MIT Commuter Common:
Measuring and Improving the Transportation Footprint
of an Urban Institution

By

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Abstract

This thesis develops a system for observing, visualizing, and understanding transportation behavior at the scale of an urban institution's entire population. In particular, the Massachusetts Institute of Technology (MIT) will serve as a case study. This research does not accept the presumption that the individual is a purely autonomous decision maker when it comes to transportation behavior. Rather, decisions can be a result of following the example of others in a given community, not necessarily a process of autonomous utility optimization. As such, human transportation behavior is examined within the context of "social institutional" and "urban tribal" constructs. By recognizing such social institutional tribes as fundamental affecters of transportation behavior, we can develop new analytical units called "commuter footprints." These footprints are derived from the "digital breadcrumbs" of user behavior within an institution. By bringing these footprints to light, it will give policy makers a new avenue to influence transportation behavior in urban areas by targeting these social institutional tribes as a whole.

Given the growing desire for policies to be evaluated with performance-based metrics, this thesis also strives to articulate metrics for a social institution's transportation behavior. These metrics will aid in annual reporting, and may even serve as useful indicators from which to measure change over time. Furthermore, the thesis proposes potential avenues for "living lab" style research and experiments that could utilize such a system.

Thesis Supervisor: Kent Larson
Title: Director of Changing Places Group, MIT Media Lab
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1.0 CONTEXT AND CONCEPTS

1.1 Transportation trends in Cities

Cities around the USA and the world are actively struggling with a resurgence of transportation-related problems, including congestion, pollution, and noise. Ironically, there was a time when American cities struggled to attract people and traffic at all, particularly during the postwar era of suburbanization. However, with a renewed appetite for the benefits of an urban way of life, citizens and businesses alike are flooding back to cities (Sweeney, 2011). Once again, urban localities are scrambling to manage new demands on their transportation infrastructure. Furthermore, municipalities must address these issues without the traditional tools of the past. Indeed, planners learned the hard way in the days of Jane Jacobs and Robert Moses that simply adding more roads, highways, and parking do not fix traffic congestion (Shoup, 2003). Instead, policy makers are hopeful that new technologies and ideas will somehow make urban traffic manageable once again.

1.2 New developments in complex multi-mobility

A number of factors are already changing the mobility in the city. Strikingly, younger people are less and less likely to strive for personal automobile ownership. Instead, a growing number of people, particularly millennials, are opting for dynamic and shared mobility options (Thompson et al, 2012).
In addition to traditional means of transportation, new technologies such as real-time ride sharing and bike sharing might also change the landscape of urban mobility. The introduction of autonomous, shared vehicles may not be as far away as we once thought, as well. We have already seen Google’s successful prototype of an autonomously driving vehicle in California, as well as the Hiriko folding car (Larson et al).

1.3 Rise of Transportation Demand Management (TDM)

Transportation Demand Management is a policy construct that emerged formally in the 1990s to address increasing demands on urban transportation infrastructure. Roads were crowded and noisy, and people were getting exasperated. The idea behind TDM is to charge a fairer price for the use of transportation infrastructure so that demand is not inflated. In Cambridge, Massachusetts, this began with the 1997 TDM Ordinance, which capped the number of parking spaces in the city and required all businesses and institutions of to report their annual aggregated transportation impact (City of Cambridge, 2006). The result was a marked rise in the price of parking, and an easing of motor vehicle traffic in the city.

1.4 Challenges to TDM

After over 15 years of successful TDM, however, traffic congestion seems to be on the rise again. Furthermore, the prices for parking have reached critical levels. In fact, officials worry that raising them any further might put undue strain
on low income workers who must commute into the in the city. Therefore, policymakers are placing high hopes on new technology and incentives that might further alleviate the pressure.

1.5 Digitization of “Human Dynamics”

Tech entrepreneurs, academics, and municipalities alike are preparing themselves for a new era of understanding human behavior. This era will be facilitated by ubiquitous digital technology, big data, and real-time evaluation and feedback via dynamic incentives. Furthermore, an individual’s social context and social networks will be given greater weight when explaining their ultimate behavior (Eagle et al, 2005).

