Highway Cycloplex: Re-appropriating Spaces of Highway Infrastructure for Transit

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A freeway interchange plays a much more significant role in a city than simply permitting the movement of automobiles from one direction to another. As they carve their way through urban centers, interchanges divide communities from one another and create lasting boundaries between neighborhoods. However, in their wake, they create an entirely new set of spaces, nestled in the concrete framework that gives these structures their identity. This thesis re-appropriates these spaces, and posits their role in urban mending.

The configuration of interchanges creates extraordinary moments of volumetric opportunity. The spaces are serendipitous byproducts caught in between the composition of ramps, overpasses, and underpasses; designed not for human occupation, but rather for vehicular expediency. The radius and the tilt of the turning road, the slope of ramps, and the height at which the overpasses take are all pre-prescribed to mediate traffic. The abundance of existing structure and available space makes interchanges a prime candidate for architectural intervention. Their soaring heights create the framework for an entirely new type of occupation; connecting the ground plane and pulling it up into the air. These previously unreachable places form a new understanding of movement, speed, and perception.

The thesis is situated at the Interstate 93–US Route 1 interchange immediately northwest of the Leonard P. Zakim bridge in Boston, MA. It seeks to function as a research prototype for infrastructural adaptation around the world.

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The Elevated Crossroad

In 1916, civil engineer Arthur Hale, was first to patent the idea of a road interchange in the United States. Initially known as a “Street Crossing”, Hale addresses the rise of automobile use and its need for efficient road configuration and traffic control. In his patent, he writes:

“This invention relates to street crossings and has for its object to provide a construction suitable for congested crossings which will render it unnecessary for traffic going in either direction on one street to ever cross at grade the traffic going in either direction on the other street; or even to cross its own street at grade when it wishes to reverse its direction of travel.”
Hale’s street crossing design focused on the cloverleaf interchange. This system consists of a two-level, four way cross street, in which changing directions or turning left require all right hand exits. This is created by a 4 looped effect illustrated in Hale’s drawings [fig. 3]. This system is one of many types of interchanges found around the world. Each are unique to its site and are developed under other factors such as safety, cost, environment, and politics.

Highway interchanges can have an allure to drivers perhaps due to the contrast from the typical driving experience. Drivers are directed through all dimensions of space when they interact with the interchange, rather than on a single plane, as encountered on surface roads. An important relationship of the interchange configuration against the driver’s experience and perception of the system. In spite of the varied, multi-dimensional way in which drivers navigate space by way of an interchange, drivers perceive the interchange in a “straight forward” kind of experience. They are unaware of the whole complexity of its structure. But more importantly, this means drivers are less distracted from the road which also provides a safer experience.

Other factors that make interchanges interesting is the actual design of these massive concrete structures. Though they are engineered for functional purposes, they can possess great aesthetic qualities as they visually exists as an elegant and weightless piece floating above ground. Even more so, the form, volume, and function are all designed through engineering and the movement of mobility. But with such a scripted form, there lies a mysterious element in which they possess which ought to be explored. We begin to see a good disconnect between the complexities of the interchange infrastructure versus the simplicity of the driver’s experience.

1 Hale. Street Crossing. Publication # US173505 A
Interchange and the Mobile City

Freeways or expressways and interchanges work together to make driving anywhere happen efficiently. Interchanges interconnect these freeways to other roads. The main concern and controversy for proposing a freeway is location and the subsequent effect on their community, which is a major concern for freeways planned in urbanized areas. Cost is also a daunting factor. A highway department with more demands than budget is bound to be “dollar conscious”.2

The organization of an urbanized area is either dictated by existing expressways, or the expressway must be planned to utilize pre-existing space. Some cities are more or less easily navigated through or around depending on its organization [fig.5]. Ideally, the freeway and its interchanges should be located to serve as a means of inception, to receive and distribute traffic or divert it. The
An interchange within an urban center requires that people drive inward in order to get out.

Interchanges located outside the urban center allow traffic to ingress and egress more efficiently and logically.

