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Environmental and Infrastructure Planning

All Roads Lead to Manhattan

Manhattan Centric Path Dependency in the New York Transportation System and the Potentail of Adaptive Planning and Tactical Urbanism to Rectify the Consequences

Key Words: New York, Transportation, Adaptive Planning, Tactical Urbanism, Self Organization, Experimentation, Path Dependancy, Manhattan Centric,

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Outline

Abstract
New York City is an international metropolis; a center for global culture and commerce. It is a site of innovation and experimentation with international pull and prestige. Like many American cities, New York has grown beyond its borders and struggles to adopt a proactive attitude towards the pressing issues plaguing the public transit systems servicing the city. New York is not the same city it once was. The only constant is change, and the transportation institutions, policies, and infrastructure that has brought New York to this moment will not suffice moving forward. This year the governor of New York declared a state of disaster emergency in response to a major subway derailment, but the problems are deeper than a single incident (Cuomo 2017). Problems with maintenance, service, and expansion have been piling up for decades and the damage from Hurricane Sandy exacerbated these issues. With the failings of traditional practices clear, and additional funding unavailable at the moment, transportation planners may consider a change in practice to accomplish more using fewer resources. This study demonstrates that New York City must encourage and facilitate urban adaptive ability and ease innovative experimentation by actively combating its own path dependency and promoting the unfettered coevolution of structure and function.

1. Changing Plans

The New York transportation system is of pivotal importance to the regional economy and is currently in crisis (Cuomo 2017). Combined with decades of chronic underfunding, the changing functions of the system have made the Manhattan-centric structure a hindrance to many who use it (Zupan & Barone 2015). In light of this crisis and the growing gap between Manhattan-centric structure and non-Manhattan-centric functions, this study aims to address the following questions.

-To what degree can adaptive planning and the practices of tactical urbanism assist New York transportation planners moving forward?
-Should adaptive planning or tactical urbanism be applicable to New York transportation planning, in what ways would these insights manifest as prescriptive actions?

Adaptive planning is framed as an emerging proto theory at the edge of the complexity sciences and spatial planning (De Roo et al 2012). This ‘adaptive planning’ emphasizes not only what a city ought to be but the tumultuous path to becoming, depicting the planner as a gentle guiding influence on an ever-changing, self-organizing, complex adaptive system. Rather than fixating on the destination, attention is paid to content, process, and most importantly the shifting context in which the journey takes place. A comprehensive long-term plan can no longer culminate in a definite and desired end goal. The passage of time, the change that it brings, and the implications of this change on the success of the plan are as significant as the plan itself. Plans must be both robust in their aims and flexible enough to accommodate unforeseen change (De Roo et al 2012). These insights come from a theoretical debate in the Dutch planning context. Planning in the United States differs strongly from the Netherlands where the adaptive planning theorists used in this research are from. Despite these differences, the theoretical discussion of adaptive planning serves as inspiration. And core elements of adaptive planning lend themselves well to the relatively localized planning structures found in the United States (Bishwapriya Sanyal 2005, Weiner 1986). It is in the interest of this study to demonstrate the potential advantages of incorporating adaptive planning and the practices of tactical urbanism into New York transportation planning.

It is easier to criticize something than to fix it. This study does not intend to simply criticize New York City transit planning but to identify strategies worth expanding and suggest changes in practice and priority. These suggestions are in response to areas of friction or stagnation that result from the out of date Manhattan-centric New York transportation system. The suggestions are the product of policy review, historical analysis, and the evaluation of potential planning interventions. The study is restricted by a lack of access to all information but uses what is available. The suggestions are inspired by the insights of adaptive planning theorists and the planning methods of tactical urbanism, a growing trend in the United States which shares core themes with adaptive planning (De Roo et al 2012, Lydon 2015, Mould 2014, Quednau 2017). This study proposes that transportation planners servicing the New York Metropolitan area pursue heightened degrees of collaboration and coordination in the pursuit of micro installations aimed at integrating the parallel transportation networks, expanding service areas, and encouraging polynucleic development. These micro installations would begin with strategically placed pilot sites and grow in number in response to lessons learned through pilot installations. The practices of tactical urbanism do not lend themselves well to robust mega projects but may serve a useful tool in the surrounding urban landscape. Subway expansion projects are not the place for planning experimentation but the network of roads, sidewalks, and bike lanes that make up the service area of that subway may benefit from adaptive and experimental micro installations aimed at easing the use of the combined transportation system.

These experimental semi-permanent micro installations are an amalgam of successes found in complementary American cities, relevant international inspirations, and have been modified to suit the New York context. The focus here is not only the interventions and methods but the attitude towards their implementation. This attitude is inspired by experiences in the Dutch planning context, both academic and professional. New York has had success with tactical semi-permanent experimental installations such as the Broadway Boulevard or the Summer Streets program (Sadik-Khan 2008, Mayor de Blasio 2016b). These methods are an important tool for a planner and demonstrate key elements of adaptive planning and tactical urbanism. Major changes can first be demonstrated to the public in smaller and nonpermanent examples. These methods reduce construction and temporal costs while creating a situation where the public can witness the potential of the installations. If the experiment is successful it can be implemented elsewhere and helps justifies more expensive and more permanent versions of the same installation (Lydon 2015, Mould 2014, Quednau 2017). Much of New York street plan revisions are conducted from a technical perspective with key considerations like safety and traffic flow. Public outreach is conducted through workshops and public forums to gauge considerations from the public (NYCDOT 2015). The shift in priority this study suggests is the use of these revisions as a short-term solution to address the growing gap between Manhattan-centric transportation structure and non-Manhattan-centric functions.

While circumferential transportation routes are planned, the same issues can be addressed through a less expensive and semi-permanent form. Developing the pedestrian and bike network in the outer boroughs and increasing the service areas of what few circumferential routes exist can address the growing gap between structure and function. There are doubts as to what degree tactical urbanism is applicable to large-scale transportation projects but their success with micro installations in mass are prevalent throughout the United States (Lydon 2015, Mould 2014, Quednau 2017). This study identifies opportunities in the bike network and pedestrian network to both expand service areas and encourage polynucleic development with semi-permanent experimental intervention, avoiding lengthy and costly planning processes, minimizing the time spatial problems go unaddressed and compound themselves, and generating information on the feasibility and justifications for an expensive wide-reaching implementation of a similar installations. These tactics become more difficult with larger scale infrastructure. A planner cannot create a semi-permanent subway line for investigative purposes. However, a planner can expand service areas of a circumferential subway route through the implementation of strategic pedestrian or bike routes to measure the increase in circumferential ridership. Rather than, or in coordination with, a lengthy planning process for a major transit expansion, a strategic semi-permanent project is used to experiment and investigate. This installation can also inspire a potential transition and create an environment in which the city pursues these installations autonomously. A pilot project can spark public dialogue and lead to public demand for the further development of similar projects. An environment supporting self-organization is cultivated by instigating dialogues through the use of strategic intervention (Lydon 2015, Mould 2014, Rauws 2017). Tactical urbanism has planners seize situational opportunities to innovate, redesign, and introduce temporary spatial alterations to structure in order to inspire or guide autonomous developments and self-organization (De Roo et al 2012, Rauws 2017, Lydon 2015, Mould 2014).

This style of experimentation is essential when one considers the unpredictable and nonlinear change of the urban complex adaptive system (De Roo et al 2012). Changes in system structure can encourage desired changes in public transit functions (Loo et a. 2010), but transportation planning is chronically slow moving and can have unforeseen consequences when completed. There is a popular call for a major transition or new generation of New York transportation that meets increasing demand and changing needs (Zupon & Barone 2015). However, limited funds restrict the ability to meet these demands in the short term and it is crucial New York transportation planners find ways of accomplishing more with fewer resources. By increasing transportation planners ability to experiment with spatial interventions, the city's ability to quickly and effectively respond to spatial problems and accommodate the shifting context is increased. Spatial interventions often result in nonlinear change and this change is very difficult to predict accurately (De Roo et al 2012). Without the ability to consistently predict outcomes of interventions, planners are left with experimentation to best understand the implications of different interventions. It is important to clarify this is not a call for unbridled experimentation from transportation planners, but a call of support for calculated and strategic incremental experimentation. It is important for public transportation to be reliable and something the public can trust, but it is also important for public transportation to meet contemporary demands and not become obsolete, outdated, or a hindrance to the people who use it.

Tactical urbanism is a practical example, succeeding in the United States context, reminiscent of adaptive planning and the perspectives this study sees as imperative for the future of transportation planning in New York. Considerations of temporal costs, nonlinear change, and the coevolution of function and structure are currently underrepresented. Tactical urbanism serves as a method of optimizing the ratio of impact to structure, temporal costs, and contribution to path dependency. The methods of tactical urbanism and adaptive planning stress a heightened consideration towards nonlinear change, which is seen by this study as an asset to New York transportation planners moving forward (De Roo et al 2012, Lydon 2015, Mould 2014, Rauws 2017). To enhance this invigorated system of experimentation and maximize its success, heightened degrees of inter-organizational coordination and communication is suggested by this study to increase the potential of each experimentation, and make information gathering more productive (Rhodes 1996). The fragmentation of the regional planning authorities and transportation providers serving New York City would not necessarily be a problem if these organizations did more to coordinate on physical planning interventions and the collection of data. Without inter-organizational collaboration, unnecessarily impediments to the flow of information and passengers across boundaries serve as areas of friction to self-organization (De Roo et al 2012).

Coordination across institutional and political boundaries is frequently encouraged, although it is encouraged more often than it is practiced. It is difficult to force coordination but one can facilitate it by eliminating impediments to its occurrence. Existing grievance mechanisms and data collection mechanisms are similarly fragmented, either by political boundaries or between transportation providers. Without holistic data collection, it is difficult to understand the commuting patterns of passengers crossing political or institutional borders. Without a clear understanding of cross-border commuting patterns coordination of fragmented institutions is hindered. There are arguments to be made in favor of integrating fragmented transportation operators but this demands a tremendous amount of reorganization in the governance networks. The fragmented organizations can work together to make the transfers between separate transportation networks more convenient. This collaboration can be facilitated through common grievance mechanisms and data collection methods, which would optimize the pursuit of micro installations across the combined systems.

Web applications make the collection and sharing of information among interested parties an easier task to accomplish. Online transportation forums in which aggrieved parties can file complaints, inspired parties can make suggestions, or confused parties can educate themselves currently exist in regards to planning, but these online forums remain organizationally and often project specific. This means a holistic web application capable of fulfilling the above tasks for the New York region is a niche that has yet to be filled. The importance of this forum relates back to one of the core tenets of adaptive planning; time, and the constant nonlinear change that comes with the passage of time (De Roo et al 2012). This study seeks to stress the importance of planners to better understand the shifting context of the transportation systems. This context is not independent of its surroundings, and a holistic view, updated in real time, is essential for planners to understand the functions of the systems they plan for. The overlapping transportation networks relate to one another and share much in common. Information regarding one could pertain or inspire actions in others, and streamlining the collection and dissemination of information means transportation planning can be more dynamic in response shifting contexts. It is important for the separate transportation entities to gather and share information between them to better understand how transportation is used as a combined system. Coordination and collaboration between the transportation networks can be enhanced by collecting and sharing information across borders and boundaries, and the public can be educated about potential physical alterations or installments that may affect them despite those boundaries. By enhancing both planners ability to collect and map data, and educating the public on strategic interventions, New York can facilitate the unfettered coevolution of structure and function as it grows beyond its traditional boundaries.

This study sees the best opportunity for tactical urbanism and adaptive planning in New York transportation as the implementation of increasing numbers of strategic semi-permanent experimental micro installations. These installations have a combined goal of addressing the growing gap between Manhattan-centric transportation structure and increasingly non-Manhattan-centric transportation functions by integrating existing transportation networks, increasing the service areas of these existing networks, and encouraging polynucleic development. In pursuit of these goals, the study also proposes the development of an online planning forum and a unified transit fare system for the New

York Metropolitan area's combined transportation system to optimize and facilitate the above elements in implementation.

These elements are framed and inspired by adaptive planning and the practical success of tactical urbanism in the United States context and could be incorporated into a wide variety of physical installations as New York transportation planners move forward (De Roo et al 2012, Lydon 2015, Mould 2014, Rauws 2017). In this study, New York's historical and contemporary context will be described to better understand the constraints of Manhattan-centric path dependency and why elements of adaptive planning theory and tactical urbanism serve as a potential solution to these constraints. The theoretical components of adaptive planning and tactical urbanism most applicable to these applications will be discussed. Finally, the report will conclude with a discussion on the key applications just proposed, how they would fit into the current planning climate of New York, and the benefits they would bring.

2. Methodology

The study conducted is a literature review focusing on adaptive planning, the practices of tactical urbanism, and the context of New York City transportation planning. This study investigates the intricacies of New York transportation planning, through a review of planning documents, in order to identify if and how adaptive planning and tactical urbanism is in practice and if it can or should be expanded. To answer the research questions of 'if' and 'how' insights from adaptive planning and the practices of tactical urbanism will lend themselves to the challenges New York transportation planning, one must first identify and understand those challenges. The Manhattan-centric structure is failing an increasing number of passengers who are forced through Manhattan along transit routes despite outer borough origins and destinations. This growing issue is identified by many government and independant reports (Cuomo 2017, MTA Report 2013, MTA Report 2013a, New Jersey State Rail Plan, 2015, New Jersey Transit 2016, NYCDOT 2017, NYCDOT 2016, NYCDOT 2015). In these reports issues, are identified but are restricted by the political boundaries of the organizations publishing the reports. For this reason, a particularly useful source of information on issues and proposed solutions with a holistic regional perspective have been nongovernmental organizations. These include academic authors, but the Regional Plan Association, which specializes in consulting government planning agencies on regional issues, has been particularly significant to this study (Khanna 2016, Preschle 2001, Regional Plan Association 2015, Riazi 2000, Weiner 1986, Zupan & Barone 2015). For example, 'Overlooked Boroughs Technical Report' compiles and analyzes a wide collection of information to illustrate the host of issues contributing to and resulting from the growing gap between Manhattan-centric structure and growing non-Manhattan-centric functions of the regional transportation system (idem). The aforementioned report identifies a collection of long and mid-term solutions regarding circumferential rail projects and reinvestment into the bus system with the revision of bus routes to satisfy outer borough commuting patterns.

A theoretical review is conducted to unpack adaptive planning theory (De Roo et al 2012, Rauws 2017). The unpacking of adaptive planning includes a descriptive summary of recent planning theory development as it contributes to the current debates on adaptive planning theory (Allmendinger 2017). This is followed by a brief investigation into the theoretical debates on some of the core tenets of adaptive planning theory. In particular, discussions of complex adaptive systems (CAS) and their propensity to adapt and self-organize (Cilliers & Spurrett 1999, Conveney et al 1996, Gros 2008, Holland 2000, Kauffman 1993, Lewin 1999, Waldrop 1993), and the potential for CAS as a model of understanding for cities (Allen 2004, Batty 2007, Portugali 2012, Portugali et al 2012). Additionally, concepts of path dependency (Liebowitz & Margolis 1995), non-linear response (Coveney et al 1996), and the self-organization through the coevolution of structure and function (Portugali 2012) are of particular note. Adaptive planning provides theoretical insight but this study hopes to do more and so prescriptive methods of tactical urbanism, seen by this study to share the interest of cultivating self-organization in urban systems, is used to situate adaptive planning in the context of New York transportation planning.