This era will also necessitate new standards and expectations for data access and privacy, as personal information becomes a valuable commodity. If many advocates have their way, access and privacy will be managed by a transparent, decentralized system that empowers individuals and institutions with control over their own data.

1.6 Human Dynamics and Tribalism

Certain theories of human dynamics are rooted in the understanding that people are social beings, and think in terms of “tribes” (Gaker et al, 2010). As such, a person’s decisions may be deeply influenced by their immediate social context. For instance, the decision to buy particular clothing might be the result of observing a
respected friend wearing the same thing, not necessarily a rational optimization of utility.

With regard to transportation, some people drive or even bicycle as a symbol of their status or values within their community. As such, new approaches to managing transportation behavior might do better to recognize the "monkey see, monkey do" aspect of human interaction.

1.7 Urban Tribalism and Transportation

An "urban tribe" is a collection of people who share common behaviors and social circles, and is often defined by observable "patterns of association" within a city (Sander, 2010). An urban tribe might be, for example, the people who travel to a particular job in a given week, which can be observed by counting the individuals that enter the establishment. Later in this research, we will be primarily interested in a "tribe" of people defined by their commute to and from MIT.

1.8 Social Institutions

The term "social institution" is used to refer to a collection of individuals that are unified in their affiliation to a particular institution. Social institutions adhere to specific values and standards of organization. Its affiliates also allow themselves to at least partially be defined by their association with the institution. Jonathan Turner, a sociologist, offers his definition (Turner 1997: 6): "a complex of positions, roles, norms and values lodged in particular types of social structures and organising relatively stable patterns of human activity with respect to fundamental
problems in producing life-sustaining resources, in reproducing individuals, and in sustaining viable societal structures within a given environment.” In this research, however, it shall suffice to for us to understand that a social institution, by virtue of its construct, both contains and influences the behavior and values of an urban tribe (Fig 1.8).

![Diagram](image-url)

**Fig. 1.8** Conceptual relationship between individuals and institutions regarding transportation.

The goal of this research is to improve a social institution’s ability to observe the transportation behavior of its own tribe. By marrying the idea of a social institution with the ideas of human dynamics and urban tribalism, we are able to conceptualize a population of people that is easily **observable**, demonstrably **influential**, and potentially **governable**. In other words, while there may be infinite subsets of urban tribes for us to choose from in a city, it may be best to focus on an observable urban tribe with an already-established mechanism (i.e. social
institutions (for internal change and idea proliferation, so that further research might refine methods for affecting mobility shift.

### 1.9 Influence of Institutions

For centuries, social institutions have had demonstrative, multi-dimensional impacts on the urban areas that they are anchored within (Simha, 2012). Their architecture can establish the form of an entire district, and their activities can serve as primary engines for an entire economy. Universities, in particular, can be the longest lasting and most influential of urban institutions, and can even define the dominant culture, values, and socio-economics of an area.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens- Plato’s Academy</td>
<td>350 BC</td>
</tr>
<tr>
<td>Alexandria Library</td>
<td>250 BC</td>
</tr>
<tr>
<td>Bologna</td>
<td>1088 CE</td>
</tr>
<tr>
<td>Oxford</td>
<td>1097 CE</td>
</tr>
<tr>
<td>Timbuctu</td>
<td>1300 CE</td>
</tr>
<tr>
<td>Harvard</td>
<td>1636 CE</td>
</tr>
<tr>
<td>MIT</td>
<td>1861 CE</td>
</tr>
<tr>
<td>Masdar</td>
<td>2007 CE</td>
</tr>
</tbody>
</table>

**Fig. 1.8.1** Bob Simha’s list of influential academic institutions throughout history.

Furthermore, such institutions have demonstrated their ability to self-actuate change within themselves. In the realm of transportation, institution-base incentives have already been shaping individual travel behavior for decades (Kearney et al, 1996).
2.0 MIT: THE CASE STUDY

In light of the characteristics discussed in Section 1, a large, urban social institution was selected as a case study for this thesis. The case study became an exercise in gathering of digital breadcrumbs, in database compilation, and ultimately in commuter footprint visualization.

