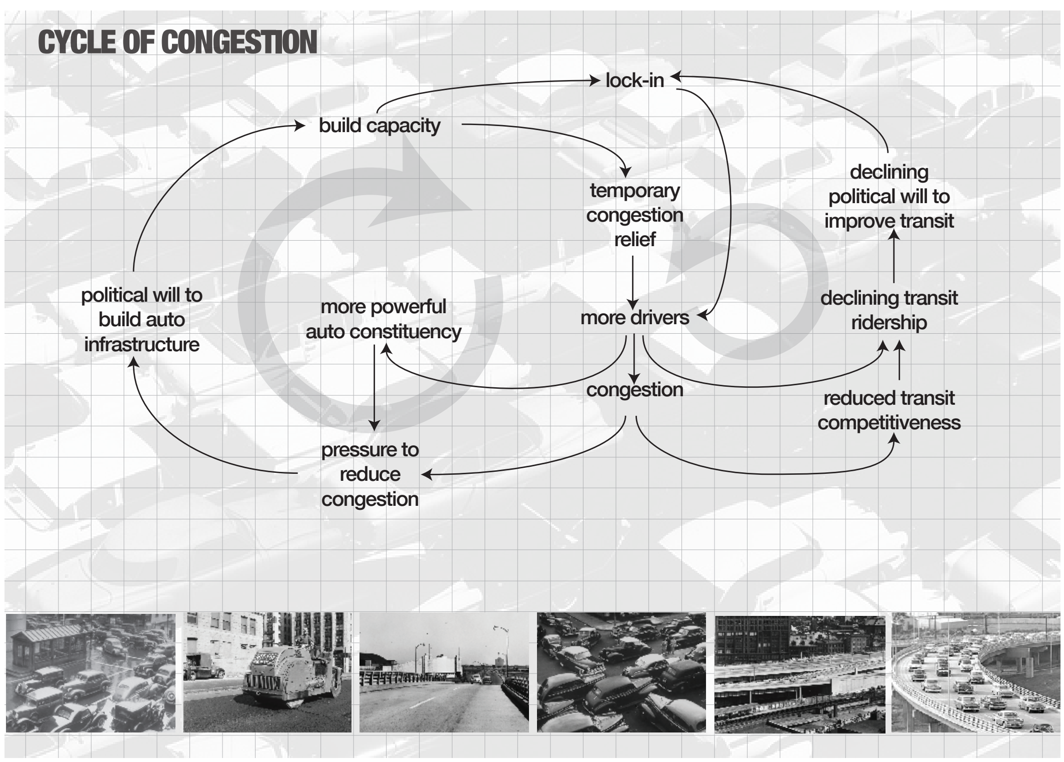

Figure 21

and more easily accessed by walking and transit).

1.4 Toward a model of automobile growth

"First we shape the cities - then they shape us"
– Jan Gehl

Three brief narratives of the growth of the automobile in American urban areas have been presented: the story of design, planning and engineering of infrastructure and physical space; the micro-economic model of demand responses to changing supply; and, the political perspective to investment in highways and urban renewal. The initial growth of the car in the city may have been an unplanned and exogenous expression of consumer demand for motorized mobility. However, the initial growth story rapidly became a self-enforcing process through the impacts of the car and car-oriented philosophy on urban design, zoning, metropolitan decentralization, suburban development patterns, individual travel choice and the political will. But, this series of outcomes did not need to be necessarily so. Congestion has been shown to be a self-limiting problem in a physical sense. However, highway engineers, land use planners, the public, and political decision-makers accepted the myth of capacity building as the solution and as key to the competitiveness of cities, thereby contributing to a vast expansion of the road-based transportation system.

Despite the fascination with the study of travel demand in the field of transportation planning, the public sector is primarily engaged in the enterprise of managing supply. The design impacts of roads and freeways on walkability, as well as the impact of an expanding and increasingly auto-oriented transportation system on individual decision making demonstrate how the provision of transportation supply has not only induced demand but also locked-in behavior. At the same time, this very lock-in supported the political will to further expand the concrete commons by creating worsening traffic conditions and a large and agitated constituency who rely on the automobile as a necessity for accomplishing life activities. However, without the collective decision to build infrastructure, the motorization feedback loop would have been cut-off. (**figure 21**) It is the key linchpin. Supply has largely driven automobile demand (rather than the other way round) and society has been driven to congestion by the myth of capacity building and the political will to build infrastructure.

2. Case study – McGrath Highway

The McGrath corridor consists of three major segments that connect Wellington Circle in Medford in the north with Leverett Circle in Boston in the south. Traveling south from Wellington Circle across the Mystic River to Interstate 93 the corridor is named the Fellsway. In Somerville, the corridor is named McGrath Highway and runs south from I-93, over the MBTA Lowell line tracks, and further south over the MBTA Fitchburg line tracks using the Squire's Bridge. Just south of the Squire's bridge, at the Cambridge/Somerville city line, the corridor changes names to Monsignor O'Brien Highway and travels south past Lechmere Square, across the Craigie Bridge where it joins Leverett Circle in Boston and Meets I-93 again[65](**figure 22**). The focus of this thesis and case study is on the portion of the corridor through Somerville.

2.1 A legacy of infrastructure: railway, street, throughway, highway

The history of the McGrath Highway and the surrounding neighborhoods in Somerville, MA, exemplifies the broader narrative described in chapter 1 of transportation growth, infrastructure change, land use effects, urban renewal and ultimately lock-in to the automobile.

Though not easily discernable today, the area along the McGrath Highway corridor has long been of historic importance to Somerville. East of the present-day intersection of Somerville Ave, McGrath Highway and Medford Street in the area now known as Brickbottom was the location of the McLean Asylum. The Ward II area to the west of this intersection was one of the most densely built areas in the city.[66] Between 1850 and 1890 dozens of streets and hundreds of building lots had been speculatively platted east of Medford Street on and near the Asylum grounds, however, only a few were built; Linwood, Joy, Poplar and Chestnut streets, which define the present-day Brickbottom neighborhood, were platted in 1855 (**figure 23**). Railroad construction through the Cobble Hill area near the Asylum began in 1837, and in 1896 the Asylum grounds were purchased by the Boston and Lowell Railroad and the existing structures were cleared for the expansion of railroad yards. [67]

Several proposals for a cross-town boulevard were proposed between 1895 and 1925, continuing a discussion on the topic of a pleasure drive for carriage traffic started in the 1850s. In 1911, a Cambridge-Somerville boulevard was considered to link Massachusetts Avenue at the Harvard Bridge to Broadway Park. The route was to

65 The McGrath is described here in terms of its relationship with I-93 to help current-day readers understand its location in the city. However, it is important to emphasize that the corridor was conceived of and constructed decades before even the concept of I-93 was put forth. At that time, the spatial logic of the corridor was a connection between the Mystic River and Charles River.

66 Zellie, C (1990), 37

67 Zellie, C (1990), 90

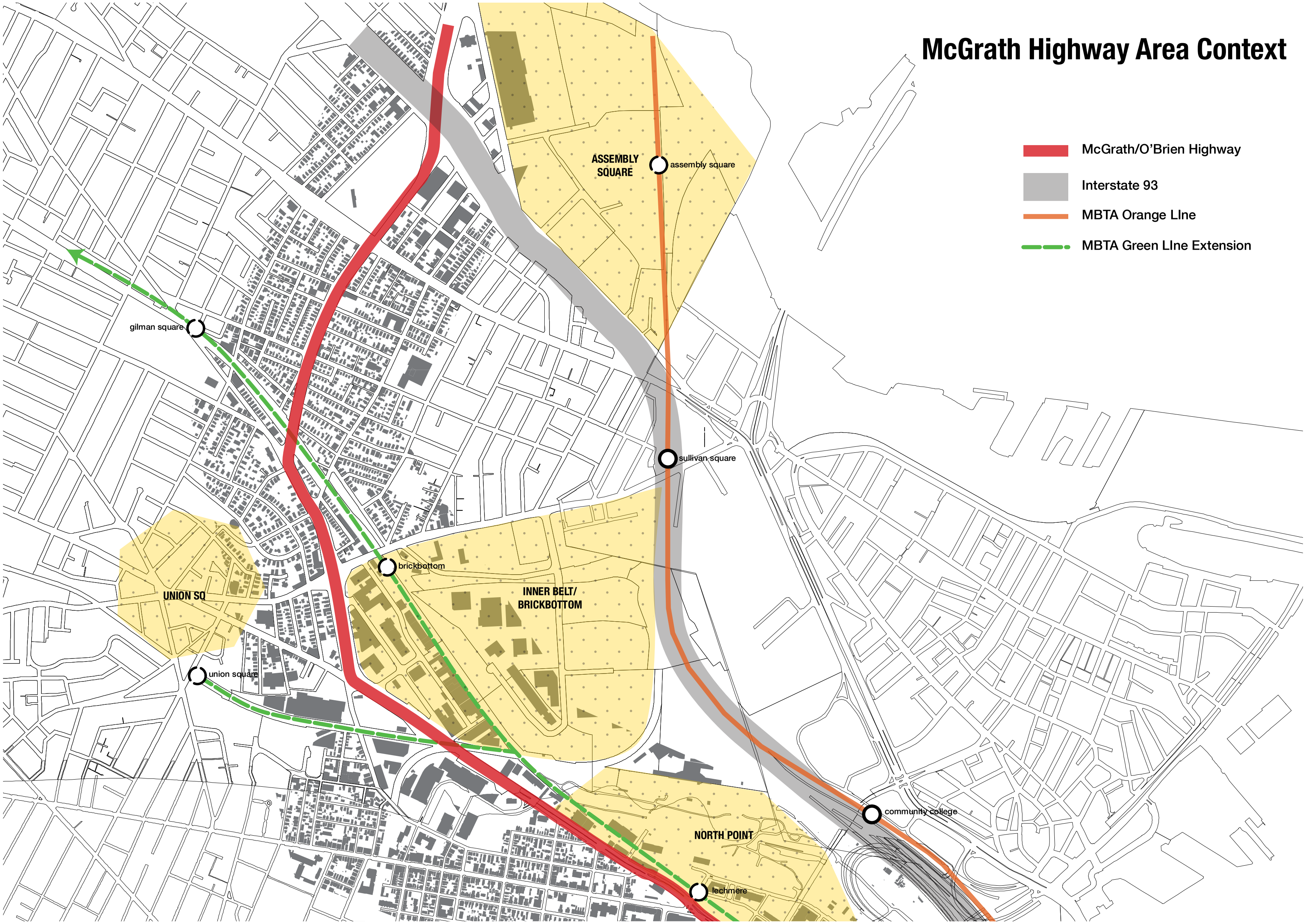
McGrath Highway Area Context
McGrath/O'Brien Highway
Interstate 93
MBTA Orange LIne
MBTA Green LIne Extension
ASSEMBLY SQUARE
assembly square
sullivan square
gilman square
brickbottom
INNER BELT/ BRICKBOTTOM
UNION SQ
union square
NORTH POINT
lechmere
community college

Figure 22

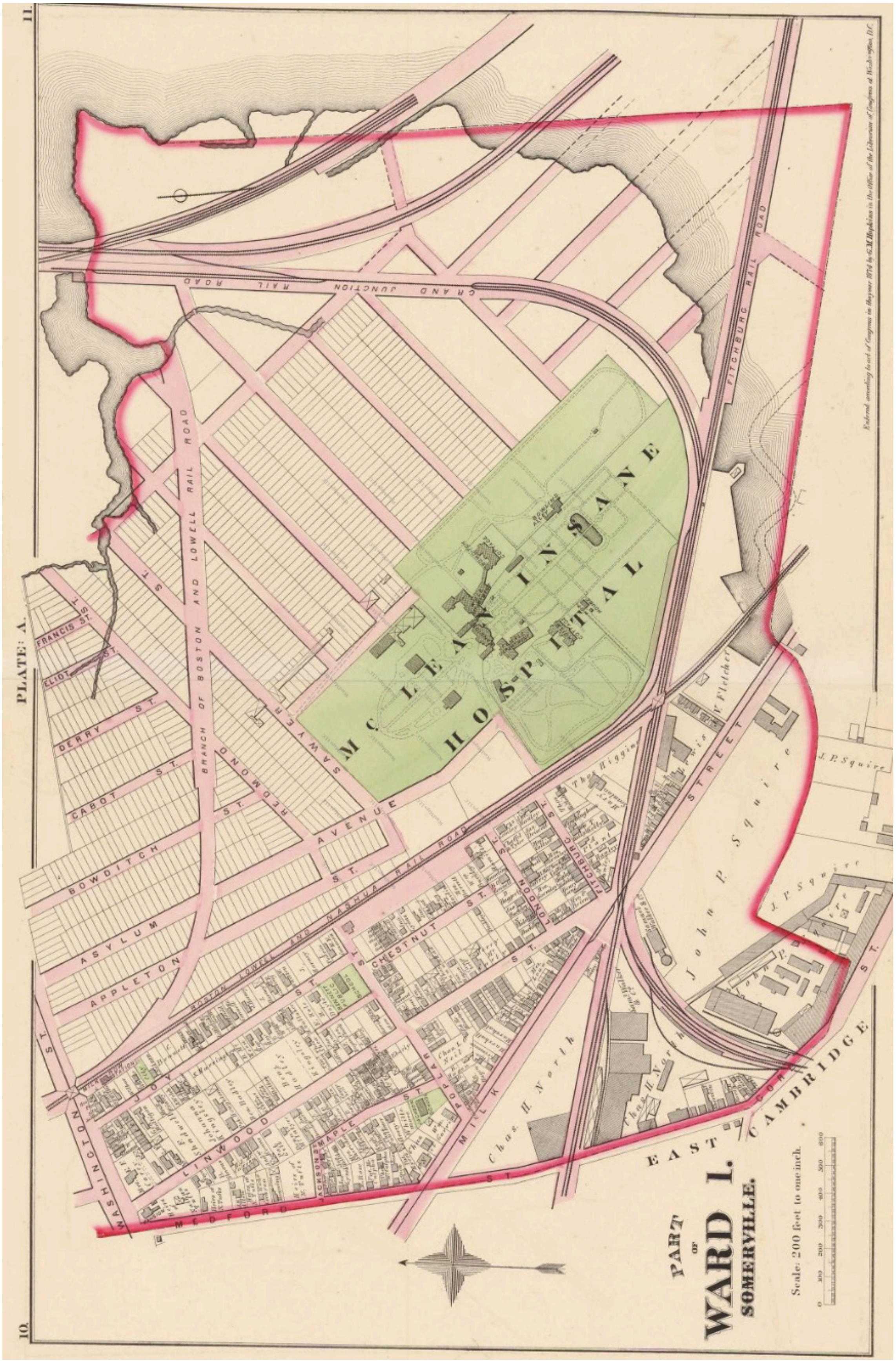

Figure 23: Atlas of The City of Somerville, 1874 by G.M. Hopkins & Co.

SOMERVILLE 1895
Path of 1925 Northern Artery

Figure 24 Path of 1925 Northern Artery superimposed on Atlas of the City of Somerville (1895)

follow Webster Ave, Prospect Hill Ave, Cross St, and link with the Fellsway across the Mystic River. [68]

In 1927, Boston Globe reporter Donald Willard wrote: "Not long ago a noted humorist wrote a sad little skit about a man who had his troubles in traffic. This motorist left home early in the morning, equipped with a radio, lunch and supplies for a week… Was the humorist exaggerating when he describe the traffic jam in such picturesque hyperbole?" To see for himself, Willard drove the city streets of central Boston for several hours during the most congested periods and measured his speed and waiting times at intersections. From the pioneering data-driven approach he concluded: "there is no question that traffic is heavy, with more than 200,000 cars coming into Boston every day, and most of them going out again every night, there is bound to be some congestion. Under normal conditions, however, there seems no insuperable difficulty in getting about… the observer found that traffic conditions in Boston are not half as bad as they look."[69]

Despite Willard's observations transportation planners and land use planners undertook bold actions to accommodate the automobile along and around the McGrath corridor. The Cambridge-Somerville boulevard discussion culminated in the construction of the Northern Artery in 1925 (renamed McGrath Highway in 1933), to provide a high-speed automobile connection between the Charles and Mystic Rivers. The southern part of the alignment of the Northern Artery followed the existing paths of Bridge Street, Somerville Ave and Medford Street. However, between the intersection of Medford St/Highland Ave and Broadway, and unlike the proposed boulevard of 1911, the Artery's alignment ran straight through the densely populated neighborhood and demolished dozens of homes fronting Aldrich St and Dana St. (**figure 24**) In total, construction of the Northern Artery demolished 220 lots and 200 homes.[70]

The Northern Artery divided the East Somerville and Winter Hill neighborhoods and also isolated from the rest of the city the few residential streets built in Brickbottom.[71] During the construction of the Northern Artery, the Boston Globe recognized the undesirable effect of road capacity expansion on the neighborhood: "for the whole three-mile stretch from Mystic av, Medford, to Commercial av, Cambridge, the 100 foot swath of the new highway shows like a huge scar upon the thickly settled communities… through which the grotesque claws of steam shovels have gashed the path." [72] Despite this disruption to the form of the existing city, the Northern Artery wounded but did not completely break the walkable urban fabric

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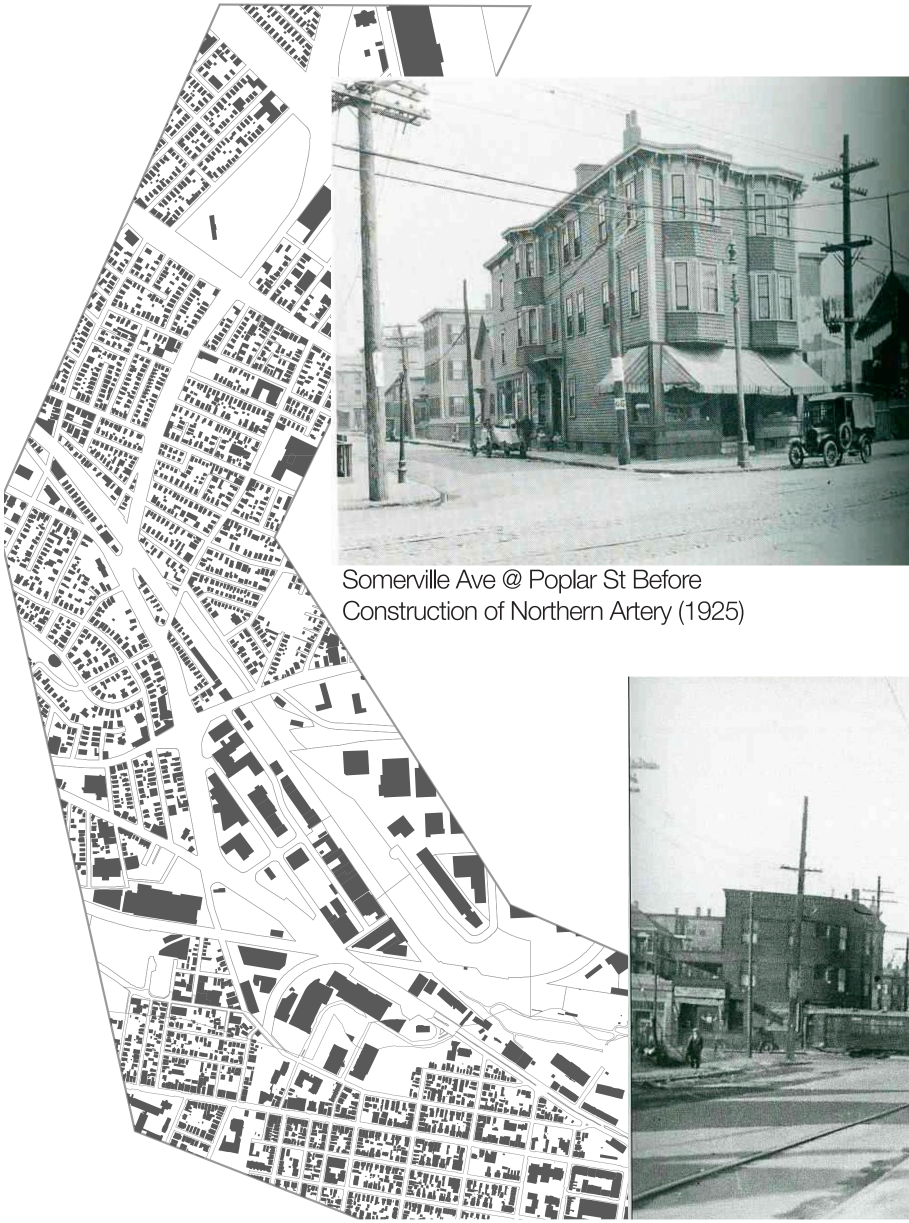
68 Zellie (1990), 48

69 "Autos Slide Through Rush-Hour Traffic Easy As You Please." Donald Willard. Boston Daily Globe; Nov 6, 1927; B1

70 Spicer (2011), 46

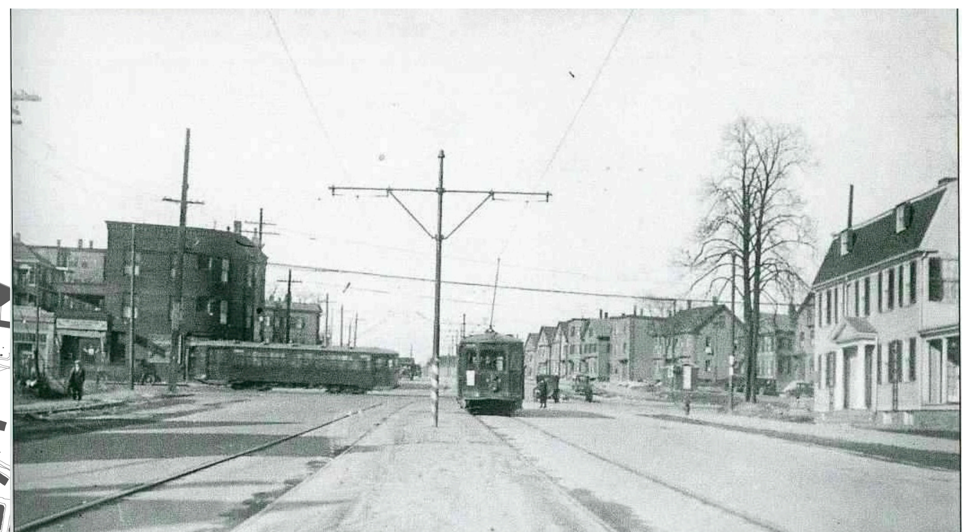
71 Zellie (1990), 48

72 "Girders of Bridge Soon Will Link Sections of Big Northern Artery," Boston Globe. 17 August 1926; 13



Somerville Ave @ Poplar St Before
Construction of Northern Artery (1925)

Three-decker commercial and residential units.
Buildng has cafe and grocery at ground level. (1925)



Two streetcars at junction of Northern Artery and

Figure 25

since it accommodated major streetcar lines that generated pedestrian interactions between the street, sidewalk and adjacent buildings. (**figure 25**) Furthermore there is evidence of efforts made to mitigate or minimize the impact of the Northern Artery on the urban fabric, as another news article remarks how: "engineers have neatly performed an operation on the big brick building in East Cambridge which jutted out into the widened thoroughfare. They have cut a slice off this building and moved the front wall back 20 feet."[73] Aesthetics were also given some consideration during construction, as "a grass plot will be placed between paving block lines in the middle of the street. This will serve the double purpose of separating traffic and beautifying the boulevard."[74]

Following the trajectory from street to throughway to highway, the McCarthy Viaduct was built in 1955. The overpass is a 4-lane structure that elevates a 0.51 mile section of the McGrath Highway corridor between the Squire's Bridge and Medford St/Highland Ave. In doing so, the McCarthy Viaduct creates a grade separation of traffic at the intersections of Somerville Ave/Medford St and Washington St, and on- and off-ramps to the elevated are provided at these intersections. (**figure 26**) Building the McCarthy Viaduct and the associated surface roads further scarred the area and doubled the width of the corridor between the Somerville Ave and Washington St intersections. This required demolishing a substantial number of the buildings along the eastern side of the alignment that provided the Northern Artery with something of an urban context and street façade. (**figure 27**) The current configuration and alignment of the corridor remains essentially unchanged since the construction of the McCarthy Viaduct. However this part of Somerville faced the threat of urban renewal and further highway construction for several decades.

The 1948 Master Highway Plan for the Boston Metropolitan Area proposed a network of radial freeways including an elevated Northern Expressway (I-93) through Somerville to connect the downtown Central Artery to Medford and points north. The 1948 plan also proposed an Inner Belt Expressway (Interstate 695) to circulate traffic around the radial system of freeways. The proposed alignment for an elevated Inner Belt highway of 170-300 feet in width would run through the Brickbottom neighborhood westward, interchange with McGrath Highway near the Squire's Bridge, and then continue westward to meet an extension of MA Route 2 in Somerville's Union Square. (**figure 28**) Plans and alignments for the Inner Belt were revised numerous times through the 50s and 60s. **(figure 29)** The proposed Inner Belt and the Southwest Expressway through Jamaica Plain and Roxbury were abandoned in the early 1970s by the protest of local citizen anti-highway movements that lead to a realignment of local and state political positions on freeway construction.

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73 "Northern Artery, Three-Mile Crosscut, In Last Stages Of Construction." Boston Daily Globe; Oct 19, 1926; A12

74 "First Stretch Of Roadway Of Northern Artery Laid." Boston Daily Globe; Sep 15, 1926; A32

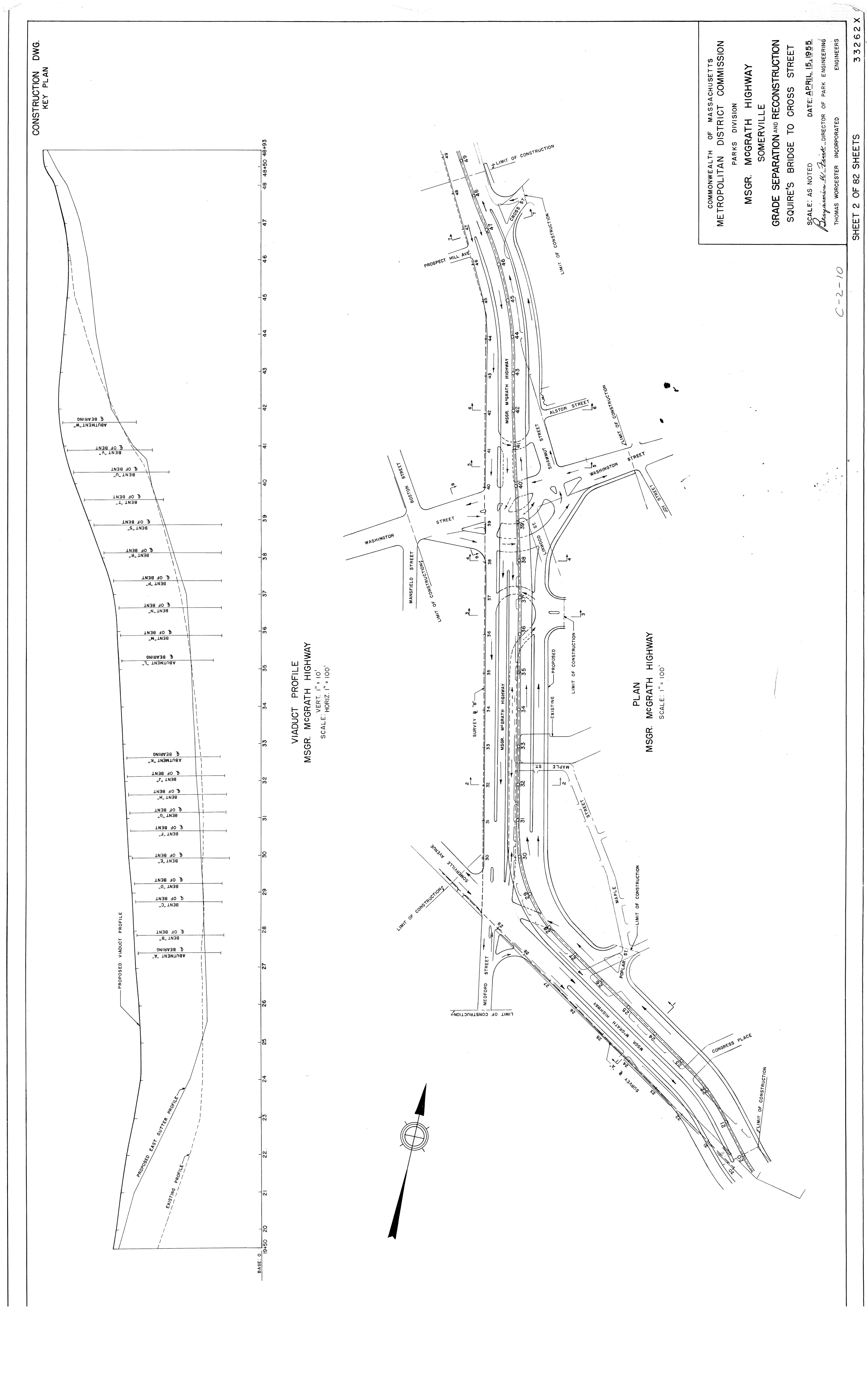

Figure 26: 1955 Contsuction plans for McCarthy Viaduct

ROAD WIDENING AND LAND ACQUISITION
1955 construction plans for McCarthy Viaduct

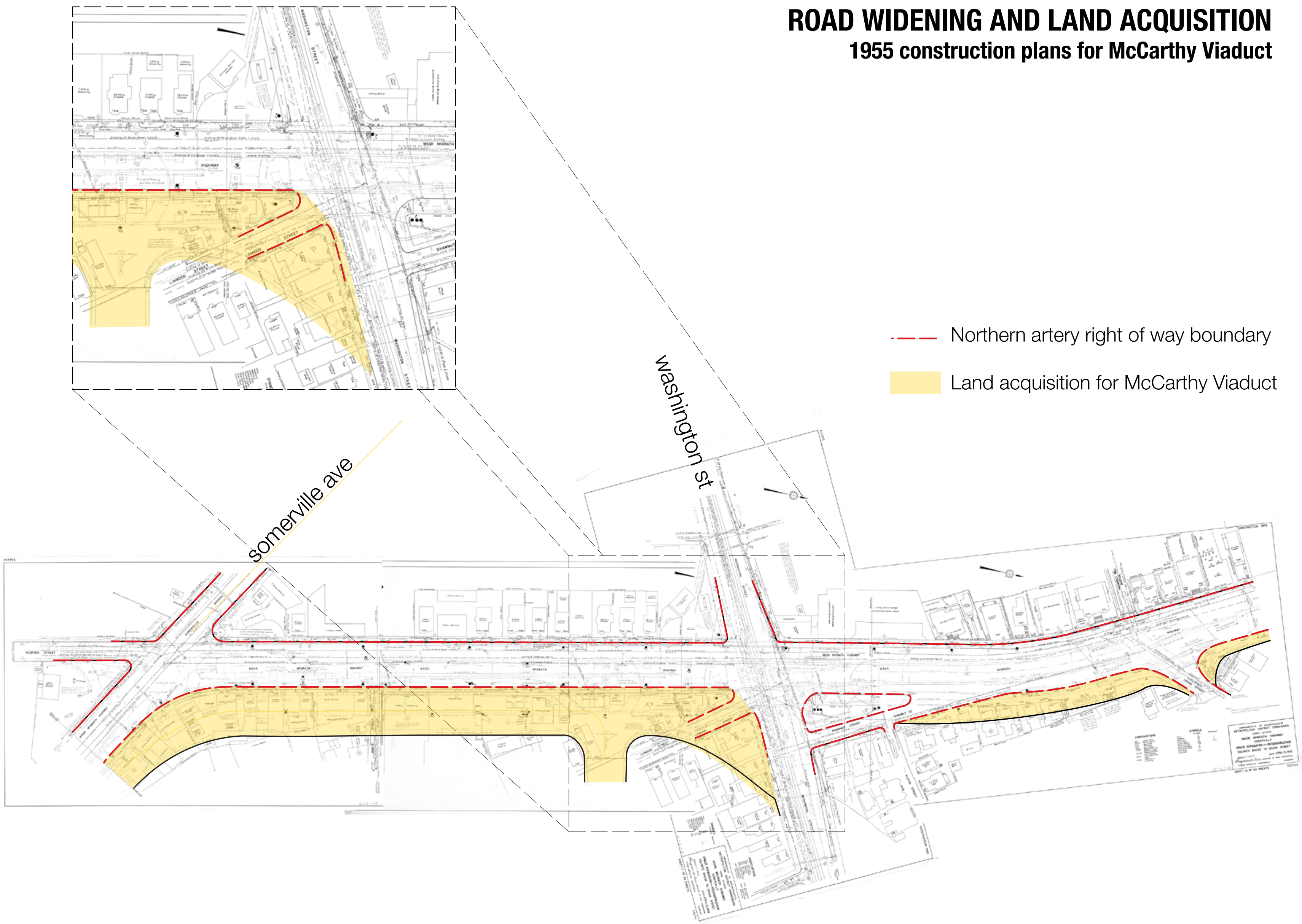

Figure 27

INNER BELT PROPSAL
1948 Master Highway Plan for the Boston Metropolitan Area

Figure 28


INNER BELT PROPSAL
1967 Alignment Concept
INTERSTATE
ROUTE 93
SOMERVILLE
CAMBRIDGE

Figure 29

However, by this time I-93 had already been built from New Hampshire up to the Medford/Somerville town line and was dumping thousands of vehicles down Mystic Avenue and McGrath Highway. Given this condition, community activism shifted away from stopping the completion of I-93 and toward advocating that the section through Somerville to the Central Artery be built as depressed highway to minimize its impact. However, I-93 was ultimately constructed as an elevated route that again displaced hundreds of families living in the dense neighborhoods characteristic of Somerville.

Although the Inner Belt was stopped, housing in the Brickbottom neighborhood and the adjacent neighborhood to the east between the MBTA Lowell Line and I-93 (now called Inner Belt) were cleared in the 1950s for an urban renewal plan to create a Somerville Industrial Park that would benefit from the anticipated highway network. The purpose of the renewal plan was to destroy the existing neighborhood grid pattern and to reorganize the area to accommodate the Interstate, provide automobile circulation and parking, and establish single-use zoning. Prepared by the Somerville Redevelopment Authority, an agency of the City, the 1968 the Urban Renewal Plan for the Inner Belt area aimed to:

> "provide a new and significant entrance to the city from the Inner Belt…; to improve the traffic circulation pattern of the City and of the Area through the correction of conditions contributory to traffic hazards and congestion and, more specifically, through... the widening and realignment of streets... the elimination of narrow and congested minor streets... the provision of adequate off-street parking; to eliminate blight and blighting factors and to prevent the recurrence of blight by the clearance of structures which are structurally substandard… by the relocation of residential uses and incompatible nonresidential uses." [75]

The primary driver of form and the control of development intensity in the plan was "the quantitative relationship between floor space and off-street parking, loading, and landscaping areas.[76] A real estate booklet advertising the anticipated industrial district describes Inner Belt as a "unique parcel [which] combines the advantages of a suburban type development in a downtown location."[77] Ultimately the comprehensive plan was not realized and the Inner Belt and Brickbottom neighborhoods redeveloped incrementally. The area is now characterized by windowless one-story concrete block style structures set back 20 to 30 feet from the roads in which warehousing, distribution facilities and light manufacturing are the primary activities.