Tactical urbanism is a prescriptive planning theory that has been successful in the United States planning arena in the last decade. It prescribes the use of strategic experimental spatial intervention by grass routes organization or by local planning authorities to insight public dialogue (Lydon & Garcia 2015, Mould 2014). Tactical urbanism exemplifies many of the core tenets of adaptive planning, in particular, the self-organization of CAS through coevolution of structure and function (Portugali 2012). Theoretical publications on tactical urbanism, as well as case studies on successful tactical urbanist interventions, are analyzed here to understand the theory and practice and inspire suggestions for New York transportation planners. A theoretical framework combining considerations of adaptive planning and tactical urbanism is developed to best suit the context of New York.

Tactical urbanism is identified by this study as an opportunity for New York transportation planners. Reports identifying the Manhattan-centric structure as a mounting issue for the New York transportation system feature long and mid-term solutions while short-term remedies are not described. This study sees strategic micro installations supporting outer borough bike and pedestrian networks as an opportunity to address Manhattan-centric structure and increasingly non-Manhattan-centric functions in the short term. These micro installations can be implemented quickly, cheaply, and demonstrate a flexibility not found in robust infrastructures like subways and bridges. Both governmental and independent research identifies the issues of Manhattan-centric structure in the transportation system with increasingly non-Manhattan-centric functions of that system. The central business district (CBD) of lower Manhattan is no longer the sole destination and there is an increasing gap between the design of the system's structure and its desired function. The Manhattan-centric transportation structure is the result of a long history of transportation development. New York has locked themselves into a Manhattan-centric radial transportation design. This study uses historical material to illustrate this path dependency. General historical monographs and publications are used in the descriptions of historical trends to demonstrate the wider cultural context in which New York transportation planning exists (American Community Survey 2010, American Public Transportation Association 2017, Bishwapriya 2005, Loo et al 2010, Moon 1995, Polzin et al 2014, Smerk 1967, Stover 2008, Weiner 1986, Yoh et al 2003). In concert with the general historical context and trends, publications referring to specific developments of particular significance are used to position New York path dependancy within this wider context (Caro 2015, Hood 2004, Loo et al 2010, Markusen & Gwiasda 1994, MTA Press Release 2017, Parikh et al 2004, Slater 1997, Snell 2001, Weiner 1986). This path dependency restricts attempts by city planners to combat Manhattan centricity and satisfy the changing functions of the transportation system. Considerations from adaptive planning and the practices of tactical urbanism are suggested to shrink the growing gap between function and structure in the short term with limited funds.

The limitations to a literature review of planning documents are numerous and constraining. There are many agencies, government and not, writing reports and plans on what this study has identified as the combined transportation system of New York. These agencies have overlapping purviews, relate to different political boundaries and levels, and publish frequently. It is not only possible but likely that pertinent reports were not included in this study. This fragmentation is touched upon in the study but should be the focus of its own research. Additionally, planning documents, press releases, and academic publications do not provide the same insight as personal experience. Planning developments yet to be announced or constraints not readily available to the public would enlighten this study but are not included. This is for two reasons. This study does not have unfettered access to all pertinent information and, the intention of this study is to investigate the potential of New York transportation planners to encourage self-organization. Self-organization is a tenet of adaptive planning and a cornerstone of this study. Self-organization can be cultivated by planners but comes from the public and so this study sees the information readily available to the public as the most important for consideration. Information concerning Manhattan centricity and potential solutions available to planners but not conveyed to the public does little to encourage self-organization.

There are also hidden factors that may play a role but might not be apparent without an intimate understanding of responsible organizations. These can be both known unknowns and unknown unknowns. For example, the level of competitiveness or rivalry between the fragmented transportation authorities servicing New York likely influence collaboration efforts, but the degree to which these factors influence transportation planning is difficult to accurately describe and would not necessarily be represented in strategic plans, press releases, or published academic works. There can also be any number of unknown factors at play to various and changing degrees and these factors would not be represented in the materials this study uses. This study attempts to understand and estimate the potential of adaptive planning and tactical urbanism as an asset to New York transportation planners with the information publicly available.

This will be done through a literature review of available planning documents, press releases, strategic plans, historical information, and theoretical debate. The issues of Manhattan-centric structure and increasingly non-Manhattan-centric functions are well represented across a variety of sources while solutions are largely mid to long-term plans. Adaptive planning proposes the system is both open and in flux, with nonlinear reactions to (De Roo et al 2012). The New York transportation system is not limited to rail and bus but all modes of transportation and how they relate to one another. This study identifies an underutilized opportunity to address the growing gap between Manhattan-centric structure and changing functions in the short term using micro installations in the pedestrian and bike networks. Currently, the revision of street plans by the New York City Department of Transportation (NYCDOT) reflect technical interests like road car carrying capacity and pedestrian safety. This study proposes that the increasingly popular techniques of tactical urbanism in road revisions can be used not only for technical purposes but to encourage self-organization by sparking public dialogue and be used to address the issue of Manhattan-centric path dependency in the short term.

3. Manhattan Centric Path Dependency

New York City reaches well beyond the administrative boundaries of the five boroughs comprising it. New York City is home to eight and a half million people, however, the metropolitan area of New York hosts over twenty-three million. This metropolitan area, and its population, is delineated by the strong economic and social ties surrounding the urban core (Office of Management and Budget, 2010). These relationships are often derived by commuting patterns. The New York Metropolitan area is the largest in the United States and dominates the North Eastern Seaboard. It stretches across Long Island and the Lower Hudson Valley. It crosses state borders into New Jersey and Connecticut. The fuzziness of borders make mapping the metropolitan area problematic, but suffice to say that New York is much larger than the city limits of the five boroughs and the context of interrelated implications of New York are not only sprawling but fragmented. When one considers the many transportation networks servicing the region to be a single combined transportation system, consisting of everything from the commuter rail lines to the sidewalks in downtown Manhattan and everything in between, the Manhattan centricity of the system becomes clear. The combined system is the product of multiple generations of overlapping infrastructure all with a design that services Lower Manhattan as the universal destination.

The Manhattan centricity of the combined system restricts the polynucleic development of outer-borough business districts. The restrictions of New York path dependency is implicated by and has implications throughout the metropolitan area and across multiple layers of political boundaries (Leibowitz & Margolis 1995, Zupan & Barone 2015). This structural fragmentation has implications on the functions of the many networks servicing New York.

The underlying issue here is that the transportation system's original purpose and current structure no longer suits the needs of the people living in the metropolitan area (Zupan & Barone 2015). While many people require reliable transportation in and out of Manhattan, it is no longer the universal destination. There is a growing gap between the Manhattan-centric structure of the system and the systems desired function which is becoming increasingly polynucleic. Fewer people each year need to commute into Manhattan regularly and instead require transportation within or between the surrounding areas of Manhattan with destinations like Hoboken, Jersey City, Downtown Brooklyn, or Long Island City to name a few. Data collected and analyzed by the RPA demonstrate significantly higher population and job growth in the outer boroughs compared to Manhattan, a higher degree of outer borough trips being taken each year in the outer boroughs compared to traditional commutes into Manhattan, and a severe lack of transit options to satisfy this growth (Zupan & Barone 2015). This is what is meant by the growing gap between structure and function.

3.1 The Death of Streetcars, Robert Moses, and the Rise of the Automobile

Over the last century, United States infrastructure development experienced the abandonment of rail and the adoption of roads (Moon 1995, Stover 2008). In the post-war era, many of the leading railroad companies failed under competitive pressures from automobiles and airlines. The expansion of the Interstate Highway System with the Federal-Aid Highway Act of 1956 attracted both passenger and freight away from railroads. With the changing mobility choices, the road networks in the United States saw significant expansion and integration while rail expansion was largely abandoned (Stover 2008). As a result of these choices, urbanizing areas became increasingly reliant on road infrastructure and modal choice transitioned towards automobiles and away from railroads and streetcars (Moon 1995, Smerk 1967, Stover 2008).

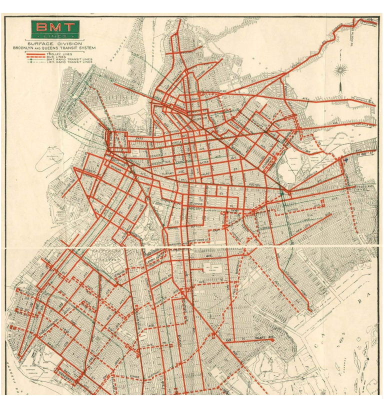

Figure 1: 1930's era BMT Surface Trolley Map. Source:http://www.nycsubway.org/wiki/Historical_Maps

In 1938, what had grown into an impressive system of streetcars throughout New York (Figure 2) and most American cities began to be replaced by buses (Smerk 1967). There is some contention on whether or not this was the result deliberate interference by a consortium of companies who stood to profit off the transition to automobiles, in particular, General Motors (Snell 2001), or if busses had become more economically viable and that the transition was inevitable (Slater 1997). Regardless of the reason, the transition was relatively rapid. In a decade, the dominant form of intercity mass transit that had sculpted the urban landscape was decimated. Streetcar tracks in most cities were dug up, roads were repaved, and the majority of urban mass transit in the United States became increasingly reliant on buses (Smerk 1967). Cars became increasingly affordable and preferable and public transportation ridership began to fall, both in New York and across the United States (American Public Transportation Association 2017). Public transportation was quickly overshadowed by the allure of the private automobile and the transition was encouraged by a massive redevelopment of the United States road network (Moon 1995). Freight and public transit took advantage of this redevelopment and moved onto the roads as well (Stover 2008). Buses required the same infrastructure as cars and so the road and highway network grew and was made a priority over alternatives like rail and streetcars. In New York, the preexisting subway system remained but largely served as a commuting network in and out of the CBD of lower Manhattan. Due to falling ridership in the late 1940's the budget for maintenance, upkeep, and expansion was reduced and the system has largely remained the same since (Hood 2004, Parikh et al 2004). The abandonment of outer-borough trolly networks and their replacement with major investments in the road network demonstrates lock-in or path dependency to the automobile network (Lebowitz & Margolis). The public transit rail network left after the trolly purge was designed to be Manhattan-centric and the replacement to the trolly network locked New York into a transit system reliant on automobiles. The rapid transition towards automobiles also demonstrates the ability of New York to make such a drastic transition in such a short period of time. Public transportation ridership fell substantially after World War II but those numbers have restored themselves despite the path dependency of decades of automobile primacy (American Public Transportation Association 2017). This trend signals a possible return and major reinvestment in public transportation.

While the transition towards roads and, specifically automobiles, was prevalent across the United States, Robert Moses could be considered one of the most influential single actors in this transition, on par with Henry Ford (Caro 2015). During his career, from the 1920's through the 1960's, Robert Moses enjoyed power and autonomy beyond the dreams or wishes of many contemporary planners. Playing a direct role in the mobility transition in New York City, Moses used his influence to actively steer New York away from public transportation and towards automobile mobility. He did this by championing car-centric projects and deliberately avoiding multi-use infrastructure installments (Caro 2015). This means rather than building a bridge with an automobile, rail, and pedestrian lane, he made sure they were for automobiles only. In particular, Moses focused on expressways, parkways, and automobile river crossings. Moses was responsible for the Tri-Borough Bridge, the Battery Park Tunnel, White Stone Bridge, Throgsneck Bridge, the Northern and Southern State Parkways, the Wantagh State Parkway, the Taconic State

Parkway, the list goes on and on (Caro, 2015). Moses designed the island of Manhattan to be the center of the regional highway network resulting in a transportation system that was increasingly Manhattan and automobile-centric. The highway design forced regional traffic through Manhattan and encouraged suburbanization and sprawl. The waterfronts of Manhattan were turned from boulevards into high-speed expressways and public transportation hubs were demolished and reduced in size (Caro 2015). The Manhattan-centric highway structure overlapped the preexisting Manhattan-centric railroad structure creating a feedback loop in which Manhattan would become increasingly dominant and congested. The flocks of people forced into Manhattan would make it uncomfortably crowded but increasingly important as a central business district (CBD). The structure of the system would encourage continued centralized growth and development making it even more crowded. The crowds would make the area more profitable to develop and the cycle continued unsustainably (Markusen & Gwiasda 1994).

Public transit ridership in New York fell significantly following the Robert Moses era. Beginning with sharp declines in the late 1940's, ridership continued to fall through the post-war period and did not rebound meaningfully until the 1990s when it began to steadily climb. MTA ridership is currently at its highest since 1946 and the trend is not unique to New York but a national transition away from personal automobiles and back towards public transportation (MTA Ridership 2015, American Public Transportation Association 2017). New York City had the highest mass transit usage in the country in 2010 with 55.7% of commuters taking public transit. New York City was followed by Jersey City, well within the New York Metropolitan area, at 45.8% (American Community Survey, 2010). Over the last decade, public transportation use has grown significantly faster than population or miles driven (American Public Transportation Association 2017). As a new generation with different mobility habits comes into prominence and the older generation fades, this transition is expected to escalate with vehicles owned, driving licenses obtained, and miles driven falling faster each year (Polzin et. al 2014, Rosenthal 2013). The transition away from automobiles towards public transportation is quite clear, but the issues of Manhattan centricity are not answered by this. Both the road and rail network feature Manhattan as the universal destination which locks New York into a paradigm of Manhattan centricity and makes a system of outer borough links capable of satisfying the growing need for circumferential commutes difficult to develop.

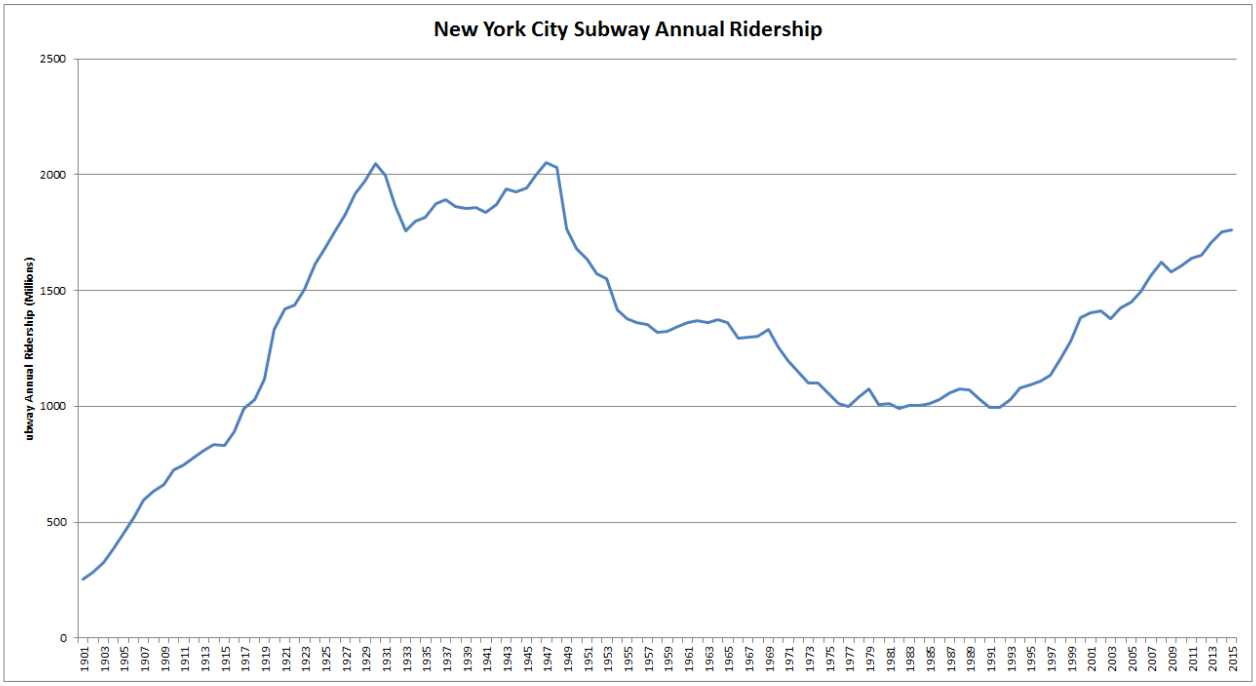

Figure 1. New York City Subway Ridership by Year. Updated Version of Graph Originally Made by Redditor Wikeywo Using a Collection of Archived Ridership Data from the MTA and DOT. Source: https://www.reddit.com/r/dataisbeautiful/comments/2bk7f5/new_york_city_subwa

3.2 The Story of Second Avenue and New York's Subway Planning

The issue of Manhattan centricity is deeply embedded in the transportation infrastructure of New York (Zupan & Barone 2015). Robert Moses and his contemporaries developed a highway network that solidified the problem but the underlying rail network exemplifies the same issue. What was originally designed to ferry commuters in and out of the CBD of downtown Manhattan now serves a city of very different functions (Zupan & Barone 2015, MTA Report 2013 & 2013a). The commuting patterns of New Yorkers are increasing but not in the ways planners predicted a century ago when most of the subway tunnels were built (Hood 2004, MTA Ridership 2015, MTA Report 2013, MTA Report 2013a).