A circumferential expressway saves land in the center of the city and preserves local streets for local traffic.
circumferential-radial freeway and major thoroughfare pattern provides one of the most effective and efficient systems of traffic distribution.

An additional consideration when planning an interchange is the decrease in property values as one nears the interchange. This occurs for several reasons, the first of which is their spatial complexity. Interchanges are engineered to accommodate a plethora of vehicles, all with varying turning radii, and to efficiently transition them either up to or down from highway speeds, to the speed limit of surface road. The resulting space in which the interchange exists makes adjacent development difficult, due to the priority of vehicle transit, and the resulting departure from grid layouts. Furthermore, the tangle of ramps and road transitions can be an eyesore to some. Finally, since these structures are engineered specifically to carry large volumes of road traffic at high speed, a great deal of both noise and air pollution is generated, which inundates adjacent areas.

Presently, legislation normally prescribes a fixed right-of-way width for highways of various categories. The total parcel of affected land is then acquired by the highway department at the appraised value and then having the cost of the property in often a lesser value than the partial acquisition [fig.6]. The excess land could then either be developed for highway related uses or sold or leased for other purposes. In the case of the interchange, this is a worthy reason to try and develop within the remaining spaces.
I-93 BOSTON INTERCHANGE

Forty years ago, we would not recognize the form which the I-93 interchange would take as it emerges off the ground and across the Charles River. Boston as we discover, is made up of 70% landfill [fig.8]. Within the 400 years of its settlement, Boston's terrain has significantly transformed through the creation of bridges across bodies of water, specifically the Charles River. It is possible to witness the growth and development of the city of Boston though the crossings of the river. The forces behind the construction of these bridges range from politics, industrialization and war, to commerce, business and state law. However, we are presently reaching a threshold wherein the number of bridges outnumbers the justification for building more connections. In this age of expediency and efficiency, the primary motivator behind building new connections would primarily be in enhancing travel across the Charles. [fig.13] The cycloplex program would be the next
significant river crossing. At this point in the history of Boston, the city is beginning to reach a realistic limit of automobile traffic. The program intends to propagate an even more efficient means of personal travel throughout the city.

The I-93 interchange is one component of the infamous Big Dig project. It assists the function of both ingress and egress of North Boston. In doing so however, it effectively splits the communities of Charlestown and East Cambridge apart. Due to the site's proximity to the Charles River, the site itself is almost entirely enclosed, thus making the area difficult to access. The interchange creates a rift between the neighborhoods of East Cambridge and Charlestown. This rift is plainly seen when comparing the local architecture of these two communities, East Cambridge being rife with tall, modern developments, and Charlestown exhibiting a plethora of smaller, older buildings. Additionally, the interchange is by definition a 'non-place'. This term refers to locations that are places of transition between two points. They are not destinations, but simply a means to get to one [fig.14]

The concept of a non-place further resonates with the fact that developments are difficult to plan and generally undesirable when directly proximal to interchanges. There are several reasons for this. Firstly, since interchanges are engineered rather than designed, to some they can be an eyesore. The high volume of traffic leads to both air pollution and significant noise pollution. Finally, considerable volume is taken up by the interchange in several dimensions. The sweeping turns intended to improve traffic patterns carve up both horizontal and vertical space, which are difficult to accommodate with traditional building practices.
ACROSS THE CHARLES TO N. STATION - PRESENT
HISTORICAL IMPACTS OF THE SITE DEVELOPMENT