The construction of the McCarthy Viaduct which elevated McGrath Highway, as well as the building of I-93 two decades later, created disruptions in the city that

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75 City of Somerville (1968) 3-4

76 City of Somerville (1968), 16

77 City of Somerville (2008)

were quite detrimental both in their linear and area effects. The elevated structures are significant visual and physical barriers that lock-in the Brickbottom and Inner Belt areas and leave them inaccessible for development. Kevin Lynch (1990) writes about how the disamenity value of elevated highway structures in central areas creates "urban remnants," citing McGrath Highway as a prime example:

> " Linwood Avenue, in inner Somerville, Massachusetts, is typical of such marginal areas. Isolated behind the elevated McGrath Highway, it is accessible only by a single indirect entrance. Its low, repatched, concrete block buildings, spotted with signs, are closed in on themselves. They are warehouses, services industries, and repair depots. They stand within ragged dirt and asphalt yards, full of discarded objects. The broad streets, surfaced in cracked and oily paving, have no regular edges, but are sporadically lined with broken chain-link fences. An ugly, polluted, yet tolerant place... it is a refuge for infant and relict enterprises."[78]

Though Lynch is both critical and congratulatory of the place for its character, the connection between the linear impact of the highway and the broader neighborhood impact is unequivocal. Actions to accommodate the car along and around the McGrath Highway corridor have had a significant impact on the character of the area. Therefore, in reconceptualizing McGrath Highway for the 21st century around a new vision of multi-modal transportation there exists the potential to not only start reversing the pattern of lock-in to the automobile along the corridor, but also a much larger potential to free the surrounding area of its infrastructural legacy and to enable a significant area in Somerville to revitalize as walkable and transit-oriented place. Indeed, the latent desirability and development potential of the Brick Bottom area, owing to its proximity to downtown Boston, has long been recognized ever since the area was burdened by the first era of infrastructure building: the railways. An 1872 article in the Somerville Journal speculates: "the grounds, from their nearness and convenience to Boston, if laid out in streets and provided with gas and water and proper sewers would be immediately taken up at good prices… and if the asylum grounds come into the market laid out in streets and building lots we shall very soon have such a population there."

78 Lynch (1990), 113

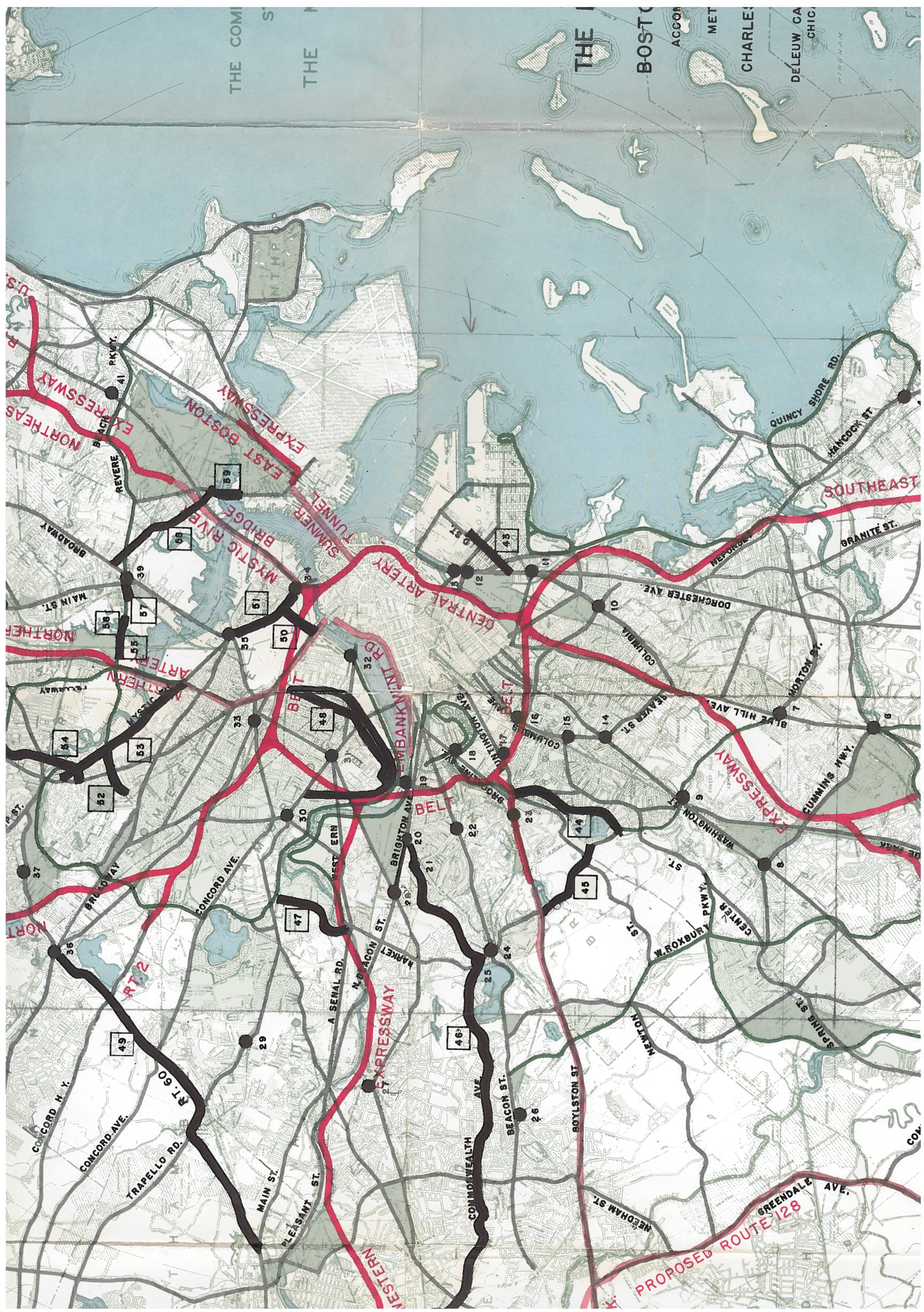

Figure 30: 1948 Master Highway Plan for the Boston Metropolitan Area

2.2 McCarthy Viaduct: reconceptualization potential

Over the past decade discussion and debate about the future of McGrath Highway have been brewing. This section describes current physical, planning and political conditions that may support the reconceptualization of McGrath Highway and surrounding areas around a more balanced and less auto-oriented vision.

2.2.1 Functional obsolescence: regional network change

The McGrath Highway corridor and McCarthy Viaduct structure were both conceived and built when the regional transportation network had a very different shape, when the road network played a different role in metropolitan mobility, and when local and regional patterns of land-use and population were different.

The Northern Artery was conceived and constructed in 1925 by the Metropolitan District Commission (MDC): ironically an agency established by the State legislature to oversee and maintain the metropolitan park system.[79] The Artery provided the primary high-speed route between the Charles and Mystic Rivers and provided access to the then outlying communities of Medford and Malden. The regional function of McGrath Highway was emphasized in the 1948 Master Highway Plan for the Boston Metropolitan Area: a more comprehensive plan for the region's roads prepared by a joint board that included the MDC, Department of Public Works (DPW) and federal assistance from the Public Roads Administration. In the 1948 plan, the segment of McGrath between the Charles and Mystic Rivers is designated part of a proposed Northern Expressway that would eventually extend from the origin of McGrath at Leverett Circle in Boston out to Route 128. (**figure 30**) To support this role the plan proposes grade separations for McGrath Highway with an underpass at Somerville Ave/Medford St and an overpass at Washington St. The construction of the McCarthy Viaduct in 1955 built both of these grade separations as overpasses.

However, the regional function of the McGrath Highway was cast into doubt by plans for the Interstate system that were developed after the McCarthy Viaduct was constructed. By the mid 1960s, highway plans developed by DPW showed a different path for the Northern Expressway (I-93) that did not use McGrath Highway, but instead follows the basic alignment of I-93 that exists today and that connects directly with the Central Artery. The section of McGrath Highway north of Washington Street was not even designated a "major arterial" in the plan of the mid sixties. (**figure 31**) Nevertheless, the planning process did not incorporate a mechanism to revisit the need and function of existing infrastructure in light of new facilities and changing facts that may replace or reshape the role of the existing. Another telling example of this in the Boston area was the steadfast reluctance of Interstate planners to abandon the proposed Inner Belt segment through Roxbury after the MassPike was extended into the city – even though the highway department's own numerical models showed that the MassPike provided the same traffic functionality and made the Inner Belt redundant and underutilized.[80]

79 Department of Conservation and Recreation (2012)
80 Remarks by Fred Salvucci, April 23, 2012

Figure 31: 1956 Boston Area Highway Plan

Observations of traffic behavior on McGrath collected over the past decade also suggest a mismatch between the corridor's design as a limited-access through route that emphasizes regional mobility and actual use patterns as a distributor route for local accessibility. In 2003 the Central Transportation Planning Staff (CTPS) conducted a corridor study of Route 28 (the state highway designation for McGrath) using data collected prior to the completion of the Central Artery/Tunnel project. The study used traffic counts and a license plate trace of vehicles to understand origin-destination patterns and the "extent to which the roadway is used for long-distance travel that may actually "belong" on I-93." Of the vehicles observed using the corridor southbound at Otis St in the AM, 58% were from the immediate vicinity including Somerville, Cambridge, Medford, Everett, and Malden. The balance originated in communities to the north and northwest with good access to southbound I-93, and it was speculated these vehicles enter McGrath via I-93. Approximately 11% of AM inbound vehicles observed at Otis St were observed to continue through to the Museum of Science, leading to the conclusion that the McGrath is "used far less as a through facility to Boston than as a collector/distributor facility between origin and destination towns that are not served well by I-93."

Repeating the origin-destination study in 2011 CTPS finds that approximately 14% of the vehicles observed at Otis St inbound in the AM follow through to Boston. Although the relative share of regional through users has changed slightly between 2003 and 2011, the absolute number has declined by about 1000 since total Average Daily Traffic (ADT) in the corridor has decreased by 27% (from 43,000 to 32,000) after the opening of the Central Artery/Tunnel.[81] These observations suggest a decline in the regional importance of McGrath Highway compared to when it was conceived, and that the corridor is not being used primarily as a through route to Boston but rather as a distributor road for trip destinations in Somerville and Cambridge. In addition to the 14% of vehicles using McGrath as an alternative to I-93 in to Boston, a notable amount of the remaining so-called 'local' traffic originating north of Otis St is likely destined toward the major employment hub of Kendall Square and should therefore be considered regional in nature too. This speculation is supported by the observation in the 2011 CTPS study that 62% of the AM inbound traffic observed at Otis St enters into East Cambridge (which provides a cut-through to Kendall Sq) through Medford St (16%) and other access roads such as Rufo Road, 3rd Street, and Land Boulevard.[82]

There is also increasing interest in reconsidering the existing design of McGrath Highway as a regional facility in light of the a legal commitment by the Commonwealth of Massachusetts to extend the MBTA Green Line from its terminus at Lechmere northward to Union Square and Medford Hillside. Projected to open

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81 Grounding McGrath Working Group Meeting #2, Aug 3, 2011
82 CTPS (2012)

between 2016 and 2020[83], the Green Line Extension (GLX) will run in disused railway right of way that lies within a few hundred feet of McGrath Highway in the section of the corridor between Lechmere and Medford St/Highland Ave. As such, the GLX will serve many of the same origin-destination patterns as McGrath Highway and offers the potential for mode shift away from the automobile and on to public transit. In addition, a new infill station on the MBTA Orange Line at Assembly Square that is under construction will provide another transit alternative that may help intercept automobile trips into Boston originating from Somerville and points north. Furthermore, the proposed (but currently on-hold) plans for Urban Ring bus service will also improve transit accessibility to Kendall Square and Lechmere, which are major origins and destinations for McGrath Highway users. Although transit cannot completely replace the need for a roadway, the scale of the proposed changes is substantial and the transformative potential quite significant. For example, the forecast increase in boardings of 30,700 passengers per day on the GLX on opening day[84] is of a similar order of magnitude to the ADT of 32,000 on the McGrath Highway. Furthermore, transit ridership tends to be skewed toward the peak hours which is when roadways get overloaded. Since peak hour traffic volumes tend to drive roadway designs that end up oversized the other 22-hours in a day, transit ridership may have a substantial impact on reducing operating and design pressures for a reconceptualized McGrath.

2.2.2 Functional obsolescence: substandard design

Despite the intent of improving traffic flow and throughput by providing grade separation, the McCarthy Viaduct and its ramps and adjoining surface roads have created an extremely complex situation.

The design of the supporting piers and bridge abutments of the McCarthy Viaduct is such that they occupy the entire width of the overhead cross-section. As such, the elevated roadway does not substantially increase the number of travel lanes that can are accommodated at-grade within the right of way since the footprint of the elevated lanes consumes most of the space beneath them. (**figure 32a,b**) Instead, the primary functionality of the elevated section of McGrath is that it allows vehicles to 'flyover' intersection delays at Washington St and Somerville Ave. With some traffic diverted overhead on the viaduct the performance of at-grade intersections should also (in theory) improve since there remain fewer vehicles to process. Yet, while freely flowing conditions are observed on the elevated viaduct throughout the day and the flyover principle is achieved for vehicles using it, conditions in the at-grade intersections are very poor.

Given the usage pattern of McGrath Highway as a local distributor discussed above, many vehicles are headed for the Washington St and Somerville Ave intersections. However, these flows are crowded on to two-lane off ramps that are constrained in

83 The opening of the project has been postponed from 2011 and then 2014. A discussion of this delay is provided in chapter 4.3.4

84 Massachusetts Department of Transportation (2010)

their capacity to process the existing volumes. The McGrath design also inhibits access to the Inner Belt area from the north and west. Paradoxically, the flyover effect enabled by the viaduct may be contributing to significantly worsening overall conditions in the corridor since there may be a misallocation of space in the right of way: too much space used by the elevated to provide regional mobility and too little on the surface roads to provide local accessibility for vehicles and pedestrians. As such, reconfiguring McGrath Highway as an at-grade roadway may not degrade performance for auto users since there is an opportunity to reallocate space in the right of way to more appropriate functions.

Furthermore, the McCarthy Viaduct causes complex, confusing and unsafe conditions at-grade. Though the elevated has created a landscape that is highly auto-oriented, complex lane channelization, unintuitive traffic islands, unusual signal phasing, and badly designed weaving sections at the off-ramps make the facility perform poorly even for automobile users. As a result, crash rates along McGrath Highway at the intersections of Broadway, Washington St, and Somerville Ave/Poplar St exceed Massachusetts averages. [85]

For abutting properties and those on foot or bicycle the McGrath Highway is an unpleasant and inhospitable environment. The width of the travel way, tangle of surface roads, and the hulking mass of the McCarthy Viaduct create a strong visual and perceptual barrier in the neighborhood. Beneath the underpass the environment is dark and characterized by spalling concrete, pigeon droppings, brake dust and soot. Walking along and across McGrath is unpleasant, inconvenient, and at times impossible. Sidewalk segments end abruptly and designated crosswalks are distant. At the intersection of Somerville Ave/Medford St/Poplar St there is no provision for pedestrian crossing across the corridor other than a painted crosswalk across 6 lanes of traffic (**figure 33**). In 2003 the Boston MPO concluded that bicycle travel along the McGrath corridor "is not safe" and that pedestrian crossings under the structure are difficult and lead to circuitous route choices. This effect is aggravated by the interruptions in the local street network, which would otherwise offer alternate walking routes, caused by the limited-access configuration of McGrath Highway. Where crossing are provided wait times for walk phases are long, and particularly at Washington St crossing requires endless 'hopping' between traffic islands. Concern over this lack of porosity and permeability across the corridor is heightened by the location of the future Brickbottom Green Line Extension station that will be sited on Washington St immediately east of McGrath Highway. Daily, 2,020 pedestrians are anticipated to try and access the station when it opens, or conversely, the ridership of the station may suffer if the station is perceived as inaccessible. In either case, remedial action is required. Similar concerns about pedestrian access exist with developing a potential GLX stop at McGrath and Somerville Ave (near the existing Target retail store).

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85 Grounding McGrath Working Group Meeting #2, Aug 3, 2011

McCARTHY VIADUCT SECTIONS

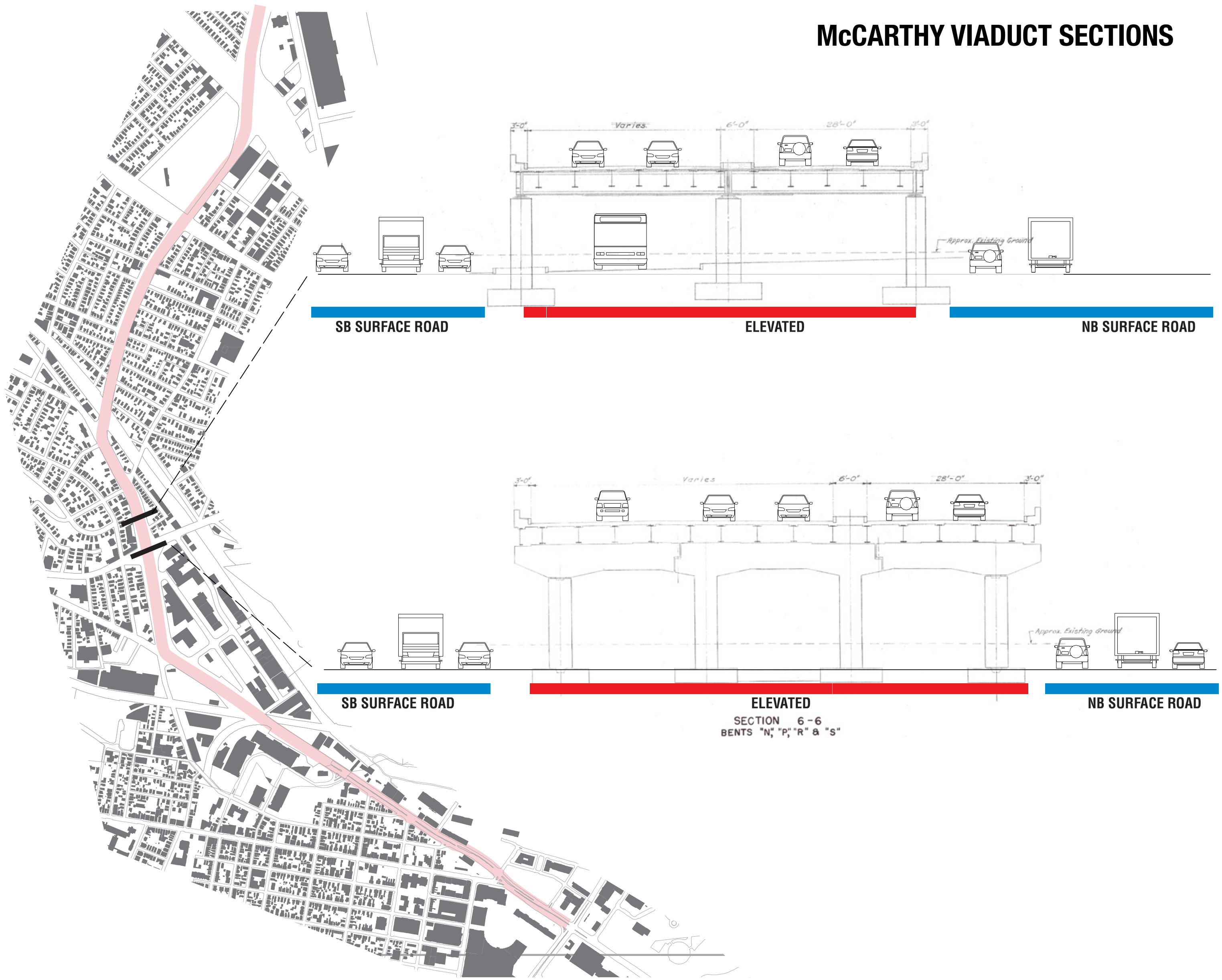

Figure 32a: Sections of the McGrath Highway north of Washington St and at Washington St

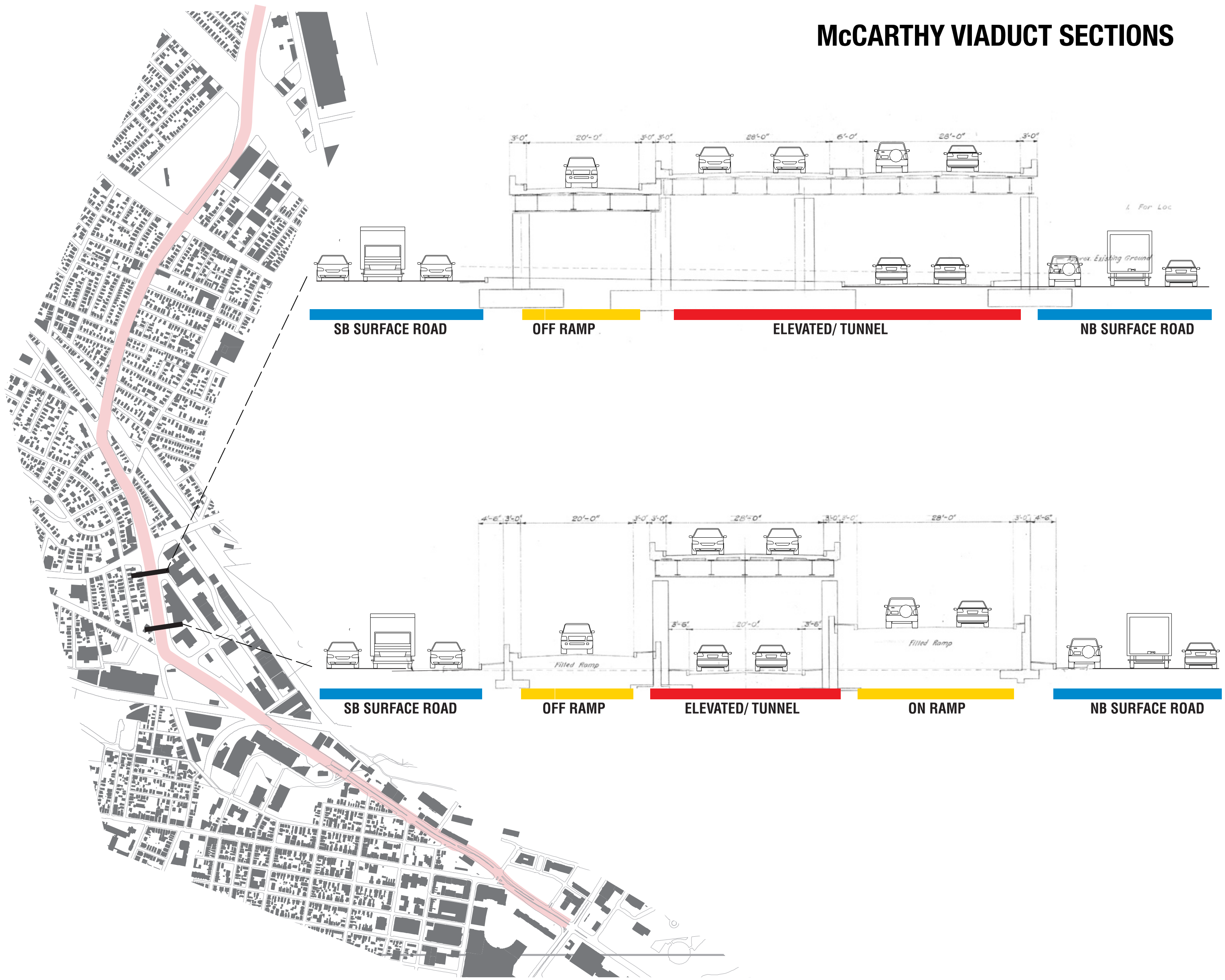

Figure 32b: Sections of the McGrath Highway south of Washington St and north of Somerville Ave / Medford St

Figure 33: Pedestrian Crossing Conditions at Somerville Ave / NB McGrath Highway

2.2.3 Political attention & planning action

The condition of the McGrath Highway has attracted political attention and led to two ongoing processes in the corridor. Because the regional function of McGrath Highway has been replaced by the construction of I-93 in the 70s, the City of Somerville has expressed a desire to modify McGrath Highway from its current classification by MassDOT as "other freeway" to an at-grade boulevard design. In response to this, as well as the other concerns about the viability of the McCarthy Viaduct, in summer 2011 the MassDOT Office of Transportation planning initiated the Grounding McGrath study as a "comprehensive effort to evaluate the feasibility and impacts of de-elevating portions of McGrath Highway." The study, which is being advised by a working group of institutional and public interest stakeholders, is being framed as a conceptual planning study (and not a formal environmental assessment or design process) and will release a package of short, medium, and long-term recommendations for the future by summer 2012. Undermining this effort, the McCarthy Viaduct is also being attended to as part of the Massachusetts Accelerated Bridge Program. The program has identified the steel in the overpass as being in "fair" condition with rusting at deck joints, and the concrete in "poor" condition with spalling and exposed reinforcement. A $14 million scope of work to address these issues has been proposed by the Accelerated Bridge Program, and the MassDOT board of directors voted to approve awarding construction contracts for this work in March 2012. (Extensive discussion of the Accelerated Bridge Program is offered in chapter 4.2)

2.2.4 Transit oriented redevelopment

More than 200 acres of land in Inner Belt and Brickbottom are now locked-in and cut-off by the McGrath, and the city of Somerville is exploring the potential of these areas as engines of economic development by improving transit access with the Green Line Extension and Urban Ring, and increasing connections in the street grid by reconceptualizing McGrath Highway as a boulevard. In its 2010-2030 comprehensive plan, called SomerVision, the City is aiming to develop approximately 10,000 new jobs and 5,000 new households in the Inner Belt/ Brickbottom district, and with a target mode share of 50% of new trips by walking, bicycle and public transit. At the northern end of the McGrath corridor in Assembly Square, 1.78 million square feet of offices, 2,100 residential units and 1.07 million square feet of retail development are planned over the next decades. At the southern end of the corridor in Lechmere Square, the ongoing North Point redevelopment is planned to add 3.6 million square feet of mixed-use development at full buildout in 20 years. However, without a supportive urban context and transportation network these major redevelopment plans risk being only transit-adjacent rather than transit-oriented. At the moment the Assembly Square plan includes building 1,300 new parking spaces, and the North Point plan over 6,500 spaces.

The success of economic development in nearby Kendall Square is an interesting precedent. Kendall Square is served by roadways of moderate capacity (Main St, Broadway, 3rd Street) and the MBTA Red Line. It seems dubious that Somerville, served by Interstate 93 and about to have the Green Line Extension, Assembly Square Orange Line Station, and Urban Ring connection to Sullivan Square, Lechmere and Kendall, needs McGrath highway to attract development.

2.3 Summary

There are clearly many factors that bring attention to the McGrath Highway and the McCarthy Viaduct at this moment in time: historical changes in the transportation network and local land use environment, planned expansions to public transit, aspirations for transit-oriented land redevelopment, functional, operational and structural deficiency, and political attention to address the challenges of aging infrastructure. All these factors and forces beg the question of whether it is preferable to reconceptualize the design of the corridor rather than to simply rebuild it in the same manner as conceived decades ago. Despite these opportunities and the current saliency of debate on the future of the highway, the next two chapters of this thesis examine how this window of opportunity for removing the McCarthy Viaduct may be threatened by: 1) the perceived myth of expanding automobile mobility beyond finite capacity constraints that is perpetuated by the transportation forecasting and modeling process being used in the Grounding McGrath Study; 2) dynamics in the planning process, political attitudes to infrastructure building and maintenance, and the distribution of costs and benefits; and 3) ignoring the network opportunities caused by I-93, the Green Line Extension, the proposed Inner Belt Road to North Point Boulevard bridge and the Urban Ring proposal. In these cases, current behavior and agency culture undermine generating the necessary political will to change course and remove the obsolete McCarthy Viaduct infrastructure rather than to follow the existing path of lock-in to the automobile.

3. Transportation planning & engineering – the status quo machine

Despite their statistical rigor, transportation forecasting and modeling may hinder the achievement of policy objectives for sustainability, multi-modality and livability since they depict the world as it is today – without necessarily recognizing the processes of how it has come to be. The approaches tend not to explicitly reflect the dynamics of system change, and instead can systemically overlook important pathways to modifying the transportation landscape – especially the interactions (from chapter 1) between road availability, user demand, and the political will to build infrastructure.

3.1 Modeling transportation behavior

A basic concept in transportation geography put forward by Edward Ullman is that the need for transportation arises in response to patterns of supply and demand that are localized in space. If the entire world could be compressed into a single point in space there would be no (and no need for) transportation. Therefore, the demand for travel is not intrinsic: it provides little value to travel in and of itself. Instead, travel is a demand derived from the desire to interact with economic and social opportunities that are arranged throughout the urban landscape. Although this may seem self-evident, the role of landscape as the driving force behind travel must be emphasized. The landscape of the American city has been produced and oriented toward the automobile for decades, both by transportation projects that handed over an ever-increasing amount of space for traffic and that eroded urban fabric in doing so, as well as by ideologies and practices in land use planning that sought to accommodate the automobile by decentralizing activities and de-urbanizing design. Implicit in both these sets of forces that shaped the form of the city was the notion that traffic congestion is a failure of the transportation and land-use system.

According to Boston's regional metropolitan planning organization, CTPS, the purpose of transportation modeling is to predict "how many trips will be made by people in a given region on a typical day, where those trips will go, and what modes and routes those trips will utilize" in order to "predict how many vehicles will use a new or modified roadway, or how many people will board a new or modified transit line."[86] Regional transportation models are also used to predict the transportation impacts of growth and change in land use patterns.

Overall transportation outcomes are the result of thousands of individual decisions about why, where, when and how to travel, and therefore, the CTPS explains, "travel models are built on the basis of people's observed behavior."[87] However, this section explores how models in use focus on the demand-side of the process, without recognizing the broader supply factors that have produced existing individual behaviors, and without recognizing constraints that make predicted flows impossible.

86 CTPS (n.d.)
87 CTPS (n.d.)

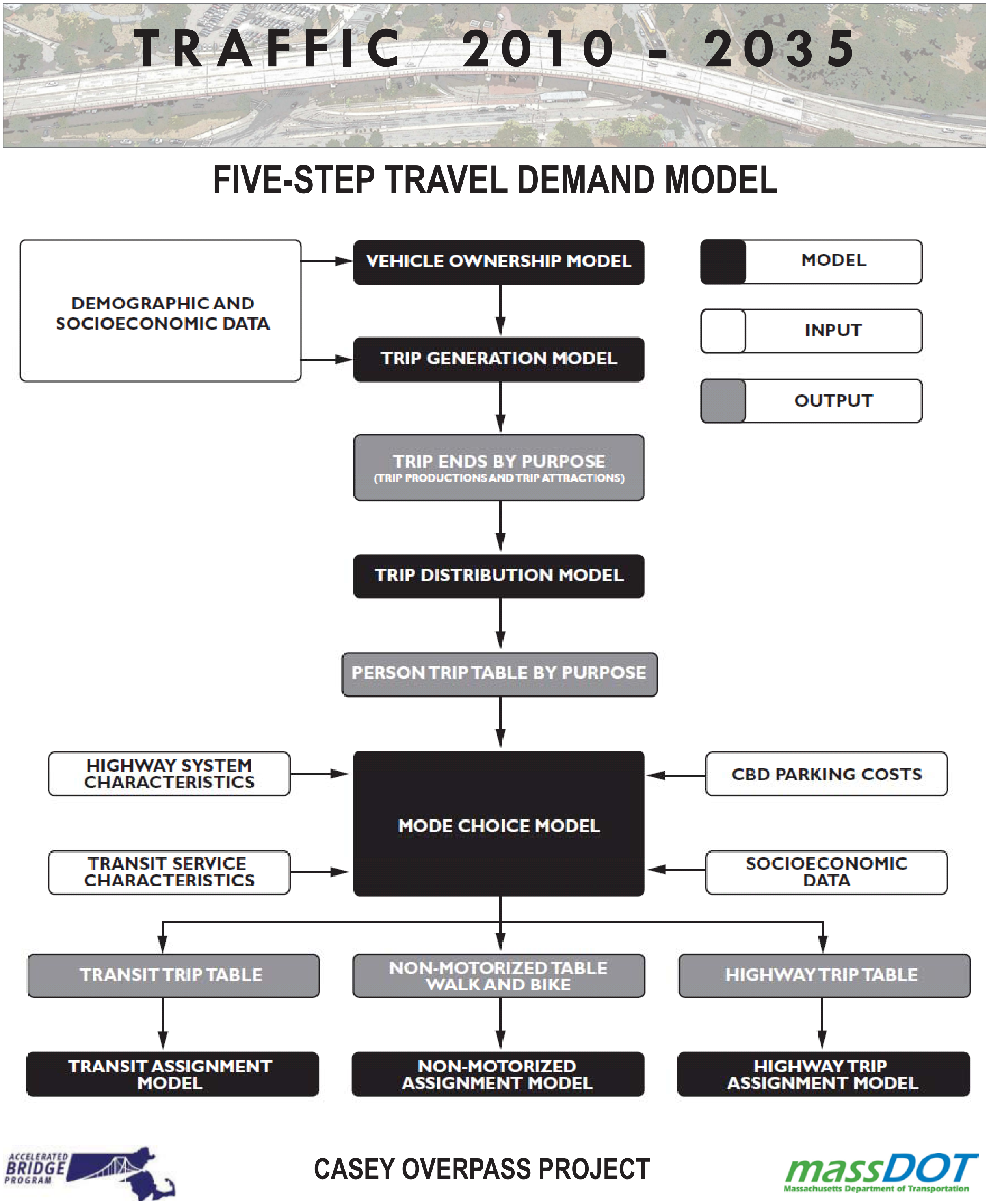

Figure 34: Schematic representation of the CTPS regional travel model from the Casey Overpass study public consultation materials

3.2 The 4-step transportation model

Transportation modeling methods were developed as part of urban transportation studies during the late 1940s and 1950s. Prior to the development of models, transportation forecasting (if practiced at all) was based on accommodating existing travel demands or forecasting future demand by applying uniform growth factors that extrapolated historical trends.[88] The use of models was substantially strengthened by the 1962 federal planning requirements; sophisticated models make possible a much more comprehensive understanding of networks and capacity constraints. Yet, paradoxically the role of capacity constraints in the application of modeling is often substantially ignored.

There have been refinements to the statistical techniques and vast increases in computing capabilities over the last decades, yet, conceptually the Boston CTPS regional transportation model used today is structured around the same 4-steps developed in the 1950s: trip generation, trip distribution, mode choice, and route assignment. (**figure 34**) These four steps are briefly described below.