The traditional nine to five workday is being replaced by a more constant work schedule that does not follow the same rules. More people are working from home or commuting at irregular hours (MTA Report 2013). The universal CBD of Manhattan is being challenged by CBDs in the surrounding areas or corporate headquarters in the suburbs (Markusen & Gwiasda 1994, Zupan & Barone 2015). Non-peak and reverse peak commuting is on the rise (MTA Report 2013). These changes in functions are polynucleic and counter the traditional Manhattan-centric paradigm. Faced with these changes in function, transportation planners understand that the structure of the system should change in response to close the growing gap between the structure and desired function.

However, the Manhattan-centric paradigm continues to dominate major expansion projects like the second avenue line and the extension to the seven line.

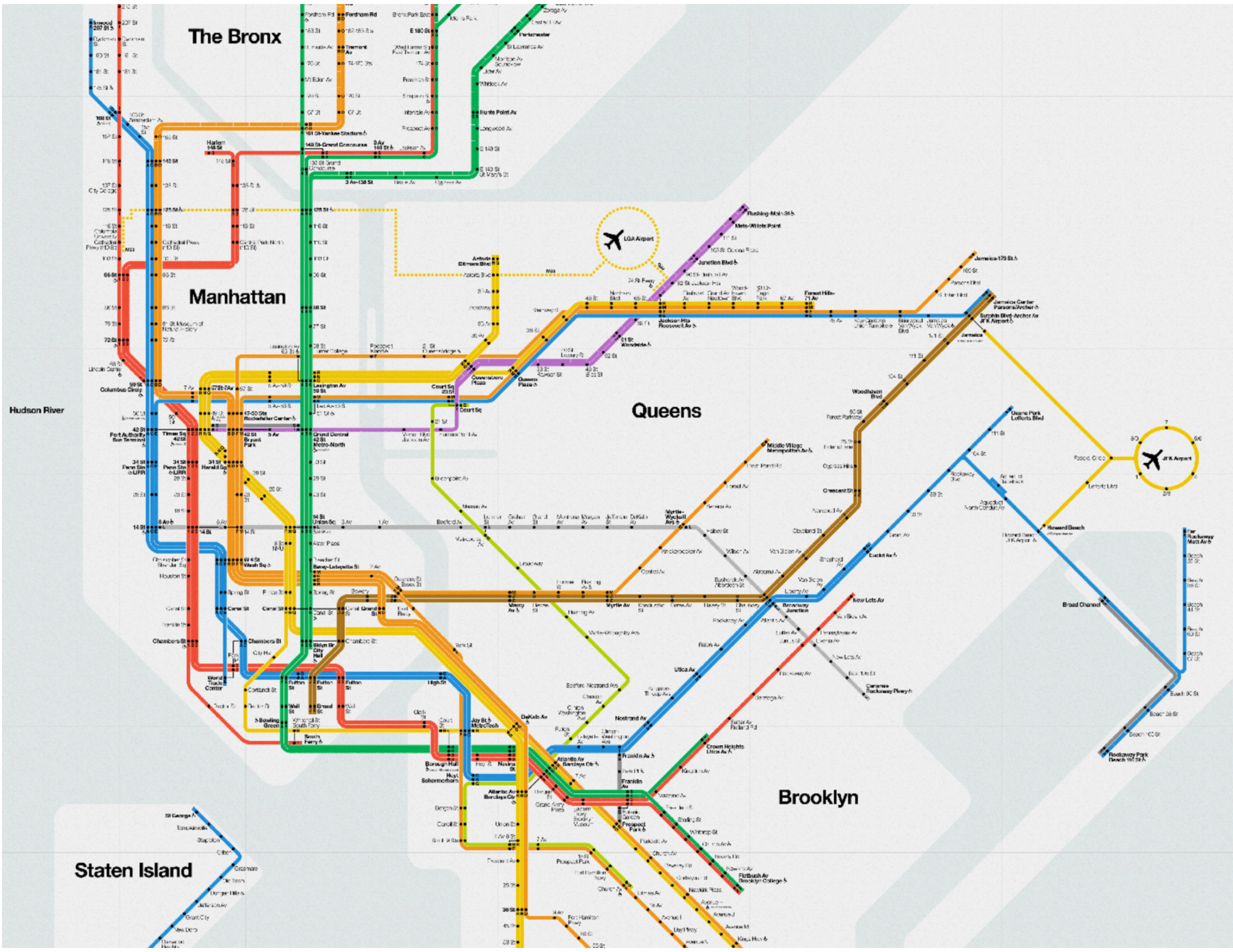

Figure 2: Massimo Vignelli's 2012 MTA Subway Map. This Map Does Not Depict True Geography and Underrepresents the Size of the Outer Boroughs in Relation to Manhattan Source:http://www.coolhunting.com/design/massimo-vignelli-2012-nyc-subway-signed-poster

Transportation planners are under pressure to expand the existing network and maintain what has become a dangerously out of date subway system (MTA Report 2013, MTA Report 2013a, Cuomo 2017, Zupan & Barone 2015). However, despite the changing functions of the system, transportation planners continue to pursue traditionally Manhattan-centric expansions like the second avenue or seven line projects, while postponing the changes to the structure that would accommodate polynucleic functions like the proposed Triboro line. The Second Avenue subway expansion was originally planned nearly a century ago and despite the drastically different functions of the current system, transportation planners continue to invest vast portions of their budget on what has become a boondoggle (Hood 2004, Parikh et al 2004).

The Second Avenue subway line was initially planned in the interwar period when New York's public transportation was experiencing unprecedented levels of ridership (Hood 2004). The Second Avenue line was an element of a plan developed by Daniel Turner (Parikh et al 2004). Turner's plan was massive and prescribed new subterranean subway lines running under Manhattan's north-south avenues and branching off into different neighborhoods and the outer boroughs. The Second Avenue line was an element of Turner's vision that was included in the down-scaled version and the expansion was tentatively approved in 1929. The initial budget for the project was greater than 1.3 trillion 2016 USD (Parikh et al 2004). For nearly one hundred years after the initial plans, the subway project would be reinvigorated and deflated over and over, costing incalculable sums between prematurely demolished infrastructure, revision after revision of plans, station placements, geological surveys, inadvertent manipulations of the real estate market, and the unknown costs associated from the absence of a reliable public transit link through the corridor (Parikh et al 2004).

Initial constructions were halted in response to the Great Depression, then to the second world war, and eventually as a response to falling ridership numbers (Hood 2004). The absence of the subway line put additional stress on the parallel Lexington Avenue line and so despite the shifting functions of the region's transportation system, the project continued when funding and ridership called for expansions to the system (Hood 2004). The first phase of the Second Avenue subway was completed at the end of 2016 (MTA Press Release 2017). It cost $4.45 billion and is comprised of three stations across a two mile run of track. Due to the deconstruction of the third avenue elevated line in 1955, the only subway line serving the upper east side of Manhattan was the Lexington Avenue line which was overcrowded, at 1.3 million daily riders (Hood 2004, MTA Ridership 2015, Second Avenue Subway...2004). The Second Avenue subway construction cites Lexington Avenue congestion as encouragement for its completion. This is to say that congestion on the Lexington Avenue line is unacceptable and the second avenue line will alleviate this congestion when completed. Without reliable data on how many riders on the Lexington Avenue line have outer borough destinations and origins, it is difficult to say if an outer borough link would also alleviate the congestion on the Lexington Avenue line, but an outer borough link would be less expensive and serve a much-needed function in the outer boroughs. Phase 1 of the Second Avenue subway line does not do much to alleviate Lexington Avenue congestion without the next three phases of the project. Phase one represents less of a solution and more of a commitment to complete the

Figure 4: The First Phase of the Second Avenue Subway Currently Depicted as the Extension of the Q Line to 96th Street. Source: MTA Subway Map 2017

next three phases. Phase two is set to begin in 2018 and has a budget of over $6 billion. This commits New York to an expensive project that does nothing to combat the Manhattan-centric concentration of transportation that is ignoring the changing functions of the transportation system. Instead, the project entrenches Manhattan centricity and the issues it causes.

While the big projects with the big price tags receive the most attention, small alterations and interventions in mass can substantially change a system. Integration with complementary networks and maintenance or service alterations strategically designed to accommodate changing functions could begin to close the gap between transit structure and function. Strategic service alterations in the subway system can begin to accommodate the changing functions of the transportation system without demanding costly and time-consuming expansions. Future network expansions should reflect changing functions and the growing polynucleic development of New York instead of entrenching the Manhattan-centric path dependency (Markusen & Gwiasda 1994, Zupan & Barone 2015).

4. Fragmented Transportation Governance

The Manhattan centricity of the physical infrastructure is reinforced by the fragmented transportation governance networks. With the governance of the combined transportation system fragmented, collaboration on integrative physical initiatives can be difficult to implement. This is important because the fragmented governance of public transportation reinforces both the Manhattan-centric paradigm of thought and the Manhattan-centric physical structure (Zupan & Barone 2015). To combat this, the separate transportation providers may consider collaboration on physical micro installations designed to ease transfers and make the use of the combined system easier. When the transportation infrastructure was designed and constructed, its purpose was to ferry commuters in and out of Manhattan and both design and governance reflects this paradigm (Zupan & Barone 2015). However, contemporary functions have changed and the Manhattan-centric design is no longer suitable. Outer borough CBDs and off or reverse peak commuting challenge the supremacy of Manhattan-centric structure. While integration of governance structures and circumferential expansions could combat this Manhattan-centric planning paradigm and structure, both are long-term solutions and the growing gap between structure and function should be addressed in the short term as well. Micro instillations geared towards the integration of the combined transportation system could ease the newly varied uses of the transportation system (MTA Report 2013, MTA Report 2013a, Zupan & Barone 2015). The structure of the system must change to accommodate the shifting functions. The authorities responsible for transportation governance should collaborate on micro installations and coordinate actions to make the use of the combined transportation system seamless.

The regional commuting networks are organized into sectors. These sectors follow both governmental boundaries and natural boundaries. Without collaboration and coordination among the many transportation networks that make up the combined transportation system, the physical infrastructure of the sectors will continue to reinforce Manhattan centricity and impede regional public transit and polynucleic development. The commuter rail networks are split and use different ticketing systems, stations, and lack outer area links forcing public transit commutes between outer areas through Manhattan (MTA Report 2013, MTA Report 2013a, Zupan & Barone 2015). Even when traveling through Manhattan, a passenger traveling from one outer area like New Jersey to another on Long Island would need to travel into Manhattan with one ticket and then purchase another for the second half of the trip. This would also require a transfer not only from track to track but to an entirely different area of Pennsylvania Station. While some transfers, like the one just proposed, can be done within a single station, this is not always the case. There is not one large rail terminus in New York but many and certain trips might require multiple connecting trips each with their own ticketing. This makes the trip more expensive, inconvenient, and contributes to overcrowding in the station. Some of this fragmented governance is exhibited in the infrastructure and will be more costly and time-consuming to correct but some of it, like the ticketing systems, can be corrected by a change in perspective. By splitting the regional rail networks and using separate ticketing services, public transportation from one sector of the region to another becomes significantly more complicated and expensive. The fragmentation of the transit systems servicing the metropolitan area support Manhattan-centric structure and impede the shifts in desired function (Zupan & Barone 2015).

Here, the governance structures managing New York metropolitan commuter rail networks will be described to illustrate their fragmentation and impediments to co-evolution and self-organization.

4.1 The Metropolitan Transit Authority

The Metropolitan Transit Authority (MTA) is a public benefit corporation responsible for transportation in New York City and many of the surrounding areas. The MTA is most popularly known for the maintenance and operation of the subway and bus services throughout New York City. Other operations are split into several subsidiaries (PCAC 2015). The Long Island Rail Road Company (LIRR) and the Metro-North Railroad Company (MNR) are the commuter rail services for the surrounding areas of New York State and Connecticut. Additionally, the MTA operates the Staten Island Railroad, MTA Bridges and Tunnels, and MTA Capital Construction. The MTA also operates some regional buses in New York.

The governance structure of the MTA features a chairman selected by the governor of New York for a six-year term in which they manage a 20 person board of representatives from across the MTA service area as well as related unions. However, voting priority is given to those board members from the City of New York, while the four board members from the lower Hudson Valley (Putnam, Dutchess, Orange, and Rockland) have one collective vote between them (PCAC 2015). The MTA subsidiaries are not integrated into a unified system and the governance structure of the MTA has a strong focus on New York City as the regional center. These features of the MTA are likely for good reason but does contribute to the Manhattan-centric structure of the transportation system through fragmented physical infrastructure and governance (Khanna 2016, Zupan & Barone 2015).

The two MTA commuter rail organizations, the LIRR and MNR, demonstrate a dendritic pattern branching out into the surrounding regions and funnel that traffic into one of two primary termini in Manhattan. The LIRR ends in Pennsylvania Station and the MNR ends at Grand Central Station. Not only are there no circumferential connections for commuters to avoid Manhattan when traveling from one sector to another, there is not a common rail terminus. MNR trips arrive at Grand Central Station while LIRR arrives at Pennsylvania Station, meaning trips from one sector to another require a connecting trip via subway (MTA Report 2013, MTA Report 2013a, Zupan & Barone 2015).

Observations on commuting patterns also depict changes in functions of this system away from the traditional Manhattan-bound 9-5 commuter traffic. The MTA could accommodate these through strategic alterations in their structure (MTA Report 2013, MTA Report 2013a). While the issues of changing functions are understood by the MTA, the paradigm of operation is still Manhattan focused and this is depicted in the schedules, ticketing services, and even the maps that are produced (Zupan & Barone 2015). Services will need to change to accommodate the shifting functions of the system. Polynucleic CBDs, shifting working hours, and reverse peak commuting are demands being placed on the system and there is no time to wait for what could prove to be lengthy and costly expansions to the rail network (MTA Report 2013, MTA Report 2013a). The MTA must pursue changes to service, ticketing, and scheduling in the short term that can alleviate the growing gap between desired functions and existing structure.