2.1 Picking a Case Study

The bulk this thesis involves the development of data collection and visualization methods for an actual urban social institution. MIT was chosen since it is a particularly strong example of a social institutional tribe that is observable, influential, and governable.

2.1.1 Observability

Observability describes our ability to witness and measure the behavior of MIT constituents, presumably through digital breadcrumbs. The social institution of MIT exceeds the requirement of observability, since it maintains a comprehensive database of digital breadcrumbs that describe the transportation behavior of its affiliates in a near-comprehensive manner. Furthermore, the MIT administration is extremely willing to provide this data internally for examination and analytics.

MIT, with approximately 25,500 affiliates, is a “goldilocks” institution that is just the right size for such observability, neither too large nor too small. A much smaller institution typically does not have the resources nor the motivation to
maintain comprehensive and rigorous data of its population. For instance, the Cambridge Innovation Center was approached for similar data, but its active body of merely 771 affiliates did not seem to warrant comprehensive, digital management of its population’s transportation behavior.

Conversely, it may be possible for a social institution to be “too large” to be observable. At a certain point, the internal mechanics and politics of a particularly large institution preclude it from sharing personnel data, even if it exists. An overly large institution may also have difficulty mandating a strict standard of data collection across its population. For example, the City of Boston itself constitutes a particularly large social institution bounded by common law and shared infrastructure. But even if the City could collect comprehensive data its millions of “affiliates,” concerns over government intrusion would likely preclude them from doing so. MIT is relatively “small enough” that the overt regulation of its employees and students through benefits and contractual obligations appears acceptable. For instance, MIT reserves the right to require some of its students to live in certain housing. It would be hard to imagine the same students being comfortable with being forced to live in public housing.

2.1.2 Governance

MIT exceeds the requirement of governability, as the institute has various and robust mechanisms of managing the behavior and demands of its own population. For any member of the MIT community, the institute enforces a code of conduct and high standards for personal responsibility. It is arguable that MIT has
special leverage to enforce certain behavior since its affiliates wish to preserve their respective status within the prestigious community (McFadden, 2007).

Furthermore, the institute has a substantial budget for implementing internal policy directed at changing behavior. For instance, the institute recently began to encourage the utilization of bike sharing by subsiding its affiliates' membership to Hubway, the bike sharing company of Boston, Cambridge, and Somerville. Conversely, the institute has discouraged driving behavior by charging ever-higher prices for the privilege of parking on campus. In some parts of the city, free parking is still seen as practically a human right, and any fee imposed would be met with stiff resistance.

2.2 Internal/External Validity

The selection of MIT as a case study begs the question: is such a case study generalizable? It is indeed true that MIT is an extremely unique institution in both its history and current organizational structure. A specific cocktail of “MIT culture” is even said to make an institution like MIT impossible to replicate. However, this thesis does its best to operationalize a process for understanding MIT transportation behavior that could, at least in theory, be adapted to any other institution. To be clear, this thesis does not make any overt claims to causality in any of its observations, but rather focuses on the operationalization of observable data within the community.

2.3 The MIT “Tribe”
The MIT tribe is comprised of a diverse but relatively well-defined set of demographics. Any given member of MIT, for instance, fits into one of four broad socio-economic categories: student, faculty, staff, or administration.

2.3.1 Students

MIT maintains a population of nearly 11,000 students, a little more than half of which is at the graduate level. Finances, age, and career priorities (to name a few) help define their identity. They are also the demographic with the highest turnover of members. Two major self-governing bodies also represent them: The Undergraduate Student Council (UCG) and the Graduate Student Council (GSC). These bodies have affectively lobbied to the MIT administration on behalf of their constituents for a broad range of issues, ranging from student life, stipend allowances, and campus transportation.