Network and Zones

To operationalize the model and reduce computational complexity, the city is first divided into a series of transportation analysis zones (TAZs). TAZs in the CTPS model are approximately one square mile in size, and each is assigned values for the amount of land use and population contained within based on survey and census data. TAZs in the model are connected with a map of the transportation network (i.e. streets, highways, transit lines) so that trips moving between the TAZs can be assigned onto the actual transport system. An overall estimate of total traffic volumes is achieved by loading all the interactions between TAZs onto the network.

Step 1: Trip Generation

There are two primary inputs to the 4-step model: a description of the city's land uses and socio-demographic information about the population. Together, these two make an attempt to represent the spatial organization of activities as well as the decision-makers moving about these opportunities. When modeling the impact of future development, such as that planned for Inner Belt and Brickbottom in Somerville, anticipated values for land use and demographics are used for the TAZs where development will occur. Following the concept of transportation as a derived demand, the number of trips generated within and attracted to a TAZ is estimated based on the type and amount of activities within the zone (e.g. number of residents, offices, schools, shopping, etc.), as well as by considering relevant attributes of the individuals traveling. For example, the number of trips made by teenagers, adults and seniors is likely to vary owing to the different activity patterns of these demographics. Trip generation uses observed trip rates (from surveys) that are averages for different segments of population and different land uses. For example, a household with 4 people and two cars may produce 2 commuting to work trips per day. When

88 Weiner, ch3

complete, the trip generation step establishes a prediction of the total amount of travel that will occur. This is summarized as a table showing the number of trips produced in and attracted to each TAZ (a production-attraction matrix).

Step 2: Trip Distribution

Using the production-attraction matrix from the generation step, which defines how many trips are emanating from the households in each TAZ and attracted to the activities within it, the distribution step establishes where trips produced are going to and where trips attracted are coming from. The distribution of trips is estimated using the "Law of Gravitational Attraction,"[89] which is a model that expresses interaction between two places as a function of the size of the two places and the time-distance between them. The gravity model recognizes that complementarity between two TAZs increases with size of population in each place, that the transferability of supply (e.g. of employees) in one place with demand (e.g. for workers) in another place decreases with distance, and that likelihood of an intervening opportunity intercepting a trip increases with time-distance. The number of trips attracted between two TAZs is assumed to be directly proportional to the relative sizes of the two zones (raised by some empirically estimated exponent): as the size of an attracting TAZ grows, it will attract a greater number of trips from a producing TAZ. Also, the number of trips between two TAZs is assumed to be inversely proportionate to the distance between the two zones: as distance grows fewer trips produced in one TAZ will be attracted to another TAZ. The result of the trip distribution step is an origin-destination matrix that quantifies the number of trips moving between every TAZ and every other TAZ.

Step 3: Mode choice

In this step, the trips in the origin-destination matrix are assigned to a particular mode. Although statistically quite complex, the mode choice model consists of defining four basic elements: alternative modes of travel, attributes of the alternative mode choices, the decision rule, and the decision maker. The travel modes considered in the Boston CTPS model are: auto drive alone, auto shared-ride, walk-access transit, drive-access transit, and walk all the way. For each of these various modes of travel for a trip between any two TAZs, attributes distinguishing the modes can be measured. In the CTPS model, the attributes considered are time (divided into walking, waiting, and transfer times for transit) as well financial costs such as fares, tolls, fuel and parking. Collectively, these attributes are conceptualized as a measure of the disutility (or generalized cost) of each alternative mode choice available for a given trip. Based on the concept that travel is a derived demand, the decision rule assumed is one that individuals will try to minimize the disutility of their travel costs when choosing how to travel from origin to destination.

Estimates of traffic speed and transit travel times generated by the model are used to define the alternatives available and the cost attributes of each one for every origin

89 CTPS (n.d)

and destination pair in the regional model. Surveys of actual travel behavior are used to observe the number of people that actually choose each of the different options. Then, statistical techniques (such as regression and maximum likelihood estimation) are used to examine relationships between the attributes of a choice and number of people actually making actually that choice. This process derives equations, known as *utility functions*, which express how people perceive the different cost attributes of a mode and how all the cost attributes sum together to form an overall cost (or disutility) for that mode. However, since the sensitivity to the different time and cost factors varies within the population (with some groups likely more sensitive to cost and others to time) the process of estimating the utility functions is conducted separately for different demographic categories. Finally, the utility functions of the different alternatives are compared using another statistical technique (Logit modeling) that provides an estimated probability of choosing one alternative versus the others available based on the relative differences in the utility functions of the options. For example, if one mode were very attractive for a given trip and had a very low disutility, the Logit equation would estimate a high probability of people choosing it over an alternative that is unattractive due to high time or cost values. By comparing utility functions using Logit for every trip made in the origin-destination matrix, each trip is assigned to a mode, and an overall estimate of the number of people traveling by each of the different modes is obtained.

Step 4: Route Assignment
The model has now determined where trips are produced and attracted, where they are going to and coming from, and the number of people using each travel mode to make these trips. The final step is to determine how these trips will use the actual travel network by assigning each trip to a specific road or transit path. Similar to mode choice, the underlying decision rule in the assignment step is to minimize travel time. The process first requires determining for each travel mode the shortest path in the network connecting every origin-destination pair. In an ideal world, every trip desires to take the shortest path. However, since any given path has a finite capacity and will become congested and slow down as that constraint is approached, the shortest path may change as trips are assigned to the network. Therefore, the assignment process is iterated. Trips are shifted between more congested and less congested links until an equilibrium is reached, whereby the traffic levels (and the associated congestion and travel times) on all the paths assigned between a given origin and destination are shorter than any unused paths. The result is a final representation of trip making in the region: volumes on specific roads and the number of boardings and alightings at transit stations and bus lines. Together these define congestion levels in the system and provide an estimate of the actual travel times between every origin and destination in the region.

Outputs & Feedbacks
The model generates many outputs, including the production-attraction matrix, origin-destination matrix, and mode choice estimates. However, the most significant output is the result of the route assignment that produces an estimate of levels

of congestion and travel times. These measures provided simple proxies of the performance and user experience of the transportation system and the underlying land use pattern that generates activities. Furthermore, travel time is an important decision variable in the 4-step model: as described above it is a key *input* to the trip distribution, mode choice and route assignment steps. As such, it is the primary mechanism to account for feedback effects within the model. If a large number of trips using a link produces congested conditions and slower travel times, this in turn could shift the pattern of origins and destinations, change the relative attractiveness of different travel modes, and also impact the links used. However, it is important to note that there is no feedback in the 4-step model between travel time and trip generation. Trip generation numbers are essentially an exogenous input derived by applying fixed trip rates to the land use scenario that specifies the location, distribution and intensity of activities.

3.3 Grounding McGrath case study

In the Grounding McGrath study, the CTPS 4-step regional travel model is being used for two purposes: first, as a forecasting tool to develop a so-called 'no build' scenario, and second as a modeling tool to analyze the performance of different alternative designs of McGrath against this base case scenario.

The No-Build Scenario: Driven to Expansion

Transportation modeling is a tool to help decision-makers better understand what, if any, impact different possible planning actions may have on outcomes of interest such as traffic volumes and levels of congestion. However, modeling as practiced, and particularly the process of developing the no-build scenario, is geared toward evaluating the performance of different options given a fixed future scenario, rather than examining how different infrastructure options themselves may shape the future.

The narrative of the growth of the automobile presented in chapter 1 demonstrates how the level of traffic in cities has been shaped by transportation and infrastructure systems, and the patterns of behavioral lock-in they created. Although attitudes about accommodating or providing for traffic growth have changed since the early days of highway building, and now include dissenting voices against the desirability of road expansion, the premise of predicting and providing for traffic growth is still deeply engrained in the transportation planning process.

> "Street facilities can and should be designed for the traffic that will wish to use them. It is wrong to start with the assumption that city growth and street traffic can or should be restricted to approximately present street capacities."
> – Report on a Thoroughfare Plan for Boston (1930)

Though perhaps not as ideologically explicit as in 1930, the present day process of determining the no-build scenario essentially works to produce future automobile demand and then prescribe this future as that which must be planned for. In the

Grounding McGrath study, the forecast travel demand for the no-build year (2035) was obtained by running the CTPS 4-step model, but using as inputs 2035 values for land use patterns and transportation infrastructure adopted from the Boston region MPO's Long Range Transportation Plan. These land use and transportation inputs for 2035 include planned changes to the transit network such as the Green Line Extension, neighborhood population and employment growth projections determined by the Boston MPO, and also assumptions about future demographics characteristics (that impact trip generation and mode choice behavior) determined by the MPO.

The purpose of the model run is to "provide travel demand peak period forecasts for existing conditions [and] a future no-build (2035) [year]. Growth in trips between the base year and 2035 are supplied to the consultant to feed a local model that completes traffic and multimodal analysis on a project scale."[90] The result of this modeling process is that automobile traffic along the McGrath Highway corridor is being forecasted as 7.5-12.5% higher in 2035 compared to existing levels.

Approached this way, the Grounding McGrath study elucidates little potential to consider reconceptualizing McGrath Highway around a less auto-oriented and more multi-modal vision. For, implied in accepting the traffic growth projections is the notion that reducing automobile capacity is directionally incorrect and likely to worsen congestion. Indeed, of the five alternative design proposals presented by MassDOT to the Grounding McGrath Working Group in March 2012, four have been designed to provide capacity such that "2035 projected volumes assume no trip diversions from current patterns." One alternative aimed at lowering automobile capacity was presented – described as a "boulevard road diet" (**figure 35**) – but its viability and attractiveness in the evaluation process is still threatened since it assumes "significant trip diversions from 2035 No Build." Important stakeholders in the process, such as local Congressman Michael Capuano, have stated that "he would not like to see any changes to McGrath that would result in traffic diversions to residential streets."[91]

However, a forecast of increased vehicle traffic in 2035 is not simply an inconvenient truth that besets aspirations to reconceptualize McGrath Highway. Instead, such projections are the product of a forecasting and modeling paradigm whose assumptions and non-mathematical biases have encouraged road expansion for decades. In particular, this approach fails to adequately consider real-world capacity constraints that will curtail traffic growth, and projects existing behavioral patterns far into the future rather than allowing for behavioral change and social learning in response to a changing decision-making landscape. These shortcomings systematically undermine seeing the potential for using changes to the McGrath Highway itself as the very pathway to a different outcome by 2035.

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90 Grounding McGrath Working Group Meeting #3, Dec 12, 2011

91 Grounding McGrath Working Group Meeting #1, June 29, 2011

Figure 35: Conceptual draft of a 'boulevard road diet' presented at the March 8, 2012 meeting of the Grounding McGrath study Working Group

The process of change is of particular relevance to the case of dealing with failing infrastructure since the reconstruction process itself will disrupt traffic patterns and force different pathways to be used. Mitigation during construction, such as the use of alternate routes or improving transit options, if used over a period of time may generate new scenarios and new equilibrium points. Yet, the models are seldom used to demonstrate such possibilities.

3.3.1 Violating capacity constraints

One of the major shortcomings of forecasting future no-build scenarios using the 4-step model is a failure to recognize real-world capacity constraints in roadway throughput that are defined by existing infrastructure conditions. In the case of McGrath Highway, there is a critical constraint in capacity at the Medford St/ Highland Ave intersection caused by the width of the bridge over the MBTA Lowell line that constrains the corridor to 3 lanes in each direction. Widening this bridge can be considered for all intents and purposes an unfeasible option since the structure is tightly hemmed-in by the neighboring buildings. Moreover, the at-grade intersection with Medford St/Highland Ave, with the presence of a heavy northbound left turn movement to Medford St and high pedestrian crossings creates an essentially complete constraint on the through capacity of McGrath. There is a finite number of vehicles per hour that can move past this segment. Therefore, this 'pinch point' or 'bottleneck' has a major role in defining the capacity of McGrath, by throttling the amount of throughput that can advance downstream beyond this point (and onto the McCarthy Viaduct or a grounded boulevard). There is an additional significant pinch point at the Lechmere end of O'Brien Highway where the existing Green Line station is being relocated to the easterly side of the road, thereby forcing all pedestrians and busses using the station to cross the Highway. In the short to medium timescale, reconstruction of various other nearby bridges and roadways in Somerville is an additional reality that will reduce capacity below the existing constraints of these intersection 'pinch-points.'

There are several conceptual failures that contribute to this inconsistency of violating capacity. First, the future land-use scenario for 2035 is an exogenous input based on population and forecasting exercises that do not consider the role of transportation supply on how, where and whether such growth will occur. Instead, forecast growth is taken as a given and the number and pattern of trips associated with new development generated by running the 4-step model are also taken as given, even though the roadway capacity to accommodate such trips does not actually exist yet – and is unlikely to ever exist. As a consequence, the output of the 4-step model for future 'no-build' scenarios often shows worsening levels of congestion and delays. However, this approach to forecasting and modeling demonstrates a contradictory relationship with capacity constraint. On the one hand, the fundamental nature of capacity constraint is affirmed by the fact that more traffic trying to use the road results in worsened operating conditions. On the other hand, it fails to recognize that worsening operating conditions constrain auto-oriented land use growth and development potential.

Developing the no-build scenario in this manner leaves little or no room for debate about the appropriate or desired size of transportation infrastructure as well as debate about land use and desired mode shares. Instead, future traffic volumes are taken as a *fait accompli.* Indeed, a senior staff member of the Grounding McGrath study team described the 2035 no-build traffic forecast to the study's advisory group as "what the world we need to plan for looks like"[92] and providing "the 2035 projections that we have to live with."[93]

Despite reforms to the goals of transport planning and the demonstrated ability for infrastructure to shape communities (in both positive and negative ways), the reluctant acceptance of future forecast traffic is the same today as was prevalent in the Interstate era. Lupo (1971) summarizes this ideological problem in his critique of the highway-oriented Eastern Massachusetts Regional Planning Project (EMRPP)

92 Grounding McGrath Working Group Meeting #3, Dec 12, 2011

93 Grounding McGrath Working Group Meeting #4, March 8, 2012

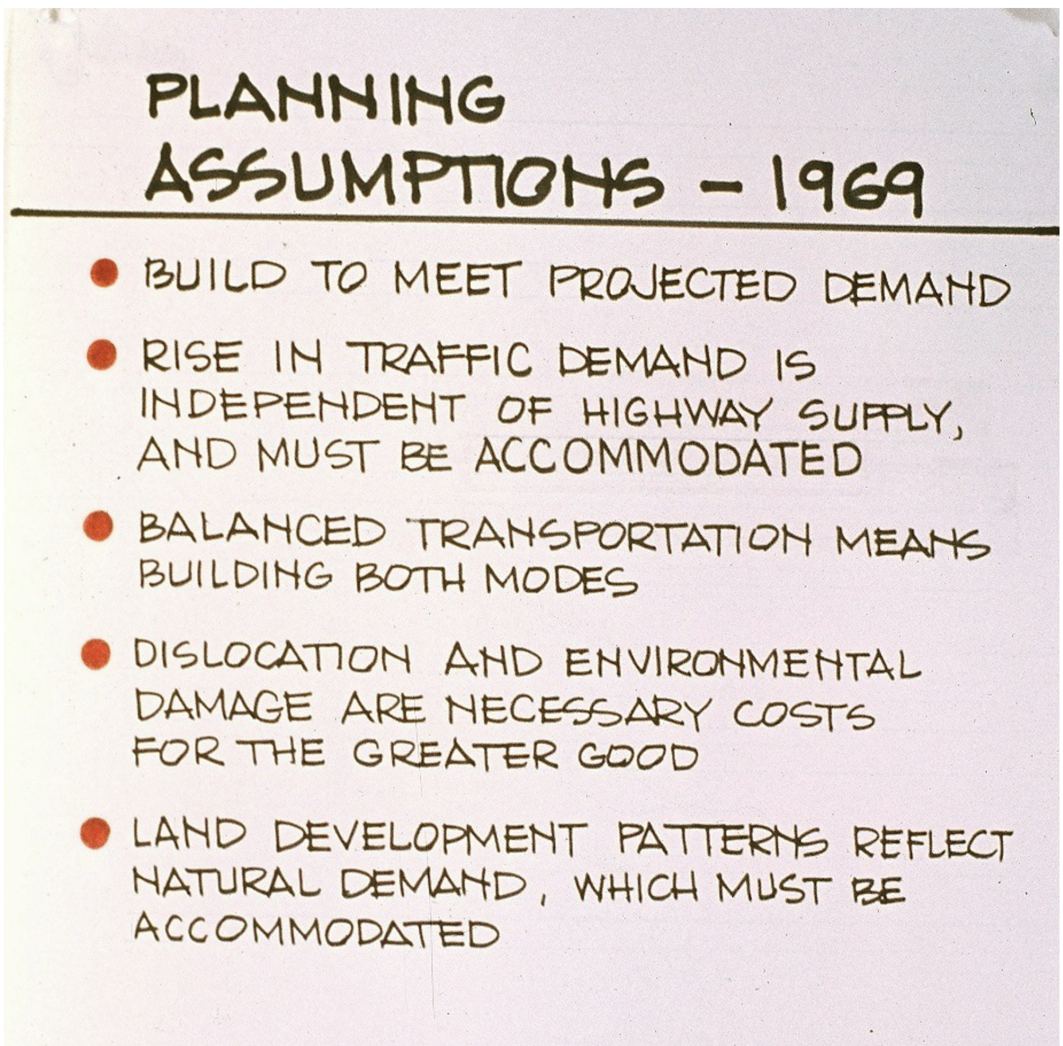

Figure 36: Photograph of a poster summarizing 1969 "DPW" planning values used in a BTPR workshop. (courtesy Jack Wofford, Director, Boston Transportation Planning Review)

of 1969 (**figure 36**) that was eventually dethroned by the BTPR of 1971-1972 and a renewed focus on building transit (**figure 37**): "the basic attitude of the EMRPP report is, by 1990 we're going to have more than twice as many cars on the road, and we'd better start building roads for them. No one stopped to ask: do we *want* twice as many cars in Boston by 1990?"[94] Equally fundamental, highway planning implicitly assumed that the capacity constraints of the already congested city roadway system and fully utilized parking supply would be "solved" by others, but with no analysis of the acceptability or feasibility of the unspecified solution.[95] Similarly, a booklet prepared in the 60s by the Massachusetts Department of Commerce and Development proclaimed: "at best, planners can plan and promote transportation improvements which reinforce development decisions made at the local level." [96]

94 Lupo (1971), 149

95 This failure for highway planning to be comprehensive at the system level is further discussed in chapter 4.3.4

96 Lupo (1971), 149

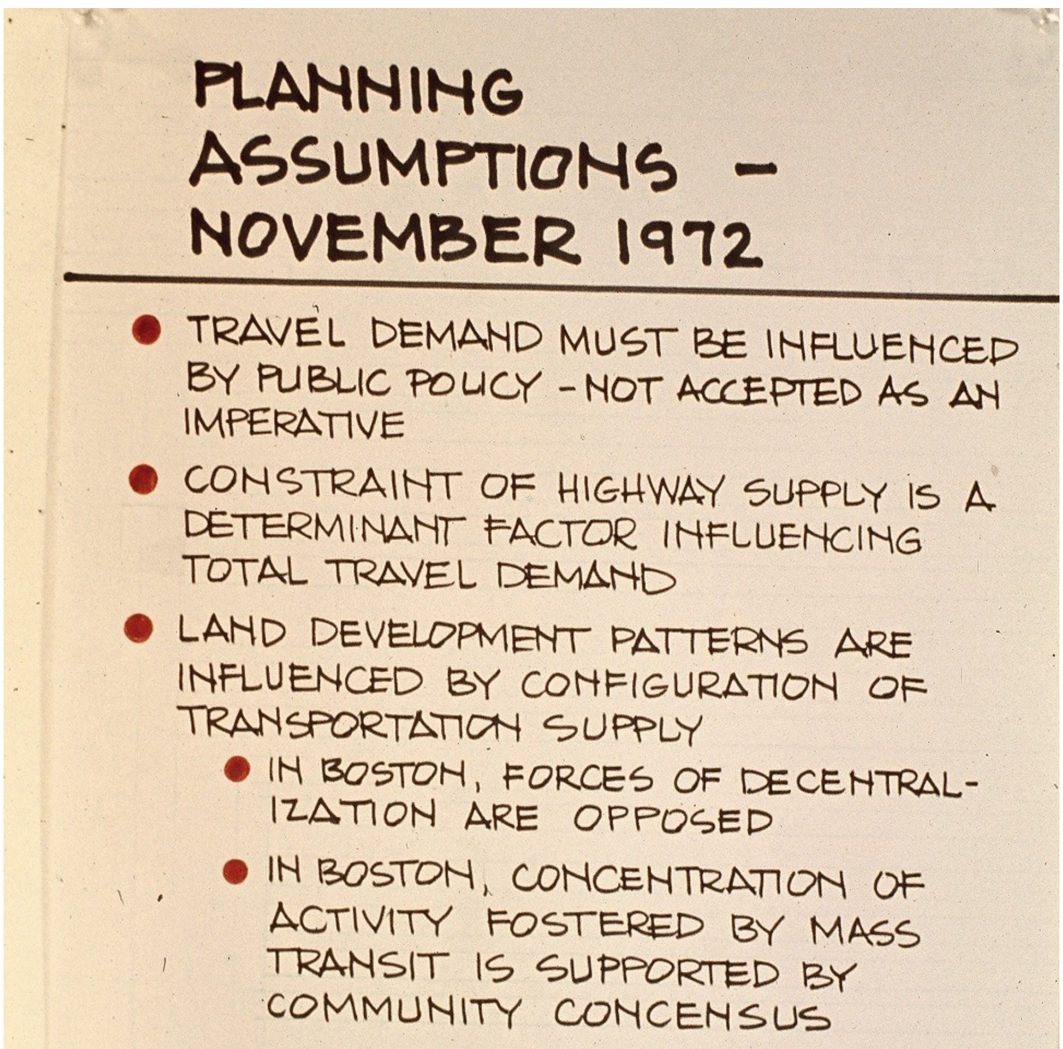

Figure 37: Photograph of a poster summarizing planning values of transportation restudy shown in a BTPR workshop. (courtesy Jack Wofford, Director, Boston Transportation Planning Review)

Although the land-use inputs may generate an improbable number of vehicle trips in the no-build year, the route assignment step of the 4-step model also fails to accurately recognize existing capacity constraints in the manner it assigns trips to specific links in the road network. This is in part because of a methodological shortcoming as well as confusion in the language. We must first define a few terms.

- Capacity: this is the maximum throughput of vehicles (e.g. vehicles/hour) for a given combination of physical roadway conditions (e.g. number of lanes) traffic control systems (e.g. signal timing), and driver behavior (e.g. following distance, speed, aggressiveness). Capacity drops when conditions are congested (but this inconvenient truth is usually ignored).
- Arrival rate: this it the rate at which vehicles approach a given point or segment of capacity constraint in a road system. (e.g. vehicles/hour)
- Volume: the actual observed throughput of vehicles past a given point of capacity constraint (e.g. vehicles/hour)

It is easy to appreciate how the capacity of a roadway is fixed due to physical limitations, and as mentioned in chapter 1 important to emphasize that serviced demand (volume) cannot in practice exceed supply (capacity) since this would constitute a physical impossibility. Furthermore, although capacity represents a finite physical constraint, it is not a static value. Instead, it is a dynamic value with a fixed upper bound (maximum throughput) and that varies with respect to the arrival rate. As the arrival rate of vehicles approaches the theoretical capacity limit, capacity is actually lost and the amount of volume that can be processed decreases (**figure 14**). This occurs because a certain amount of maneuvering and following space is required by drivers, and as this space becomes inadequate traffic flow becomes unstable, breaks down, and can experience jammed conditions. This results in a loss of throughput and exponential delays.

However, the route assignment step of the CTPS 4-step model allows V/C >1: that is for demand to in fact exceed supply! This occurs because 'volume' (V) in the model is not is not taken to be the actual throughput of vehicles that can pass through the network (which is inherently constrained by capacity), but instead the "desired demand" (more similar to the arrival rate) as based on the first 3 steps of the model: trip-generation, trip distribution, and mode choice. These values are simply forced through the road network, despite violating capacity constraints. Furthermore, the CTPS model uses a so-called 'static assignment' process that does not reflect how capacity breaks down and delays grow exponentially as volume approaches capacity. These exponential delays hold the possibility to create exponential changes in the trip distribution and mode choice steps of the model (in which travel times are key sensitivities), thereby offering the potential to elucidate how constrained roadway space can be a trigger to move traffic away from McGrath on to alternate routes (such as I-93 and the proposed North Point to Inner Belt bridge), shift trips out of cars and on to other modes such as the Green Line Extension, and trigger policy changes. But instead, the static assignment process allows vehicles to flow though the road network at volumes exceeding capacity, but at imaginary speeds (e.g. 5-10mph). (**figure 38**)

These curves should be contrasted with those in *figure 14* that show how capacity drops when conditions are oversaturated. Keeping the cars moving artificially perpetuates the relative attractiveness of driving in the model. This problem could be in part corrected using dynamic traffic assignment methods (which recognize queue propagation between intersections) that are supported by many commercially available transport modeling packages.

Initial modeling of the 'Boulevard Road Diet' alternative for McGrath was reported to have a V/C ratio of 3 to 4,[97] which therefore dramatically undercuts the perceived viability of this design by suggesting that it will not be able to handle traffic demands. However, the opposite is equally true: that the traffic demand will not be able to handle the road. The latter is a more instructive way of thinking of the model output since a modifying the roadway design is something that can be achieved in a relatively short timeframe, whereas 2035 traffic growth represents an abstract forecast that can not actually happen.

3.3.2 The statistical approach & Homo Automobilicus

According to CTPS, travel models are built on the basis of people's observed behavior.[98] However, herein lies another way that the forecasting and modeling practice can be implicitly driven to suggest road expansion. There are many technicalities in each step of the 4-step model that could be discussed at great length. For each step there exist differing theoretical approaches and practical methods to achieve results. Leaving aside the conceptual and empirical validity of these differences (which are beyond the scope of this thesis), all forecasting and modeling approaches, regardless of their rigor, share an inherent similarity in their underlying logic and approach. The basic premise is to describe the phenomena of interest as equations that capture the relationship of dependent and explanatory variables. In other words, the various elements of travel behavior of interest (trip generation, destination choice, mode choice and route choice) are all expressed as functions of other measurable quantities. The following are some illustrative examples:

97 Grounding McGrath Working Group Meeting #4, March 8, 2012

98 CTPS (2012)

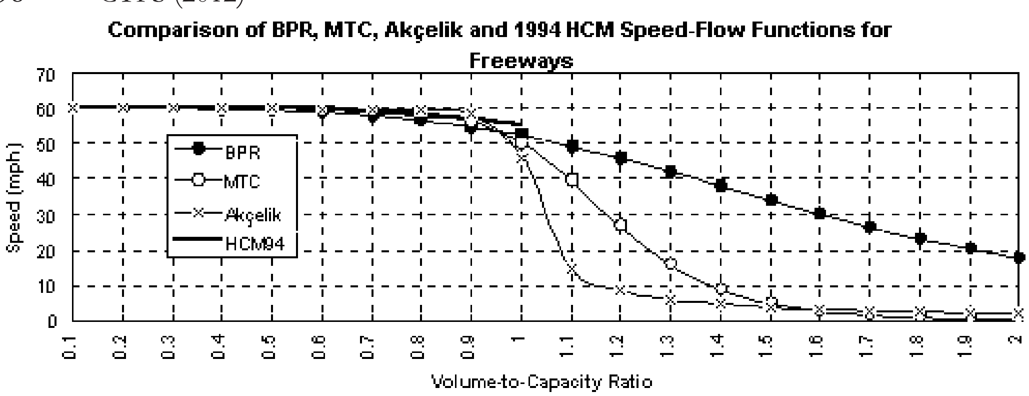

Figure 38: Comparison of different speed-flow curves used for traffic modeling which allow forved traffic flow at V/C>1 and at (imaginarily) low speeds.

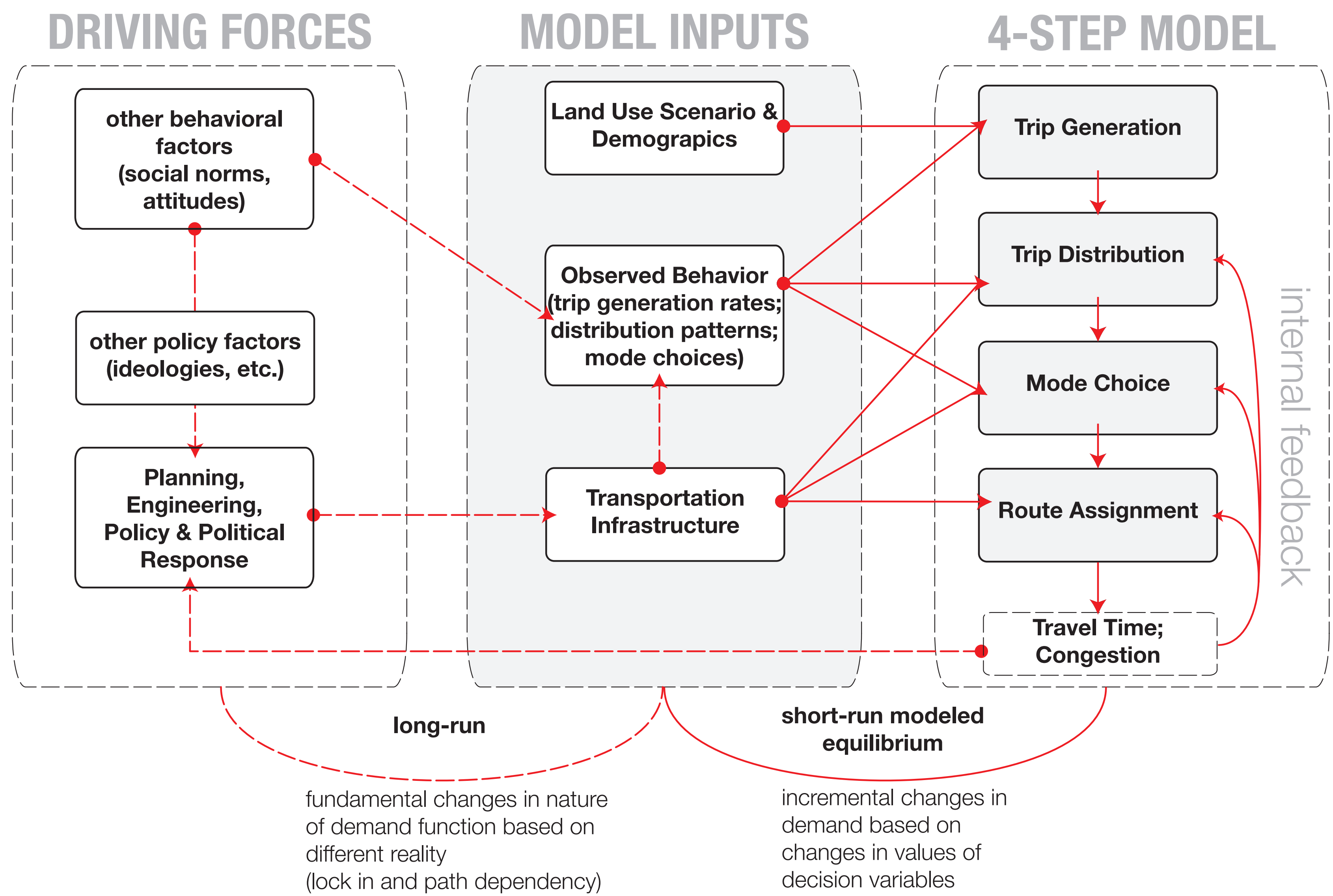

Figure 39: A broader model of transportation decision making and the infrastructural, behavioral, and political forces shaping travel decisions. The 4-step model effectively models current behavioral relationships in the short-run, but does not recognize how these behaviors may change as the underlying context for decision making changes in the long-run.

Trip generation rate for condominium
number of trips generated = 0.827*ln(number of dwelling units) + 0.309

Trip distribution
number of trips from zone i to j = $k[(P_i P_j)/d_{ij}]$

Mode choice
Disutility of transit = 2.356 + IVTT + Walktime + WaitTime + Xfer_Wait + Fare

Despite the apparent differences, all of these equations share the same basic form:

$$\text{variable of interest} = f(\text{explanatory variables})$$
$$y = ßx_1 + ßx_2 + ßx_3 \ldots + ßx_n$$

'Y' is the variable of interest, 'X_n' are the explanatory variables, and ß's are the coefficients that describes the strength and direction of the relationship between X's and Y. For example, if a $ß_n$ is large then a small change in the variable X_n produces a proportionately larger change in Y than if $ß_n$ were smaller. The foundation of all transportation modeling is to apply statistical analysis techniques to survey data in order to develop statistically significant equations and estimate the ß's. Thereon, the process of modeling outcomes for different scenarios is conceptually no more than inputting different explanatory variable values into the equations (e.g. a shorter wait time for the bus or a larger number of dwelling units).

The 2035 no-build scenario for the Grounding McGrath study was developed primarily by modifying the quantity of and spatial arrangement of land uses being inputted into the trip-generation step of the model. The distribution of trips, mode choices modeled, and assignment of traffic to the network are outputs. The fundamental shortcoming of approach is that it assumes that the relationships between explanatory and dependent variables are absolute (that ßs are constant) rather than contingent on broader conditions and varied through time. This modeling and forecasting approach based on using current behavioral relationships (as defined by statistical analysis) fails in entirety to recognize that infrastructure changes can result not only in changes to behavioral outcomes, but changes in the nature of the decision-making process itself. Explicitly considering these second-order effects of infrastructure on changing the nature of behavioral responses is key to elucidating the transformative potential of infrastructure reconceptualization. Failing to do so categorically ignores an important pathway to path-breaking change. (figure 39) Even more fundamental, volume approaching the limits of capacity creates unstable disequilibria that demonstrate that existing behaviors can no longer be supported.

Existing behavioral relationships between transportation demand characteristics (e.g. trip generation, destination choice, mode choice, and route choice) and explanatory variables (such as the disutility of travel time and travel cost) are imbedded in the realties of the existing decision making context. The (in)sensitivity of the mode choice decision is indicative of a landscape which often lacks reasonable or desirable alternatives to the automobile, and a political establishment which for decades has continued to justify construction projects based on the flawed logic of building your way out of congestion and proposing expanded road capacity in an effort (albeit unsuccessful) to abate growing travel delays. In chapter 1.2 the discussion demonstrated how this structuring of transportation supply and urban form around the automobile have worked to fuel induced travel demand and create lock-in to the car. These demand responses were modeled as movement to new demand curves (higher and steeper), which in turn, represent supply and demand relationships that are defined by changing ß's.