Figure 3: The MNR and the LIRR Depicted in the Same Map, Demonstating a Dendritic and Manhattan Centric Design. This is Rare, As the Two MTA Subsidiaries are Usually Depicted Individually, Further Evidence of Their Fragmentation. The MTA has not Published a Map like this Since and it is No Longer Found on Their Website. Source: MTA 2013. Found: http://www.adriftskateshop.com/mta-metro-north-map.html

4.2 New Jersey Transit

New Jersey Transit is another transit authority responsible for large sections of the New York metropolitan area. New Jersey Transit operates twelve commuter rail lines with a Manhattan-centric design. While the system can be used to move throughout New Jersey, the largest stations of NJT ridership by a multiple of three are the NYC rail terminus Pennsylvania Station, and the NYC bus terminus Port Authority Bus Terminal (NJ Transit Facts 2016). The system is designed to ferry commuters to transit hubs like Secaucus Junction and Hoboken, then through tunnels to the island of Manhattan. The Manhattan-centric paradigm is problematic as it leaves communities between the radial rail lines underdeveloped. NJ Transit has actively combated Manhattan centricity by developing new circumferential transit routes, connecting the growing CBDs of Hoboken, Jersey City, and Newark. These circumferential paths connect to the preexisting radial ones to increase connectivity, both to lower Manhattan and throughout the developing New Jersey CBDs.

These circumferential expansions increase connectivity but still support the Manhattan-centric perspective due to the pronounced path dependency. While encouraging polynucleic development, NJT is also expanding the service areas of the already overcrowded Manhattan connections (New Jersey Transit 2016, New Jersey State Rail Plan 2015). Physical connections between New Jersey and New York have been limited, both due to the political and physical partition. There is a single pair of commuter rail tunnels NJT shares with Amtrak currently operating at capacity during peak hours (Regional Plan Association 2015). The tunnels are over a century old and suffered heavy damages during Hurricane Sandy. The tunnels are at the end of their lifespans and will need to be closed within two decades. The need for replacements is bigger than NJT. Manhattan is locked in as the center of regional transportation and NJT and Amtrak both depend on this pair of tunnels. However, the issue of their reconstruction raises questions on the dependance NJT has on these tunnels and the precarious position it puts them in. The failure of these tunnels before viable replacements are constructed would be disastrous. As it is, these North River Tunnels are the biggest bottleneck in the regional rail network and serve as a major connection for the entire Northeastern United States. In their replacement, planners should consider Manhattan-centric path dependency and the problems that come with it. The reliance on this connection puts the region and its economy in a vulnerable position. This is not to suggest the abandonment of these tunnels but to encourage consideration of path dependency in their replacement and the cultivation of a stronger CBDs on the New Jersey side of the river. This can be pursued by further encouragement in the polynucleic transit patterns that have been growing in strength rather than focusing on Manhattan-centric transit links.

Figure 4: New Jersey Transit Map Depicting a Manhattan Centric Design With Evidence of a Growing CBD Along the Hudson Across from Lower Manhattan. Source NJ Transit 2017.

4.3 The PATH

The PATH is a subway like subterranean rail transport system. Connecting major transport hubs in New Jersey to several high demand areas in lower Manhattan (New Jersey State Rail Plan 2015, McLaughlin 2011). The PATH connects New Jersey and New York using two lines, but it is not connected to parallel transportation systems (PATH 2017a). While the PATH stops at major transit hubs and subway stations, the entrances are separate and do not provide free transfers. The PATH is operated by the Port Authority of New York and New Jersey as opposed to the MTA or New Jersey Transit. The PATH adds an alternative route into lower Manhattan from New Jersey, adding two additional connections across the river south of the NJT and Amtrak tunnel (McLaughlin 2011). By adopting the Metrocard it has integrated itself with the MTA system but there is room for improvement (PATH 2017). By servicing separate stations without free transfers the PATH supports Manhattan centricity as opposed to polynucleic CBD connections. For example, one of the two PATH termini in Manhattan is the 33rd Street Station. This PATH station is close enough to Pennsylvania Station to feature an underground walking connection like many subway stations do but there is not one connecting the PATH. This serves as an impediment to the polynucleic functions of the system and instead reinforces Manhattan centricity. Expansions of the PATH could improve by making physical connections to the subway and NJT stations it serves as connections to. Plans for the renovated Pennsylvania Station, soon to be named Moynihan Train Hall, should consider promoting polynucleic functions by physically connecting to the PATH and making that transfer more convenient (New Jersey State Rail Plan 2015). Cohesive integration with parallel systems would make the PATH a connection between various CBDs instead of another commuting route in and out of downtown Manhattan.

4.4 The Need for Adaptive Planning and Tactical Urbanism

New York desperately depends on its public transportation system; now more than any time since the 1940's. The system is not only underfunded but fragmented and manhattan centric by design. New York transportation planners are now called upon to do more with less, and quickly. A growing gap between Manhattan-centric structure and increasingly polynucleic function demands changes to the system, and while these issues are acknowledged by transportation planners, substantial action to close the gap between function and structure has not been pursued. This is partially because the plans to address the growing gap focus on large-scale circumferential expansions to the system. This will address certain issues but not in the short term and the short term is where this study sees the biggest opportunity for tactical urbanism. The incorporation of insights from adaptive planning and the practices of tactical urbanism could serve as a useful addition to the standard regimen and alleviate the mounting pressures of the growing gap between existing structure and desired functions of the transportation system.

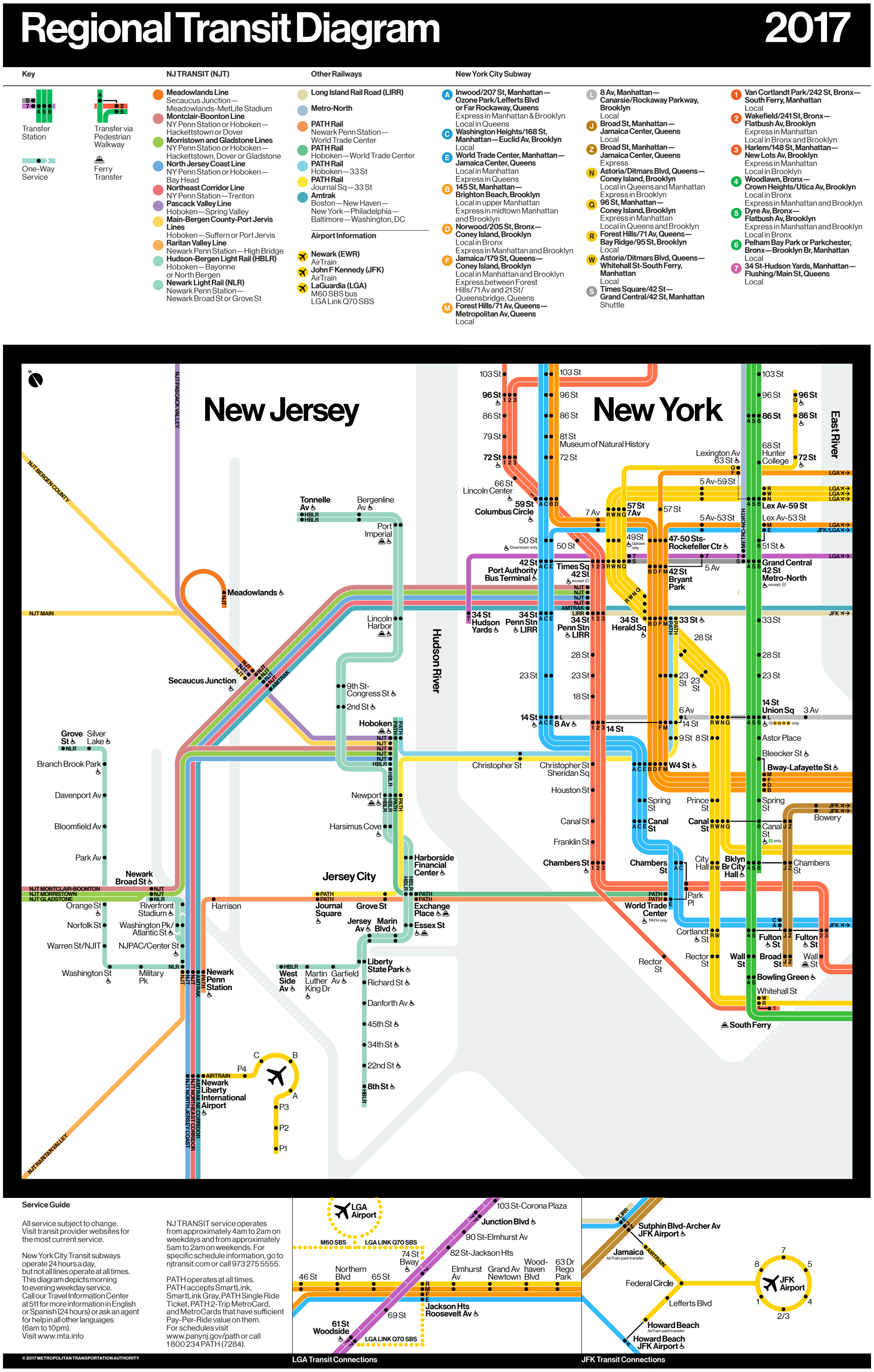

Figure 5: Map of Regional Transit - MTA, NJT, and PATH Shown Together to Demonstrate the Potential of an Integrated System. Source: MTA 2017

5. Theory

The purpose of this study is to consider the potential of adaptive planning and tactical urbanism in New York City transportation planning. To do so, we must first unpack adaptive planning and tactical urbanism to understand what elements of them lend themselves to the challenges faced by New York transportation planners. First, a brief review of planning theory is conducted to better understand where adaptive planning and tactical urbanism lie in relation to contemporary planning paradigms. Then, the core tenets of adaptive planning deemed most suitable to the context of New York transportation planning are described and connected to the increasingly popular practices of tactical urbanism in United States transportation planning. The issues of Manhattan-centric transportation structure and the growing gap between function and structure in New York are issues being considered and addressed by planning organizations and authorities. However, many solutions being proposed are long-term and large-scale planning installations. While adaptive planning could and may already play a major role in the formulation of mega transportation projects in New York, the experimentation of tactical urbanism does not resonate with the robustness and technical expertise required for large-scale transportation installations. This study does see an opportunity to utilize adaptive planning and tactical urbanism in micro installations which would address the growing gap between user function and physical structure in the short term.

5..1 Review of Planning Theory

Adaptive planning is inspired by insights from the complexity sciences and is a new notion but one that is gaining traction (Allen 2004, Batty 2007, Cilliers & Spurret 1999, De Roo et al 2012, Kauffman 1993, Lewin 1999, Portugali 2012, Webster 2010, Wolfram 2002). Contemporary planning theory is relatively atemporal and adaptive planning would stress the influences of time and change on the planning process (De Roo et al 2012). Planners must observe, plan, and do their best to predict situationally in acceptance of complexity. Complexity planning and the study of complex adaptive systems enlighten the study of planning through their emphasis on nonlinear change and reaction, coevolution and autonomous adaptation, and the importance of time and constant and unpredictable change in what has largely been an atemporal field (Allmendinger 2017, De Roo et al 2012).

For much of its history, planning has been a stagnant and linear process (Allmendinger 2017). Beginning with the technical rationale, planners operated under the impression there was a true knowable world that could be studied to the point of understanding. That from a place of understanding, a planner would be able to develop a solution to a problem, and that if that problem manifested elsewhere the same solution originally devised would also solve the problem in its new context. In this way, planning problems were independent of their context. Like a chemistry experiment in a lab, a planning problem could be studied, understood, solved, and that solution could be replicated elsewhere in an entirely different context.

There are certain advantages to this way of thinking, particularly in regards to transportation planning. Transportation relies heavily on the technical rationale. Ridership numbers, operational capacity, the engineering of large infrastructure projects, and many more aspects of transportation planning relies on a degree of certainty. Public transportation also relies on the public trust and transportation systems should demonstrate predictability and reliability to earn that public trust. There are many aspects of social planning that are dependant on their context or a communally agreed upon the truth but which side of the road to drive on or what a red light means at an intersection should not vary from one neighborhood to another. The technical rational has its faults, particularly when left in the hands of planners with unchecked power like Robert Moses, but that is not to say it is useless and it has many advantages in regards to transportation planning.

This logical-positivist philosophy placed planners as architects behind a growing utopia which could be built by formulating a series of steps towards a pre-devised goal (Faludi 1973, Faludi 1987, Allmendinger 2017). This 'command-and-control' paradigm found its dominance in the reconstruction and growth following the world wars. Closed, or Class I, system models were developed to illustrate the context independent projects planners developed to rebuild Europe after so much destruction (McLoughlin 1969, Kauffman 1993). 'Stamp' or 'blue-print' planning became popular, in which neighborhoods or entire towns could be copied and pasted repeatedly. They were devised by a planner who supposedly understood how to make an ideal community. There was a burst of growth to plan for in the post-war era, but these growth strategies were dependant on a predictable rate of urban growth, and strategies were often ignorant to local contexts (Chapin & Weiss 1966). Variations between situations restricted the success of these methods. Nothing in life is constant but change. Planning strategies and theories based on anything else are doomed to falter in the face of the unpredictable.

The certainty on which the technical rationale and functional planning stood came into question as early as the 1960's (Alexander 1984). Knowable certainties and linear extrapolation of trends had demonstrated themselves to be flawed thinking, particularly in strategic planning settings (De Roo 2003). Progressive planning and feedback planning developed, both featuring the uncertainty of contextual changes and mechanisms to respond to changing circumstances (Forester 1989, McLoughlin 1969). The idea of semi-closed systems or Class II systems emerged to explain and manage this new lack of certainty (Kauffman 1993). This is an important shift away from knowable certainties. Planning for various contingencies demonstrates an acceptance of a certain level of ignorance to the future. Planners could make their guesses as to what might happen but accepted that they could not know for sure and that certain externalities would affect future outcomes. This represents an important step towards situational planning and a lack of absolute certainty. The consideration of potential scenarios in the planning process is particularly useful in regards to transportation megaprojects and the uncertainty of external change throughout their lifetimes. It can often be useful to draft contingency plans that can be enacted in response to changing circumstance (Wall et al 2015).

Communicative planning takes the opposite approach. Instead of relying on the technical certainty of calculation and data, communicative planning represents ideas of intersubjective reality as an alternative planning method (Healey 1992, Forester 1989). Intersubjective reality meant that reality, truth, and value were not knowable certainties but ideas that were developed and agreed upon by consensus (Allmendinger 2017). A city's value was more than functionality but livability and the cultivation of this value was a community endeavor (Jacobs 1961). This method of planning is of particular use when there is a diminished degree of certainty available. Without the certainty technical planning relies on, communicative planning actions develop some degree of certainty by cultivating consensus through community outreach. With this method, planning is a Class III system or an open network. An open network stressed not only the actors of a system but their interactions and the wider context in which the system exists (Kauffman 1993). These interactions are as meaningful as the nodes of the system, and the context influences both actors and interactions. The actors responsible for these interactions are independent and their actions cannot be predicted. This dispels any remaining element of certainty left to the planner and is seen as one end of the planning theory spectrum, the opposite of technical rational (Kauffman 1993, De Roo et al 2012). Saying the two planning methods are opposites does not mean they are mutually exclusive. On the contrary, they are often found used together in varying degrees. Transportation planners considering an intervention like the locations of new bike share parking stations might consider both the technical concerns like population density or the service areas of nearby bus and rail stations, but planners would also want to consider suggestions from the community that will receive and live with the installations. Community suggestions will provide the insightful localized knowledge and technical considerations will generate ideal locations based on a set of determined criteria and the two lists of locations can then be cross-referenced.