VISIONARIES

COLONISTS AND SOLDIERS

ANDREW CRAIGIE AND SPECTATORS

RAILROAD COMPANIES AND INDUSTRIALS

GOVERNMENT TRANSPORTATION AGENCIES

PROPERTY OWNERS AND DEVELOPERS

VISIONS

INITIAL CONNECTIVITY AND DEVELOPMENT PROFITS

DENSE CONNECTIVITY AND TRANSPORTATION PROFITS

CONNECTIVITY FOR AUTOS AND HIGHWAYS

PEDESTRIAN CONNECTIVITY, MIXED-USE DEVELOPMENT, AND GREEN SPACES

FORCES

COLONIAL POLITICS AND WAR

BRIDGE CONSTRUCTION, LOCAL GOVERNMENT, AND IMMIGRATION

RAILROADS, LANDFILL, REGIONAL AND INTERNATIONAL TRADE, AND STATE REGULATORS

DEINDUSTRIALIZATION, AUTOMOBILES, AND FLEXIBLE PRODUCTION

LEGAL SYSTEM, PAST REGULATIONS, AND LOCAL GOVERNMENTS

THESIS COMMUNITY CONNECTIVITY AND TRANSIT DEVELOPMENT, AND URBAN PROGRAM

1. CHARLESTOWN BRIDGE

2. CRAIGIE BRIDGE/DAM

3. O'BRIEN HIGHWAY BRIDGE

4. NORTH STATION RAILWAY/CANAL BRIDGE

5. STORROW DRIVE BRIDGE

6. ZAKIM BUNKER HILL BRIDGE

7. CHARLESTOWN AVE. OVERPASS

8. NORTH BANK BRIDGE

9. "INFRA-ROUTE"
BRIDGING ACROSS THE CHARLES

[Fig. #13]
ADJACENT PROGRAMS OF INTERCHANGE

A. North Point Development
B. Boston Sand and Gravel
C. Bunker Hill Community College
D. BRA-Owned Parcels
E. CANA Landscape Parcel
F. Multiple-Owned Property:

POTENTIAL SITE AREA = 850,000 sq.ft
EXISTING FLOWS

CONNECTING POI

PROPOSED CONNECTIONS

[fig. #16]
DESIGN APPROACHES

The unique space generated by the interchange is a large part of what makes developmental programs adjacent to such structures difficult. Ultimately, we want to re-appropriate these remaining spaces. There are two design programs that will be interjected within the space: An "Infra-route"; a new transit route for pedestrians and cyclists that can be used as an expressway route and an "Asym-Velo"; a velodrome that creates the interchange as a destination for regional cyclists. This cycloplex program will attempt to occupy this unique space, as well as disturb the existing infrastructure as minimally as possible.
SITE CONTEXT

The program is intended to function on three scales, and not just within the confines of the I-93 interchange site. Nationally, there are both existing and proposed bike paths, such as the East Coast Greenway “ECG”, and the United States Bicycle Route System, intended to make travel by bicycle across the entire nation feasible [fig. 20 and 21]. These routes tend to follow existing rapid transit infrastructure such as highways and interstates. As such, there is precedence for bicycle routes to append pre-existing infrastructure. Therefore, potential exists for the program of this highway cycloplex to be replicated at any interchange wherein a transition is made from freeway to city center.

At a metropolitan level, the city of Boston has two similar interchanges. The program and aforementioned proposed cycling networks could easily be extended to these sites to serve as bicycle highway for more efficient transit via bicycle, each site acting in a similar fashion to a subway stop.

There exists a relationship between and interchange, the city it feeds, and the freeway it is attached to. Interchanges act as nodes of transportation for the cities they are adjacent to. Also of note is the difference between a freeway that encircles a metropolitan area, and one which exists within city limits. Freeways within city limits are generally rife with interchanges, offering greater potential for development.

As previously mentioned, at a local level, the site is the cause of three issues. It creates a rift between the neighborhoods of East Cambridge and Charlestown. This rift is plainly seen when comparing the local architecture of these two communities, East Cambridge being rife with tall, modern developments, and Charlestown exhibiting a plethora of smaller, older buildings. The site is also central
The goal of The United States Bicycle Route System is to connect America through a network of numbered interstate bicycle routes. Prioritized Corridors are not routes, but 50-mile wide areas where a route may be developed. These corridors have been assigned route numbers.

Alternate Corridors provide additional consideration for interstate routing. These corridors have not been assigned route numbers but may be prioritized. Corridors may be added or existing corridors shifted as needed.