The Tragedy of the Commons described by Hardin (1968), in which every human is "locked into a system" has been criticized for naturalizing homo economicus: a competitive, capitalist social order in which individuals and society are incapable of social learning and co-operation. In a similar vein, the tragedy of expanding the concrete commons (discussed in chapter 1.3) is perpetuated by a transportation forecasting and modeling approach that naturalizes homo automobilicus: Americans who will drive, only drive, and always drive! This view disenfranchises pedestrians, urban residents and transit riders.

The assumption that existing behavioral responses will carry forward to future planning actions may be reasonable for short timescales and minor interventions. However, the opportunity to redesign the McGrath Highway corridor around different values that reduce the emphasis on automobile throughput and increase environmental quality for pedestrians and transit users promises an opportunity to reverse lock-in to the automobile and create a fundamentally different decision-making context. A boulevard design for McGrath encourages regional auto traffic to use I-93 and drivers to prioritize using McGrath Boulevard only for local access at lower speeds. Retaining the McCarthy Overpass, which provides a perception of high-speed movement (even though the corridor is constrained at one end by the Medford St / Highland Ave intersection and at the other by the Lechmere intersection), invites regional traffic and causes traffic problems for all – a phenomenon known as Braess's Paradox. Perhaps even more importantly, forecasting for 2035 ignores the dimension of time and actions along the path from now until then.

3.3.3 Pattern break

> " The conclusion from Copenhagen is unequivocal: if people rather than cars are invited into the city, pedestrian traffic and city life increase correspondingly"
> – Jan Gehl (2010)

The notion that reconceptualizing McGrath Highway can have a transformative effect on behavior is far from just wishful thinking. However, the conventional transportation modeling process is not structured to see this potential. In a review of the literature on the effects of added transportation capacity on travel, Kitamura (2009) notes that induced traffic is not captured in the sequential travel demand forecasting procedure, and that “it is not common practice” to use variables that represent the effect of transportation supply on trip generation. These two forces are the very effects that stand to be actuated by reconceptualizing McGrath Highway: unleashing induced and latent demand for non-automobile travel modes and altering trip generation and traffic growth patterns by managing supply. Empirical evidence suggests that behavioral responses can change substantially and rapidly in response to large infrastructure changes in transport supply as well as to minor tweaks.

Zegras and Hannan (forthcoming) attempt to identify such changes between 1991 and 2001 in the rapidly urbanizing and motorizing environment of Santiago de Chile. They find that elements of the built environment such as proximity to the expanding metro system influence vehicle ownership, but the extent of this influence changes over time. Preferences influencing vehicle choice have changed, and in lower income groups there is a decreasing tendency for vehicle ownership that is possibly due to improvements in public transportation. In summary, they find: “household preferences for vehicle ownership are dynamic over time and that they respond to the rapidly developing and evolving environments around them.”

In Los Angeles, a concerted social marketing campaign by the Metropolitan Transportation Authority that poked fun at car culture resulted in “a 40% increase in user perception of efficiency, frequency and quality of service, even though at that time, there were no significant changes made to these areas.” Although transit frequency is captured in the mode-choice step of the 4-step model, it is considered an objective variable as measured by travel time, rather than a variable that changes with perception and image. Similarly, the image of congested roadways is well understood by motorists in the real world, but not reflected if models allow volume to exceed capacity.

Compelling support of shifting behavioral responses in response to changing roadway characteristics also comes from research on the phenomenon of ‘traffic evaporation.’ Cairns et al (1998) examined over 100 cases of road-capacity reductions such as closures, car-free zones, and roadway demolitions. They observe a 25% average overall reduction in traffic along the studied corridors, and more notably that a proportion of traffic that had previously traveled along the corridor with now reduced capacity could not be found diverted on to neighboring streets. In a follow-up study, Cairns et al (2002) find a median traffic reduction from similar projects of 11%, and conclude “that predictions of traffic problems are often unnecessarily alarmist” and “traffic reduction is a real phenomenon that occurs when road space for cars is reduced.”

3.3.4 Timescale & self-selection 'bias'

As describe earlier, a substantial amount of new development is planned along the McGrath Corridor from Assembly Square to Lechmere Square. Traffic impact studies have forecast an 18% transit mode share for the Boynton Yards redevelopment. For Assembly Square, the projected transit mode shares are 35-47% for residential trips, 25% for office trips, and 5% for retail trips. These forecasts estimate large increases in vehicle trip generation at full build-out: the Assembly Square development alone is anticipated to put another 11,000 vehicle trips per day on to the McGrath Highway through Somerville. The anticipated addition of thousands of residents and jobs in these developments largely drives the 7.5%-12.5% growth in vehicle trips associated with the 2035 no-build scenario being used in the Grounding McGrath study. Although such traffic could be interpreted as reason to increase (or at least maintain) the capacity of McGrath Highway, the exact opposite could be advisable. Without substantial changes to make the McGrath Highway a pedestrian friendly corridor, these new developments risk never occurring. Reconfiguring McGrath with a boulevard design that emphasized local accessibility over regional capacity is essential to attract the new development, but also will reduce the attractiveness of the link for through traffic and work to dissuade further traffic growth (before it happens) by establishing hard constraints on the automobile. Reducing road capacity with respect to existing traffic levels might contribute to increased delays, congestion, and reduced accessibility if there is a lack of alternatives. However, redesigning McGrath Highway in the near future and constraining capacity decades before anticipated land use development and growth occurs can work to curtail the auto-orientation of new travel behaviors. This is since existing travel behaviors and automobile use patterns are to some extent rooted in habits and bound by preexisting decisions about residential and job location choice as well the sunk costs of automobile ownership.[99] However, the travel patterns of future residents and workers are far more elastic and malleable. This notion is corroborated by two concepts.

First, 2035 travel demand patterns will not be experienced instantaneously. Instead, they will form over the next 20 years. If the McGrath corridor and adjacent developments are truly transit-oriented, there is good reason to believe that travel preferences and behavioral responses will adapt to this changing landscape as illustrated by the empirical studies of Santiago, Los Angeles and the work of Cairns et al (1998 and 2002). Indeed the argument is somewhat tautological: auto-oriented development will necessitate auto use and transit oriented development that has constrained automobile access and limited parking should encourage transit ridership.

Second, if prospective tenants in the surrounding redevelopments are aware that auto access in the area is limited, but that access to the Green Line Extension is pleasant and plentiful, this may help attract individuals interested in walking, transit use and a car-free lifestyle to choose these areas. This hypothesis is supported by the work

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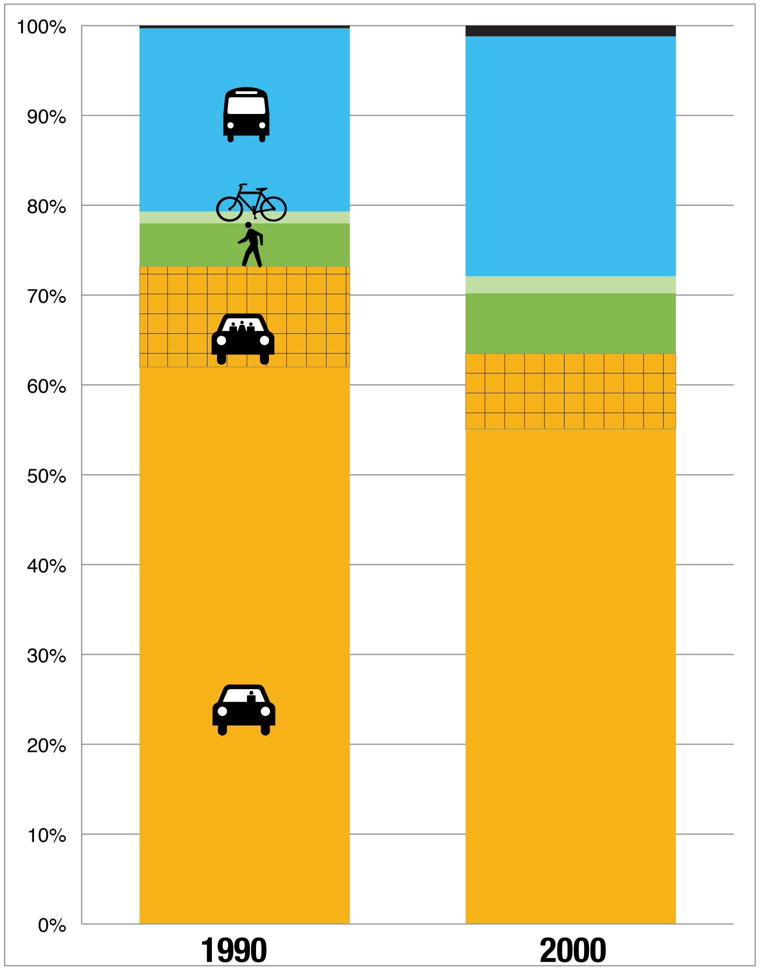
99 Bamberg et al, (2003); Garling and Axhausen (2003),

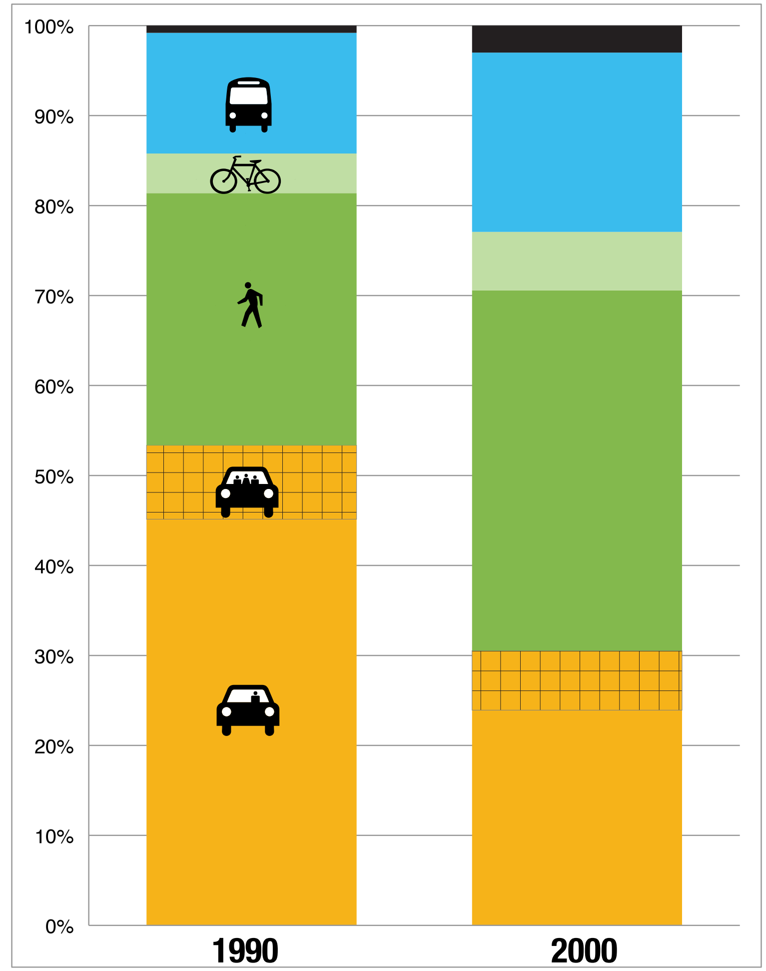
of Zhao (2009), who examined the impact of eight psychological factors including personality traits, environmental attitudes and car pride, on individual mode choice and levels of vehicle ownership in London. Findings from this research suggest that individual preferences have an effect on behavior similar in magnitude to the effects from household income and population density. For example, the proportion of the population who do not own a car increases substantially by 5.1 percentage points when individuals' general environmental attitudes and support for government's actions and taxations to protect the environment increased by one standard deviation. Research interested in the association between the built environment and travel behavior has long expressed concern about this so-called self-selection effect, whereby people sort themselves into built environments that are conducive to their preexisting values and travel preferences (Mokhtarian and Cao 2009). In this research self-selection bias has been described as potentially masking the "true effect" of built form on travel behavior. In other words, there exists uncertainty as to whether transit oriented developments cause higher rates of transit use all else equal, or whether they merely enable people who are already predisposed to use transit to do so more. However, in the case of Somerville this debate is academic. Redevelopments along the McGrath corridor need not attract a complete cross section of the entire population of the Boston metro region to be successful. Rather, they need only attract a sufficient number of residents and business tenants interested in this form of low-car living to be economically viable for development. As such, self-selection bias is not the problem as usually portrayed in the literature, but rather a phenomenon that could be harnessed as an opportunity in the McGrath corridor.

Much closer evidence of these phenomena in support of the potentials of auto-constrained development comes from the neighboring Kendall Square in Cambridge. Kendall is booming economically and home to a cluster of research and innovation that is of global significance. Over the last fifteen years approximately 4 million square feet of development has been added in the Kendall neighborhood without any significant expansion of road capacity. At the same time, mode shares for non-auto choices have increased from 1990 to 2000. Among those working in Kendall and living in Cambridge, the non-automobile mode share for the journey to work in 2000 was 76% (47% walk and bike) versus only 44% for all employees irrespective of household location. (**figure 40**) This demonstrates the potential of live-work proximity on automobile use. Over the last past fifteen years as Kendall has grown average daily traffic (ADT) on the main corridors leading into the area has remained fairly stable and even shows a potential trend of net decrease. (**figure 41**) Traffic in the auto system has not grown with Kendall since the limits of roadway capacity had been reached already and conditions continue to be congested at peak times. While this has had undesirable impacts on bus service, it did not strangle growth.

KENDALL SQUARE JOURNEY TO WORK MODE SPLIT



all journey to work origins

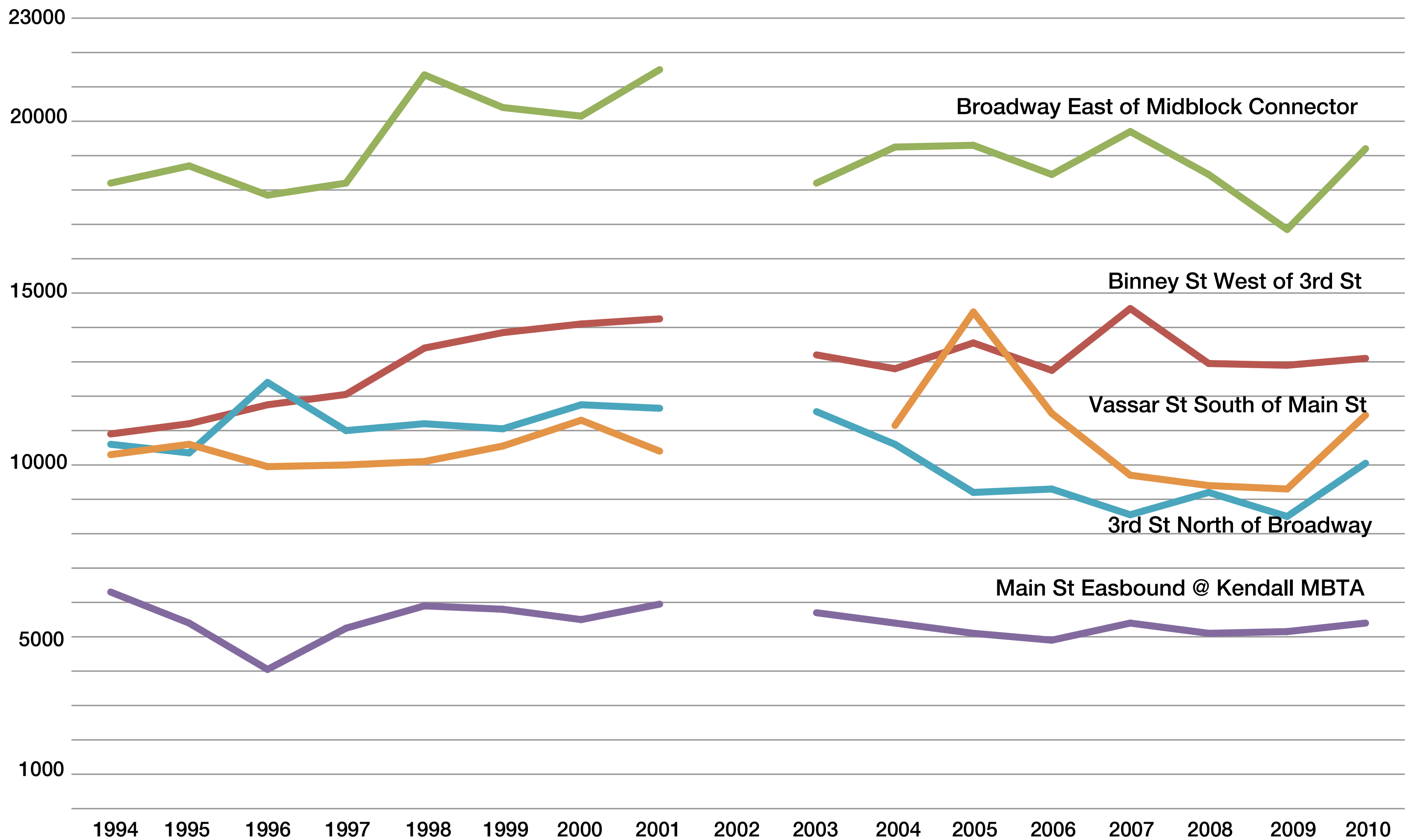


journey to work origins in Cambridge, MA

data source: http://www2.cambridgema.gov/cdd/data/jtw/index.html

Figure 40

24-Hour Average Daily Traffic in Kendall Sq (1994-2010)



data source: http://www2.cambridgema.gov/CityOfCambridge_Content/documents/OnLineReport.pdf

Figure 41

In understanding the ability of Kendall to grow, it is critical to emphasize that public transit constitutes the majority of non-automobile trips to Kendall and is the travel mode that has grown the most between 1990 and 2000. The growth success story of Kendall with constrained auto access is likely in large part due to the availability of transit access by the MBTA Red Line and the increased regional accessibility of Kendall that was achieved by extending the Red Line north to Porter Sq, Davis Sq and Alewife in the mid 80s and southward to Quincy in the 70s and Braintree in 1980. Transit expansions connected Kendall via a one-seat subway ride to a diverse set of neighborhoods in the Boston region from which Kendall can attract a labor pool. The importance of transit expansion to the growth and success of Kendall is evidenced by the shifting of the peak load point on the northern half of the Red Line. Today there are more people inbound in the AM alighting at Kendall than boarding at Kendall and Charles/MGH combined. Outbound in the PM, more people board at Kendall than alight at Kendall and Charles/MGH combined.[100]

Given these values from Kendall, it seems highly unnecessary to maintain the automobile capacity of McGrath Highway to support the future growth of Inner Belt / Brickbottom by an anticipated 2 million square feet of commercial space. Compared to Kendall in 2000, SomerVision target mode shares for Inner Belt/ Brickbottom in 2030 (50% of new trips by walk and bike and transit) seem highly plausible. Furthermore, the primary road capacity servicing Kendall is limited to the local street network (Massachusetts Ave, Broadway, Hampshire) and Memorial Drive, and this has not been a limiting factor on growth. A redeveloped Inner Belt / Brickbottom would have excellent regional automobile access to I-93 at Sullivan Sq, and on top would be complemented by the access from Washington St, Somerville Ave, and a future at-grade McGrath boulevard and Inner Belt to North Point boulevard bridge. The Green Line Extension will provide a significant addition to transit service and capacity through the area, and this will be vital and fundamental for Somerville in the same way as the Red Line for Kendall. These two neighborhood context comparisons suggest no need for the McGrath as another highway to service job and population growth in Inner Belt / Brickbottom.

100 Remarks by John Attanucci, May 21, 2012

3.4 Summary & implications

> "it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new."
> – Niccolò Machiavelli

In the Grounding McGrath study process the forecast 2035 no build traffic volumes are essentially insensitive to the future designs possibilities for the corridor – so much so that completely eliminating McGrath would have little or no effect on the desire to use that corridor. This is since critical pathways of behavioral change in response to infrastructure change are systemically missing in the 4-step model.

Forecasting of the 'no-build' year is a misnomer since the practice of doing so is both conceptually and technically biased to perpetuate the business as usual approach of preferencing the car and providing for it. Forecasts of volume to capacity ratios exceeding 1 (V/C>1) create alarm over the operational (in)feasibility of traffic growth at levels that are fundamentally infeasible. Road capacity expansion becomes a self-fulfilling prophecy if no-build forecasts that violate existing capacity constraints are taken as given. The reality of capacity constraint is used selectively: on the one hand it undermines the perceived viability of road-diet options by imagining that V/C will exceed one in 2035, while on the other hand there is an underestimate of the role of approaching these constrained conditions in creating the very pressure necessary to change behavioral responses and trigger adaptation in terms of destination choice, mode choice and route choice decisions, and broader changes to policies and land use decisions.

Reconceptualizing the McGrath Highway around a vision that has a smaller emphasis on accommodating automobile traffic than the existing conditions is a challenging political proposition. By virtue of the fact that the corridor's design is oriented around the car today, automobile drivers are the primary users of the corridor. As such, there is a strong political constituency in favor of maintaining the status quo and this creates substantial inertia to change. By contrast, pedestrians, transit riders, bicyclists and transit-oriented developers are at best a small, but vocal, constituency, and at worst latent stakeholders who do not yet exist because their presence has been excluded by (roadway) design. Providing for all of these constituencies simultaneously would be an ideal solution; however doing so is inherently unachievable since heavily auto-oriented designs are necessarily inhospitable to walking and bicycling. Furthermore, available space in any corridor is constrained, and so, width dedicated to one function, such as a sidewalk, is space necessarily unavailable for another use such as an additional automobile lane. Therefore, there is a Catch-22 in corridor planning: it is politically difficult to summon the will to allocate scarce space to marginalized travel modes when they represent a minority of users, but these travel modes will not realize their potential to grow so long as the infrastructure to encourage their safe and effective use is not provided. Although it may be grandiose to anticipate that the transformation of a single corridor holds the possibility for path-breaking changes in transportation behavior, 'the dose makes the poison.' Any single corridor transformation may have a more limited effect on behavior change and mode shift, however analyzing the performance of each project individually as a series of small doses poisons the potential to see the gradual path of change that leads to building a strong multi-modal network. Rather than evaluating the performance of every project at a distant 'no-build' year, if a package of gradual improvements were modeled successively, each would benefit from the incremental changes in behavior in support of walking, cycling and transit use created by the previous interventions.[101]

Unfortunately, the misuse of modeling and forecasting as described in this chapter perpetuates the demand first versus infrastructure first paradox, and does not support such visionary thinking or incremental change. This is unfortunate since sophisticated models make possible a much more comprehensive understanding of networks and capacity constraints. Instead, the existing forecasting and modeling paradigm used by CTPS in the Grounding McGrath study does little to provide technocratic evidence that would support the political will to consider reconceptualizing the corridor with a smaller focus on the automobile. The process works to perpetuate the myth of capacity building, and provides pseudo-scientific results that help strengthen the arguments of constituencies that favor maintaining the established order of automobile-oriented transportation planning. Such misuse of the tools make modeling and forecasting policy-making, rather than policy analysis, by over-predicting traffic demand growth and pre-determining auto-oriented outcomes by projecting existing behaviors far into the future.

101 It is unlikely that walking, cycling and transit will completely supplant the automobile and the access it provides in the relatively short-term (especially considering the large expanse of the metropolitan region). However, the presence of pedestrians and cyclists inevitability reduce automobile throughput, and as walk and bike modes become more prevalent the ability to accommodate the auto in the urban in the urban street system declines. As such, it is directionally incorrect, and un-responsive to the dynamics of the system, for the Grounding McGrath Study or CTPS models to assume growing automobile capacity in the future. Rather, auto capacity is likely to *decline* in the McGrath corridor as walk and bike 'pioneers' grow in numbers. Planning attention should be focused on responding to this capacity reduction by creating a more distributed street system, redirecting regional traffic to appropriate Interstate facilities, and also encouraging more mode shift.

4. A perfect storm – for or against change?

> "Culture eats policy for Breakfast"
> – Jeffrey Mullan; former Massachusetts Secretary of Transportation

As a response, in part, to the top-down nature of early road and highway projects national and state level environmental and planning process legislations were passed during the 1960s and 70s. As such, many highway structures in the country can be considered relics that may not have come to exist in their current configurations had the very environmental protections which they spurred been enacted earlier.

Despite now being longstanding laws, the force of these legislative protections and reforms only become meaningful and relevant at the discrete points in time when infrastructure decisions are being considered. Indeed now is such a time across the United States as the bulk of the nation's highways that were built with federal grants during the 1950s and 60s are ailing. Therefore, as this 'grandfathered' infrastructure reaches its end of life it is all the more relevant to ensure a strong application of planning process laws.

However, the proclivity of governments to reinforce the status quo threatens to undermine the application of existing planning processes. Furthermore, environmental approvals processes, project evaluation methods, and the distribution of federal transportation funding systematically favor highway expansion over transit alternatives by placing a higher analytical burdens on transit projects. These dynamics are likely to have a strong impact on whether the political will to change course rather than follow the existing path can be generated.

4.1 The Highway Revolt and emergence of environmental policy

> "Four years ago, I was the commissioner of the Department of Public Works: our road building agency… then nearly everyone was sure highways were the only answer to transportation problems for years to come. We were wrong."
> – Francis Sargent; Governor of Massachusetts (Feb 11, 1970)

The anti-highway movement grew as Interstate construction spread into cities and tore though neighborhoods. Typical of countercultural activities of the 1960s, the highway revolt was a collection of individual, bottom-up, neighborhood movements in cities across the nation that were threatened by highways. Highway revolts rose in the 60s and early 70s in response to the destructive and dividing nature of freeway construction in cities, and because of a growing rejection of top-down decision making, concern about community change with out consultation, and increasing skepticism of technical expertise in planning and distrust of government.[102] Public agitation against freeways led to local victories against projects across the nation. In addition to reaction from threatened neighborhoods, there was critical support from suburban and middle-class allies, and allies within government agencies and political leadership.

102 Mohl (2004), 675; Weiner, 59

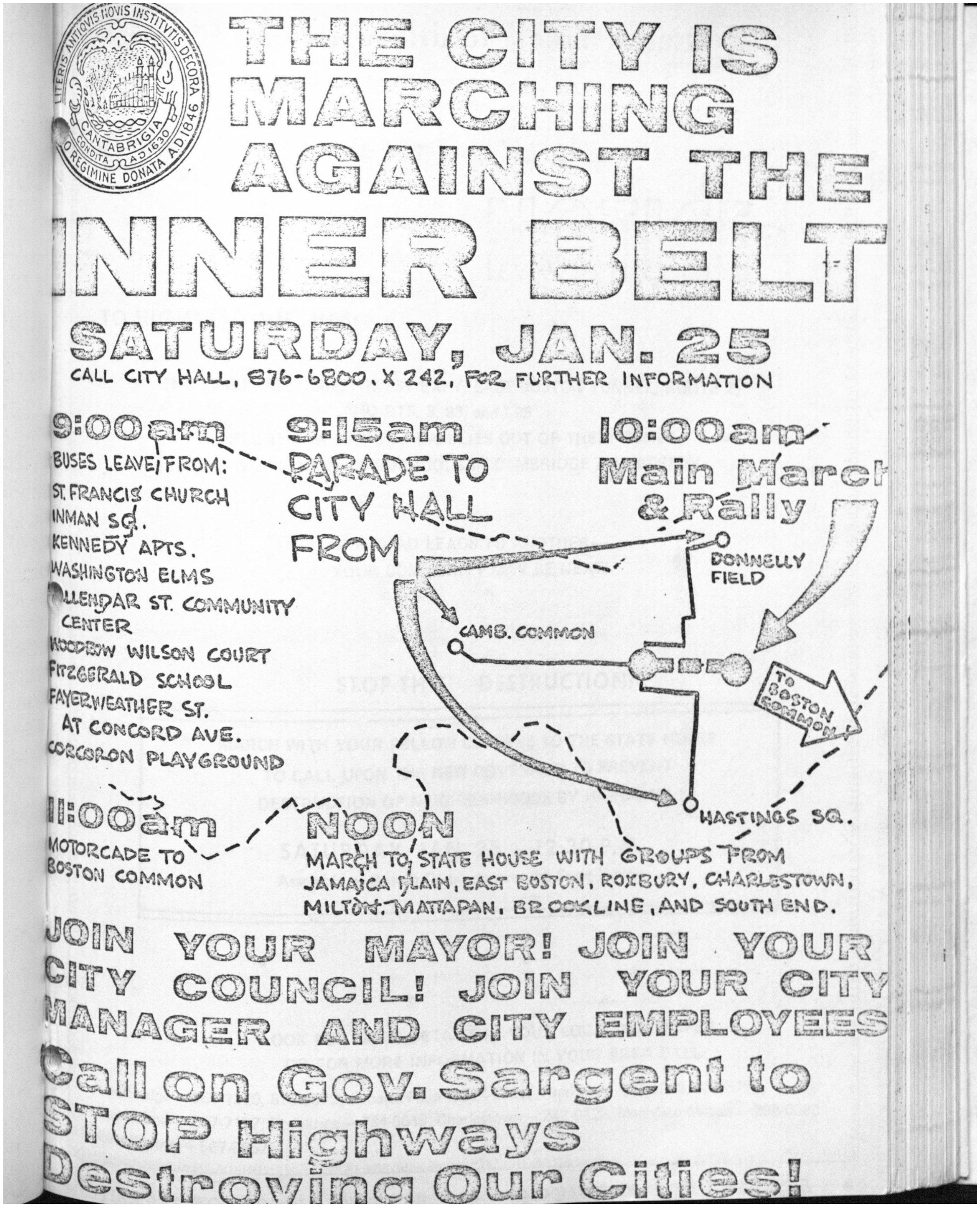


Figure 42: Poster for a public rally against the proposed Inner Belt Expressway (adorned with the official seal of the City of Cambridge)

The highway the revolt helped triggered a massive reversal in the political will to support building freeways through cities, (**figure 42**) and even more monumental the creation of landmark legislation to require a more thoughtful and responsive planning process. Notable policy and institutional changes that reflected a changing political climate began in 1962 with reforms to the Federal Highway Act. The Act required the state highway departments which were executing the Interstate plan to implement a 3 C's process: "a cooperative, comprehensive, and continuing urban transportation planning process."[103] In 1966, the road-building paradigm was intended to be significantly reformed by the creation of the United States Department of Transportation; the DOT incorporated the Bureau of Public Roads (now Federal Highway Authority) into an agency with a mandate to administer a multimodal transportation system. Moreover, Section 4(f) of the Department of Transportation Act that created the US DOT included a strong directive to protect the environment. Section 4(f) permitted the taking of public parks, recreation areas, or land from an historic site for federal transport projects "(1) only if there is no prudent and feasible alternative to using that land; and (2) the program or project includes all possible planning to minimize harm." In legal tests of section 4(f), including the landmark Overton Park v. Volpe case (1971) regarding a proposed section of I-40 though Overton Park in Memphis, the judiciary has set a high standard of compliance with 4(f) and established a precedent that favors selecting an alternative that avoids harming 4(f) resources unless such an alternative would create "uniquely difficult problems" or "costs or community disruption of extraordinary magnitude." Section 4(f) helped to reverse the dynamic of highway opposition by establishing a strong default rule that normalizes protecting 4(f) resources, and placing the onus on the road building agency to prove a negative: "there is no prudent and feasible alternative to using that land."[104]

As public and political opinions about how highway building should be considered changed, small signs of reform within highway agencies began to emerge. In 1968 an independent group of professionals was invited by the Federal Highway Administration to prepare a set of guidelines for the planning and design of urban expressways. The report, *The Freeway in the City*, recognizes how "the urban highway must not only function physically, as a path for vehicular movement; it must contribute to the total city environment," and that once brought into cities by freeways "the thousands of parked vehicles themselves can themselves destroy the very area they were meant to serve."

To further reduce the perceived inevitability of a highway project once proposed, in 1969 the FHWA established a two-hearing process. The first hearing was to be held before a route location decision was made in order to afford the public with the ability to comment on the need for and location of a proposed highway.[105] The second hearing was to see the actual proposed design, allowing the public to

103 Mohl (2004), 680

104 49 USC 303

105 Weiner, 59

comment on specific design issues that would affect the extent of impacts and also to propose mitigation measures.

The National Environmental Policy Act (NEPA) of 1970 created further regulatory checks against heady highway building, and established the basic principles of planning process and environmental project review still in use today. NEPA requires federally funded projects to analyze their impacts on the environment, and to communicate the information by preparing an Environmental Impact Statement (EIS) that defines the purpose and need for the proposed action, documents existing conditions, considers alternatives to the action, enumerates impacts on the environment, and also contemplates measures to mitigate potential impacts. NEPA requires only that impacts be considered and does not have a mechanism to prevent projects from proceeding even if the documented environmental impacts are severe. Nevertheless, NEPA enforces a process that enables the public and decision makers to think about outcomes and impacts before actions can proceed, and the findings of an EIS may demonstrate that certain projects are politically unacceptable in light of the anticipated outcomes. More importantly, the process creates a procedural mechanism that challenges the mentality that highway expansion is inevitable, by requiring alternatives to be considered and also that the very need and purpose of a proposed action be articulated. However, NEPA leaves the highway agency as the administrator of the assessment process and the ultimate decision maker on whether or not to proceed with a proposed action.

In parallel, the reversal of political support to push highways through neighborhoods was quite swift. In 1961, the governor of Massachusetts, John Volpe, announced plans to extend the Massachusetts Turnpike twelve miles through Boston's dense fabric up to the Prudential Center.[106] In January 1969, just seven days after being appointed U.S. secretary of transportation, Volpe retracted the approval of the US Department of Transportation for a section of contested Interstate freeway through the Vieux Carré of New Orleans because it had not been adequately considered as required by the National Historic Preservation Act of 1966, and his administration also cancelled I-5 through Seattle in July 1969.[107]

In Boston, the efforts of anti-highway citizen groups, supported by Mayor Kevin White and his transportation advisor, Fred Salvucci, led to the declaration of a moratorium on highway construction in 1970: Governor Francis Sargent halted work on all freeway projects (except I-93 through Somerville) occurring inside the boundary of Boston's Route 128 circumferential highway. In tandem with the moratorium Massachusetts Secretary of Transportation, Alan Altshuler, convened the Boston Transportation Planning Review (BTPR) to reevaluate the region's transportation plans. The BTPR marked a significant expansion from the FHWA "3C's" and "two-hearing processes." The BTPR involved professionals, citizens, interest groups, and decision-makers extensively throughout the entire review

106 Lewis (1997), 198
107 Lewis (1997), 208-9

process. Public transit was evaluated on an equal footing with highways. The study used a wide set of evaluation criteria to account for social and environmental factors in addition to traditional transportation performance metrics.[108] As mentioned in chapter 3.3.1, the BTPR was premised around very different values and assumptions than those advanced by the Department of Public Works. In particular, the review recognized that decisions about the future direction of the transport system were not a purely technical exercise, but rather that "travel demand must be influenced by public policy – not accepted as an imperative." (**figure 37**) It was designed to implement the just enacted NEPA rules and funded with federal funds. To this end, and perhaps the most important feature of the BTPR, the review was organized and run out of the executive branch of government and not by the highway or transportation department. Indeed, if highway building to date was culture eating policy for breakfast, the BTPR was the moment that policy ate culture for lunch and dinner.