Communicative planning meant that planning interventions were reflective of the context. No more could towns or neighborhoods be replicated from one place to another. Instead, planning interventions were to be decided upon by the community they would affect (Healey 1992). This increased the vested interest of the community with itself. The destiny of the neighborhood would be decided by the community and no one else would know better what the community needed than themselves. From a communicative perspective, the idea of a planning expert who knew better than the masses and would design an ideal society was antiquated and dictatorial (Allmendinger 2017, Healey 1992, De Roo 2012). Strategic planning interventions could be seen as the will of the people, or at least those who participated, and not the meddling of a planner whose interests were uncertain.

The communicative rational depends on an open, equal forum in which educated actors are free to openly represent their interests, desires, and negotiate the differences between them (Healey 1992). However, this forum rarely exists in reality. Differences in education, vested interest, and power distort the dialogue and ensure that ideal communication is seldom found (McGuirk 2001, Huxley 2000, Bengs 2005, Stein & Harper 2000). While ideals can be criticized as being naive and fantastical, they serve an important purpose. Ideals are what one strives for. While a completely unbiased forum with full participation is ideal, it can prove unlikely. Still, without community involvement a planners power can be unchecked and their interests can be corrupt. The planner should work for the interests of the people and the common good. This should be done with some degree of dialogue with the public as the common good is not purely functional (Jacobs 1961).

Just as one must balance between ideals and reality, one must find a balance between the two extremes in spatial planning that have been introduced. Technical and communicative planning are the two ends of a spectrum, with technical being a more top-down, planner directed approach and communicative planning being a bottom-up, community-led approach (Allmendinger 2002, De Roo et al 2012). Issues or interventions containing a high degree of certainty lean more towards the technical side of the spectrum while issues with a high degree of uncertainty demand a more communicative approach. All interventions will fall somewhere between these two extremes as the situation dictates (De Roo et al 2012). This is important as both planning styles have their respective pros and cons and planners who operate situationally will find more success in their endeavors (De Roo et al 2012). However, this situational spectrum is not the extent of the theoretical ideas to be presented here.

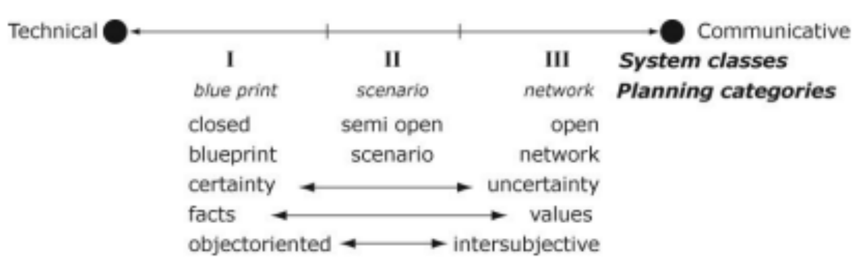

Figure 6: Rationality Spectrum for Spatial Planning and its Relation to Class I, II, and III Systems. Source: De Roo et al 2012

5.2 Introducing Complexity

It is not enough for this balance to simply be a situational compromise between two extremes. The importance of finding the right balance between communicative and technical planning methods cannot be stressed enough, but those who are inspired by insights from the complexity sciences hope to add an additional perspective (Cilliers & Spurret 1999, De Roo et al 2012, Rauws 2017). The communicative and technical rational are both atemporal when compared to adaptive planning(Allmendinger 2017, De Roo et al 2012). Whether a planner relies more on technical or intersocial truth, adaptive planning stresses temporal change of those truths. If a planner develops some degree of certainty and acts upon that certainty with a planning intervention, that intervention may have unforeseen effects that alter the initial certainty the plan was based on. Circumstances are in constant flux and a plan should be in a constant revision to accommodate those changes (Rauws et al 2014).

If one observes the link between planning theory and system classes (De Roo et al 2012, De Roo 2015, Allmendinger 2017), we see a progression from Class 1 (closed systems, technical rational) to Class II (semi-open systems, scenario planning), to Class III systems (network, open, communicative rational). If all we needed was a compromise between the communicative and technical rationals we would have it with a sliding scale on the spectrum of certainty or the 'fuzzy middle' (De Roo 2003). Different planning issues demonstrate different degrees of certainty and while some, particularly at the strategic level, may be uncertain in the extreme, others have a relatively higher degree of certainty and may be prime for more technical styles of planning (De Roo et al 2012). However, we as planners may grow beyond the fuzzy middle and find an additional perspective that provides original insight into stale problems.

When we draw insight from the complexity sciences we incorporate an essential element that is largely absent from the first three classes mentioned. Class IV systems, or complex adaptive systems, place significance on the passage of time and the constant change that time brings (Cilliers 1999, Coveney & Highfield 1996, Gros 2008, Holland 2000, Lewin 1999, Waldrop 1992). Complex adaptive systems are a useful perspective for understanding cities (De Roo et al 2012, Rauws 2014). Spatial problems are not atemporal nor are they context independent, and neither are the planning interventions meant to solve them (De Roo et al 2012). A strategic city plan and long-term vision are important but not sufficient. Additional focus is needed on the method of becoming. This means that there should be more than just long-term goals, planners must develop steps towards achieving that goal and be constantly aware and perpetually monitoring how external changes and changes initiated by their own actions affect the context in which they are operating (De Roo et al 2012, Rauws 2017, Rauws 2014). This is not a minor shift in focus but a fundamental shift in perspective.

This report aims to demonstrate the advantages this paradigm shift could have in New York public transit planning, but first, will illustrate the intricacies of some of the major elements of ‘complexity planning’. This is not a theoretical report and can’t describe all aspects of ‘complexity planning’ that can be found in prevailing literature but will limit itself to aspects deemed to be essential to the understanding the perspective from which the suggested applications come.

First, it is important to make the distinction between that which is complex and that which is complicated (Cilliers & Spurret 1999). It is insufficient to say a complex system is complicated. While it is true a complex system is complicated, the word complex means more in this context (idem). A complicated system might have a vast number of components, but if one is able to give a complete description of the system it is not quite complex. Imagine a computer. A computer is a complicated machine made up of numerous and intricate parts. However, a computer comes with a blueprint. A computer is made up of a set of pieces, each of which one could remove, disassemble, and put back together again. Each piece of the computer can be fully understood and reassembled with its other pieces. In this way, a computer is the combination of its parts and can be described and understood despite how complicated it is.

A complex system is also made up of a number of components but these interact dynamically, autonomously, and continuously, and their interactions result in non-linear change (idem). These interactions are performed to various degrees of ignorance to the complete system. Actors are not omniscient or all-knowing but are operating locally with the limited information at their disposal. Actions are taken with various degrees of understanding and in relations to external enhancers or repressors that encourage or discourage certain behaviors (Cilliers & Spurret 1999). When the complex adaptive system is made up of human actors, as is the case with the city, the system is comprised of self-aware actors. Issues like disproportional levels of ignorance that are cultivated or serendipitous, anticipatory reactions, and management ability contribute to the complexities of the system (Walker et al 2004). The New York transportation system is more than a sum of its parts. The system is more than the roads, rails, and stations, but is the people who use it. The ways the system is used by passengers have as much influence on the system as the infrastructure. This ‘use’ is the combined action of millions of autonomous actors operating in response to countless contributing factors in a particular moment in time (De Roo et al 2012).

Local actions taken at a local scale can have far-reaching and disproportional implications (Cilliers & Spurret 1999). This is the result of the intermediaries distorting, enhancing, or diminishing local actions taken. This is the concept of non-linear change (De Roo et al 2012). Local actions can have unpredictable and far-reaching consequence because of the way a particular action is responded to and how that response has its own consequences. Actions and reactions feedback on one another with the potential of a calamitous result. The common metaphor is the butterfly effect, in which a relatively small action like the flapping of a butterfly’s wing can serve as a tipping point that results in a hurricane (De Roo et al 2012). This kind of disproportionate consequence is the result of a context that was prime to create the storm and needed a small action to set the cycle in motion. If the context was understood completely it could be possible to foresee these tipping points but a complete understanding of an ever-changing context is impossible (Batty 2007). Planners must do their best to understand their context and consider the degrees of certainty of that context. Planners must also remain mindful of the change their actions may cause as well as predict potential reactions to these consequences. It is important to note the irreversibility of their actions (De Roo et al 2012). Irreversibility in the sense that each action taken will alter the system and simply reversing the action will not return the previous context. The system is in perpetual flux with each action altering the system in nonlinear ways. There is no moving back and each current state will be new and unique(Coveney & Highfield 1996, De Roo et al 2012). As a planner, one must understand the potential impacts of their actions as best they can but appreciate the challenge of this and understand that full understanding is impossible. For New York transportation planning, this sentiment translates to the importance of collecting as much information from both the technical and communicative realms as quickly as possible, while appreciating the impossibility of complete understanding.

Complex systems are open and subject to environmental and contextual circumstances as well as being guided by historical context, and since the actors in this instance are self-aware, the anticipated context. This is known as 'path dependency' and relates to the contextual factors that encourage or discourage particular behaviors (Liebowitz & Margolis 1995). Complex adaptive systems naturally evolve and develop but the course of that development is influenced by the contemporary context, historical context, and the anticipations of the actors within the system. In the case of New York's public transit, path dependency comes in the form of existing infrastructure, past failures and precedents that have been set, governance structures, and technological ability. Not only what exists and how it is governed, but what came before, what is anticipated to come in the future, and the public opinion. The list of influencing factors is lengthy and the degrees to which each factor on the list influences the system is constantly changing, but it is essential to consider these factors in the planning process and how they will change with time and future interventions (De Roo et al 2012). It is therefore important for New York to collect both technical and intersocial information throughout the complex adaptive system in real time to observe change as it presents itself.

Complexity planning literature reflects on a city's robust and flexible nature (Allen 2004, Batty 2007, Portugali 2012, Portugali et al. 2012). The robustness of a city is attributed to a city's resilient presence. Cities remain despite being bombarded or conquered, despite name changes or changing trade routes, despite technological advances or economic crashes. Cities remain. This is not universally true and there are cities that have been lost to ruin and never rehabilitated, but those pale in comparison to cities like Rome or Mexico City, built over the ruins of the city there before. Another example discussed in complexity planning literature is Hiroshima or Nagasaki (De Roo et al 2012).

These cities were utterly destroyed and left a radioactive wasteland yet they remain. Why cities are as robust as they are is not an easy question to answer. Some attribute property values as a crucial component (Webster 2010, Webster & Lai 2003). The value of resources, infrastructure, and human capital gathered in one location serves as an incentive to maintain a city as well. Beyond the material value is the city's sense of place (Pred 1984). A city is more than a location but the result of a history of people endowing this location with meaning. The emotional ties tethering people to a city, even after it has been conquered or destroyed, are substantial and unquantifiable. The nostalgia a city can evoke in an individual is substantial enough to keep them there when it might be more logical to relocate. This sense of place is an amalgamation of social and environmental factors that make a city unique and endow it with meaning. A city is more than a frantic flurry of independent autonomous actors.

Robustness aside, complex adaptive systems like cities are also inherently flexible (Allen 2004, Batty 2007, Portugali 2012, Portugali et al. 2012). Cities are capable of remarkable feats of adaptation. Local demographics, industries, technological capabilities, and every other fundamental aspect of the city will change over the course of its history yet it remains and continues to serve similar functions. A city originally used as a fortress might find a new purpose as an industrial port and then change again to a center for commerce and trade. However, through all of those phases, the city has served as a safe place for people to live, work, and succeed. In this way, cities exemplify a process of co-evolution (De Roo et al 2012). Co-evolution refers to the way in which cities adapt to contextual changes in a self-organizing manner. Function or structure will change for any of infinite reasons and in response, the other will adapt to that change. Both respond to one another back and forth and together through this process they will develop and grow into something new and particularly adapted to meet contemporary challenges (De Roo et al 2012). Examples of this might be the changes a city goes through during an economic crash or depression. The context and functions of the city have changed and in response, the structure will change. This change is not led in a top-down way but autonomously through self-organization. Mobility patterns, demographics, the cost of living, every aspect of life in the city will change in response to the economic collapse. Autonomous action and reaction of independent actors are the response to circumstance and to one another or the changes other actors create through their action. This cycle feeds back on itself. It is perpetual and cyclical. It spans the city and beyond but is the result of individual actions adding up to patterns of significance (Allen 2004, Batty 2007, Portugali 2012, Portugali et al. 2012). This process can be referred to as coevolution and is how cities remain flexible and adaptable.

The propensity to adapt spontaneously and autonomously to contextual changes is the logical state of a system made up of numerous independent actors. However, the adaptations of a city are not limitless and are constrained by numerous factors. Recall the earlier discussion of path dependency (Liebowitz & Margolis 1995). Path dependency is the contemporary impacts of historical choices and events and the self-fulfilling prophecies of anticipatory behavior. Presence and cost of outdated infrastructure can easily impede on the replacement of that infrastructure or the adoption of an alternative system. Again, these limitations can impede upon adaptation and self-organization.

The impacts of path dependency are not limited to previous planning interventions but planning governance as well. Cities exemplify self-organization and will spontaneously generate governance bodies, even out of chaos (De Roo et al 2012, Cilliers & Spurret 1999). When a new system of governance is generated and is not designed with mechanisms for systemic change or checks against entrenched powers it will inevitably become outdated. A governance system without perpetual self-reflection and evolution that is designed to handle the problems of the present will not grow and evolve with society. As a result, there will come a day when the governance system is no longer capable of handling contemporary issues and becomes antiquated, useless, and a barrier to adaptation and autonomous co-evolution. This too is a form of path dependency (Liebowitz & Margolis 1995).

The complex adaptive system can be used to discuss many social structures and networks at multiple scales (Allen 2004, Batty 2007, Portugali 2012, Portugali et al. 2012). All these parallel complex adaptive systems influence one another and influence their counterparts at other scales. There is no way to isolate one complex adaptive system because they are open and depend so heavily on their context, including their relation to other systems (Kauffman 1993). A complex adaptive system could be an entire city, or one aspect of a city, like that city's transportation system. In this study, the complex adaptive system being addressed is the combined transportation system of the metropolitan area of New York. This includes the roads, railroads, bridges, and tunnels in and around New York City as well as the sidewalks, parks, public spaces, and connecting paths that might serve as the last leg of the trip or a connection between two modes of transportation. The paths connecting a commuter rail tunnel to a nearby subway or the walk through the park from the subway stop to the office. All these aspects relate and contribute to one another. Few public transportation trips are made with a single mode of transportation and quality of each mode as well as the ease with which one can connect between modes contribute to the overall quality of the trip.

An essential aspect here is the interactions between numerous autonomous actors that endow the system with meaning. The combined transportation system of New York means nothing without the interactions of the city's citizens. There are some elements like the bridges or tunnels of the combined system that are quite robust. Some have existed for one hundred years and have solidified their place in the system. By being reliable, these elements of the system have inspired developments that rely on them. This can be considered path dependency and the reliability one expects in their public transportation system. The flexibility of the system is the human element and found in how well the system adapts to unexpected change. A sidewalk that is closed for construction but has a temporary path set up parallel to that construction is not uncommon in New York. Subway delays or closures are compensated by alternative routes and shuttle service with buses. The question remains, how well are these alterations in service declared to the public. The human element of the combined system is how well passengers are able to navigate the structure of the system to satisfy their desired functions. Physical connections between platforms, ticketing systems, signage, and advertisements for alternative routes are all examples of structure intended to ease human use. These are the elements of the system that are the most flexible and capable of short-term change to accommodate changing functions.