2.3.2 Faculty

MIT maintains a small but influential elite of faculty, consisting of 1,022 individuals as of October, 2012. The faculty are also some of the most prominent members of the MIT community. As such, their actions and behavior are well known, if not actively scrutinized. They faculty are loosely organized through regular, opt-in meetings. They also publish the MIT Faculty Newsletter to voice their opinions and concerns to the greater community.

2.3.3 Staff
MIT Staff are perhaps the most vaguely defined demographic, but they are indeed a quiet majority with 11,279 individuals. Staff duties range from auxiliary research, medical services, and custodial duties, but they all ensure the daily operation of the institute. They have no substantial organizing body.

2.3.4 Administration

2,137 administrators make up MIT's executive class, and are responsible for making many of the political, academic, and financial decisions that drive the institute. They are organized into a strict hierarchy headed by the President and the Board of Trustees.

2.4 Mobility Behavior

MIT commuters utilize a broad array transportation options. For the large part, these behaviors can and have been operationalized (Fig 2.4).

Fig 2.4 MIT's multi-modal logo from its department of commuter affairs.
Indeed, the institute's own department, "MIT Commuter Connections" categorized and branded various transportation options for the benefit of the community.

Until the most recent decades, the MIT campus sustained a relatively simple population of drivers who commuted via single-occupancy vehicles. The trend was so prolific that many of the green spaces we enjoy today were once expansive parking lots (Fig 2.3.3).

Fig 2.3.3 MIT's west campus quad was once a sea of parking lots (Photo: MIT Libraries).

Even those who commuted by other options, including transit, bicycling, and walking, did so with modest regularity. However, as David Block-Schachter pointed
out in his thesis, “The Myth of the Single Mode Man,” recent decades have shown that commuters dynamically change their transportation behavior daily, and are even utilizing multiple modes during a single day’s commute (Block-Schachter, 2009). To date, people are known to drive, take mass transit, bicycle, shuttle, walk, carpool, taxi, and even work from home (MIT Transportation Survey, 2012).
3.0 DIGITAL BREADCRUMBS

3.1 Help from Internal Departments

One can understand much about MIT commuter issues by simply speaking with individuals and participating in the community. However, this knowledge is largely qualitative and, at best, anecdotal. Gaining an accurate and quantitative understanding of MIT transportation behavior requires us to access and join individual-level data from various departments in the institute. This horizontality of data information systems in an institute is key for transit behavior observability.

![Organizational map of MIT's departments as they relate to commuters and data.](image-url)

**Fig 3.1** Organizational map of MIT's departments as they relate to commuters and data.
3.1.1 MIT Institutional Research (IR)

MIT Institutional Research (IR) is effectively the keyholder to all of the institute's internal data. One might argue that the existence of such an internal entity is a key requisite for an institution to be observable. IR is not only responsible for practicing discretion in the use of MIT data - allowing its use within a master student's theses, for instance - but also for joining datasets according to individual unique identifiers. The ability to join data allows individual behavior to be viewed in the context of any other observable personal characteristic deemed important. For instance, the writer asked IR to link personal mobility behavior data from one department to residential address data from another department.

3.1.2 MIT Commuter Connections

MIT Commuter Connections primarily concerns itself with managing the institute's transportation resources. It also distributes subsidies and collects fees based on persons' transportation behavior. Much of the transportation behavior data from Commuter Connections is contained within proprietary software used to track parking, ridesharing, and the like. In order to link this data to other identifying information, it was necessary for Commuter Connections to manually "harvest" the data and submit it to MIT IR for processing.
3.1.3 MIT Campus Planning

MIT Campus Planning aided this effort by translating the addresses of MIT community members into geolocations. Such geolocations are readable by geographic information systems software, and therefore compatible with a long-term database of MIT commuter behavior.

Fig 3.1.3 Graphic produced to demonstrate the MIT population's residential geodata. (orange dots are staff, blue dots are administrators, and red dots are students).