Political pressure against the federal Interstate mandate continued. By the mid 1970s an effort supported by Governor Sargent, Representative Tip O'Neill, and Secretary of Transportation John Volpe (as well as other representatives on Capitol Hill and other governors and city mayors across the nation) succeeded in convincing Congress and President Richard Nixon to relax the inflexibility of Interstate funding promises. Money from the Highway Trust Fund, which was collected from federal gasoline taxes was reserved exclusively for highway building. Under the change, cities could now 'trade-in' their Interstate highway for an equivalent amount of money (though not from the Highway Trust Fund) to pursue a public transit alternative. Based on the results of the BTPR, this flexibility in highway funding was used in Boston to relocate and rebuild the Orange Line subway into a corridor that was cleared for a proposed (but defeated) Southwest Expressway, to extend the Red Line subway to Alewife in the north and Braintree in the south, as well as to renew equipment and rolling stock through the MBTA system.

In 1991, the Intermodal Surface Transportation Efficiency Act further reinforced the multimodal flexibility to use many categories of federal funds for transit as well as highways, put more stress on proper maintenance, and strengthened the role of the Metropolitan Planning Organizations (MPOs) vis a vis the state highway departments.

More recently, concern about global climate change has triggered another motivation to reconsider automobile oriented transportation planning. In Massachusetts, the transportation sector generates more than one-third of the state's total greenhouse gas emissions. As a response, in 2010 MassDOT launched its GreenDOT initiative to achieve three primary goals: reduce greenhouse gas (GHG) emissions; promote the healthy transportation options of walking, bicycling, and public transit; and, support smart growth development. GreenDOT targets to reduce transportation sector GHG

108 Gakenheimer (1976)

emissions 7.3 percent below 1990 levels by 2020, by "balancing highway system expansion projects with other projects that support smart growth development and promote public transit, walking and bicycling."[109]

4.2 Crisis and process failure – Accelerated Bridge Program and McGrath Highway

Due to decades of neglect, more than 500 bridges in the Commonwealth of Massachusetts are classified as structurally deficient. In August 2008, the Patrick-Murray administration passed legislation to enable a $3 billion Massachusetts Accelerated Bridge Program (ABP) in response to the fatal I-35 bridge collapse in Minnesota. More than 200 bridges are planned to be replaced or repaired over the course of the eight-year program. The goals of the ABP are to:

- reduce the number of structurally deficient bridges in Massachusetts by 1) removing current bridges from the structurally deficient list, and 2) preventing additional bridges from being classified structurally deficient;
- create thousands of construction-related jobs and maintain the critical infrastructure necessary for the long-term economic growth of the Commonwealth; and,
- generate significant cost savings by accelerating projects now, thereby avoiding construction cost inflation and cost increases due to deterioration caused by deferred maintenance.

As part of the ABP legislation Accelerated Bridge Program work is exempted from the environmental review and planning process requirements of the Massachusetts Environmental Protection Act (MEPA) so long as "the design is substantially the functional equivalent of, and in similar alignment to, the structure to be reconstructed or replaced." [110] MEPA would otherwise require MassDOT to engage in formal public process to prepare an environmental impact report that would consider reasonable alternatives to the proposed project and their environmental consequences.

With the exemption from MEPA given to the ABP, MassDOT has been granted a level of power and discretion in project definition and execution not held by transportation agencies since the early days of the Interstate era. This is a very troubling aspect of the ABP legislation since the very structures that helped catalyze the change in political will and enact planning process legislation are now being given a free pass from the scrutiny of this legislation as their lifespan expires. This normalizes the continued existence of these structures as the null-hypothesis or 'do nothing' scenario. However, there is serious doubt as to whether many highway structures through cities were ever reasonable propositions.

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109 MassDOT (2012)

110 The specific exemption is from sections 61 to 62I, of chapter 30 of the Massachusetts General Laws

The proclivity of governments to respond swiftly to perceived crisis situations threatens to systematically circumvent engaging in a serious planning process, and by doing so, to undermine a momentous opportunity to reconsider the need and purpose of aging highway infrastructure and to engage public participation that was not possible when many of the relics of the highway building era were built by the heavy handed methods of the 1950s urban renewal mentality. Although the need to rapidly improve bridges in poor structural condition is a compelling public policy objective, this end of life stage is also the very time that infrastructure investments are made and when such process legislation is triggered. Special exemption from legislation like MEPA is almost tantamount to striking these laws completely from the books, and fundamentally undercutting the commitment to thoughtful planning process.

4.2.1 Troublesome timelines

> 'Would you tell me, please, which way I ought to go from here' asked Alice. 'That depends a good deal on where you want to get to,' said the Cat. 'I don't much care where--' said Alice. 'Then it doesn't matter which way you go,' said the Cat.
> – Lewis Carroll (1865)

In the absence of a formal planning and evaluation process, the way that ABP projects are being scoped and phased has become quite troubling. As required by the enabling legislation, the Structurally Deficient Bridge Improvement Program Coordination and Oversight Council submitted its initial Bridge Preservation and Repair Plan for Calendar Years 2009 to 2011. The bridge list was developed using "a combination of data analysis and professional judgment." The selection of projects resulted in a mix of replacement, rehabilitation and preservation, with individual projects prioritized for repair based upon: "the seriousness of the structural problem, the structure's regional and local importance, geographic equity and cost and budgetary considerations… [and] each project's relative level of difficulty, since one of the overarching requirements of the Program is that all projects be completed within eight years." In this plan the McCarthy Viaduct was identified as "functionally obsolete," meaning that it was not assessed as "structurally deficient," but "included in the Program because cost effective preservation work is being undertaken in order to keep them from declining into structural deficiency."[111] Despite "transparency and accountability" being one of the program's stated goals, the ABP has not provided any mechanism for formal public involvement or consultation either in identifying the selected ABP projects, in deliberating the scope of proposed maintenance, repair or rehabilitation actions, or in prioritizing projects and sequencing construction. Instead, these decisions have been made by the MassDOT bureaucracy and simply communicated to the public through update reports and construction notices.

111 Commonwealth of Massachusetts (2008)

Based on these reports, the following sequence of decisions about the McCarthy Viaduct has been assembled. In the December 2010 ABP update report, MassDOT showed a timeline with work on McCarthy Viaduct going out for bid in August 2013 and construction starting in early 2014. The work estimate for the McCarthy Viaduct in this plan was $22 million. In the spring of 2011, the MassDOT Office of Transportation planning initiated the Grounding McGrath study, a study whose very title substantiates that there is a serious doubt about the necessity and utility of the existing McCarthy Viaduct. The Grounding Study was scheduled to release a package of short, medium, and long-term recommendations for the future of the McGrath corridor by summer 2012, which would be well before August 2013 when any possible repair work on the McCarthy Viaduct would be put out for bid. With this sequence, the ABP could be used to repair, remodel or even remove the McCarthy Viaduct in a manner consistent with the findings of the Grounding Study. Moreover, the loss of 50% of capacity on McGrath Highway in 2014 when the necessary Gilman St bridge reconstruction is scheduled is the sensible time to carry out disruptive reconstruction of any kind on the McCarthy Overpass.

However, this logic of study, followed by decision, and then action has been completely upset by the discretionary scheduling of ABP projects. In the March 2011 ABP update report the construction budget for the McCarthy project is reduced to $10 M from $22M. This is ostensibly as a response to a reduced scope of work, however, reasoning for the change is not explicitly specified in the report. In the September 2011 ABP update report, issued when the Grounding Study was well underway, a revised timeline is shown. In this schedule, the $10 M scope of work for McCarthy goes out to bid in fall 2011 (instead of summer 2013) and construction is scheduled to start in early 2012 before the scheduled release of the Grounding Study's recommendations. Absurdly, this would have the effect of spending public money to lock-in the admittedly functionally deficient situation.

In its update reports, MassDOT does not provide any compelling reason or present any new structural assessments to the public to demonstrate why the start of repairs on McCarthy should be moved up by two entire years from spring 2014 to 2012. There is only a cursory connection offered in the September 2011 ABP report between scope and timeline. As reason for the February 2012 bid date the report cities: "project re-scoped as a repair contract while the 'De-elevation' study is being performed." However, the logic of the September 2011 report is obscure, and it does not follow that re-scoping the work from $22 M to $10 M should demand a fast-tracked timeline. In fact, reducing the scope of work should enable pushing back the timeline (or at least maintaining the original timeline) since there is a smaller amount of work to design and execute by the program's 2016 end date. Regardless, even if the change of scope and timeline are indeed somehow related on technical merits, then MassDOT should have then indicated the change in timeline in the March 2011 ABP update when the reduction in scope from $22 M to $10 M was first communicated to the public (instead of six months later in September 2011).

Lacking a communication mechanism of its own, the ABP has used the Grounding McGrath Study as a medium to share information about the McCarthy repairs and to respond to public outrage about the modified repair timeline. MassDOT ABP representatives define the scope of repairs to the McCarthy Viaduct variously as: "short term solution (approx.10 years) – not a long term rehabilitation plan" with the goal to "maintain existing level of service, while minimizing impacts to surrounding area, for the duration of Grounding McGrath Study."[112] In another public meeting, the rationale given for undertaking repair work is to "restore the viaduct and keep it in good repair for approximately ten years, the expected time that would be required to implement any long-term recommendations."

These rationales and stated purposes are extremely weak and it is difficult to accept them as good faith actions by an agency that is actually committed to transparency, accountability and an open public process to debate the future of the McGrath corridor. By injecting millions of dollars into the existing elevated to provide ten years of life-support, MassDOT is making a de facto policy decision about the future of the McGrath corridor that completely undercuts it own ongoing public engagement process through the Grounding Study. The Grounding Study can reach one of three general recommendations about the path forward:

- to fix/replace the existing viaduct more or less in its current design;
- to maintain an elevated portion but with significant modification in design; or,
- to tear-down the McCarthy Viaduct and reconceptualize the corridor with an at-grade design.

Although the exact future of McGrath is yet to be determined, at least two of the three possible outcomes involve demolishing part of or the entire McCarthy Viaduct. Partial demolition of the viaduct, such as the elimination of certain on- and off-ramps to improve safety and usability could be implemented within far fewer years than ten. As such, it would be prudent to defer investing any money toward the repair of the McCarthy Viaduct as long as possible. The ABP has the laudable goal of trying to correct for decades of neglect and deferred maintenance, and also to be forward-thinking by making repairs to the McCarthy now that would forestall the need for much more costly repairs in the future should the structure fall into more severe disrepair. However, the costs of not acting now must be weighed against the very real opportunity that the goal of reducing the number of structurally deficient bridges can be achieved simply by tearing-down the McCarthy Viaduct so that there is no bridge to maintain at all. This very approach was selected in spring 2012 for another similar ABP project: the Casey Overpass in the Jamaica Plain neighborhood of Boston.

In the case of Casey, MassDOT initiated in March 2011 a process to study alternatives to replace the overpass and established a Working Advisory Group

112 Grounding McGrath Study Public Informational Meeting, September 20, 2011

(WAG) to support this work. By March 2012, MassDOT selected an at-grade alternative for the Casey Overpass that will use ABP funds to demolish the existing elevated structure and replace it with an at-grade boulevard. It is difficult to understand the reasons behind the completely different attitude and approach that MassDOT has demonstrated on the Casey overpass versus the McCarthy Viaduct. However, one notable difference is in the way the state has framed the existing condition of the two structures. In the case of McCarthy, repair work is being conducted to prevent the structure from deteriorating into a deficient condition. On Casey, MassDOT has asserted that the structure has already "deteriorated to a point where it can no longer be maintained…and is at the end of its serviceable life."[113] Yet herein lies the irony of programs such as the ABP. In her work examining the factors contributing to successful and unsuccessful urban highway tear-down projects in the United States, Napolitan (2007) identifies several preconditions for success, including:

"(1) the condition of the freeway must be such that there is concern over its integrity and structural safety, (2) a window of opportunity exists; the window may be the precondition itself or another event that enables a freeway removal alternative to gain serious consideration and legitimacy"

Decades of neglect have created such concerns over the integrity of McCarthy Viaduct and open the necessary window of opportunity to reconsider its future; this opportunity has been recognized through the initiation of the Grounding Study. However, with construction scheduling left to the discretion of those in MassDOT administering the ABP, the agency is rushing to lock-in multi-million dollar contact commitments that will eliminate this window of opportunity.

The lack of coordination between the timeline of ABP repairs on the McCarthy Viaduct and the issuing of recommendations by the Grounding Study is a sign of a major institutional failure within MassDOT. But this behavior is also a product of bad incentives in an agency operating in silos. MassDOT was created in 2009 to streamline and merge many legacy agencies (such as The Massachusetts Highway Department, Executive Office of Transportation and Public Works and Massachusetts Bay Transportation Authority) into a single body. Despite these reforms, the Highway Division within the new MassDOT is implementing the ABP while the Office of Transportation Planning is coordinating the Grounding Study. Although both bodies are part of the same overarching agency, and therefore ostensibly share the same overarching goals, each is in charge of implementing more specific mandates. In the case of the Highway Division the ABP has created a strong mandate, supported by a special act of the legislature, to repair bridges. The ABP legislation gives the Highway Division a $3 billion check that expires in 2016 for the purpose of fixing and building bridges. The structure of this legislative earmark does not necessarily create incentives for good planning by the Highway Division – instead the motivation is to

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113 MassDOT (2012), Casey Arborway Project

deliver projects and spend money as quickly as possible lest any remaining balance be clawed back in 2016. Therefore, it would not be particularly counterintuitive to the MassDOT Highway Division to spend $10 on a McCarthy Viaduct that may not be necessary (or desired) in the Somerville community, since by doing so they are satisfying their institutional mandate. Indeed, construction progress on several big ticket ABP projects such as the Longfellow Bridge over the Charles River has been held up by lengthy environmental assessment processes triggered at the federal level, likely creating pressure within the Highway Division to deliver other projects more quickly. This may seem like a rather cynical interpretation of the agency behavior, however, it is consistent with the goals of the ABP to rapidly finish projects, create jobs, and spend money rapidly. Leveraging the ABP as an opportunity to improve or reconceptualize the functioning of the State's transportation system has not been found anywhere stated explicitly as a program goal or implementation objective of MassDOT. Furthermore, this proclivity of highway departments to focus on spending the money is a chronic problem. During the height of the highway revolt in Boston, Governor Sargent's task force in 1970 reported: "the interstate highways within Route 128 will be built as planned, it appears, not because they are the best public investment – or even the best highway investment – for the money. They will be built solely because they involve ten cent dollars from the state standpoint."[114]

There is widespread agreement that the McCarthy Viaduct is in bad structural condition. However, the current scoping of even the scaled-back $10 million repair proposal has an arbitrarily narrow definition of deficiency that further suggests an institutional bias in the implementing agency. The deficiency of the McCarthy Viaduct encompasses more than the mere physical state of the concrete and steel in the bridge. The current deficiencies extend just as much to its functional (in)ability to safely accommodate even the basic demands of city street traffic, pedestrians, cyclists and ADA users. These are not 'side-effects' of the bridge, but instead structural consequences of the design of the bridge, its ramps and approaches, the intersections it crosses, and the streets it cuts off. Though it could be argued that the concrete and steel concerns are 'structural' deficiencies and the local access, pedestrian and bicycle shortcomings are 'functional' deficiencies, all structural deficiencies can only be defined with respect to a functional group of users. For example, if traffic on the viaduct were hypothetically restricted to pedestrians only (if, for example, the Viaduct were turned into a park like the High Line in New York City) there would not be anything deficient about the structure as it stands today. Instead, concern over the current load-bearing capacity today arises due to truck traffic that passes on the viaduct. Therefore, if it is legitimate to deem the structure deficient because of concern about its inability to carry trucks (which constitute only 4% of the traffic volume), it is just as legitimate to include the other modes that are not being supported by the structure in the scope of ABP repairs. This interpretation is consistent with the ABP legislation which specifies establishing funds "to provide for an accelerated structurally deficient bridge improvement program…for the

114 Lupo (1971), 97

design, construction, reconstruction and repair of or improvements to bridges and approaches." Furthermore, MassDOT is choosing not to adopt the full breath of the ABP earmark, which specifies "bridges and approaches," by proposing a scope of work to repair the McCarthy Viaduct that only considers the elevated structure and not also the surface roads and approaches. It is completely inexcusable for MassDOT to consider spending $10 million primarily to enable trucks to continue using the McCarthy Viaduct (who have I-93 as a possible alternative too), while completely ignoring users who have been structurally excluded for decades. Doing so is an ugly and unnecessary trade-off between taking proactive action to avert future decline into structural deficiency, and forgoing even basic reactive action to address current failures for non-vehicular users. MassDOT is choosing to take the narrowest interpretation of the ABP mandate possible, a decision driven by an institutional culture of road building and a repair program that incentivizes this illogical behavior. Furthermore, MassDOT's own assessment is that the McCarthy Viaduct is "functionally obsolete." However, the proposed scope of repair work is poised to re-invest in the most outdated and dangerous design features of the existing structure: the obscure and dangerous northbound tunnel movement; the lack of protected pedestrian crossing across northbound McGrath at Somerville Ave; and, the dangerous and confusing weaving between the Somerville Ave down-ramp and the southbound frontage road.

Despite the formal exemption from MEPA, it is clearly unacceptable behavior for MassDOT to use the structurally deficient condition of McCarthy Viaduct to rush through a civil engineering patch job that would fundamentally undermine the saliency of proper public debate about whether or not the overpass should exist in the future.

4.3 Death by 1000 cuts – Green Line Extension and Grounding McGrath

Realizing the potential for large parts of Somerville to revitalize and re-develop around the vision of walkable neighborhoods and transit-oriented land use requires both grounding the McGrath Highway and completing the Green Line Extension. The highway revolt and environmental movement of the 60s created landmark legislation to require a more thoughtful and comprehensive planning process and funding flexibility to support transit. However, with the automobile and the infrastructure to support it established as the status quo, planning processes and infrastructure funding programs are working to create anti-environmental outcomes that hinder the development of transit alternatives and transit-oriented land use necessary to reduce auto dependence. In particular, this section discusses the impact of systemic distortions in how the benefits and costs of auto-oriented projects compared to public transit are measured and considered.

4.3.1 Benefits, costs and decision-making

In their article on cognitive barriers to environmental action Shu and Bazerman (2010) discuss decision-making biases at the individual level that lead people to systematic and predicable errors. Some of these same biases can be used as a framework to understand the behavioral economics of political decision-making about infrastructure. Two biases in particular are very relevant to this discussion: discounting the future and loss aversion. Despite outwardly stated positions about wanting to leave the world in a good condition for future generations, or even to improve it, implicitly people and organizations heavily discount the value of future benefits and use an extremely high discounting rate that creates an overweighting of short-term considerations. [115] As applied to political decision-making this tendency could translate to a fixation on the short-term benefits and costs of infrastructure implementation. A second relevant behavioral trait, and one of the most robust contributions of behavioral economics, is that "losses loom larger than gains." [116] This loss aversion results because individuals anticipate and experience the pain of a loss to be larger than the pleasure of an equal-sized gain. Shu and Bazerman (2010) suggest the important policy significance of these two behavioral biases. Loss aversion creates a tendency to perceive any deviation from the status quo as an "aversive loss." This, together with the over-discounting of future benefits, creates an unlikely climate for the success of policies that need to upset the status quo to deliver significant benefits.

4.3.2 Cost-benefit jujitsu

The tendencies of loss aversion (the focus on costs rather than benefits) and of discounting future benefits help explain the history of road and highway building in the United States. In fact, many public policies for automobile infrastructure have been implicitly formulated to take advantage of these biases. During the 1930s, the deficit spending concept of WPA projects enabled government to build infrastructure without doing the 'cost' side of the benefit-cost consideration. Benefits were delivered rapidly, whereas the imageability of costs was postponed. The dedication of gasoline sales taxes exclusively to finance road construction also creates a dynamic that avoids the cost side of the road building calculus. Taxes that are inevitably collected at the pump become the cost in the motorists mind, whereas infrastructure expansion is the resultant benefit. Under this user pays myth, the other costs of road building to society may be skirted, since there may be a perception that the facility has already been paid for through dedicated taxes. Although such reasoning is non-Pareto efficient, Rose (1990) notes that by the late 1930s state road engineers were of this mindset: "because roads were financed from user taxes, or so went this reasoning, they had to produce benefits for them. Motorists' costs, either for vehicular wear and tear or time lost traveling in an older route, appeared the best measure of the value of a new road." The structure of Interstate highway transportation funding programs, which offered state DOTs 90 cents for every dollar spent building the Interstate network, was another great strategy taking advantage of the tendency to implicitly discount the future and the non-pareto, non-compensation of negative

115 Shu and Bazerman (2010), 2

116 Shu and Bazerman (2010), 13

impacts. For the states, financial costs became benefits as they could leverage nine times more short-term benefits from construction activity and medium-term benefits of enhanced auto-mobility. As freeway construction moved into urban areas, the cost-benefit dynamic was again distorted in favor of the automobile. In the 1950s ideology which perceived the inner city as blighted, the short-term costs of neighborhood destruction were portrayed as benefits, absorbed and absolved by urban renewal and improved mobility.

However, with the creation of planning process requirements and project environmental review, the cost-benefit landscape began to tip away from mindless road expansion. NEPA requirements helped move toward a full disclosure of costs and benefits where the costs are short-term and the benefits are distant and fuzzy, therefore, helping the no-build scenario to win politically. The success of community-based highway revolts also has an explanation in the perceptions of costs and benefits. Groups were initially fighting highways for reasons that had little to do with transportation. Rather, they organized around a loss aversion sentiment and concern about how proposed road projects threatened some important values that highway bureaucrats overlooked, downgraded or did not share. For example, a plan to cut down dozens of mature trees in Cambridge to widen Memorial Drive brought out strong protests and the plan was ultimately stopped. Across the river, citizens in Boston fought fiercely to have the Inner Belt through the Fens buried because of visual impacts on the Museum of Fine Arts and other revered cultural and educational institutions. [117]

In the renewed focus on transit investment that emerged from the Highway Revolt, the ability to generate significant construction spending stimulus on transit was a key element in securing political support including the support of construction and labor interests who would also be primary beneficiaries of a transit-oriented plan.

Unfortunately, the dynamics of internal and informal MassDOT cost and benefit perception do not seem to align in favor of grounding McGrath or achieving the timely extension of the Green Line. Grounding McGrath holds a larger potential to free the surrounding area of its infrastructural legacy and to enable a significant area in Somerville to revitalize as walkable and transit-oriented places. However, these are the promise of future benefits, and they are likely to be discounted heavily or not considered at all by MassDOT. Unlike in the Highway Revolt where citizens rallied around saving existing neighborhood assets, the area around McGrath has been badly affected by the disamenity value of the elevated McCarthy Viaduct. As such, keeping the elevated up is a more of a non-decision that maintains the status quo and that has few present-day costs (but many latent opportunity costs). Furthermore, the discussion in chapter 3 demonstrates that transportation modeling as practiced does little to help (and in fact hinders) the perceived attainability of a more transit-oriented and walkable future. Therefore, there is likely a substantial discounting of

117 Lupo (1971), 215-218

the benefits of this potential to transform Somerville. Even worse, the modeling and forecasting process perpetuates the imaginary benefits of auto-oriented infrastructure decisions by violating capacity constraints and promising mobility gains and travel time savings in the short- and medium-terms that are fundamentally unachievable.

4.3.3 Do-nothing?

The cognitive and political evaluation of costs and benefits discussed above suggests that there is a strong permanence of infrastructure once it is built and established. This inertia is further compounded and institutionalized by NEPA and similar state-level environmental assessment process such as MEPA. The Environmental Assessment (EA) and Environmental and Impact Statement (EIS) prepared under NEPA and Environmental Impact Report (EIR) prepared under MEPA examine impacts of a proposed action on the environment in comparison to the existing conditions and the benchmark of a so-called 'do nothing' / 'no-build' scenario.

The reconceptualization potential of America's ailing infrastructure lies in the structurally deficient condition of facilities. Structural deficiency implies an unacceptable condition if nothing is done (e.g. safety risk or even bridge collapse), and this forthcoming scenario initiates interest in infrastructure investment, which in turn triggers NEPA and NEPA-type processes. However, with ailing infrastructure that exists today but whose future is in question, NEPA is enabling highway agencies to perpetuate the status quo by defining the no-action scenario as undertaking maintenance and repair to maintain the existing condition: the condition that a bridge or facility exists. However, defining the existing condition based on a simple binary physical condition (that a facility does or does not exist) rather than in terms of the policy condition (that some decision is now required) does not provide a fair counterfactual. The do nothing alternative should entail exactly that: doing nothing. This would provide a meaningful counterfactual that would allow a complete range of outcomes to be considered in an environmental review, from facility closure (due to inadequate structural condition) to repair, rehabilitation, or replacement.

The EIS on the Goethals Bridge between Staten Island and New Jersey exemplifies this interpretation of existing conditions with a default to accepting the continued existence of the highway landscape: "given continued and increasing repair and maintenance needs and related questions of structural integrity associated with the 82-year-old bridge, this preliminary alternative [no-action alternative] would include future rehabilitation activities in addition to routine maintenance in order to maintain this critical crossing in the interstate highway network." [118] Defined and interpreted this way, the NEPA process institutionalizes and legitimizes the persistence of existing infrastructure for decades into the future even when a significant departure from no action is required to achieve this outcome (i.e. considerable maintenance and rehabilitation that should be subject to environmental review). (**figure 43**)

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118 Port Authority of New York and New Jersey (2010)

Furthermore, it is important to recognize that the structurally deficient condition of infrastructure has largely been self-inflicted by decades of highway agencies actually doing nothing and failing to undertake maintenance.

In comparison to the free pass that existing highway infrastructure gets from meaningful deliberation over whether or not its existence should continue, transit projects such as the Green Line Extension that are meant to be environmentally benign or even beneficial are heavily burdened and delayed by significant scrutiny. Ironically, in the case of the Green Line Extension instating transit service actually a represents a return back to a prior existing condition, reversing the discontinuation of rail service in Somerville that was never subject to environmental review; the proposed GLX right of way occupies the corridor of the former Boston and Lowell Railroad and GLX stops at Gilman Square, Lowell St, Ball Square, and College Avenue are near the historic stops at Prospect Hill, Winter Hill, Somerville Junction and North Somerville.[119] However, reinstating this service with the GLX is considered a departure from no-action and today's existing condition, and a lengthy and counterproductive environmental process has plagued its progress. This process is discussed in the section below.

4.3.4 Comprehensiveness bias

In 1993, the Commonwealth of Massachusetts made a legal commitment to the Green Line Extension in its State Implementation Plan (SIP) to attain air quality standards of the Clean Air Act. Extending the Green Line from Lechmere to Medford Hillside was a measure to ensure that air emissions and congestion relief benefits from the Central Artery / Tunnel project (the 'Big Dig') are realized. Despite the 1993 commitment to commence service to Medford Hillside by 2011, meaningful progress on pursuing the extension lagged behind schedule and the Conservation Law Foundation (CLF) and other parties filled a lawsuit against the State to try and

119 Block-Schachter (2012), 82

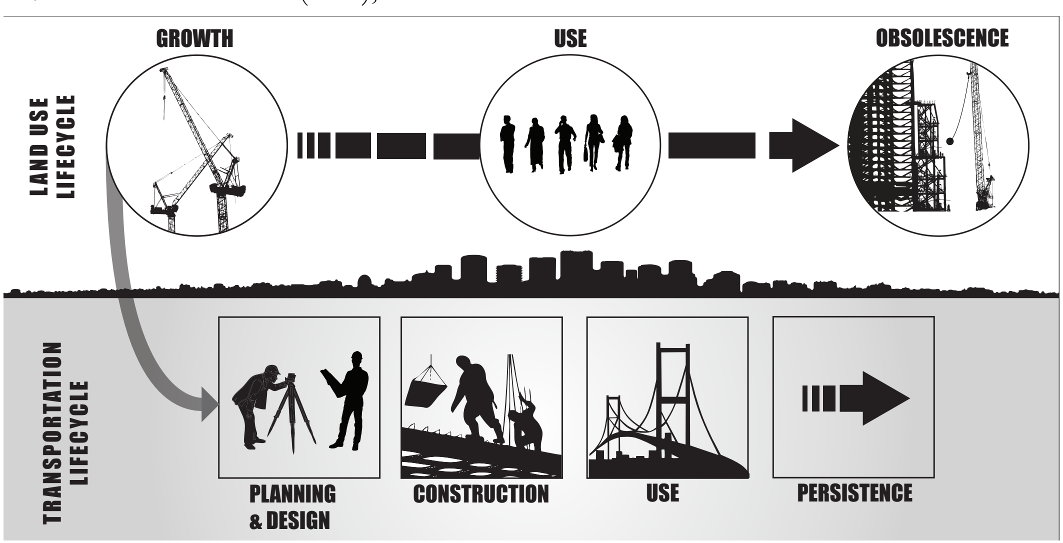


Figure 43: Comparison of the cycle of growth and obsolesence in land use versus permanence in transportation infrastructure.

keep the project moving. As a result of the CLF court challenge in 2006, the State made a commitment in the 2007 SIP to have the Extension open and operating by Dec 2014. In 2010, further slippage to 2015 was announced, and in summer 2011 MassDOT announced that it would not be able to complete the project by 2018 at the earliest and most likely only by 2020.

Since the 1962 reforms to the Federal Highway Act to create a "3 C's process," there has been a clear directive for highway planning to be "comprehensive." However, as discussed in chapter 1.3, public expenditure on road building is just the tip of the iceberg since a large share of the cost and investment to make the highway system function is externalized on to other parties. Notwithstanding the federal regulation requiring plans to be comprehensive, environmental processes for highway and road building simply assume that sufficient street capacity and parking would be provided to accommodate forecast traffic volumes, absent any physical plan, financial plan, or political support for such changes and investments. Indeed, this was an important critique in the Boston Transportation Planning Review, which in January 1970 expressed to Governor Sargent: "the entire viability of the Expressway plan for the regional core depends on certain key assumptions about the local street capacity in the vicinity of interchanges. Some of these assumptions appeared quite weak: the South End bypass is scheduled to absorb half of the peak hour traffic coming off the Southwest Expressway. The bypass is a local project, which the city at present does not expect to be implemented. All observers, including those at the DPW, agree that the Expressway cannot work without the bypass."[120] However, this level of comprehensiveness was unique to the BTPR, as even the currently ongoing Grounding McGrath study fails to be comprehensive by considering roadway capacity constraints *within* the corridor of study.

In contrast, building public transit triggers a system investment that is inherently comprehensive given the need to provided not only the right of way, but also the vehicles, stations, and operation and maintenance support that make the system functional. Yet, in a perverse manner this attention to the comprehensive requirements of a transit system has led to an environmental review process for the Green Line Extension that is forced to consider a specter of action, alternatives, and impacts drastically greater in scope. As such, much of the schedule slippage on the GLX timeline has been self-inflicted by the State and Federal environmental process working in an anti-environmental way.

In October 2006, the Executive Office of Transportation (EOT) submitted an Expanded Environmental Notification Form (EENF) on the GLX as required by MEPA to be review by the Massachusetts Secretary of Environmental Affairs. At this time EOT requested that the Secretary grant permission to use a clause under MEPA that streamlines the process and enables the requirement for project environmental review to be satisfied with a single Environmental Impact Report (EIR) rather than the usual process of a draft (DEIR) followed by a final. However, in the Certificate of

120 Lupo (1971), 96

the Secretary on the EENF, the secretary denies the request for a streamlined process because of shortcomings in the comprehensiveness of the EENF. Consequently, the secretary specifies the extent of comprehensiveness and that the "DEIR should identify temporary and permanent land takings… analyze feasible alternatives to the Yard 8 [maintenance] site, including but not limited to the BET [Boston Engine Terminal]… propose specific station locations based on this analysis and describe how they support ridership goals and other objectives of the project… provide more detailed designs and renderings of the stations, describe amenities that will be provided (canopies, street furniture, lighting, vending machines, trash receptacles, etc.)" The Secretary's Certificate further specifies that the EIR should "describe operating parameters for the service including the type and number of cars required to provide service and headways… should detail requirements for the maintenance facility including parking… describe electrical systems including the catenary and support structures, substations and signal and communication systems."[121]
After three years of work, in January 2010 the Secretary of EOEA releases the certificate on the completed DEIR for the Green Line. Although the DEIR is approved, the secretary declined to allow the DIER to be considered a final EIR because of "the ongoing evaluation of maintenance facility siting alternatives, the need for additional discussion of impacts at College Avenue and Lechmere Stations, and a requirement for clarification of the future mitigation and community participation commitments." Finally in July 2010, the Secretary of EOEA approves the final EIR submitted by MassDOT.

The burden of environmental review on MassDOT was extensive and far more detailed than what a highway project would be subject to; parking, maintenance, and fuel sources are simply beyond the scope of road projects that are narrowly defined to the extent of the right of way. Furthermore, significant delay was caused by the MassDOT effort to locate the maintenance facility at an unacceptable location (Yard 8) and by Mass Executive Office of Environmental Affairs (EOEA) insisting on an additional environmental process to address the revised maintenance location. However, the proposed maintenance facility is not an essential element of the GLX as promised in the SIP.

Although State-level environmental review was completed in a three and half year period by summer 2010, the Green Line project still did not move ahead into more substantial design and construction. Instead, the project progress was held back by undertaking a completely separate Federal Environmental Assessment, which duplicated much of the effort and findings from the state-level DEIR/EIR process under MEPA. The need for a federal environmental review was triggered by the bureaucratic decision of the Federal Transit Administration (FTA) to not continue to participate in the state MEPA process. The Green Line is attempting to secure funding under the FTA New Starts program that helps fund new fixed guideway transit systems, and substantial delay to the project was created as a

121 Massachusetts Executive Office of Environmental Affairs (2006)

separate federal EA to satisfy FTA was produced. The Federal EA was released in October 2011. However, as of May 2012 FTA has not yet released a Finding of No Significant Impact (FONSI) that would allow the project to enter into a preliminary engineering phase. Much of the delay caused by the ongoing federal process is related to the evaluation of the Green Line through New Starts, which allocates funding to projects on a competitive basis across the nation based on a cost-effectiveness formula. Moreover, despite the hoops that FTA makes applicants jump through, the Administration "continues to encourage project sponsors to request a Federal New Starts funding share that is as low as possible" and FTA has been instructed by Congress "not to sign any new full funding grant agreements after September 30, 2002 that have a maximum Federal share of higher than 60 percent."[122] By contrast, the Federal Highway Administration, which administers the Federal-Aid Highway Program, funds eligible state DOTs projects on an 80/20 basis (federal/local) and requires no measures of cost-effectiveness. Nevertheless, the Massachusetts ABP generally does not seek federal 80/20 bridge funds in order to avoid the NEPA environmental assessment process.