Transportation networks are not traditionally thought of as being particularly dynamic or adaptive due to the high degree of technical planning and robust structure (Gros 2008). These networks usually require a considerable amount of planning, funding, construction time, and then remain stationary for their lifetimes. The subway lines in New York were largely built nearly a century ago (Zupan & Barone 2015). While expansions and alterations to service have changed how and where they operate, the original tunnels have not moved and have instead guided development around them. However, these alterations to service, delays, cancellations, or external factors influencing mobility patterns and modal choice of individuals; all these and more influence how the subway network operates. The function of the system is as significant as its structure and the two influence one another. Congestion or underuse influence degrees of service. Popularity and ridership numbers influence future expansions or improvements to the system (Duffy 2000, Yoh et al 2003, Zupan & Barone 2015). The human element of the system gives it meaning and influences how it is used and changed. This human element takes a system that could be called complicated, if one only looked at the tracks and cars, and makes it truly complex. The complex adaptive system being investigated is not limited to the subway system. Regional rail, bus routes, bike shares, all of these are influenced by and have influence on the subway system as a result of the way they are used by their passengers. The focus of this report is to analyze the combined transportation system of the metropolitan area as a complex adaptive system.

5.3 Temporal Cost of Delayed Intervention

An underrepresented concept in adaptive planning discussions, but one that fits nicely into a more temporally focused planning process is the concept of 'opportunity cost' (Payne et. al. 1996). An economics concept, an opportunity cost is the idea that if one has a certain amount of capital and saves it rather than investing it, that individual will incur a loss of capital rather than maintain it. By not investing their capital they have missed the opportunity to grow it and this is considered a loss. This concept does not seamlessly apply to transportation planning, but it does provide interesting and potentially valuable insight. Hypothetically, a city has the opportunity to improve on a particular type of infrastructure in their transportation system but postpones this development due to the cost of the project. Atemporally, this might make sense if the current infrastructure is adequate enough to serve its function. However, the improvements would make the system more efficient, perhaps by using less fuel, costing less to maintain, or by being faster. Every moment these improvements are not incorporated the 'temporal' costs collect and at a certain point, these costs will outweigh the cost of implementation. While some elements like fuel efficiency can be easily monetized, not all impacted elements can be so easily monetized.

Improvements to the New York transportation system will have many effects and not all are easily or at all capable of being monetized. Farther reaching, cheaper, more reliable, and fast transportation service might encourage the use of public transit and result in the use of fewer automobiles. This might have far-reaching consequences to various degrees including a reduction in air and noise pollution and safer streets. These impacts could be monetized though any monetization of these impacts would be highly debatable. Regardless of their monetary value they have value and can be seen as a desirable influence that increases the livability of the city (Jacobs 1961). Installations aimed at increasing ridership would also increase the farebox recovery rate, which is the percentage of the transit operating budget that is generated by collected fares. Some transit systems are capable of generating well above their operating budget with collected fares, however, these are largely found in Asia and not in the United States. In New York, the fair recovery rate ranges from 36% (MTA) to 56% (NJT) meaning operation is still heavily subsidized and this does not include the costs of initial construction (Lindquist et al 2009). In New York, public transit like the subway is not a money-making mechanism expected to return on investment but a socially funded enterprise in the interest of a functioning city. However, the motivations behind public transit are not strictly altruistic either. A well-connected area of the city is seen as being more valuable, and higher property values generate higher taxes for the city and higher profits for property owners. The city of New York has proposed a new streetcar line through underserved areas of the outer boroughs. This project is championed by the 25 billion dollars in economic development it is estimated to bring to the area over thirty years compared to the 2.5 billion it will cost to construct (Friends of the BQX 2016, HDR 2016). Here we see both societal and financial interests at play and regardless of how each is derived, there is considerable potential value in the project between increases in tax revenue and connectivity for local residents. Remote causalities of a complex adaptive system make the full understanding of what is missed by not pursuing a project impractical (Allen 2004, Batty 2007, De Roo et al 2012, Portugali 2012, Portugali et al. 2012). However, there is value, either societal or financial, associated with potential projects and each year or month this project is not implemented that value is lost. A new transit route to be added to the system will generate a certain degree of economic activity in the corridor, or perhaps reduce commuting times or congestion throughout the system. Accurate and holistic calculations of the added value of an expansion like this are difficult to determine but there is some degree of added value. This means that not enhancing the system or postponing the project is a lost opportunity and this opportunity or 'temporal cost' collects the longer the enhancement is put off. This is not an argument in favor of rushing the planning process of what could potentially be hugely impactful and intrusive projects. Rather, this section is meant to stress the importance of timely action and, if need be, the implementation of strategic short-term solutions to alleviate lost societal or financial value to the planning and construction of long or intermediate term solutions.

5.4 Tactical Urbanism

Tactical urbanism is a method of planning practice that has become increasingly popular in the United States in recent years (Lydon & Garcia 2015, Mould 2014). Reminiscent of core elements of adaptive planning, tactical urbanism calls for experimental strategic spatial interventions that provoke public dialogue and encourage self-organization. The phenomena can originate from either planning authorities or public activists and feature small-scale strategic pilot projects, usually in a semi-permanent manifestation, that demonstrate the possibilities of similar projects and provoke public discussion (idem). Popular examples can be empty walls suddenly depicting public art, or the spontaneous installation of bike lanes in a city devoid of bike infrastructure (Quednau 2017). The installations are not necessarily permanent, especially if they are performed by citizen activists without the permission of local authorities, but the effects of them are felt for a short time and often their removal prompts public outcry in favor of their restoration and expansion.

This style of experimental spatial intervention is important because often public opinion is not overly expressed or educated. Citizens do not always know what type of spatial intervention a certain space is missing. Not all citizens can or will attend the planning meetings on proposed installations. However, if the route they typically walk to work suddenly has a bike lane along it they may consider taking their bike to work and start to formulate opinions on the expansion of the bike network. Tactical urbanism is a method of engaging members of the public in the planning process who might not have otherwise been involved. It is also a method for planners to experiment with installations that would otherwise remain unknown and unsupported by the public. In this way, tactical urbanism actively encourages self-organization by provoking public dialogue on different planning issues.

Tactical urbanism also reflects well the temporal elements of adaptive planning. Rather than engaging in time-consuming public outreach campaigns, planners respond to an identified issue with a strategic semi-permanent intervention. The intervention is usually quickly and inexpensively implemented. If successful, the project can be expanded upon and if it is not successful it can be removed and alternatives can be pursued. The key element here is that less time is spent in preparation, planning, and public outreach. The intervention is small in its pilot phase but is proactive action as opposed to a lack of action. These strategies have been quite successful in the United States and in New York and demonstrate the potential of adaptive planning principles in the New York context. Concerns of path dependency, nonlinearity, and the cultivation of a planning environment that encourages self-organization in a complex adaptive system are core elements of adaptive planning that may be well suited to New York transportation planning in the form of tactical urbanist interventions.

The theoretical framework proposed here relies heavily on tenets of adaptive planning. While transportation planners can and should adaptively reflect on changing circumstance throughout their planning process, public transportation often requires large-scale projects that require extensive planning and public outreach programs. The construction time and cost, as well as the reliability of public transportation in the eyes of the public, demand a heightened degree of robustness which may not allow for the flexibility adaptive planning or tactical urbanism seeks. It is therefore the view of this study that tactical urbanisms and adaptive planning are best suited to remedial short-term solutions in the form of micro semi-permanent installations. These installations would be strategically designed to ease connections between parallel networks within the combined New York transportation system, increase service areas, and encourage polynucleic connectivity and development.

6. System Integration and Circumferential Expansion

The fractured networks that make up the combined transportation system of New York are a hindrance to polynucleic development and the changing functions of the complex adaptive system. Manhattan-centric path dependency splits the commuting areas of New York City into separate sections and reinforces Lower Manhattan as the universal destination. Manhattan centricity is ignorant to newly evolving commuting patterns that depict outer borough commuting or reverse peak commuting (Zupan & Barone 2015). It is pivotal for the structure of the system to reflect changes in function and while this intention is described by planning authorities in long-term plans (MTA Report 2013 & 2013a), there should be action taken to satisfy these changing functions in the short term. The integration of the systems and development of outer-borough expansions throughout New York's transit systems would accommodate these functions, encourage poly-nucleic development, and alleviate restrictions on the self-organization of commuting patterns. These could manifest as integrative interventions to ease the use of multiple transit networks within the combined system, circumferential route expansions to provide outer borough transit routes, or the further development of pedestrian and cycle spaces to both increase service areas and encourage polynucleic development. However, these changes can cost time and money unavailable to the planning authorities responsible. It is therefore important to identify strategically significant projects that can optimize the ratio between the impact on the system and construction and temporal costs while simultaneously creating an environment that supports self-organization.

6.1 The MetroCard

It can be time-consuming and expensive to integrate the structures of separate networks, but this integration is essential for the creation of an environment that supports self-organization. The overdue replacement of the Metrocard system is a timely opportunity to integrate parallel transit systems without rebuilding stations or tunnels (Flegenheimer 2013, MTA Press Release 2010, Pelletier et al 2011, Preschle 2001). The Metrocard is a magnetic strip prepay fare system for New York City Transit. Initially used to replace the New York City Subway token fare system, the Metrocard has successfully increased ridership as it expanded its purview and incorporated multiple transit networks (Duffy 2000, Riazi 2000). Rising ridership can be attributed to external factors like employment or population, but the Metrocard system has been a significant contributing factor (Yoh et. al. 2003). It serves not only as an efficiency mechanism but as a unifier between what would otherwise be separate transportation systems.

The expansion of the Metrocard to the New York City bus system and the introduction of free transfers between subway and bus reversed declining bus ridership figures in the 1990's and led to annual double-digit gains, resulting in substantial reinvestment into the bus system (Duffy 2000). Without redesigning stations or routes, the MTA was able to make two separate transit systems complimentary and enhance both. The MetroCard subway and bus free transfers of 1997 and the resulting surge in ridership are credited with the pivot from downscaling the NYC bus system by 25% to expanding the fleet by 900 buses (Duffy 2000). The automation of the transit fare system and the marketing and sale strategies for the automation are also credited with the continued increases in transit ridership which is currently at its highest since the mid 20th century (Riazi 2000). Over its lifespan, the Metrocard has been expanded to incorporate parallel systems like the Roosevelt Island Skytram, the JFK Airport Airtrain, and the PATH. A unified ticketing service allowed passengers to more freely maneuver the otherwise separate transit systems of the city.

Since the introduction of the MetroCard, technological ability has increased and there are obvious advancements that could make the system more efficient (Flegenheimer 2013, MTA Press Release 2010, Pelletier et al 2011, Preschle 2001). These upgrades are an opportunity to expand the integrated system, eliminate needless impediments to self-organization, and allow planners to develop innovative ticketing deals in response to changing functions. The magnetic strip Metrocard is out of date and smart turnstiles capable of reading QR codes, smart cards, or bank cards will be the next generation once the MetroCards are phased out (Preschel 2001). A common standard among the fragmented transit authorities would make agreements on free transfers or common ticketing services a possibility and experimentation with these services much easier. Smart cards are fast becoming the standard in transit fares. Their efficiency and detailed transit data make them a favorite among transit planners (Pelletier et al 2011). The transit data these cards collect would behoove transportation planners and their ability to map changing functions and respond to them. This is key for the adaptability of transportation planning in New York. Current data collection shows the number of passengers moving through turnstiles at each station. Smart turnstiles could inform transit planners of each passenger origin and destination. This would drastically improve the ability of transit planners to observe changing commuting patterns in real time and planners ability to respond to these changes in function. For New York, a common transit card could also serve as a unifier for the fragmented transportation networks into the combined system this study is describing.

A pilot program for this transit card was initiated in 2010 on select lines and described a potential for free transfers across the MTA, NJT, and PATH lines (MTA Press Release 2010). However, the project stalled and while the transit authorities of NJT and the PATH have continued implementing smart turnstiles, there have been no new announcements on a unified ticketing service. The MTA has announced intentions to modernize stations with smart turnstiles among other services. Smart turnstiles will begin operation on select NYC buses and subways in 2018 with a progressive expansion of the system in the following years. The MTA is also releasing a regional rail mobile ticketing app with intentions to integrate separate MTA subsidiaries, allowing commuters to pay for regional rail, subways, and busses with a common account (MTA Press Release 2016). However, since the pilot in 2010, there has been no news on integration with PATH and NJT ticketing services.

The replacement of the Metrocard with smart turnstiles is progressing incrementally across the metropolitan transit authorities. With smart turnstiles uniform across the system, it would be quite feasible to introduce innovative ticketing options that would allow passengers to use what is now several separate systems as one unified system. The smart turnstiles would collect transit data allowing transit planners to view changes in function in real time and use this data to adapt to changing functions and experiment with ticketing options unique to particular circumstance. The integration of these fragmented transit networks into a unified system with a common ticketing service would allow planners to more easily experiment and track changing functions.

6.2 Circumferential Expansion Projects

Circumferential expansion projects, or outer borough links, like the proposed Brooklyn Queens Connector (BQX) or Triboro line, are important initiatives in combating Manhattan-centric path dependency. These projects would expand service into underserved communities, alleviate congestion on an overburdened system, all while addressing the growing gap between changing functions and the structure of the transit system (HDR 2016, Zupan & Barone 2015). However, expansion

Figure 9: Map of the Proposed BQX with Relation to the Subway Network. Source: Friends of the BQX 2017.

projects can be expensive and time-consuming. It is important to weigh financial and especially temporal costs when considering potential projects, as the issues caused by Manhattan-centric path dependency are time sensitive. Additionally, there is a tremendous value associated with expansion projects, both financial and societal, and the longer these projects are delayed for whatever reason, the greater the opportunity cost (5.3). Planning is a temporal field and the issues facing New York transit, like chronic congestion, delays, and the costs to the economy induced by failures in the system, are pressing concerns.

Origin and Destination	Current Travel Time (min)	BQX Travel Time (min)	Time Saved Per Ride (min)
Hallets Point to Midtown	55	37	18
Astoria to Williamsburg	61	26	35
Queensbridge to Navy Yard	59	27	32
Long Island City to DUMBO	48	33	15
Downtown Brooklyn to Williamsburg	40	26	14
DUMBO to Williamsburg	55	21	34

Figure 10: Estimated Time Saved Along Common Outer Borough Routes. Source: Friends of the BQX 2017.