Established U.S. Bicycle Routes designated by asphlcs appear as defined lines on the Corridor Map. For specific route information visit www.adventurecycling.org/routes/usbrs.
to several points of interest, namely the North Point Park in Cambridge, Bunker Hill Community College and City Square Park and the adjacent Charlestown Naval Yard in Charlestown and the iconic TD Garden, in North Boston.

The TD Garden is of considerable significance, as the attached North Station is the terminus of one avenue of transport, and it is a venue for major sporting events, as the cycloplex aims to be. Secondly, due to the enormous volume of the interchange, local traffic is unable to pass through the site at ground level. All modes of transport must alter their path to move around the site, rather than through it. The cycloplex will seek to mend the existing paths and generate new ones to allow much more efficient travel for all modes of transport through the site.
The dense, colonial layout and relatively small population of Boston lends itself to alternate means of transport such as walking and bicycling. Indeed, Boston has a reputation of being one of the most ‘walkable’ cities in the country. However, only until recently was the city conducive towards cycling. As recently as 2006, Boston’s cycling infrastructure was criticised by Bicycling magazine which deemed the city as one of the three worst cities in the county to bicycle in. Since 2007, improvements were being made to better support those who travel by bicycle. Additionally, the Hubway bike share service began in 2011.

Boston’s shift towards a more bike-friendly city is no surprise. The region is home to countless cycling teams and businesses. Though most of these teams are private organizations, several universities field their own teams such as Harvard, MIT, and Northeastern. Businesses that find their home in the Boston metro area include frame builders Seven, Geekhouse, and Independent Fabrications; Pedro’s bike tools finds its home in Haverhill, north of the city. French wheel and clothing manufacturer Mavic finds its eastern US office in nearby Beverly, as will as Swiss clothing company Craft.

\[\text{Transportation in Boston. Wikipedia.com}\]
DIFFERENT MODES OF TRANSIT FOR 60 PASSENGERS

BIKE

CAR

BUS

[fig. # 24]
The main idea for the "Infra-Route" is to shadow the path of automobile highways as well as cater to pedestrian and cycling transit. Being able to follow the same path of the highway will allow commuters to bypass the grid of the neighborhood traffic. The Infra-route is sought to be an expressway and an extension of a regional bike route. It will connect the city of Medford to Quincy, intersect with the ECG, and have the option of expansion [fig. 22 and 23]. The I-93 interchange will act as a destination node on the route called "Cambridge/Charlestown".
PROPOSED SITE PLAN
SCALE: 1:1000

[P] PARKING GARAGE
NORTH POINT DEVELOPMENT
RE-LOCATE BOSTON SAND AND GRAVEL
[P] VELODROME / CYCLING FACILITY
[P] INFRA-ROUTE
[P] AUTOMOBILE ROADS THROUGH SITE
[E] PARK
FUTURE SKATEPARK

- ACCESS POINTS TO INFRA-ROUTE
- EAST COAST GREENWAY ROUTE

1. BUNKER HILL COMMUNITY COLLEGE
2. MUSEUM OF SCIENCE
3. TD GARDEN / NORTH STATION
4. BUNKER HILL MONUMENT

[Fig. #25]
A new pedestrian and cycling path will take form beneath the I-93 interchange. Using the infrastructure as a backbone, the route will follow as an expressway connecting the 3 surrounding neighborhoods in a safe manner. There will be 3 access points to the Infra-route in this destination node: 1. The overpass intersection of Charlestown Ave and the I-93 Interchange. 2. Ground ramp under the velodrome. 3. The beginning of the Zakim Bridge.

With the massive amount of area to build around, the Infra-route can house a number of other programmatic activity which include, bike polo, people watching, and cafe.
A velodrome will be built in sync with the Infra-route. Seen as a cycling facility, the velodrome will become the key destination of the interchange. It orientates itself perpendicular to the Infra-Route to allow separation from cyclists who want or need to exercise versus cyclists who need to bypass it.

The form the velodrome takes is asymmetric, a departure from traditional velodromes. With one side under the interchange, there are height restrictions and columns in which the velodrome needs to avoid. The result is a less banked and longer distance on that side. To compensate for this, the other side is a tighter and steep banked turn [fig. 26 and 29]. This will introduce a new and exciting strategy to track racing.