4.4 Summary

A decided political departure from endorsing headfirst highway construction emerged in response to the backlash of building the Interstate system. Significant legislative protections for the environment were created, changes made to policy to enable flexible use of funding for road or transit projects, and measures enacted to reform the infrastructure planning process to enhance transparency and public participation and require the evaluation of alternative actions for projects proposed by the state.

However, at a time where there is momentous opportunity across the nation for the reversal of road building policy to be expressed physically in the reconceptualization of infrastructure, processes do not seem adequate to prevent highway re-building and support public transit as a replacement. Systemic distortions in how benefits and costs are considered, how the status quo is normalized, how project impacts are evaluated, and how funding is allocated, are contributing to a proclivity to repair or replace existing highways rather than to build the political will to reconceptualize them. The factors and forces that enabled the bottom-up success of the Highway Revolt are not aligned now as they were in the 1960s. The stakeholders and beneficiaries of the auto-mobility system are widespread and locked-in to the car, whereas the transformative potentials of reconceptualization are latent and distant.

Without doubt, the nation's aging infrastructure requires urgent attention, but for structures which typically last 50 years the projects should be thoughtful. Paradoxically, the cognitive fixation on losses and the implicit discounting of the future which reflect short-term biases fails to consider the system change potential of reconstruction pressures. The potential of focusing on these construction disruptions to enable better outcomes is discussed in the following chapter.

122 Federal Transit Administration (2012)

5. An opportunity to rethink automobile infrastructure

Faced with the fact that re-building existing highway infrastructure will be more challenging than the initial construction, since there are existing traffic loads to accommodate, and also faced with the need to consider a broader set of objectives than just automobile level of service, this unique set of circumstances requires a different approach to infrastructure planning. Instead of planning for a distant "design year" outcome as an endpoint, a strategy focused on near-term constraints and the process of construction implementation may hold promise to hold back the seemingly inevitable growth of vehicle traffic driven by the existing approaches.

Both the Grounding McGrath study and the Accelerated Bridge Program are focused on long-term outlooks for the future of the McCarthy Viaduct. However, neither of these two efforts explicitly considers the process of implementing the desired outcome, and the problems and opportunities that construction itself creates. Any construction work on the McGrath Highway has the potential to create significant traffic disruptions that will likely worsen the already poor conditions in the corridor. There is a tendency to regard these disruptions as an unfortunate period of pain, but an unavoidable means to realizing a greater end. However, the 'grin and bear it' approach is not politically savvy. It front-loads the costs of project implementation in terms of construction disruptions that can last for months or even years, but does not provide any of the anticipated benefits until project completion. Doing so weakens political support among the dominant stakeholder groups of existing users, but also does little to catalyze support from new beneficiaries since they remain a latent constituency. This interpretation is supported by the previously discussed findings of Shu and Bazerman (2009), who note the behavioral predilection to focus on the short-term and to weight losses heavier than costs.

Instead of framing corridor reconceptualization as a showdown between the automobile worldview and prioritizing other values, this chapter examines how taking mitigation actions for inevitable construction disruptions, as well as making spot improvements to improve pedestrian and motorist experience, can be used to create an incremental implementation strategy that recognizes the automobile while moving toward considering an at-grade McGrath Boulevard as the new normal.

5.1 Repairing the construction timeline on McCarthy Viaduct

The existing schedule to begin Accelerated Bridge Program repair work on McCarthy Viaduct before the completion of the Grounding Study seems clearly in favor of promoting automobile-oriented values over the potential of reconceptualization. However, the schedule of planned ABP and road construction projects over the next several years (listed below) is likely to create severe traffic disruptions for drivers in Somerville unless some significant changes in sequence can be secured.

Existing Schedule of Construction Projects

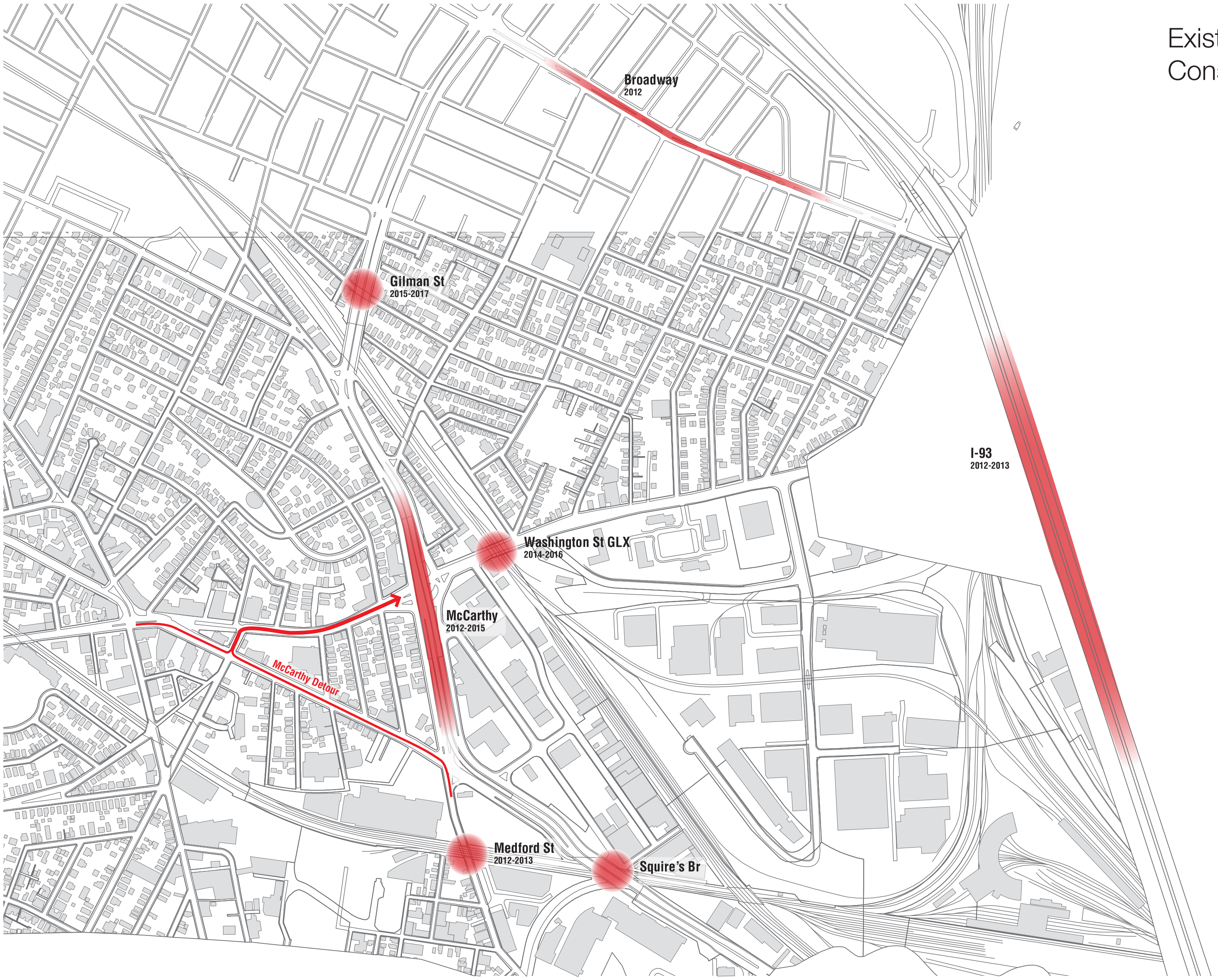


Figure 44: The current sequencing of bridge repair investments in Somerville scheduled by MassDOT does not demonstrate a strong logic of coordination and may inundate Somerville with traffic unless an appropriate sequencing and mitigation strategy is devised.

- Broadway, East Somerville construction, Summer 2012: reduced access to I-93 through to Sullivan Square during construction and long-term reduction in capacity from road-diet project.
- I-93 Maintenance, Summer 2012-2013: reduction of regional relief capacity for McGrath Highway
- Medford Street Rail Bridge construction, Fall 2012-Summer 2013: reduced throughput to Gore Street
- Gilman Street Bridge, 2014-2017: reduced throughput on McGrath Highway by 1 lane in each direction and 50% of capacity.
- Washington Street, Green Line Extension Station and Bridge: reduced throughput on Washington Street. The GLX Federal EA has noted that this requires mitigation.
- Squire's Bridge reconstruction: reduced throughput on McGrath Highway

As currently sequenced, this set of construction plans that will see MassDOT investing $50 million on bridges in the area threatens to create unnecessarily prolonged and disruptive changes that may inundate Somerville with traffic. (**figure 44**) Most concerning is that the current sequence of ABP projects brings the McCarthy Viaduct into construction in 2012.

This proposed timeline to start this repair work in spring is not sound from a technical point of view, even when just considering the interests of drivers. With limited resources and many other bridges in the Commonwealth meriting far more urgent structural attention, it is not a wise use of funds to expedite repairs on the McCarthy Viaduct. In particular, the 2012 start date is far before the much-needed re-construction of the Gilman St Bridge in the McGrath corridor (scheduled for 2014) which has been assessed structurally deficient and is in "serious" condition.

Work on the Gilman St Bridge will cause a significant disruption to traffic and generate a capacity constraint in the McGrath corridor. Furthermore, the proposed 2012 start date for repairs on McCarthy overlaps with scheduled construction work on Broadway and I-93. Advancing the timeline on the McCarthy Viaduct repairs to start in 2012, rather than to be simultaneous with the Gilman St reconstruction as initially proposed by the MassDOT ABP, only achieves a prolongation of the traffic disruption to the community. If done simultaneously, the Gilman St replacement and the McCarthy repairs could be completed with greater speed, efficiency and safety, and at lower cost, since the duration of the disruption is reduced and the work is coordinated to achieve a consistent reduction in capacity along the entire corridor rather than a protracted condition of spot bottlenecks moving between the various construction locations. The original schedule would also allow modifications to the I-93 HOV lane barrier curb that could increase I-93 capacity and provide somewhere for McGrath Highway traffic to go (other than local streets) during capacity reductions caused by the Gilman St Bridge reconstruction. Therefore, simply from the point of managing traffic disruptions it is prudent to restore the original repair timeline for McCarthy Viaduct to start in early 2014. Similarly, this sequencing also

Figure 45: The nothrbound and southbound directions of McGrath Highway at Somerville are separated by the median in which the supports for the SB elevated sit (top) and also divided by the northbound tunnel (bottom).

enables the partial or complete de-elevation of the McCarthy Viaduct to commence in 2014 under the ABP funding program should the Grounding Study recommend such action in its findings when they are issued in summer 2012.

Regardless of the sequence and timing, the proposed reconstruction of the Gilman St Bridge and currently proposed repairs to McCarthy Viaduct will reduce vehicle throughput in the McGrath corridor and require lane closures and turn restrictions. The following sections examine using these realities as further opportunities to reveal and realize the potential for a major reconceptualization of the corridor as an at-grade boulevard.

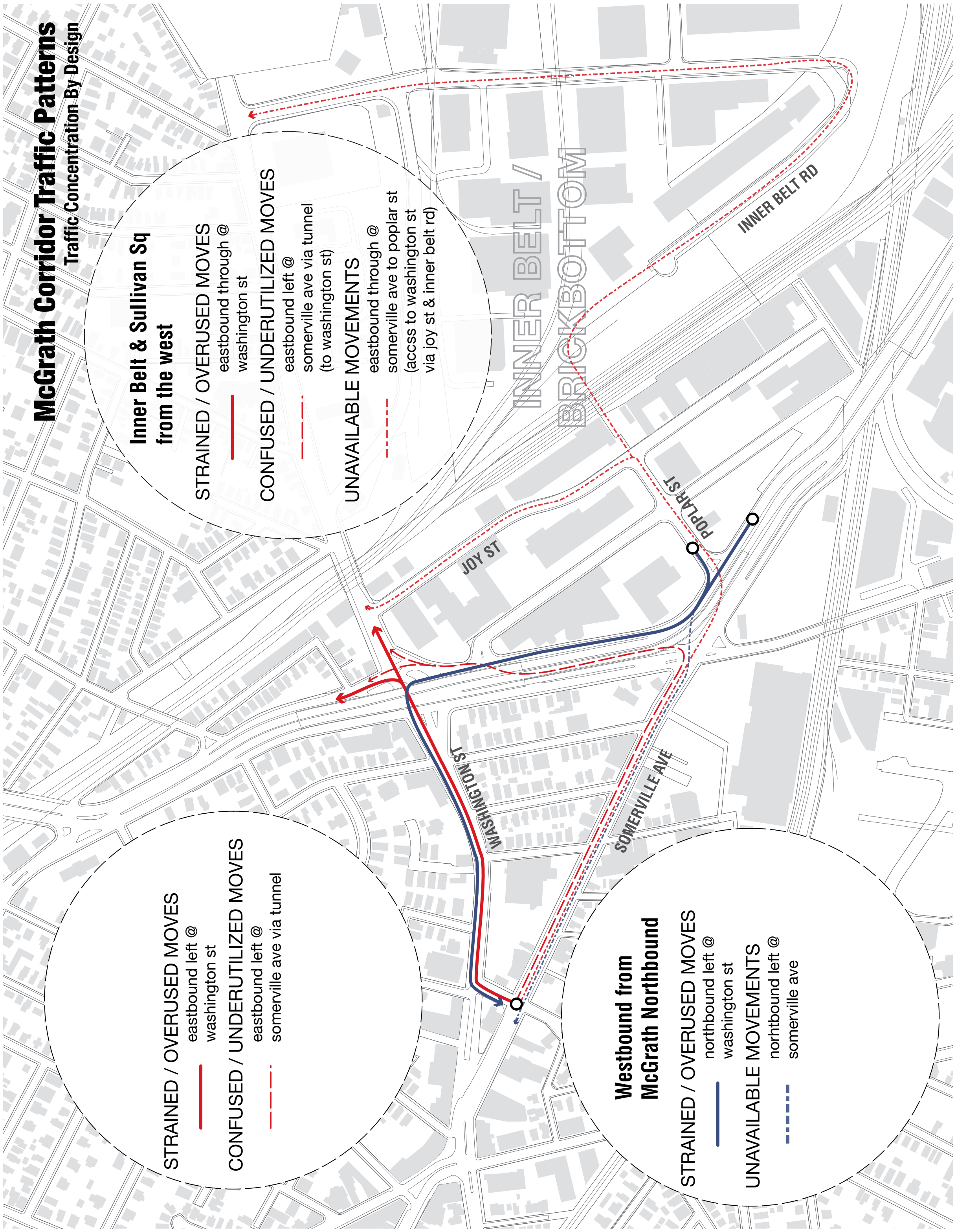
5.2 Heading toward a new normal

As discussed in the case description, the primary traffic function of the McCarthy Viaduct is to provide a grade-separation for through traffic at the Washington St intersection and the Somerville Ave/Medford St/Poplar St intersection. By reducing the number of vehicles being processed through these two key at-grade intersections, the elevated viaduct can in theory contribute to improving the operational performance of the intersections compared to if all traffic were handled at grade. However, the design and configuration of the elevated structure and its ramps at these two key intersections also result in unsafe conditions and traffic flow patterns that strain the local surface street network.

Perhaps the most troublesome location is the Somerville Ave/Medford St/Poplar St intersection. At this point, the southbound direction of the McGrath frontage road and the Somerville Ave southbound down ramp from the elevated meet at the signalized intersection. The northbound direction of McGrath is at grade, descending from the Squire's bridge, and then separates into a northbound frontage road and northbound on-ramp onto the elevated over Washington St. The northbound roadway of McGrath is physically separated from the rest of the intersection by a concrete median in which the piers of the southbound elevated sit. (**figure 45**) This configuration creates several major problems.

• For pedestrians, there is no means to cross McGrath Highway at the intersection (east-west) between the Union Square and Brickbottom neighborhoods, other than a jumping onto the concrete median and then running across three lanes of northbound McGrath traffic approaching at high speed as it descends from the Squire's Bridge. (**figure 33**) This pedestrian movement is not infrequent as there is a bus stop for MBTA routes 80, 87 and 88 at Poplar St and northbound McGrath Highway.

• Because of the median, vehicles cannot access Brickbottom and Inner Belt from southbound McGrath or from eastbound Somerville Ave. Traffic from Somerville Ave and Medford St headed northbound also cannot access the on-ramp to go over Washington St, but instead join McGrath Highway via an obscure and counterintuitive at-grade tunnel that goes under the northbound elevated and joins the northbound surface road just shy of the Washington St signal. (**figure 45**)


McGrath Corridor Traffic Patterns
Traffic Concentration By Design
Inner Belt & Sullivan Sq from the west
STRAINED / OVERUSED MOVES
eastbound through @ washington st
CONFUSED / UNDERUTILIZED MOVES
eastbound left @ somerville ave via tunnel (to washington st)
UNAVAILABLE MOVEMENTS
eastbound through @ somerville ave to poplar st (accss to washington st via joy st & inner belt rd)
INNER BELT / BRICKBOTTOM
INNER BELT RD
JOY ST
POPLAR ST
WASHINGTON ST
SOMERVILLE AVE
STRAINED / OVERUSED MOVES
eastbound left @ washington st
CONFUSED / UNDERUTILIZED MOVES
eastbound left @ somerville ave via tunnel
Westbound from McGrath Northbound
STRAINED / OVERUSED MOVES
northbound left @ washington st
UNAVAILABLE MOVEMENTS
norhtbound left @ somerville ave
Figure 46

This constrains the usability of the northbound McCarthy Viaduct to only traffic approaching from the Squire's bridge and headed past Washington St. All other northbound traffic is in the tunnel or on the frontage road.

• As a result of the limited-access configuration at Somerville Ave, east-west traffic flow in the area is concentrated on Washington St since it provides the only through connection between Union Sq and Sullivan Sq across the McGrath corridor. Similarly the confusing and obscure access to McGrath via the tunnel at Somerville Ave results in a significant portion of eastbound left turns originating from Union Sq and points west to occur at Washington St rather than at Somerville Ave (450 versus 71 in the AM peak hour). As a result, 35 seconds of green time in the signal cycle (120 seconds) at Washington St are allocated to the eastbound movement, while only 12 seconds are available for the southbound phase that accommodates the vehicles not using McCarthy Viaduct. These patterns exert significant pressures on the at-grade Washington St intersection that significantly undermine any operational benefits that may be created by the existence of the elevated viaduct and the vehicles it removes from surface intersections. (**figure 46**)

• The configuration of the southbound down ramp and surface road at Somerville Ave creates a dangerous weaving section where vehicles leaving the elevated heading onto Somerville Ave and Medford St conflict with motorists on the surface road heading southbound toward Squire's Bridge. This conflict is not only dangerous, but it also reduces intersection throughput. (**figure 47**)

5.2.1 Short-term remedies

The traffic detour plan proposed by the ABP to enable repair work to the McCarthy Viaduct stands to only aggravate these existing problems. During rehabilitation of the tunnel, northbound traffic from Medford St and the eastbound left turn from Somerville Ave to northbound McGrath will be detoured through the Somerville Ave and Prospect St intersection in Union Sq and sent up Washington St. This plan will further stain the eastbound left turn movement at Washington St and McGrath, by adding another 278 vehicles to the eastbound phase in the AM and an additional 611 in the PM. Furthermore, the Somerville Ave / Prospect St intersection in Union Sq already faces peak hour operational challenges under existing traffic volumes and origin-destination patterns.

This undesirable disruption to and worsening of intersection conditions is to accommodate repairing the tunnel, which is a functionally obsolete and confusing design that ought to be rectified. However, if MassDOT were to consider mitigation actions to the traffic disruptions related to the proposed repair projects as well as to address the obvious functional deficiencies in the McGrath corridor, the Accelerated Bridge Program could be harnessed to create short-term benefits that improve existing operational conditions and also to keep open the window for de-elevating the McCarthy Viaduct. This suggested alternative scope of work for the ABP is now proposed.

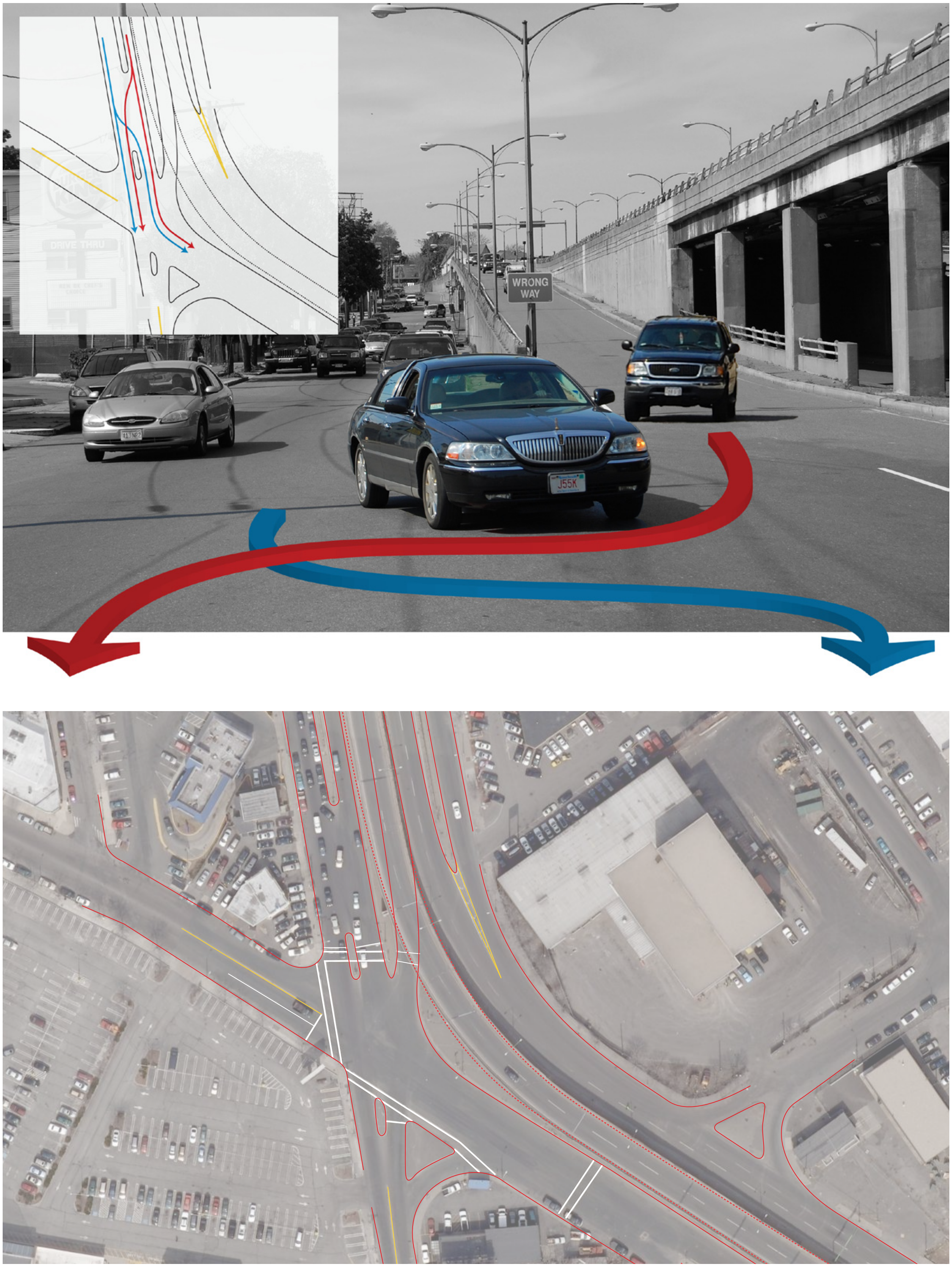


Figure 47: The current configuration of the southbound frontage road and down ramp at Somerville Ave creates a dangerous and confusing weaving movement

• *Signalize northbound McGrath Highway at Somerville Ave /Medford St /Poplar St*
This need for this modification is irrefutable from the point of view of providing basic pedestrian safety since the existing un-signalized crossing of McGrath is a completely unacceptable condition. (**figure 35**) Doing so also has the additional benefit of enabling the northbound tunnel to be eliminated by modifying the median under the McCarthy Viaduct to allow eastbound left and northbound through traffic at the intersection to directly access the northbound McGrath roadway. (**figure 48, 49**) This configuration has several operational benefits for motorists over the existing tunnel arrangement since it reduces the concentration of traffic at the Washington St intersection (described above), by allowing direct access to Brickbottom via Poplar St, providing a more clear and visible path from Somerville Ave to northbound McGrath, and providing a path from northbound McGrath toward Union Sq and points west. Making this modification does require changing the traffic signal timing at the intersection to accommodate an additional phase that allows the northbound left movement from McGrath to Somerville Ave.[123] (**figure 50, 51**) Although this change would reduce intersection capacity for the existing movements on Somerville Ave, Medford St and Southbound McGrath, this effect can be mitigated by the next recommendation.

• *Remove Somerville Ave southbound down ramp*
As described above, the existing down ramp design leads to a weaving pattern that is not only dangerous, but also reduces the saturation flow rate of the southbound phase at the Somerville Ave / Medford St intersection. Removing the down ramp will not change the number of vehicles approaching the intersection, and therefore, will not require any widening or addition of lanes at the intersection to maintain the existing level of service. (**figure 52**) Instead, with all approaching vehicles at grade, intersection throughput will improve since drivers will have more time and distance to choose the appropriate lane position ahead of the intersection. This capacity improvement can be used to offset the shortening of the signal phase associated with implementing the removal of the tunnel as suggested above. This recommendation also requires prohibiting parking on the east side of the southbound frontage road between Washington St and Somerville Ave (parking is currently allowed on both sides of the three-lane frontage road) to accommodate the additional flow of vehicles from the ramp on to the frontage road. Removing the down ramp not only improves operational conditions at the Somerville Ave / Medford St intersection, but also creates space to plant trees, improve sidewalks, and improve the visual and environmental quality of the corridor. (**figure 53, 54, 55**)[124] Removing the down ramp will create upstream impacts on the Washington St down ramp and

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123 Alternately, this movement could be accommodated by a mid-block U-turn on McGrath at the existing signal with Linwood St, a concept being examined in the Grounding McGrath Study.

124 A similar removal of a down ramp from the old elevated Central Artery was key to building support for depressing the entire structure since it demonstrated in small-scale the great potential to improve neighborhood conditions from de-elevating the structure. (Remarks by Fred Salvucci, April 23, 2012)

intersection by adding another 623 southbound movements in the AM peak hour. These additional vehicles can be accommodated at-grade.[125] Furthermore, the condition of the intersection will improve because the some of the very heavy eastbound Washington St left to northbound McGrath movements can be displaced to Somerville Ave. (**figure 46**)

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125 See section 5.2.2 bullet point "*Redesign Washington St at grade intersection*"

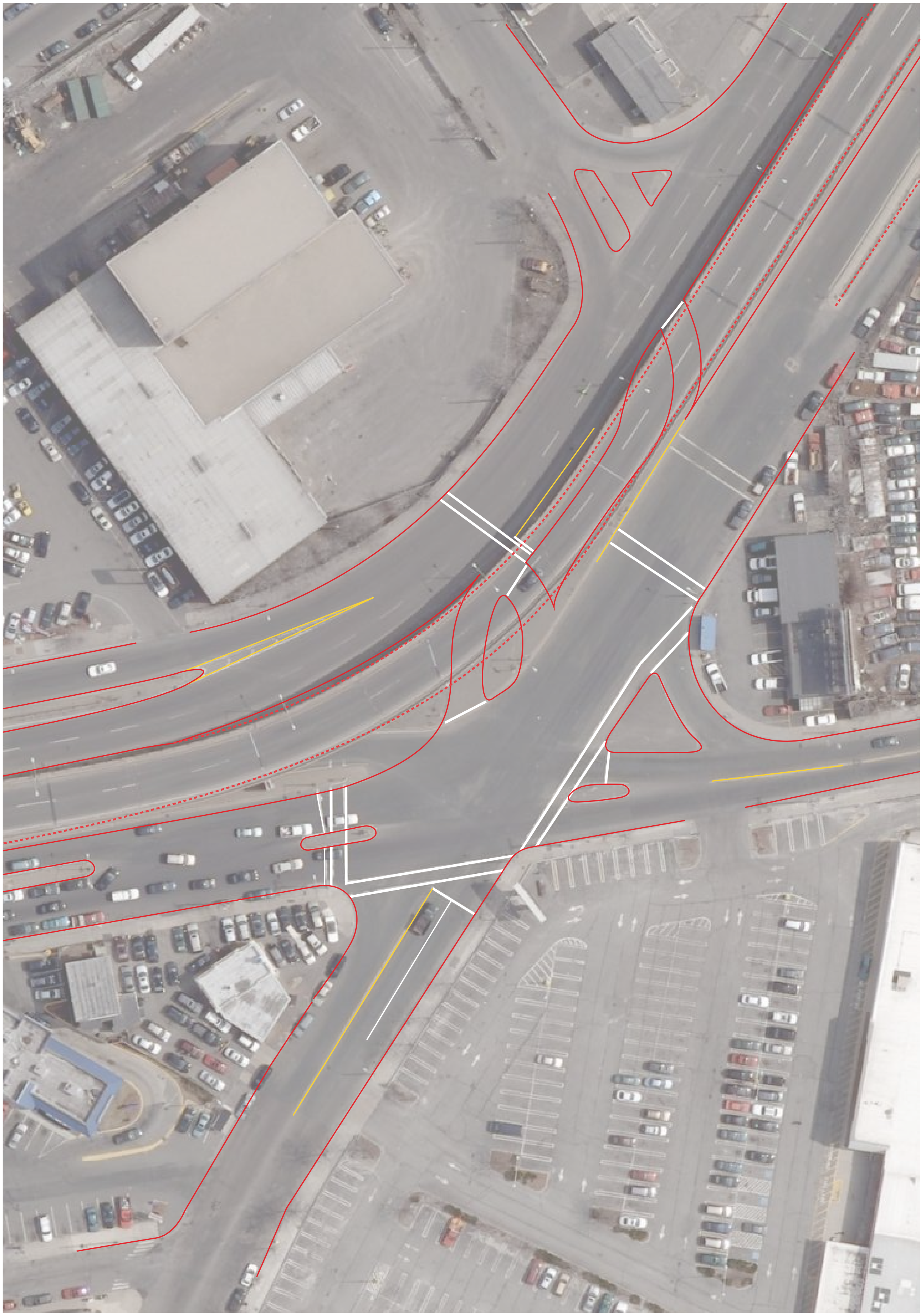

Figure 48: Proposed reconfiguration of lane geometry and access patterns at Somerville Ave / Medford St and McGrath Highway

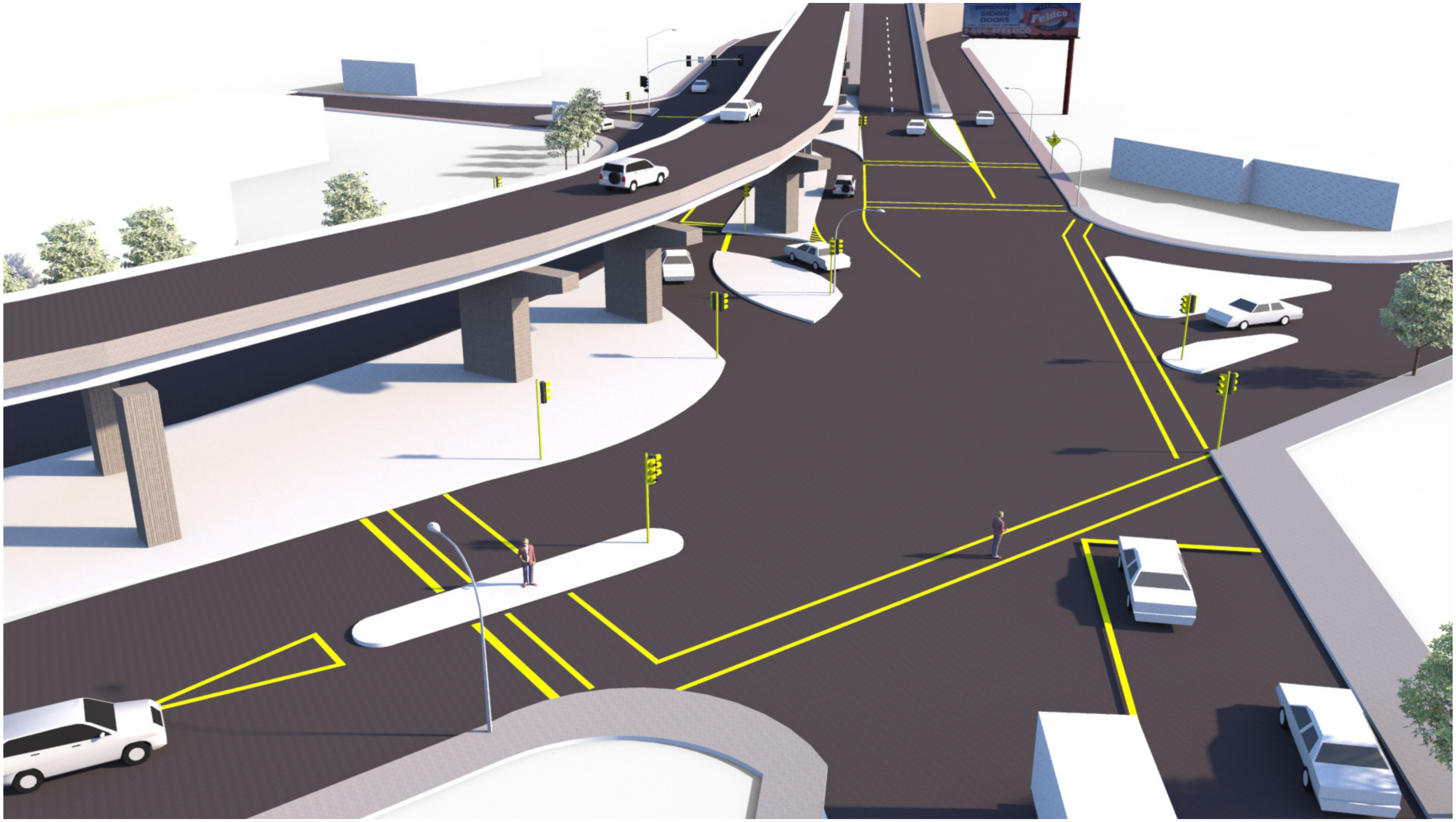

Figure 49: Visualization (looking south down Somerville Ave) of proposed modifications at Somerville Ave/Medford St and McGrath Highway, with signalization of the norhtbound McGrath Highway to provide a protected pedestrian crossing, access to northbound McGrath without the tunnel, as well as access to Brickbottom via Poplar St