The Brooklyn Queens Connector (BQX) is a proposed streetcar with a circumferential route through the outer boroughs that could prove to be a comparatively inexpensive and time efficient rail project. The streetcar would run on tracks built into the road and feature traffic priority and either a separate lane or flow with traffic depending on the situation. This route is still a matter of debate but would run along the East River from Redhook, Brooklyn to Astoria, Queens. The BQX would have average speeds five times higher than a comparable bus route (HDR 2016, New York CIty Department of Transportation 2016). The project has been endorsed and even championed by Mayor de Blasio. He claims the route will be designed to connect neighborhoods neglected by the transit system and, as a result, underdeveloped (Mayor De Blasio 2016). The project would actively combat the Manhattan-centric paradigm of New York public transit and substantially cut outer borough commute times (Friends of the BQX 2017). The BQX will increase the connectivity of the wider system by connecting to 10 ferry landings, 30 different bus routes, 15 different subway lines, 6 different LIRR lines, and up to 116 different Citi Bike stations (Friend of the BQX 2017, HDR 2016). The exact route has not been decided and the proximity of these connections is not certain. The BQX fare will be pegged to a single ride Metrocard fare (Mayor de Blasio 2016). This is an important point because the success of the route will depend on how well the BQX is integrated with the wider transit system and a common fare system like the Metrocard, or its replacement, is an essential aspect of that integration (Duffy 2000). Most recently the project has come under scrutiny as the impact assessments continue to describe costs higher than initially estimated. In particular, the cost of moving preexisting infrastructure is sighted as the single highest cost (HDR 2016). Utility lines needing to be moved or deepened could raise the cost of construction considerably. It is easy to condemn the project for its price tag because that is a hard number, but little attention is given to the costs of not implementing the project because those are much more difficult to monetize. The economic benefits resulting from the BQX are estimated to be 25 billion over thirty years, compared to the 2.5 billion it would cost to construct (HDR 2016, Office of the Mayor 2016). This is not considering the alleviation to congestion it could provide to the rest of the transportation system.

The BQX is a major change in structure specifically proposed to combat the Manhattan-centric orientation of the transit system (New York City Economic Development Corp. 2016). If considered as a tactical urban experiment, all be it an extreme and permanent one, the BQX could encourage the future development of similar circumferential expansions. The temporal and financial costs of the BQX are dwarfed by the Second Avenue subway project, especially when one considers the compared lengths of the projects. The BQX supports the polynucleic development of CBDs as opposed to entrenching Manhattan centricity and if transportation planners were reflecting on the changing functions of the transit network, perhaps the BQX would have been pursued as opposed to the Second Avenue Subway.

A similarly circumferential rail project is the Triboro line proposed by the Regional Plan Association (Zupan & Barone 2015). A plan devised specifically to combat the failings of the Manhattan-centric public transit system, the Triboro repurposes existing but underused railroads and bridges to create a circumferential route for New York City. The twenty-four-mile route running from Bay Ridge, Brooklyn to Co-op City in the Bronx would intersect with seventeen subway lines and four commuter rail lines and create twenty-four new stations. The project would drastically reduce commuting time between the outer boroughs and reduce congestion in the Manhattan subway lines (Zupan & Barone 2015). The Triboro is designed to service underserved communities in the outer borough but would also be a response to the shifting functions of New York commuters (MTA Report 2013, MTA Report 2013a). Perhaps most importantly, the Triboro uses existing infrastructure and no new bridges or transit corridors would need to be created to accommodate the project which would reduce both the cost and impact of the project.

Figure 11: The Proposed Triboro Line. Source: Zupan & Barone 2017.

There are two essential differences between projects like the Triboro and the BQX when compared to the expansion projects like the Second Avenue subway. The first is that they are significantly cheaper and faster to implement (HDR 2016, Second Avenue Subway…2014, Zupan & Barone 2015). The second is that they address the shifting functions of the transit system instead of entrenching an outdated Manhattan-centric paradigm (MTA Report 2013, MTA Report 2013a, Zupan & Barone 2015). Transportation planning is not an atemporal enterprise. It is not satisfactory to acknowledge the changing functions of the system and continue business as usual. The changing functions should influence current plans, not be a side note in the twenty or forty year plans (MTA Reports, 2013 & 2013a). While faster and cheaper, the Triboro and BQX are still long-term solutions to current problems. At the moment there are no bus routes that accommodate the circumferential route of the BQX (NYCDOT 2016), but the RPA proposes investment into the MTA bus system and the reorganization of bus routes as a mid-term solution (Zupan & Barone 2015). The enhancements proposed by the RPA could be paid for by increasing the MTA budget by 1% and the new routes would be modeled after survey data collected from user requested routes. Adaptive reflection on changing functions can be difficult with inherently robust infrastructure projects like rail lines, but the use of bus services to accommodate increasing outer-borough commutes as a short and mid-term solution could mitigate the growing gap between increasingly non-Manhattan centric function and Manhattan-centric structure.

6.3 Parallel Bus Systems

The bus network serves as a good opportunity for the combined transportation system to adapt to changing functions in the short and mid-term through experimental changes in service options and routes. They serve as an adaptive medium to experiment outside of the Manhattan-centric path dependency limiting adequate response to changing functions in the system (Lydon & Garcia 2015, Mould 2014, Zupan & Barone 2015). The MTA and NJT operate bus services within their own service areas as well as commuter routes into NYC. While the highway system demonstrates Manhattan-centric path dependency, surface streets, on which many buses run, do not. Despite this ability to alter routes to suit the shifting functions of commuters, bus routes still tend to run radially (New York City Department of Transportation 2016, Zupan & Barone 2015). Unlike commuter or inner-city rail networks, the adaptation of bus service to changes in mobility patterns does not require the same degree of planning and infrastructure investment. Busses are frequently used as shuttle service to compensate for construction and closures in the subway system(New York City Department of Transportation 2016). While the bus networks should still demonstrate a degree of robustness in reliability and predictability, they offer much more flexibility than the rail networks.

There are qualms over the long-term efficiency of buses over rail, for sustainability and speed purposes (New York City Department of Transportation 2016). However, the speed with which the bus system can adapt to changing mobility patterns and the costs saved not constructing new lines make them an ideal medium for adaptability and experimentation purposes (Zupan & Barone 2015). Using the bus system to satisfy increasingly circumferential commuting patterns in the short term could also reverse their stagnant or falling ridership numbers (New York City Department of Transportation 2016). Newly proposed rail lines take time to plan and construct. There must be changes to the system's structure in the short term to satisfy changes in function in order to prevent unnecessary and potentially costly congestion and longer commuting times (Payne et al 1996, Webster 2010).

6.4 CITI Bike Share

We have discussed the combined transportation system of New York as being more than road and rail but as being the sidewalks, public spaces, all the connections between parallel networks, and in this case the bike infrastructure. Bike infrastructure allows for and encourages a growing mode of transportation in New York and one that is relatively underdeveloped, meaning there is substantial opportunity for the methods of adaptive planning and tactical urbanism in the growing bike network. There are significant advantages to capitalizing on and encouraging the increasing popularity of bikes as a mode of transportation in New York and the new bike network is a prime opportunity to implement the methods of tactical urbanism (Lydon & Garcia 2015, Mould 2014, New York City Department of Transportation 2017). The CITI bike share is a privately owned public bike share system formally launched in 2013. Since then it has become more popular than initially expected and management has had a hard time balancing operating costs with system expansions and the demand of ridership (Bike Share Outreach Report 2013). The system is made up of 605 stations as of May 2017 (Citi Bike Monthly Operating Report 2017). These stations are filled with an average daily fleet of just over 9.1 thousand bikes. The system is also Manhattan-centric with a substantial spatial concentrated in Manhattan (Bike Share Outreach Report 2013, Gordon-Koven & Levenson 2014). There is significant demand and plans to expand to select neighborhoods in New Jersey and the outer boroughs of New York City. While the Citi Bike Share is privately owned, it's success depends upon the prevalence of suitable bike network infrastructure (Gordon-Koven & Levenson 2014). This infrastructure is also in higher demand due to the success and expansion of the Citi Bike Share and the two will hopefully continue to contribute to one another in a positive feedback loop.

The structure and function of the bike system react to one another and co-evolve. Changes to the system's structure allow for different functions, and changes in function inspire changes to structure as this new system develops. The more bike riders there is the more demand there is for safe and expansive bike infrastructure. The safer and more expansive the bike network is, the more appealing a transit choice it is and the more riders there will be. The bike network is a relatively new and emerging transit system in New York. Biking is gaining public support and is an ideal opportunity for experimentation on the part of New York City transit planners (Gordon-Koven & Levenson 2014, Lydon & Garcia 2015, Mould 2014, New York City Department of Transportation 2017, Bike Share Outreach Report 2013). First, aspects of the system's structure will be described before the intricacies of its function are explored. Finally, an analysis will be given of current examples of planning experimentation resulting from this co-evolution and the potential of this methodology for projects in the future development of the bike network.

The Citi bike share is one of the largest bike share systems in the country and stands out as the most densely designed and the best connected to mass transit. With nearly twenty stations per square mile, Citi Bike is far denser in station placement than comparable bike networks in Chicago or Washington DC (4.4 and 6.8 respectively) (Gordon-Koven and Levenson 2014). This concentration is largely limited to Manhattan. A year after operations began, 72% of Citi Bike stations were within a quarter mile of a subway station and the bike share system encouraged multimodal commutes and expanded the service areas of the subway stations it served, yet remained largely in Manhattan (Gordon-Koven and Levenson 2014). This was in 2014 and the number of Citi Bike stations has doubled since (Citi Bike Monthly Operating Report 2017). So far the planning process for Citi Bike station locations has reflected the 'fuzzy middle' using both communicative and technical planning methods depending on the situation (De Roo et al 2012). Online surveys were conducted to collect suggested locations from local residents and these sites were then narrowed using technical criteria (Bike Share Outreach Report 2013). Planners should perpetually revise these locations in light of changing functions and the changes induced by internal and external factors, particularly the issues resulting from the Manhattan-centric structure of the transportation system.

The majority of bike lanes in New York are described as class II and III or standard and curbside lanes, respectively (New York City Department of Transportation 2017). Class II or standard bike lanes are a painted lane between the traffic and parking lanes. Class III or curbside lanes are painted alongside the curb of a road with no parking. Both lanes are separated from the traffic lane by white lines painted on the pavement. Class I, or protected bike lanes, are separated from traffic by a physical partition (Herman 1993). In New York, class I bike lanes are becoming popular and the safety benefits of them are becoming apparent (New York City Department of Transportation 2017). Most class I bike lanes are largely removed from the system. Many of New York's class I bike lanes are in parks and do not follow roads. They run through greenways and connect neighborhoods but are not integrated with the road network. The issue with this is that these routes are also frequented by pedestrians and their popularity among both cyclists and pedestrians has caused congestion issues (New York City Department of Transportation 2017). As cycling becomes more popular, issues regarding the integration with parallel transit networks and the specifics of cyclists right of way will be essential for its continued success and the practices and experimentation of tactical urbanism could encourage the expansion and integration of the bike network. In New York and other American cities, tactical urbanism has successfully encouraged the development of bike networks by using semi-permanent partitions or barriers to separate bike lanes from both pedestrian and automobile traffic (NYCDOT 2017, Quednau 2017, Ullman 2012). The safer and more expansive the bike network becomes the more desirable a transit choice bikes will be.

At the moment, bike lanes along roads are largely Class II and III and the lack of a partition raises safety concerns (New York City Department of Transportation 2017). Risks of automobiles passing on the left and car doors opening on the right give cyclists a very small lane of safety. Added to this, the frequent practice of double parking directly conflicts with space that has been denoted for cyclists by the white outline. These obstructions can force a cyclist out of their delineated lane and increase the risks of injury. Despite these risks, the functions of the shared road network have begun to shift with increased presence and awareness of cyclists on the roads. Transportation planners should remain keenly aware of these shifting focuses as they redesign roads and encourage increased usage and expansion of the bike network.

The popularity of automobiles is decreasing and the trend is expected to continue (Polzin et. al 2014, Rosenthal 2013). Changes to system structure do not need to be strictly in response to changes in function but can also prompt or encourage changes in function. Structure and function co-evolve (De Roo et al 2012). The methods of tactical urbanism have been particularly successful in the development of new bike networks and the encouragement of biking as a transit choice (NYCDOT 2017, Quednau 2017). There was a significant initiative to introduce a bike network to New York around the turn of the century and it successfully decreased risk and increased ridership (NYC DOT 2017). Tactical urbanist efforts to suddenly create a bike network have successfully encouraged regular biking in other cities in the United States despite a previous absence of any bike infrastructure or cyclists (Quednau 2017). Bike infrastructure installations could be avidly pursued in the outer boroughs and satisfy the changing functions of the transit system with minimal construction time and cost (MTA Report 2013, MTA Report 2013a). Additionally, the streets in the outer boroughs are wider and less congested making the implementation of additional infrastructure less obstructive (NYCDOT 2015). With more job and population growth in the outer boroughs and more trips being taken within boroughs as opposed to the traditional Manhattan-centric transit paradigm, enhancements to transit should be focused there (Zupan & Barone 2015). Expanding the bike network in the outer boroughs would serve as an additional mode of travel, expand the service areas of existing outer borough links, and reduce congestion in Manhattan. Lower density and wider streets in the outer boroughs means the integration of more class I bike lanes is more feasible in the outer boroughs, and a focus on class I over class II or III lanes would make the bike network safer and a more desirable mode of travel (New York City Department of Transportation 2015, Zupan & Barone 2015). Expanding the service areas of subway and bus stations, connecting disconnected neighborhoods, and timing the rollout of complimentary bike infrastructure to complement the growing Citi Bike network are all examples of installations that could be first initiated as semi-permanent strategical experiments (Lydon & Garcia 2015, Mould 2014). This uses the methods of tactical urbanism but would also create an environment which not only encourages bike use but facilitates public debate and reflection on the place of bikes in the combined transit system and the structure of streets and public space.

6.5 Public and Pedestrian Space

Public transportation is frequently associated with rail or bus networks but it is not limited to large infrastructure investment. This is key because rail and bus represent aspects of the combined transportation system that are and should remain relatively robust. However, there is an opportunity for flexibility and adaptability in the combined transportation system of New York and the key avenues for this adaptability is in bike and pedestrian networks. The pedestrian transportation network is perhaps the perfect example of the most public transportation network. Free to use and open to everyone, the pedestrian network is quite popular, particularly in the more densely developed areas of New York (New York City Department of Transportation 2015). Experimentation in the interest of pedestrian and bike traffic can be a powerful tool in encouraging favorable changes in desired function and structure (Lydon & Garcia 2015, Mould 2014), because planning is a temporal field and the conditions in which one plans are never constant (De Roo et al 2012). Planners should take these changing conditions into consideration when experimenting with and developing plans for public or pedestrian space, shared space, and traffic calming installations.

Experiments in New York like the Broadway Boulevard or Summer Streets are an important tool for New York transportation planners and exemplify core elements of adaptive planning and tactical urbanism (De Roo et al 2012, Lydon & Garcia 2015, Mayor de Blasio 2016b, Mould 2014, Ullman 2012). They are semi-permanent experiments allowing planners to observe the effects of changes to the system and the experiments take into account the temporal aspects of the context in which they occur (Lydon & Garcia 2015, Mould 2014). Summer Streets converts substantial sections of roads in Manhattan to public space on certain Saturdays during summer months. The roads are blocked at key entrances by removable barriers and reserved for bikers and pedestrians and used as outdoor eating and shopping space (Mayor de Blasio 2016b). This program capitalizes on the changing functions of the city within a calendar year and even within the week. Peak leisure days during months when pedestrian and bike traffic is at its highest points is the optimal time to alleviate additional space for those modes of transit, while these functions diminish in winter months and even on other days of the week.