"ASYM-VELO"
VELODROME MARKINGS

COTE D' AZURE: No ride zone; entry and exit only
POLE LINE: Used to measure time trials, begins sprinters lane
SPRINTERS LANE: Shortest run to finish line
SPRINTERS LINE: Limit for pole line
NO MANS LAND: Used for passing riders in sprinters lane
STRAYERS LINE: Slower, relief cyclists ride above this line
There are several teams, organizations, and companies that can benefit from having a velodrome in the Greater Boston Area. There are about 25 velodromes in the U.S. where 3 are located in the northeast region. Having a new velodrome location would allow several universities to be more competitive in the track cycling discipline. It would also make the city of Boston a better candidate to host the summer 2020 Olympics since they have been considered [fig. 28].

Firstly, and crucial to what makes all velodromes work, and what makes the track proposed by the cycloplex so unique is the banked surface of the track. As tracks become smaller, so too do the radii of the turns. Steeper banking is required for shorter tracks to prevent cyclists from losing traction when at high speed due to lateral forces encountered when cornering. Conversely, longer tracks can have shallower banking as the turns are more relaxed. The proposed velodrome is unique in comparison to all other tracks in the world, as it has two different turning radii at either end of the track. One is consistent with that of a large track, approximately 400 to 500 meters in length and the other is consistent with a track measuring 250 meters. Thus, the banking of the thesis' track is 27 degrees as it passes beneath the interchange, and the banking that needn't interact with the interchange as closely is greater, measuring 45 degrees.

The asymmetric nature of the track also means that the wider radius turn meshes perfectly with the existing infrastructure, both leaving it undisturbed and honoring it by mimicking the dynamic way in which it carves its way through space. The track also ducks beneath ramps, preventing drivers from becoming distracted by cyclists below. Additionally, the horizontal plane upon which the track is built is elevated, so as not to disturb existing rail infrastructure [fig. 32 and 35].
PATH DIMENSIONS VARIATIONS

PATH TO SIDE PATH IN BETWEEN PLATFORM AROUND INFRASTRUCTURE

+/− 49'-0" F.F. PATH [COND. 1]
+/− 43'-0" F.F. PATH [COND. 2]

27'-4" BOTTOM OF SUPPORT

66'-0" Underside of Highway
56'-0" F.F. of Platform
23'-6" F.F. of Platform
12'-0" Bottom of Platform
0'-0" Grade

GENERAL NOTES:
< REFER TO CONNECTION DETAILS

OVERALL CONDITIONS OF "INFRA-ROUTE" CONNECTIONS TO INFRASTRUCTURE

(fig. # 30)
UNDERSIDE CABLE WIRE CONNECTION DETAIL

SCALE: 3/4" = 1'-0"

WIRE TO PATH CONNECTION DETAIL

SCALE: 3/4" = 1'-0"
Structure

There are three means by which the Infra-Route is connecting to the existing infrastructure. The first two conditions show a dual system that "suspend" the users. This includes a cable wire system from above and a leg support from below. The third and last conditions seeks to create wider spaces. The path itself becomes a platform where a "tree house" system is involved. The platform connects around the whole infrastructural column (fig. 30 and 31).

The section cut of the proposed paths/platforms and rails are inspired by the existing paths found on site i.e. The North Bank Bridge and the highway. This creates a better blend between the existing system and what is proposed. The main structural material will be carbonfiber for strength and lightness in weight.
Beyond Boston

The Highway Cycloplex will be an example of how many other city interchanges can be infilled. This is only one example of what program can be implemented. Due to the flexible nature of the cycloplex, and its ability to append the unique space afforded by interchanges, the program is easily replicable in elsewhere. To that end, it is not hard to imagine each highway interchange in the nation functioning both as a transition point for automobiles, but for pedestrian transit as well. If one were to link these cycloplexes with long distance bicycle routes, pedestrian transit across the whole nation would be made feasible.
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