McGrath @ Somerville Ave

Existing Signal Phasing

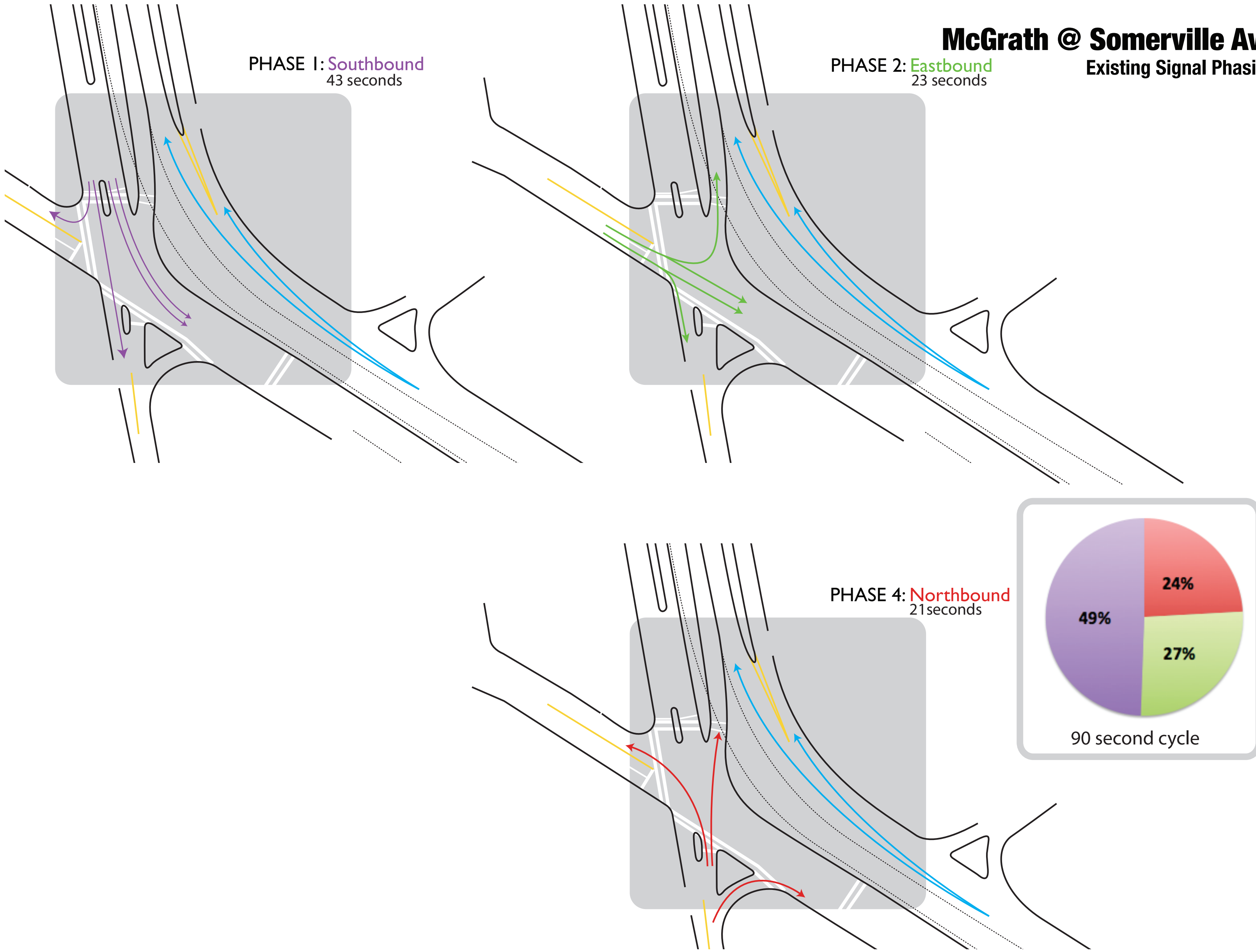

Figure 50

McGrath @ Somerville Ave

Geometry Modifications and Proposed Signal Phasing

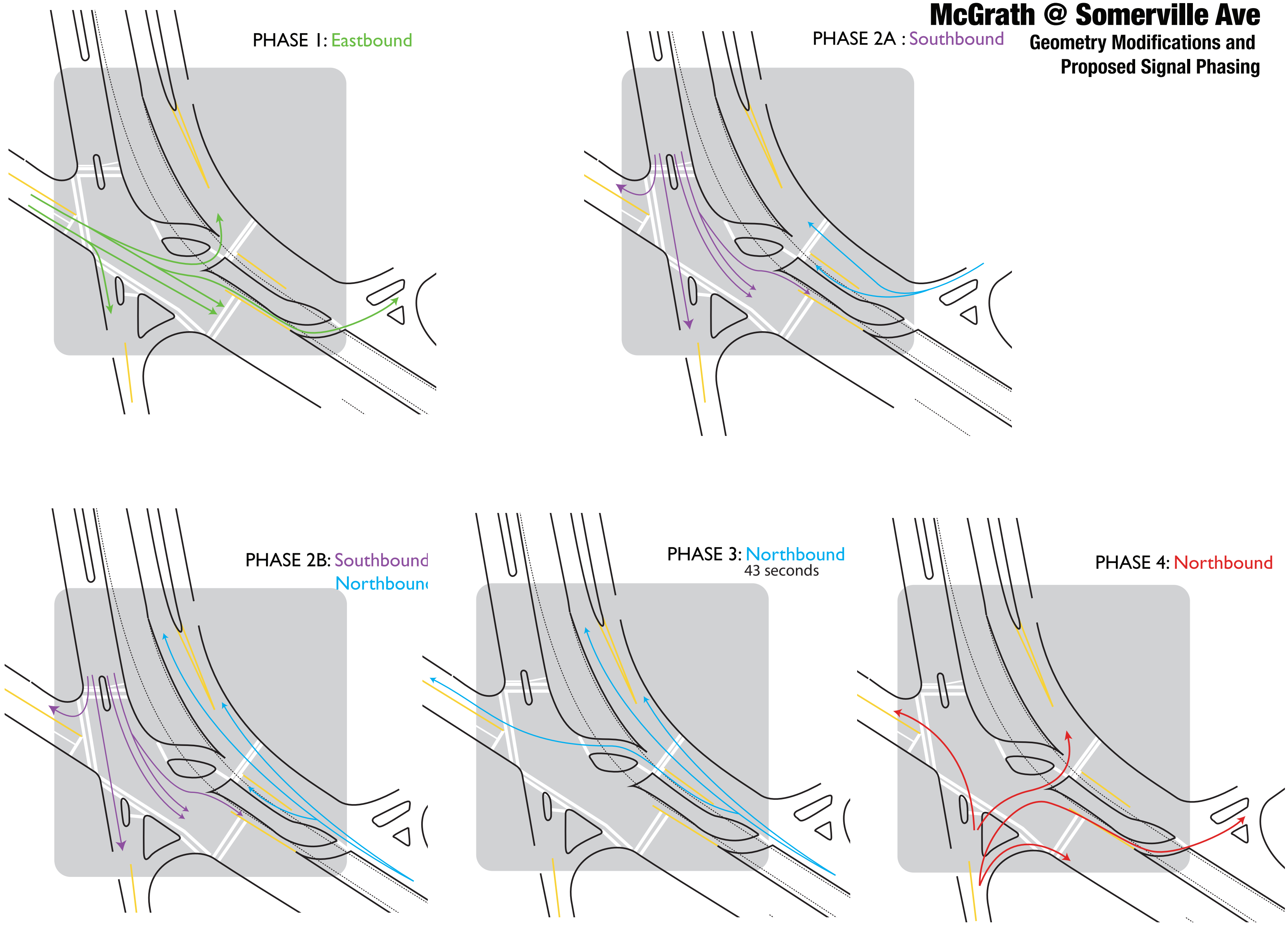

Figure 51

McGrath Highway Traffic Volume Scenarios

TRAFFIC VOLUME AT KEY LOCATIONS	AM PEAK HOUR TRAFFIC VOLUMES					
	Scenario A: Current O-D Patterns and 2011 Traffic Volumes			Scenario B: Gilman St Bridge Construction (-50% southbound volume and displacement ot I-93)		
	Configuration 1A Existing McCarthy Viaduct	**Configuration 2A** Remove Somerville Ave Down Ramp	**Configuration 3A** McCarthy Viaduct Removed & Traffic to Existing Frontage Roads	**Configuration 1B** Existing McCarthy Viaduct	**Configuration 2B** Remove Somerville Ave Down Ramp	**Configuratoin 3B** McCarthy Viaduct Removed & Traffic to Existing Frontage Roads
Washinton St SB Down Ramp	587	1210	3003	587	1012	1919
Somerville Ave SB Down Ramp	623	--	--	425	--	--
McGrath Frontage Road SB at Somerville Ave	1143	1143	2936	945	945	1851
McCarthy Viaduct SB over Somerville Ave	1793	1793	--	906	906	--
	CHANGE IN AM PEAK HOUR TRAFFIC VOLUMES COMPARED TO CONFIGURATION 1A (CURRENT 2011 VOLUMES)					
Washinton St SB Down Ramp	--	623	2416	--	425	1332
Somerville Ave SB Down Ramp	--	--	--	-198	--	--
McGrath Frontage Road SB at Somerville Ave	--	0	1793	-198	-198	708
McCarthy Viaduct SB over Somerville Ave	--	0	--	-887	-887	--

Figure 52

Figure 53: Visualization (looking north toward Washington St) of existing McGrath Highway southbound frontage road and down ramp at Somerville Ave.

Figure 54: Visualization (looking north toward Washington St) of McGrath Highway southbound frontage road with the proposed removal of Somerville Ave down ramp.

Figure 55: McGrath Highway southbound frontage road looking south toward Boston: existing condition with Somerville Ave down ramp (top), and visualization of proposed removal of the ramp (bottom).

5.2.2 Revealing long-term reconceptualization potential

If the recommendations to remove the northbound tunnel and eliminate the down ramp at Somerville Ave are implemented the only traffic remaining on the McCarthy Viaduct are trips headed over the Squire's Bridge to destinations in Cambridge and Boston.[126] Therefore, a partial de-elevation condition begs the question why not remove the entire McCarthy Viaduct? If all the traffic on the McCarthy Viaduct were shifted to the frontage roads, in the AM peak hour there would be an additional 2416 vehicles through the Washington St intersection (412% increase) and 1793 vehicles through Somerville Ave / Medford St (156% increase). (**figure 52**) These volumes could not be accommodated without substantial queuing and delay for motorists within the existing configuration of the surface roads. However, accommodating all the existing traffic from the elevated at grade is not necessarily a suitable or fair standard to test the feasibility of de-elevation given other traffic realities in the corridor.

The current proposed scope of work by the Accelerated Bridge Program will anyway increase the number of vehicles moving through the at-grade Washington St intersection when capacity on the McCarthy Viaduct is reduced to enable repairs to it. However, no mitigation action has been proposed for this in the ABP plans. Even more significant is that during the reconstruction of the Gilman St Bridge, the southbound throughput of the McGrath Highway will be reduced by 50% for several years.[127] During this construction period there will be a significant reduction in traffic volumes along the McCarthy Viaduct. The circularity in MassDOTs logic is inescapable. On the one hand, the McCarthy Viaduct must be repaired until a comprehensive de-elevation study is completed because of the significant volume of traffic it caries. Furthermore, this de-elevation study has established a 12.5% increase in traffic as the scenario for evaluating the viability of removing McCarthy. Yet, on the other hand the repair program necessarily constrains vehicle throughput in the corridor for several years and has been subject to no traffic study.

If society will have to survive with a 50% reduction in capacity on McGrath Highway for several years, then advocates for de-elevation argue why this shouldn't be established as a long-term reality. Furthermore, there is an additional and long-term capacity pinch point emerging at the Lechmere end of O'Brien Highway where the existing Green Line station is being relocated to the easterly side of the road, thereby forcing all pedestrians and busses using the station to cross the Highway. If MassDOT truly believes there is a capacity issue in the corridor, then the current construction activity must be accompanied by mitigation measures. In either case, the reality of the capacity drop must be recognized. Strategies to respond to the

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126 This analysis is focusing on the southbound direction since the inbound AM peak is heavier than the PM peak. The Grounding McGrath study is also using the same analytical approach.

127 The Gilman St Bridge construction phasing plans to keep two of three lanes of capacity on McGrath at all times, but capacity will likely drop by 50% because of a lower saturation flow rate in construction zones, and the constraint of the adjacent truss bridge.

capacity reduction and harness the potential of reduced flow on the McCarthy Viaduct are now suggested.

• *Regional traffic displacement & I-93 HOV modification*

Analysis of origin-destination patterns on the McGrath Highway using data from the CTPS (2012) study reveals that 14% of southbound traffic in the AM peak (296 vehicles/hr) is regional in nature and travels from Otis St to the Museum of Science in Boston. This traffic is better served by I-93. (**figure 56, 57**) In addition, 64% of the traffic observed at Otis St (1399 vehicles) exits the corridor at Medford St and other points in Cambridge (Rufo Rd, 3rd St, Cambridge St, Land Boulevard) and is likely destined in large part to the major employment hub of Kendall Square and should therefore be considered regional in nature. When the Gilman St Bridge capacity reduction occurs it is likely that these regional trips, which should be on I-93, will be the most easily shifted away from McGrath Highway. In fact, the 50% capacity reduction (1085 vehicles/hr) can be resolved entirely by shifting away all of the through trips into Boston (296 vehicles/hr) and 56% of the trips seen at Otis St that are headed for Cambridge destinations (789 vehicles/hr). (**figure 58**) To support this shift, the Accelerated Bridge Program should reduce the size of the HOV lane barrier curb on I-93 and add this scope of work to the I-93 maintenance scheduled for 2012-2013. Currently, the HOV barrier design wastes an entire lane on I-93, and if modified this additional capacity (1800 vehicles/lane/hr) could easily accommodated the 1085 displaced vehicles from McGrath without an appreciable effect on the I-93 level of service.

• *Redesign Washington St at grade intersection*

Whether the conclusion of the Grounding McGrath study is to rehabilitate or remove the McCarthy Viaduct, repairing or demolishing the Viaduct will require closing the facility and losing the traffic capacity it provides. Therefore, in any scenario the Washington St intersection will experience increased traffic volumes for a period. As mitigation for this disruption, MassDOT should improve the geometric configuration and signal timing at the intersection. The existing condition wastes capacity, is confusing for drivers, and hostile to pedestrians. (**figure 59**) A redesigned layout with 3 approach lanes from each direction is proposed. (**figure 60**) This design can be built with the McCarthy Viaduct in place, and substantially simplifies the complexity of the intersection. The proposed redesign also reclaims a significant amount of space at the corners that could be reallocated for pedestrian amenities and public space uses. Preliminary analysis of traffic volumes using critical lane analysis demonstrates that this intersection design could accommodate all the traffic from the McCarthy Viaduct at grade during the period of 50% reduced capacity caused by the Gilman St Bridge reconstruction. (**figure 61**)[128] Signal phasing is also simplified to three phases from the existing four. (**figure 62, 63**)

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128 The design accommodates an additional 1332 vehicles southbound per hour in the AM peak on the Washington St Ramp. Therefore, the option to only remove the Somerville Ave down ramp in chapter 5.2.1 (which only adds 623 vehicles to the intersection) is also enabled by this design.

McGrath Corridor Traffic Paths

Origins and Destinations

(AM Peak Hour)

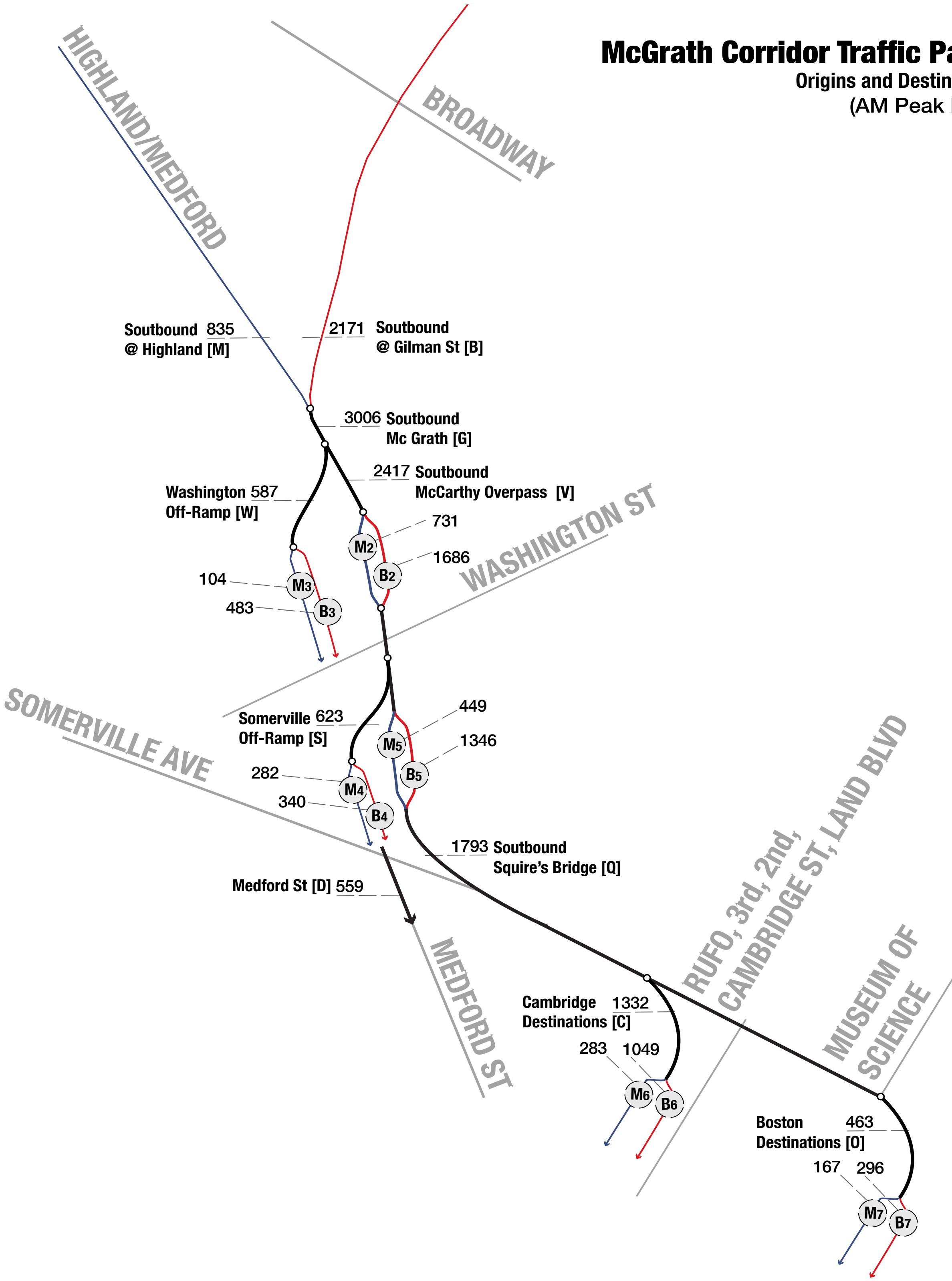


Figure 56

McGrath Corridor Traffic Paths

Origins and Destinations

(AM Peak Hour)

DESTINATION

ALL SB TRAFFIC

ORIGIN		McCarthy Overpass	Washington St	Somerville Ave	Squire's Bridge	Cambridge	Boston
		[G]	[W]	[S]	[Q]	[C]	[O]
Southbound McGrath	[G]	2417	587	623	1793	1332	463
Southbound McGrath	[G]	80%	20%	21%	60%	44%	15%
McCarthy Overpass SB	[V]			26%	74%	55%	19%
Squires Bridge	[Q]					74%	26%

DESTINATION

SB FROM MEDFORD/HIGHLAND

ORIGIN		McCarthy Overpass	Washington St	Somerville Ave	Squire's Bridge	Cambridge	Boston
		[M2]	[M3]	[M4]	[M5]	M[6]	[M7]
Southbound McGrath	[M]	731	104	282	449	283	167
Southbound McGrath	[M]	88%	12%	34%	54%	34%	20%
McCarthy Overpass SB	[M2]			39%	61%	39%	23%
Squires Bridge	[M5]					63%	37%

DESTINATION

SB FROM BROADWAY

ORIGIN		McCarthy Overpass	Washington St	Somerville Ave	Squire's Bridge	Cambridge	Boston
		[B2]	[B3]	[B4]	[B5]	[B6]	[B7]
Southbound McGrath	[B]	1686	483	340	1346	1049	296
Southbound McGrath	[B]	78%	22%	16%	62%	48%	14%
McCarthy Overpass SB	[B2]			20%	80%	62%	18%
Squires Bridge	[B5]					78%	22%

Figure 57: existing origin destination patterns on McGrath highway based on analysis of CTPS license plate survey

McGrath Corridor Traffic Displacement

Gilman St Construction Period
(AM Peak)

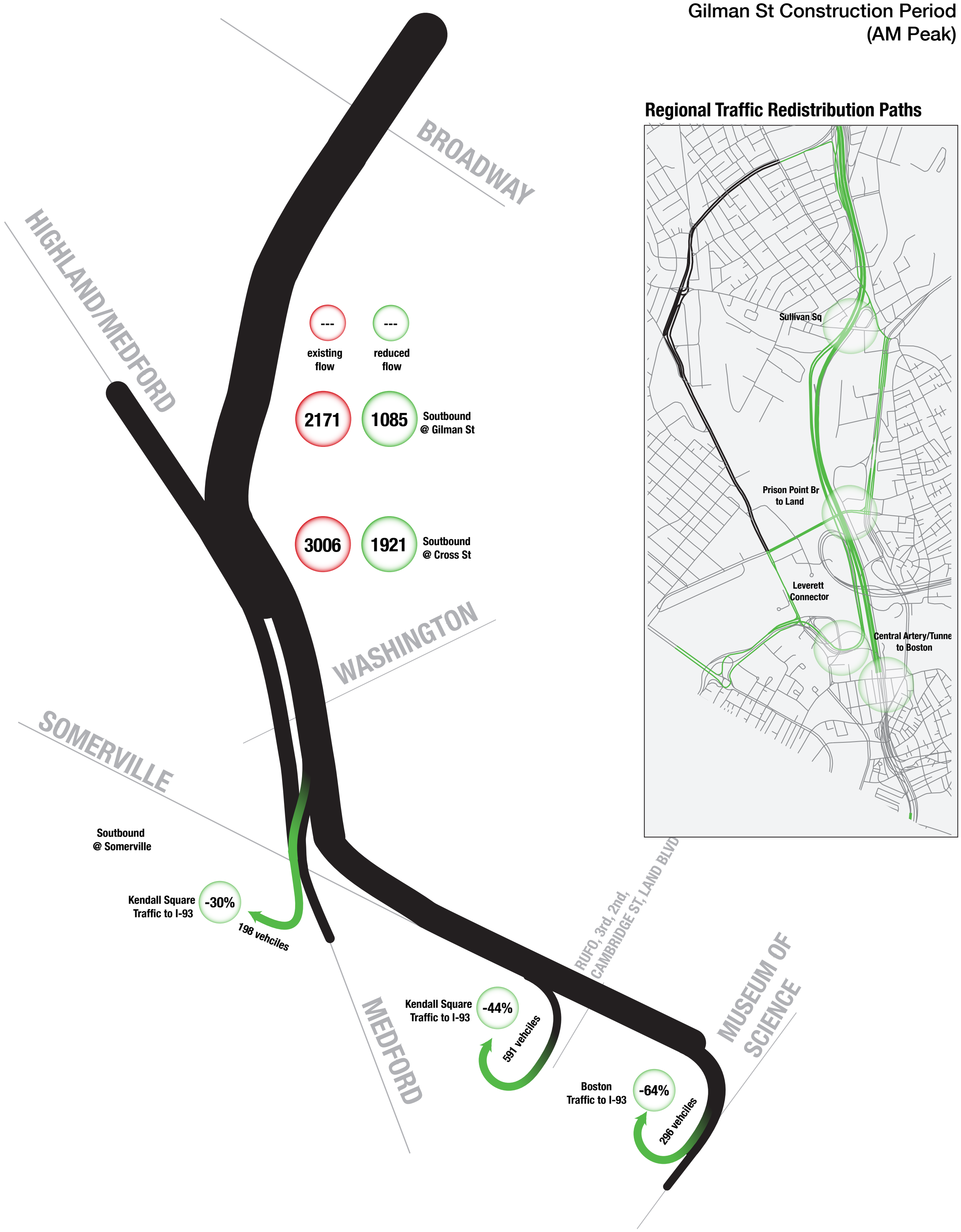


Figure 58

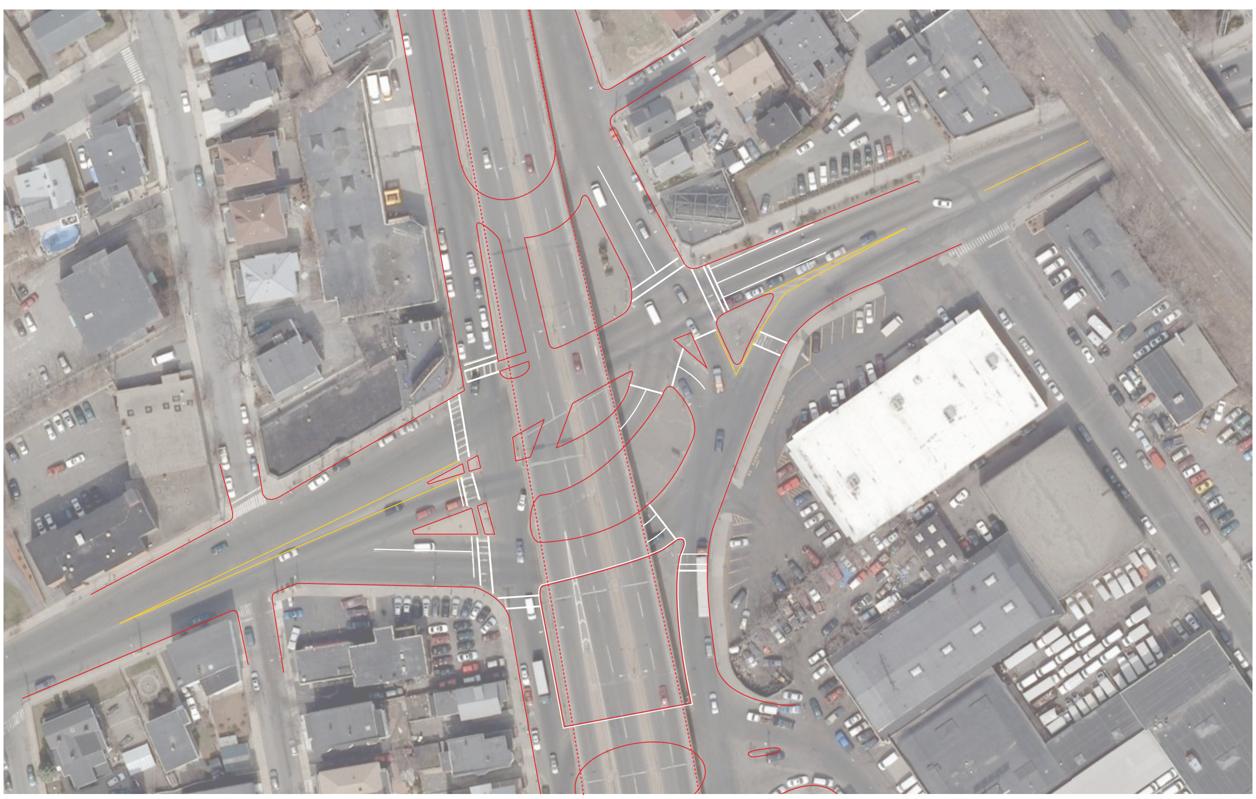


Figure 59: Current conditions and geometric configuration of the Washington St and McGrath Highway intersection

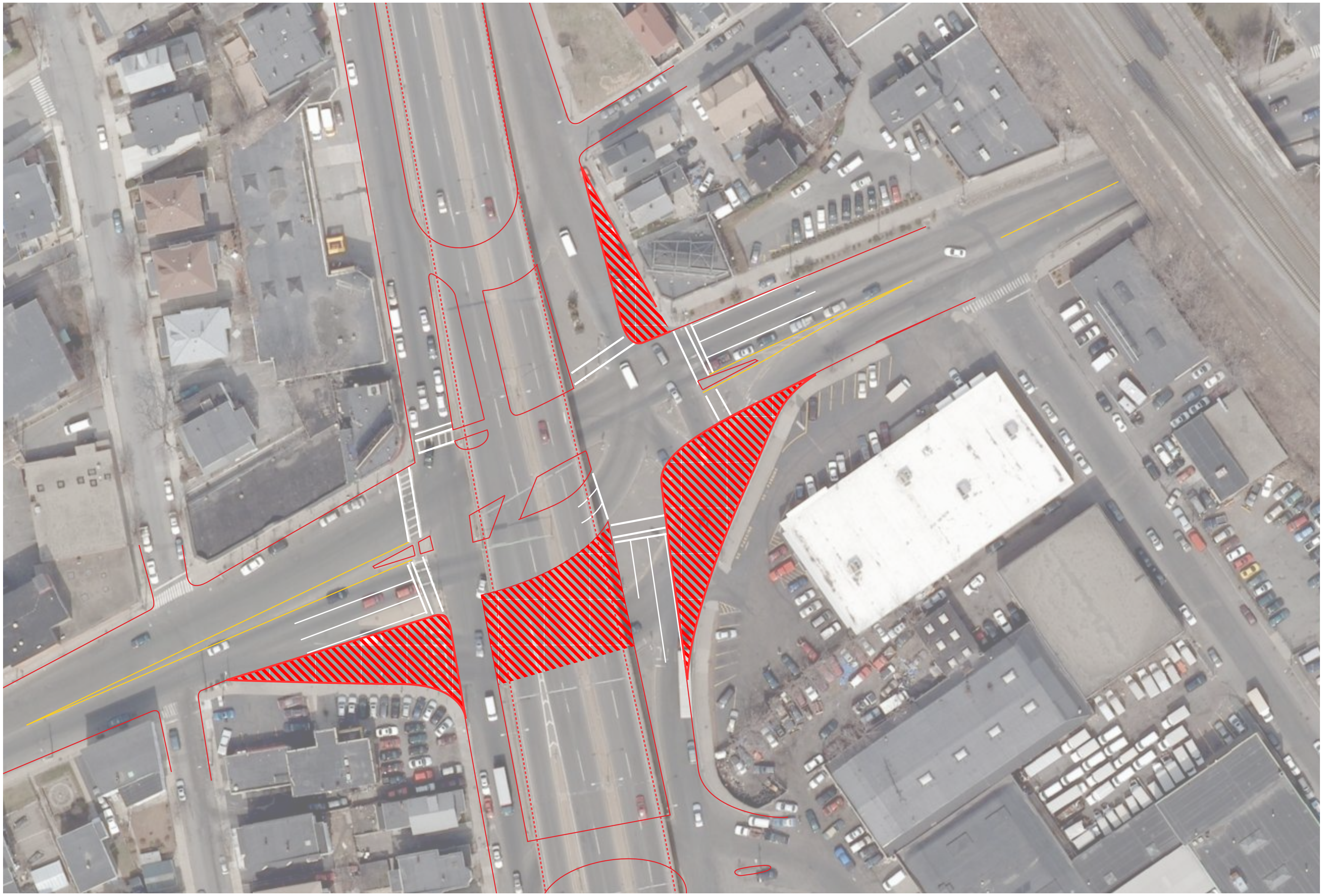
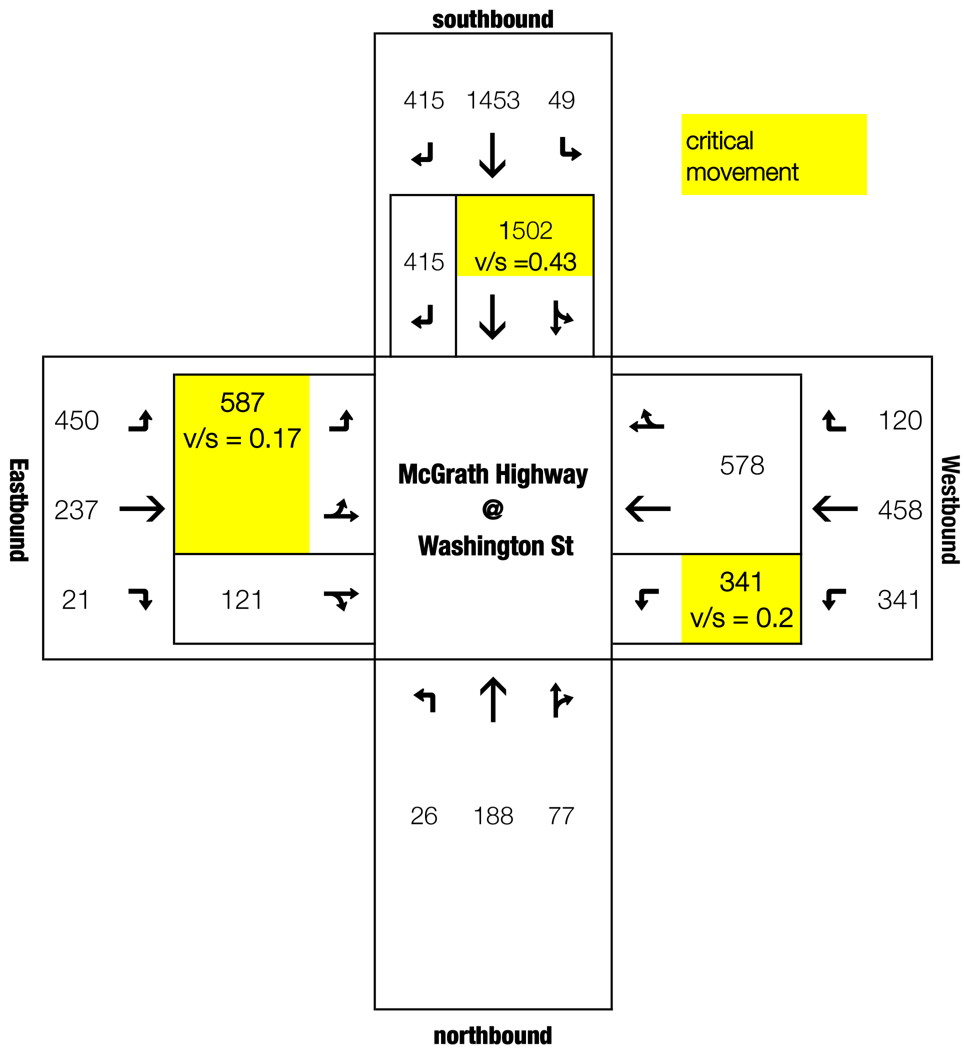


Figure 60: Proposed reconfiguration of Washington St intersection to manage all traffic at grade during Gilman St Bridge construction period as well as during the potential de-elevation of the McCarthy Viaduct. Space reclaimed from the current design is hatched in red.