The experimental program was introduced under Mayor Bloomberg in 2008 and has returned each summer and been expanded upon. Mayor de Blasio has kept the program and enhanced it, adding to it a program called Shared Streets in which all roads in Manhattan south of the Brooklyn Bridge have their speed limits reduced to 5 mph during one of the Summer Streets Saturdays and the roads in the allotted area are converted into shared space (Mayor de Blasio 2016b). Empirical numbers on the success of the program are difficult to quantify, but the success of such an experiment is demonstrated through its expansion and growing acceptance (Lydon & Garcia 2015, Mould 2014).

Paralleled to these initiatives is the Weekend Walks program that encourages communities to apply and suggest local traffic routes to be closed for trial periods in an experimental fashion. During the closure, outdoor cultural activities are organized and outdoor dining and pedestrian or bike traffic is encouraged (Mayor de Blasio 2016b). Similar to the previously mentioned Summer Streets and Shared Streets, these programs are examples of the experimental semi-permanent changes to system structure. The impacts of the intervention are observed and spark public dialogue. Should the changes be desirable, these programs can progress and expand with minimal temporal and financial costs (Lydon & Garcia 2015, Mould 2014). In this way, these methods of spatial intervention cultivate an environment that encourages self-organization.

Unfortunately, even these initiatives feature a Manhattan-centric paradigm. Summer Streets and Shared Streets are in lower Manhattan where the worst congestion is already present. These programs could be used to cultivate and encourage the polynucleic development of CBDs in the outer boroughs. They could lead to the development of boulevards that connect growing neighborhoods outside of Manhattan and encourage desirable functions. This may even be more feasible due to the relative lack of congestion and wider roads in the outer boroughs compared to the dense, narrow, and busy streets of Manhattan (New York Department of Transportation 2015). This would require a paradigm shift in New York transportation planning and a reevaluation of priorities.

The Broadway Boulevard was a project that sought to redesign a major road cutting diagonally across Manhattan's iconic street grid (Sadik-Kahn 2008, Ullman 2012). The redesign was intended to favor pedestrians, cyclists, and public space at the cost of automobile convenience. The site was selected due to the dangerous levels of pedestrian and automobile congestion through the corridor. The intervention was first realized in 2008 with semi-permanent installations to first observe the impacts the change in structure would have on the function of the space. After the impacts were better understood the project was realized in a more permanent manner (Sadik-Kahn 2008, Ullman 2012). The experimental change in structure demonstrated what could be possible permanently if the changes were seen favorably and had favorable impacts (Lydon & Garcia 2015, Mould 2014). The experiment generated public support and started a dialogue about potential boulevards for pedestrians and cyclists throughout the city. This too had a Manhattan-centric paradigm and hopefully, in the future, these experimental installations appear outside of that paradigm and encourage polynucleic development and outer borough connectivity.

These experiments account for the complexity of the city and test the cities reactions before committing to a permanent intervention but still demonstrate a Manhattan-centric mindset detached from the changing realities of the systems function. An important element of experimental semi-permanent spatial installations is that they are situationally designed to meet their contexts and that they are modified based on the lessons learned from their previous installations (Lydon & Garcia 2015, Mould 2014). Some streets might be best suited for periodic public space like the summer streets or the weekend walks program. Others can be seasonal or permanent traffic calming installations like curb extensions or raised crosswalks. Coordinating these installations with other projects like utility maintenance can cut costs and minimize construction obstruction, but spatial issues should not be neglected and allowed to fester. Opportunities like this should be seized within reason but should not be the only times experimental spatial installations are pursued. These experimental spatial installations can be achieved in cost-effective and semi-permanent ways to cut costs, while also affording the planner the opportunity to observe the changes they bring to both structure and function and learn from this for their more permanent upgrades or other installations in similar contexts (Lydon & Garcia 2015, Mould 2014).

These experiments share certain key aspects that are representative of adaptive planning (De Roo et al 2012, Rauws 2017). They are semi-permanent experiments reflective of temporal changes. The changes to the physical infrastructure are limited, meaning lower financial costs and faster construction. They are reversible in case of changing contexts limiting the path dependency they force on the system (Liebowitz & Margolis1995). These experiments embrace the uncertainty of the complex adaptive system and demonstrate bottom-up self-organization as well as experimental installation (Lydon & Garcia 2015, Mould 2014, Rauws 2017). These successes speak to the potential for adaptability in the otherwise robust and inflexible combined transportation system. The bike or pedestrian aspects of the combined transportation system are a relatively inexpensive method, both financially and temporally, for New York transportation planners to address the growing gap between Manhattan-centric path dependency and developing trends like polynucleic development and circumferential commuting patterns. (Zupan & Barone 2015).

7. Outreach and Feedback

This study sees an oppritunity to increase the success of both strategic micro instillations and the public dialoge they may provoke and suggests the creation of a common planning app to service planners and citizens across the combined transportation system by collecting and dissiminating information. Adaptive planning calls for the cultivation of an urban environment in which self-organization occurs through the unfettered coevolution of structure and function (De Roo et al 2012, Rauws 2017). Tactical urbanism facilitates this by sparking public debate and reflection through spontaneous strategic physical intervention (Lydon & Garcia 2015, Mould 2014). The discussion of the public realm does not occur in a vacuum but in a forum, or in several different forums. This could be in town halls or planning board meetings. Neighbors or friends could discuss installations with one another or file a complaint with one of the many planning agencies. For a public debate to occur optimally it is important not only for the citizens to be informed but for a planner to receive this feedback.

When planning for the complex adaptive system of New York transportation, it is important to hear suggestions and feedback from citizens as well as monitor changes in function caused by internal and external causalities and revise plans in light of those changes. It is impossibile to collect all the information a planner needs to completely understand the combined transportation system. Change occurs nonlinearly and perpetually at an inconsistent rate. To best operate in the public's interest, a planner should be as informed as possible. Consistent and irregular change across the combined transportation system may call for a streamlined information gathering and disiminating tool to increase the success of the proposed strategic micro instillations and the public dialouge they may provoke.

Modern technology has made methods of collecting technical and intersubjective information from the public more efficient and far-reaching. The prevalence of smartphones with GPS technology makes the collection of spatial data from numerous autonomous actors viable. Attendance numbers of public forums are shattered by the participation numbers of planning apps that collect suggestions and grievances at any time across any distance (Bike Share Outreach Report 2013). This is not to say public forums are not an important aspect of planning outreach, but by coupling these more traditional methods with modern strategies, planners can appeal to more people across more demographics and widen the net with which they collect their feedback, grievances, and suggestions.

An example of something similar to what has been described is the Department of Transportation outreach program on the expansion of the Citi Bike Share (Bike Share Outreach Report 2013). For two years the DOT performed 159 public meetings or presentations of various forms as well as 230 meetings with pertinent stakeholders like elected officials or property owners. Additionally, an interactive mapping website was created to collect suggestions on possible bike share stations. 10,000 unique suggestions were generated by the public and an additional 55,000 supports or 'likes' were filed on those suggestions (Bike Share Outreach Report 2013). Tools like this are relatively inexpensive methods of dramatically expanding the coverage of outreach efforts.
This type of outreach is prevalent in modern New York planning but is largely project specific and fragmented across the transportation networks. The website described earlier is specifically for the suggestions of bike share stations. However, there are numerous aspects of the transportation systems that can best be brought to the attention of New York planners through similar methods and does not relate to a particular project.

Feedback can be sent to planners but the fragmentation of transportation governance means there is no common feedback mechanism for the combined transportation system. Making a single unified 'planning app' that provides information about projects, construction, obstructions, delays, and potential pilots would be a major step forward in combating the fragmentation Manhattan centricity has caused. This app could also serve as the aforementioned forum in which public debate guided by transit planners could reflect on the strategic micro installations throughout the city. This public dialogue, streamlined through a common venue, would support and facilitate the self-organization of the combined transportation system. A common venue to suggest planning interventions, support already suggested interventions, file complaints, and report issues would help planners and citizens to begin thinking of New York transit as a common system that reaches across the metropolitan area. Instead of project specific apps and websites, there could be a pre-existing and familiar forum that would be regularly updated (idem). Instead of discovering the new app or website for each project, citizens would know where to go to learn about current or upcoming projects, give feedback, or make a suggestion. With the functions of the city constantly changing at an unknown and inconsistent pace, and nonlinear change resulting in unexpected results planners might not be looking for, it could be tremendously helpful for planners to have a regular and reliable forum where these constant nonlinearly changing functions could be expressed. This information gathered would make desired action clearer but would still require actions to be taken. The forum could serve as a useful tool but the tool would not solve issues alone and would demand active participation by citizens as well as the responsive actions of transportation planners.

Public forums can be time consuming to organize and not all members of the community are willing or able to attend and their insights may go unheard. Additionally, residents do not always know what is possible or how particular interventions can influence the structure of the system. The 'planning app' could serve as a useful method of educating concerned citizens to successful installations elsewhere and encourage autonomous self-organization and development. This unified online forum would serve both as a mechanism for public education and for receiving suggestions and criticisms from the public. By collecting information on changes in system function in real time, planners can better respond to unforseen changes. A single unified planning application for the metropolitan area would be a worthy investment and enhance the co-evolution of structure and function; allowing information to be gathered from the public in real time across the metropolitan area and this information could then be shared across all agencies responsible for the planning of the transportation system.

Examples of curb extensions, public furniture, bike parking, or traffic calming installations are only some of many semi-permanent micro planning installations that could collectively shrink the growing gap between the Manhattan-centric structure and polynucleic functions of the combined transportation system (New York Department of Transportation 2015, Zupan & Barone 2015). Projects like this might not be at the forefront of a planners list of priorities but could be easily implemented if the public support of local residents was more easily made aware of (Lydon & Garcia 2015, Mould 2014). It is important that these installations be semi-permanent to avoid unforeseen path dependency (Liebowitz & Margolis 1995). It is also important to streamline public outreach to know where these installations are most wanted and where they will be most useful (Lydon & Garcia 2015, Mould 2014). Local residents can provide unique insights. They live in the neighborhood and experience that particular environment more often than any city planner. These suggestions can then be cross-referenced with technical considerations and strategically implemented. In mass, these micro installations can be implemented quickly and efficiently to serve as integrators of parallel transportation networks. Strategic micro installations can encourage desirable trends like polynucleic development in lieu of mega projects like subway expansions. A planning app for the combined transportation system could be an inexpensive tool to increase the success of these micro instillations and facilitate the public dialogue they are meant to insight.

8. Conclusion

The issues of Manhattan-centric transportation structure and increasingly unconventional non-Manhattan-centric functions is well documented (Zupan & Barone 2015). The proposed solutions to this growing gap between structure and function, like the BQX, Triboro line, or reinvestment and revaluation of the bus network, are all mid to long-term solutions (idem). While mid and long-term solutions should be pursued, the potential costs of delayed intervention encourage short-term solutions that will build towards and compliment circumferential transit expansions. These short-term solutions are inspired by the successes of tactical urbanism, particularly in semi-permanent strategic micro installations in the bike and pedestrian networks. There are two elements identified to encourage the success of these semi-permanent strategic micro installations. One from the technical side is already in the process of being implemented. The outdated MetroCard system is in the process of being replaced with smart turnstiles in New York City subways and buses. Smart turnstiles are also being implemented throughout NJT and the PATH. These turnstiles will offer New York transportation planners much more detailed information on commuting patterns and the changing functions of the system in real time [6.1]. Coupled with these enhanced technical insights, this study sees an opportunity for the consolidation of existing, or the creation of a new online forum for the combined New York transportation system [7]. This forum, or app, would serve as a venue for citizens and planners to communicate and share information. Citizens would be able to share support or grievances regarding the combined transportation system; particularly these strategic micro installations, but there is no need for the app to be limited to only these installations. Additionally, planners would have a venue in which to declare to the public the significances of these installations; why they are particularly important or impossible in certain places.

Advancements in technical and intersubjective information gathering are important when planners observe the combined transportation system as a complex adaptive system. With the system undergoing perpetual and irregular change, the expedience of reliable information gathering is important so that planners are informed with a closer idea of what is instead of what was. Smart card turnstiles and a planning app for public debate would provide real-time updates to planners on the changes in the combined transportation system. This information can then be used by transportation planners to guide the development of the combined transportation system and cultivate the self-organization of that system. This study identifies the use of strategic micro installations in the more flexible pedestrian and bike networks as a relatively underused method for planners to cultivate that self-organization and shrink the gap between Manhattan-centric structure and increasingly non-Manhattan-centric functions. Long-term and mid-term plans for circumferential transit routes are in development but there are opportunities to begin implementing short-term solutions. There are several options for pedestrian or bike-friendly infrastructure that would increase the livability of neighborhoods and support circumferential elements of the combined system. Transportation planners are well aware of these ideas but to implement them in mass these installations would need widespread public support and participation.

The self-organizing environment planners may consider cultivating is one in which public dialogue on potential enhancements to the pedestrian and bike networks is ongoing and leads to consideration, suggestion, and support for these interventions. This study suggests the use of tactical urbanism on the part of transportation planners to spark public discussion on the variety of potential installations. Tactical urbanist interventions can be designed to be semi-permanent to incorporate a degree of flexibility and experimentation in the combined transportation system. Semi-permanent micro installations can be quickly installed and decommissioned if there are unforeseen changes that make these installations unfavorable. The rail network is not particularly flexible, nor is there convincing evidence that it should be. But the rail network does not exclusively comprise the transportation system. In the view of this study, the transportation system is all modes a commuter might use on their way to work. The pedestrian and bike networks contribute to the combined transportation system and these networks are more flexible and suited to strategic and experimental interventions.

9. Reflections

Manhattan centricity is a well documented spatial issue of the New York transportation networks. This study sees strategic experimentation in the pedestrian and bike networks as an underutilized method for combating Manhattan centricity. However, Manhattan-centric structure and increasingly non-Manhattan-centric functions are so interrelated with such a variety of separate phenomena it is difficult to discuss holistically. As mentioned, the combined transportation system of New York is sprawling and in constant change. There are a number of contributing factors not adequately discussed in this work. Geographic constraints and economic priorities supporting Manhattan centricity are countering forces to potential solutions in addressing the growing gap between structure and function. The fragmentation of transportation authorities was touched upon in this study but deserves additional research. The viability and practicality integration between fragmented entities is questionable. This study resigns to advocate for collaboration between transportation authorities regarding strategic micro installations of bike and pedestrian networks in the outer boroughs. However, the success of this without incentives or mandates is questionable. This study proposes possible solutions to address the growing gap between structure and function and cultivate self-organization. But the success of these strategies depends on the ability of planning authorities to collaborate and coordinate their actions. The cultivation of self-organization also depends on how these actions are responded to by the public. There is no guarantee the intentions of citizens will be seen as favorable by planners or if the use of strategic micro installations will provoke a self-organizing response from the public. Any forum is only as just, honest, and fair as those who use it. The planning app is suggested by this study because it is seen as improving upon existing outreach methods and consolidating them into a single easily accessed location. But depending on who actually uses the app regularly, it could be a hugely beneficial and educating tool for transportation planners and citizens or it could be a less than accurate representation of public interest. This study proposes strategic micro installations and tools to increase the success of those installations, but their success depends on how they are implemented and responded to. In the view of this study, incremental experimentation and better information gathering will increase the successful development of the bike and pedestrian networks and those will contribute to the flexibility of the combined transportation network. But this combined transportation network is a complex adaptive system which is open to unforeseen externalities and features nonlinear reactions. The effects of these strategic micro installations are uncertain and that is why it is important they be pursued incrementally and in perpetual consideration of new information. These plans must regularly reflect new information and that is why it is important to collect that information accurately and in real time.

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