McGrath @ Washington St

Critical Lane Analysis and Potential Signal Timing



v_i = *hourly volume for critical approach*
s_i = *saturation flow rate*
$X_c = 0.90$ = critical (v/c) ratio
$L = 12s$ = lost time

$$\sum_{i=1}^{n}\left(\frac{v_i}{s_i}\right) = 0.43 + 0.2 + 0.17$$

$$cycle\ time = \frac{L \bullet X_c}{X_c - \sum_{i=1}^{n}\left(\frac{v_i}{s_i}\right)} = 108\ seconds$$

$$green\ time_{phase\ i} = (v_i/s_i) \bullet (C/X_c)$$

green time $_{\text{Southbound}}$ = 52 seconds
green time $_{\text{Westbound}}$ = 24 seconds
green time $_{\text{Eastbound}}$ = 21 seconds

Figure 61

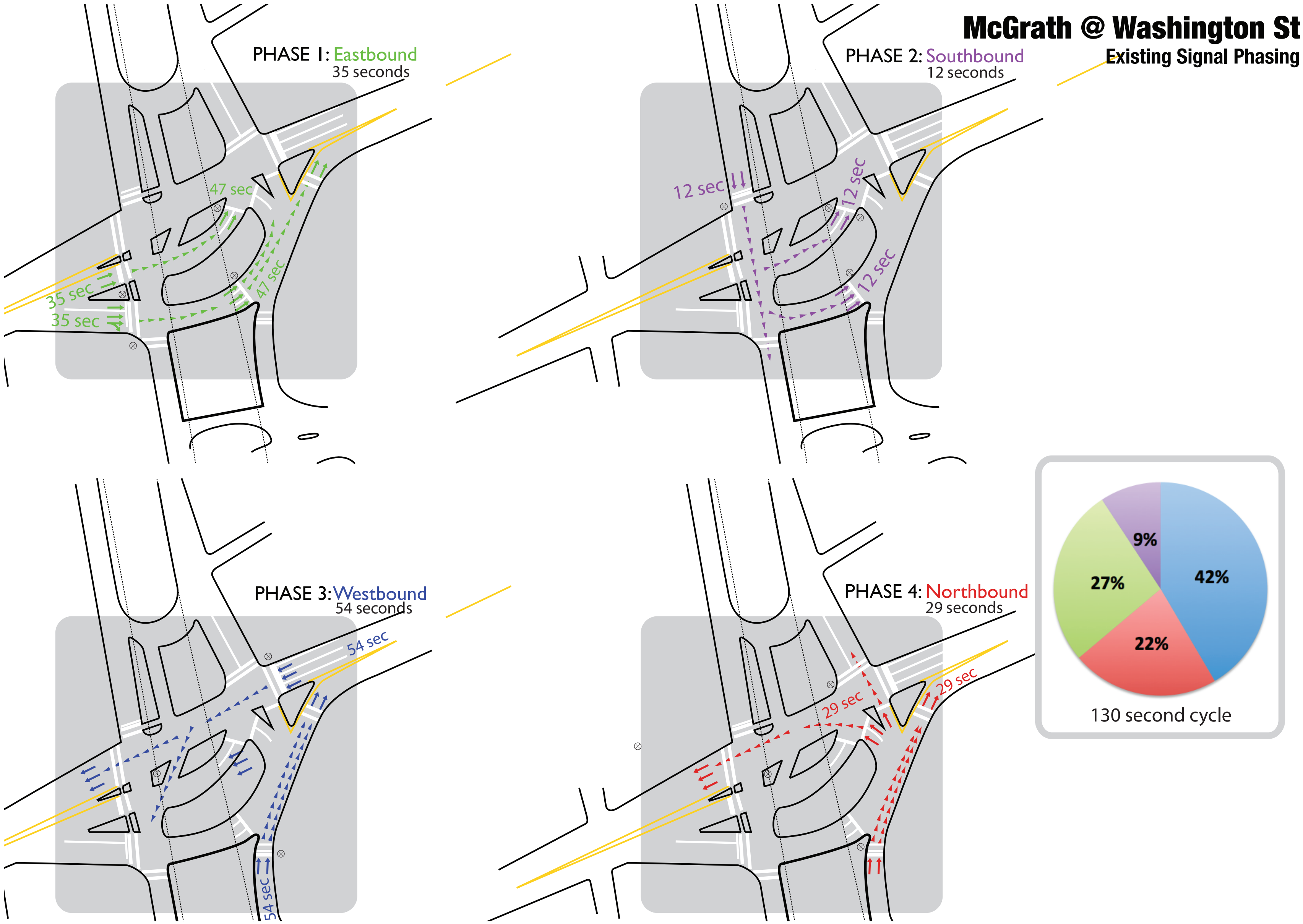
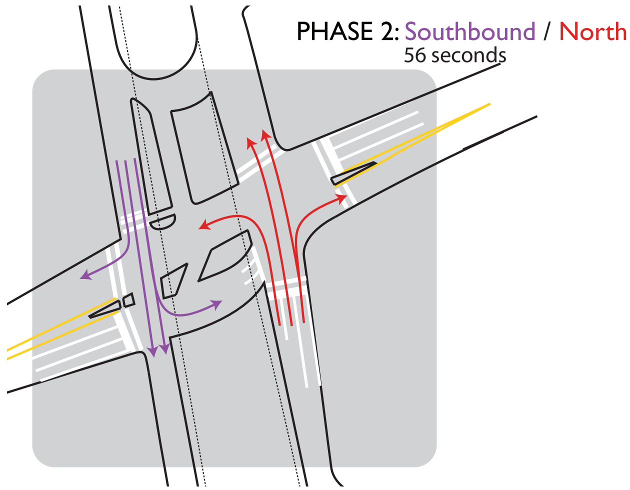

McGrath @ Washington St
Existing Signal Phasing
PHASE 1: Eastbound
35 seconds
47 sec
47 sec
35 sec
35 sec
PHASE 2: Southbound
12 seconds
12 sec
12 sec
12 sec
PHASE 3: Westbound
54 seconds
54 sec
54 sec
PHASE 4: Northbound
29 seconds
29 sec
29 sec
9%
27%
42%
22%
130 second cycle

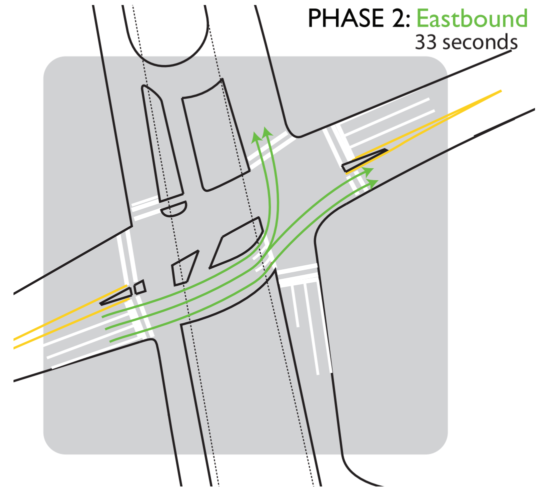
Figure 62

McGrath @ Washington St

Channelization Modifications and Proposed Signal Phasing

108 second cycle





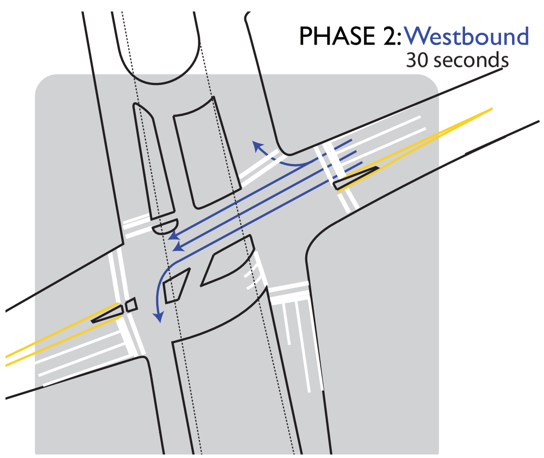


Figure 63

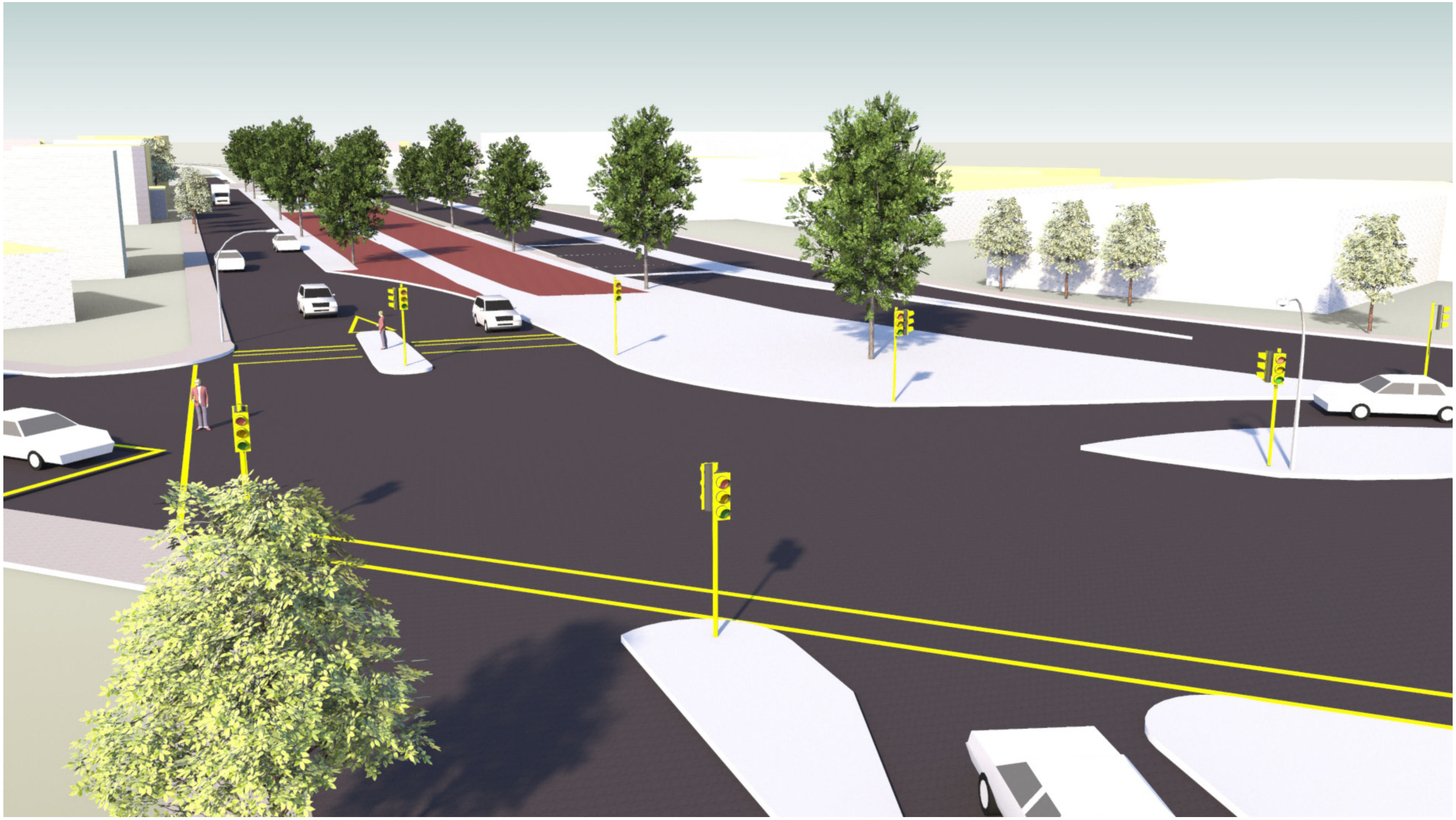


Figure 64: Visualization (looking north toward Washington St) of McGrath Highway southbound frontage road showing potential of an interim at grade scenario. The McCarthy Viaduct is removed, and the corridor remains functional during the period required for a comprehensive design of an at-grade boulevard.

5.2.3 Grounding McGrath Highway

MassDOT has described the proposal to repair the McCarthy Viaduct as a "short term solution (approx.10 years) – not a long term rehabilitation plan" with the goal to "maintain existing level of service, while minimizing impacts to surrounding area, for the duration of Grounding McGrath Study." However, the failure of the agency to consider construction detours undermines this stated goal since traffic disruptions related to repair activity would worsen existing levels of service during the short-term.

Instead of repairing the McCarthy Viaduct prematurely, the series of construction disruption mitigation actions proposed in this chapter, each with a sound rationale of its own, create a set of measures that work together to eliminate the functional need for the McCarthy Viaduct in the short-term. The proposed redesign of the Washington St intersection and retiming of the traffic signals to improve the configuration of the intersection (actions that warrant implementation by MassDOT on their own merits) would be sufficient to handle traffic volumes without the McCarthy Viaduct under this new normal. As such, during the multi-year reconstruction period of the Gilman St Bridge, MassDOT can implement and interim grounding solution that removes all ramps and the McCarthy Viaduct. Both during construction and the removal of the Viaduct this design would operate without appreciable adverse impacts on the traffic performance at the Somerville Ave and Washington St intersections. (**figure 64**) This design could also be used as an interim solution that would enable more time for a complete and comprehensive public process to redesign and reconceptualize McGrath Highway at-grade. Alternately, the interim scenario can choose to remove only the ramps, and leave the main elevated section still standing (but closed to traffic) until the conclusion of the Grounding Study and subsequent design processes are completed. Whichever the case, the mitigation measures proposed here in section 5.2.1 and 5.2.2 do not pre-determine the future of the McGrath corridor but also satisfy MassDOTs objective to "maintain existing level of service, while minimizing impacts to surrounding area, for the duration of Grounding McGrath Study." On the other hand rushing to repair the McCarthy Viaduct at the moment does constitute a de facto decision about de-elevation.

5.2.4 Long-term implications

One of the main criticisms of the approach by MassDOT on the Grounding Study and the ABP to repair the McCarthy Viaduct is that the outlook is temporally shortsighted and uncoordinated as well as spatially narrowly defined to a single corridor. While the series of mitigation actions and improvements proposed in chapters 5.2.1 and 5.2.2 are also short-term, they are relevant to and directionally correct for the long-term and a broader outlook.

The displacement of regional traffic equivalent to the capacity reduction during the Gilman St Bridge reconstruction can be maintained as a long-term shift by modifying the HOV lane barrier on I-93. This represents a more livable and appropriate distribution of traffic through the available road network in Somerville.

There is a history of such transportation shifts in the Boston area related to roadway construction. Reconstruction of the Southeast Expressway in the mid 80s and the Central Artery/Tunnel project involved enhancing commuter boat services. However, the ability to maintain the traffic shifts enabled by these expanded services was reduced by the return or expansion of roadway capacity after construction. This would not be desirable for Somerville; a 50% throughput reduction on McGrath Highway can and should be established as a new normal rather than an interim condition to promote livability, neighborhood economic development, and the success of the $1 billion investment in the Green Line Extension. These reduced volumes and the changes associated to I-93 should be used as the analysis and design scenario for the Grounding Study rather than examining the McGrath corridor in isolation. Furthermore, the suggested set of short-term actions addresses longer-term issues of capacity constraint in the corridor by providing an outlet for regional traffic through the modifications to I-93. On the other hand, the ongoing Grounding Study narrowly examines only the McGrath corridor and attempts to deal with the difficult and illogical situation where forecast 2035 traffic volumes will exceed inescapable capacity constraints.

6. Summary & Conclusions

6.1 Summary

The thesis examines the story of cars in American cities and how planning and engineering, individual demand responses, and the politics of transportation infrastructure align to establish, preserve and perpetuate the automobile metropolis.

The growth of automobile travel, the infrastructure to support it, and the changes in metropolitan structure and development patterns it enabled have been attributed to many different explanations in the literature, however, the key interpretation of this thesis is the lens of the political will to accommodate automobile. The initial growth of the automobile city rapidly became a self-enforcing process through the impacts of the car on urban design, zoning, metropolitan decentralization, suburban development patterns and individual travel choice. The viability or existence of other modes of travel in cities and the fabric that hitherto supported them was undermined, and new landscapes opened up by freeway connectivity are oriented wholly around automobile mobility.

The key observation is that traffic growth cannot simply just happen, since congestion is an otherwise physically self-limiting condition given the existence of finite roadway capacity constraints. To become as pervasive as it is today, the automobile had to be invited into the city – or at least accommodated. However, a failure to recognize the myth of accommodating the car as a way to relieve congestion has led to the political 'tragedy of expanding the concrete commons' that perpetuates the political will to keep building the very infrastructure that is a key driver of systems lock-in to car use.

Dissatisfaction with the top-down highway building culture and concern over the corridor-, neighborhood-, and regional-scale impacts of freeways through cities generated significant revisions to transportation policy in the late 60s and early 1970s. Significant increases in funds for public transit became available at both the national and state levels. Citizen movements were at times successful in stopping certain urban highway projects, and they helped catalyze political will to enshrine protections for the environment and due planning process (such as section 4(f) and NEPA) that challenged the mentality that highway expansion is inevitable. These requirements helped move toward a full disclosure of costs and benefits, tipping the landscape away from mindless road expansion and helping the no-build scenario to win politically.

Now, the nation faces a new type of infrastructure scenario to consider: the 'de-build.' America's highway infrastructure, the bulk of which was built with Federal grants since the 1950s and 60s and inadequately maintained is now ailing. There is interest, need and opportunity to reconceptualize these facilities both to improve the sustainability of the transportation system and to serve as a catalyst for much more widespread neighborhood regeneration and revitalization.

The case study of the McGrath Highway in Somerville, MA, demonstrates a quintessential example of a scenario ripe for de-building highway infrastructure. Historical changes in the transportation network and local land use environment, planned expansions to public transit, aspirations for transit-oriented land redevelopment, functional, operational and structural deficiency, and political attention to address the challenges of aging infrastructure bring attention to the McGrath Highway and the McCarthy Viaduct at this moment in time. For abutting properties and those on foot or bicycle the McGrath Highway is an unpleasant and inhospitable environment. Complex lane channelization, unintuitive traffic islands, unusual signal phasing, and badly designed weaving sections at the off-ramps make the facility perform poorly for automobile users too. Concern over this these substandard conditions is heightened by Green Line Extension: the GLX offers the potential to relieve the need for automobile capacity in the corridor by supporting land use and behavior that is transit-oriented. However, the success of this $1 billion investment also hinges on reconceptualizing McGrath as a boulevard to generate a surrounding context that supports last-mile connectivity to and from the stations, and to make feasible the attraction of new, dense, transit- and pedestrian-oriented development by removing the disamentiy value of the ugly Viaduct.

Unfortunately, the discussion in chapters 3 and 4 of this thesis suggest dynamics of cost and benefit perception that do not seem to align in favor of grounding McGrath or achieving the timely extension of the Green Line. The ongoing processes for these two complementary projects are dominated by the tools, methods and assumptions, political biases, procedural failures, and instilled human behaviors of the first highway-building era. This status quo approach has significant policy implications since it threatens to implicitly usher in a second era of highway (re)building.

The misuse of modeling and forecasting as described in this thesis perpetuates the demand first versus infrastructure first paradox, and does not help summon the political will for visionary thinking where infrastructure change is the necessary catalyst for neighborhood change and behavior change.

- Transportation forecasting and modeling as being conducted in the Grounding McGrath study does not explicitly reflect the dynamics of system change, and instead systemically overlook important pathways to modifying the transportation landscape. In particular, the 4-step travel model built on the basis of people's existing and observed behavior misses critical pathways of behavioral change in response to infrastructure change. Forecasting the 'no-build' year is a misnomer since the practice of doing so is both conceptually and technically biased to perpetuate the business as usual approach of preferencing the car and providing for it. Such misuse of modeling and forecasting have become policy-making, rather than policy analysis, since future traffic volumes are taken as a *fait accompli.*

- Forecasts of volume to capacity ratios exceeding 1 (V/C>1) create alarm over the operational (in)feasibility of traffic growth at levels that are fundamentally infeasible since they violate real-world capacity constrains. Static traffic assignments in the models also violate capacity constraints by allowing cars at V/C>1 to keep moving artificially, thereby creating imaginary mobility benefits of auto-oriented infrastructure decisions that are infeasible.

With the automobile and the infrastructure to support it established as the status quo, planning processes and infrastructure funding programs are working to create anti-environmental outcomes that preference the car and hinder the development of transit alternatives necessary to reduce auto dependence.

• Much like the structure of the Federal-Aid Highway Act, which offered state DOTs 90 cents for every dollar spent building the Interstate network, targeted repair programs like the Massachusetts Accelerated Bridge Program incentivize and motivate highway agencies to spend money as quickly as possible. This program structure takes advantage of the tendency to discount the future and disregard the negative impacts of poor or thoughtless planning.

• Special exemptions from environmental process legislation, such as MEPA, for emergency repair programs that remedy self-inflicted deferred highway maintenance dramatically undercut the legislative intent of such acts, since the end of life stage is also the very time that infrastructure investments are made and when environmental and planning process requirements are triggered.

• When environmental processes are applied to infrastructure end of life decisions, there is a risk that processes normalize the continued existence of existing structures as the null-hypothesis or 'do nothing' scenario. However, there is serious doubt as to whether many highway structures through cities were viable propositions had they been subject to adequate the environmental review when first constructed.

• By contrast, transit projects that are meant to be environmentally benign or even beneficial, and which have the potential to avert the tragedy of expanding the concrete commons are heavily burdened and delayed by the significant scrutiny of "environmental" processes that fixate on the minutiae of details and demand a level of comprehensiveness that far exceeds that which highway projects are subject to.

When considering the four supporting factors for highway removal that Napolitan (2007) identifies, neither the technocratic nor the political environment seems well situated at the moment to generate the forces required to overcome the inertia to change: repair programs obscure the necessary window of change that structural deficiency creates to allow freeway removal to gain serous consideration and legitimacy; modeling and forecasting practices overstate the mobility benefits of continued road expansion; and stakeholders and beneficiaries of the auto-mobility system are widespread and locked-in to the car, whereas the transformative potentials of reconceptualization are latent and distant.

6.2 Implications for national policy

The Federal Highway Authority has rated one in nine bridges in cities "structurally deficient," and estimates that an investment of $70.9 billion will be needed to rehabilitate these structures.[129] The $70 billion national bill for highway and bridge repair is also in large part self-inflicted by failure of DOTs do regular maintenance: the initial federal Interstate program which provided 90 cents on the dollar to state DOTs incentivized over-building in the short-term without considering the long-term ability to fund and execute maintenance, and state road funds continue to be prioritized to match federal dollars for new projects. As such, money to address this infrastructure crisis should not be simply handed unconditionally to highway agencies so that they may again be allowed to repeat the failures of the past and continue bad institutional practices.

The Boston region demonstrated a dramatic policy change with the BTPR, intstitutionalized the capacity of the BTPR in the CTPS, and adopted best practices and focused over the last 40 years on major transit investments such as the Orange Line relocation, Red Line extensions and Silver Line. Nevertheless, current conditions have slipped badly again into a climate of thoughtless repair programs, non-participatory decision-making, uncoordinated planning, and painfully slow progress on legally committed and environmentally beneficial transit expansion. Despite efforts to make project planning more thoughtful such as the 1962 reforms to the Federal Highway Act, the 1966 DOT Act and section 4(f), NEPA in 1970, the multi-modal flexibility of funding of 1973 and 1991, and the linking of transportation planning and air quality goals in the Intermodal Surface Transportation Efficiency Act (1991), the out of sequence planning of repairs on the McCarthy Viaduct under the Massachusetts Accelerated Bridge Program demonstrates that the institutional culture of highway agencies has still not evolved to the point where self-evaluation and self-enforcement of planning and environmental objectives is a reasonable option. The case study of the McGrath Highway presented in this thesis is therefore a cautionary tale with policy relevance to the entire nation. A planning process is required to respond to the country's infrastructure repair crisis.

The technical and political merits in favor of reconceptualizing aging highway infrastructure will vary from project to project, but in light of the scale of national investment forthcoming it will be necessary to carefully consider the need for and purpose of this infrastructure. Several types of project circumstances exist.

- *Type 1*: In many cases there will be a strong rationale to rebuild existing bridges and highways because they play a vital role in the transportation network not easily substituted. For example, there is little debate in the community about the need to rebuild the Gilman St Bridge on McGrath Highway, since without it the corridor would be severed for all modes of transportation.
- *Type 2*: Those similar to the iconic Longfellow Bridge define a second class

129 Transportation for America (2011), 3-6

of rehabilitation projects. Here again there is little debate about the necessity for rebuilding this vital link between Cambridge and Boston. However, there has been considerable and ongoing debate about how the reconstructed bridge should allocate space between transit, vehicles, pedestrians and cyclists. There is also a significant discussion about using reconstruction as an opportunity to restore earlier historic conditions by reversing undesirable changes made to the infrastructure over time (such as sidewalk narrowing) as well as taking remedial action for current impacts of the infrastructure (such as the intrusion of roadways related to and under the bridge into the Esplanade parkland).

• *Type 3*: A third class of projects are those similar to the McCarthy Overpass where there have been significant changes in transport and land use over time that raise serious doubt about the functional necessity for the facility and simultaneously create a strong latent potential for corridor and neighborhood revitalization.

• *Type* 4: A fourth class of circumstance is that where there is a significant opportunity for roadway down-sizing and potential to generate positive neighborhood impacts, but where this potential is tied to providing alternate capacity through public transit improvements or tunnels.

For projects such as the Gilman St Bridge where the need and purpose of reconstruction is not contested, the general spirit and intent of the Accelerated Bridge Program is appropriate and I do not recommend that these projects be subject to lengthy environmental assessment processes such as those delaying the extension of the Green Line. Nevertheless, a serious process is required. The goal of environmental process is ostensibly to enhance livability, but lengthy and seemingly indefinite processes are themselves not liveable. However, with the BTPR a major reversal in the direction of transportation policy in Boston was achieved in only 18 months and completed with the same rigor demanded of an environmental impact statement. Therefore, process does not necessarily result in undue delay. In fact, the lack of process increases the risk of unexpected and unpredictable delays, such as when major community concerns over a proposed scope of work surface at the moment of implementation.

For all classes of projects (types 1 through 4), a new approach to define the 'do-nothing' and 'existing conditions' are required for end of life highway evaluations. This approach should recognize that many existing structures came to be in a policy and political environment that did not subject projects to the same level of scrutiny as is expected today, and that now is the time and opportunity to rectify those past failures. Given that highway infrastructure has created a disamentiy value on surrounding areas for decades, the baseline comparison in environmental review for end of life highway projects should be raised from doing no harm to a counterfactual baseline of a non-degraded environment. Doing so would create an onus for highway agencies to explicitly consider generating neighborhood and community benefits during project implementation, and to take meaningful steps to remedy the externalities from a legacy of poor planning as a part of project definition.

Projects in the 'type 1' category may likely constitute the majority of forthcoming highway reconstruction projects in the United States. Nevertheless, these projects should include public participation to at least determine if there is reasonable consensus on the merits of rapid rehabilitation. Furthermore, even if functionally required, some projects may create such unlivable and intolerable impacts on surrounding areas that they should be rebuilt in a substantially more sensitive way such as below grade. Indeed, the Central Artery/Tunnel project in Boston and the recently started work in Seattle to replace the elevated Alaskan Way with a tunnel demonstrate this idea of accommodating automobile capacity in cities in a more context sensitive and responsible way.

> "For a while there, the highway department was so focused on construction and road projects, it's almost as if the contractors became their customers." [130]
> – Frank DePaola; Administrator, MassDOT Highway Division

The institutional culture of highway agencies to feed contractors undercuts the intent of all the policy reforms of 1962, 1966, 1970 and 1991 which imply reasoned comparison, choice and evaluation of projects. Behind the successes of having highway projects stopped, such as I-40 through Overton Park in Memphis or the Inner Belt in Boston, is that the tension between spending and thoughtful planning was relieved; in the Overton Park case money was transferred to another highway project and in Boston funds were traded-in for investments in public transit. These arrangements satisfied in part the desire to secure the short-term stimulus of federally matched construction dollars into the local economy and to gain the political support of construction and labor constituencies who are the immediate beneficiaries of infrastructure investment. However, the differential treatment of funding for highway projects by FHWA and transit projects by FTA undermines this solution by constricting the flow of dollars to transit projects in relative and absolute terms.

Despite the dominant focus on highway and road building in the 20th century history of transportation planning and funding in the United States, there is some evidence of recognition even from auto-oriented interests that transit can help to avoid excessive congestion. During the Nixon administration federal funding was extended to cover transit operating costs and during the Reagan administration the gasoline tax was expanded by 5 cents per gallon: 4 cents for highway and 1 cent for transit. Even Los Angeles, a city lampooned globally for its car culture, successfully passed a public referendum in 2008 (with a two-thirds majority) to enact a half-cent transit sales tax to raise $40 billion to aggressively expand transit service over the next 30 years.[131] Although type 3 and 4 projects may be more niche opportunities among the inventory of infrastructure requiring attention, given the way that FTA process slows and stalls projects there is likely a huge backlog of requests for transit projects in many cities across the nation. Therefore, to support type 3 and type 4 projects work is required to reform transportation policy.

130 Schwartz (2012)
131 Nagourney (2010)

Highway agency culture has been a major force in shaping the transportation and land use landscape that exists today in the United States – and still continues to influence project planning and implementation in unfavorable ways as in the case of McGrath Highway. However, since the 1960s there has been recognition of the failures of inadequate and thoughtless planning, and in response increasing requirements from the legislative branch to reform and improve the infrastructure investment process. 1962 reforms to the Federal Highway Act, the 1966 DOT Act and section 4(f), NEPA in 1970, the multi-modal flexibility of funding of 1973 and 1991, and the linking of transportation planning and air quality goals in the ISTEA (1991), show this sporadic but directionally consistent effort at reforming the process.

With the expiration of SAFTEA-LU in 2009 the United States has been without a surface transportation act for over two and a half years. The nation wanders without direction from Congress on transportation and infrastructure priorities and without stable funding to make badly needed investments. Highway agencies have been the single biggest institutional beneficiaries of federal spending on transportation infrastructure, and now their existence is threatened by the lack of a stable federal program. Interests that have been historically less powerful or marginalized in US transportation policy (such as transit, walking and cycling) are threatened too by political inaction, but have far less to lose than highway agencies by virtue of their subordinate status. Worse yet, the Tea Party movement, so steadfast in its anti-government rhetoric, seems unfazed by the nation's infrastructure crisis and willing to stand behind a nonsensical position of cutbacks and disinvestment as structures risk literally falling into the water. Recognizing this dynamic, there is now a window of opportunity to build coalitions among interest groups that may traditionally hold different ideas in transportation policy, but all of whom are fundamentally united in recognizing a need for policy and for public investment in infrastructure. Therefore, in the process to reauthorize the surface transportation act, interests traditionally not well integrated into the transportation debate are important power brokers since their buy-in can be crucial to building the critical mass of support required to build the political will to address the issue. As such, there exists a great opportunity to continue reforming highway agency culture through federal legislation and to continue correcting many of the systematic biases in favor of automobile use. These reforms can help increase the focus on providing multi-modal accessibility, on ensuring thoughtful planning process and balanced project evaluation, and on considering interactions between transportation, land use, and other policy realms such as health, energy, environment, and equity. Perhaps all funding and environmental review should be managed through the Metropolitan Planning Organizations, rather than the highway departments which have demonstrated a strong highway advocacy culture. The funding match from FTA for transit should be increased and the New Starts process streamlined to allow the concurrent completion of design work and preliminary implementation with the funding evaluation. Federal Highway Aid dollars should be subject to cost effectiveness measures too. Assessments of road projects should be required to seriously consider and evaluate maintaining the "new normal" scenario (inevitable reduction in road capacity caused by construction disruptions) as a possible long-term solution. This would be conceptually similar to the FTA requirement for New Starts to compare against a baseline of more modest transit improvements.

These suggested reforms are not only relevant in the United States, but should also be considered a cautionary tale for transportation policy in the developing world, especially by institutions involved in funding global infrastructure development such as the World Bank.

6.3 Future outlook

Despite the structural challenges facing infrastructure reconceptualization at the policy level and in the political arena, this thesis identifies an alternative implementation strategy for McGrath Highway to curb the growth of vehicle traffic that seems inevitable with existing planning approaches. Instead of planning for a distant "design year" as an endpoint, I recommend a strategy that focuses both on near-term constraints and on the system change potential of project implementation itself and reconstruction pressures.

Corridor reconceptualization need not be a confrontation between the automobile worldview and prioritizing other values. Chapter 5 of this thesis demonstrates how considering mitigation actions for inevitable construction disruptions to motorists as well as undertaking basic remedies to rectify the deficiencies of highway designs for pedestrian (such as signalizing crosswalks) can be used to rapidly establish an at-grade McGrath Highway as the new normal. The suggested approach is likely to generate political support among the dominant stakeholder groups of existing motorists interested in the concrete commons since it addresses short-term disruptions to level of service. At the same time, incrementally humanizing the highway helps build support from new beneficiaries and from advocates of the green commons who support a long-term shift of the transportation system in a directionally correct manner.

On the other hand the existing approach of being beholden to the interests of 2035 motorists (as implied by the misuse of modeling) is a political approach with little strategic value since it considers a scenario that is not real. It also fails to provide immediate benefits to existing auto users and generates disbenefits and agitation amongst livable streets advocates who see their interests swept off the agenda to accommodate those of future motorists who do not (and cannot) exist. This current approach is driven by and large by the culture of highway departments with a vested interest in expanding the concrete commons and perpetuating their institutional existence.

Future Research Directions

At the project planning scale improved technical practices are needed to help elucidate the transformative potential and benefits of corridor reconceptualization, and this support of the technical bureaucracy is key to help generate and support the political will for projects like grounding McGrath Highway. Future work to improve modeling should adopt a systems approach and understand the second order effects of transportation supply characteristics on the underlying nature of behavioral decisions like trip generation and mode choice. Modeling should also be used as a planning tool to evaluate many different scenarios and test for key sensitivities which can act as policy levers. Model results, which are simple equilibrium points, should not be considered as final outputs. Instead, model outputs should be considered in a broader systems sense in terms of how the magnitude of modeled values will effect changes in behavior and also trigger different policy decisions. Transportation models and analytical methods should also focus on operationalizing the behavioral findings from work like that of Zhao (2009), to better understand how land-use and travel can be jointly planned to shape travel preferences in a manner that supports infrastructure reconceptualization. Detailed analysis of local cases studies such as the growth in Kendall Square will be key to understanding the factors underlying transit-oriented growth potential and to recreate and even surpass this pattern of development elsewhere in the region.

The findings and recommendations of this thesis, along with the contribution of future research identified here, can help to begin a slow reorientation of transportation systems in cities in the United States. By revealing the latent potential of unique conditions in certain corridors and neighborhoods to support transit expansion, and land use development that is transit-oriented, roadway right-sizing and reconceptualization can be achieved and begin to demonstrate a more balanced and multi-modal model of infrastructure to support city life.

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