3.2 Data Sources

Working with numerous helpful departments at MIT, we worked to compile a comprehensive "Commuter Common" database of all MIT affiliates, including key
information related to their transportation behavior. We chose a sample date of October 31, 2012, since the date coincided with the institute’s biannual transportation survey. The goal was to create a database with the following columns of data describing each individual: unique ID, MIT Affiliation, MIT Department, geolocation of residence, and identifiers of the individual’s transportation behavior(s).

3.2.1 Human Resources (HR) Database

The general institute HR database could provide anonymous, individual-level information regarding affiliation (student/staff/faculty/admin), department, and residential address. Affiliation and department information was operationalized into a discrete amount of categories, while residential addresses were converted into latitude and longitude coordinates thanks to Adam Serafin from MIT Campus Planning.

3.2.2 Transportation Records

Parking, T-pass, shuttle, and bicycle data was contained within the servers of MIT Commuter Connection’s various proprietary transportation management software. Since roughly half of MIT is enrolled in either a parking program or a subsidized transit program, this database was an excellent source of up-to-date, comprehensive MIT affiliate data.
3.2.3 Voluntary Transportation Survey

In addition to its registry of commuters, MIT also surveys a sample of its population every two years with granular transportation-related questions. Because surveys are completed online with MIT credentials, responses are also associated with unique individuals. Therefore, responses related to transportation behavior can be joined with records of their residential location in the MIT HR database, helping to complete our picture of the population.

3.3 Consolidation

In the end, all of these disparate data are joined into a single repository that can be analyzed with geospatial tools. Consolidation is primarily possible because of the centralized ID system for all MIT affiliates. Whether you take an MIT survey, or register for MIT parking, all of those activities can be traced to a single unique identifier. This centralized identifier for personnel is the minimum requirement for linking disparate data sets within a social institution.

3.3.1 Challenges

It is an understatement to say that such consolidation was difficult. Along with the generous time volunteered by staff from various departments, there are many internal regulations and policies that had to be carefully considered before utilizing such sensitive data. Above all, ensuring privacy and control over access was the top priority. As an example, any visualizations or analysis of the data had to
Fig 3.3 Workflow map describing how data was ultimately collected, processed, and cleaned by various internal mechanisms (i.e. generous individuals).

be aggregated in bins of no less than 5 individuals. This was primarily to minimize the risk of exposing anyone’s identity.

With this method, we were able to verifiably observe 60% of travel behavior within the MIT community. For those we could not observe, we still had a
comprehensive understanding of their MIT affiliation and residential address. The 40% of people not observed did not own parking permits through MIT, did not take advantage of transit subsidies, and did not complete a transportation survey. It is possible that such individuals walk or cycle, park in non-MIT facilities, neglect to take advantage of MIT travel subsidies, or simply to not commute to campus altogether.

3.3.2 Systemizing Annual Data Management

Compiling a dataset of transportation behavior for October 31, 2012 required a good deal of trail blazing. However, effort was made to institutionalize the process as much as possible (Fig 3.3), and there are already plans to repeat the process collecting these digital breadcrumbs in the coming years.
4.0 COMMUTER COMMON: PRESENTING THE DATABASE

After using digital breadcrumbs to deduce the affiliation, location, and transportation behavior of unique individuals, it is finally possible to compile MIT's "Commuter Common" with a resolution not before possible. As of thesis publication, interactive prototypes the MIT Commuter Common database are located online:

http://web.mit.edu/jiw/www/ICTFP

http://web.media.mit.edu/~clwen/mit-footprint/#

The online prototypes were constructed using a combination of Google Maps API, jquery, Javascript, and HTML. Note: For troubleshooting, please contact the author with any questions.

4.1 Database Fields and Descriptions

The fields are typical of a geographic information systems database, consisting of a series of unique points at specific geographic locations. Each point is associated with characteristics determined by a set of fields:

<table>
<thead>
<tr>
<th>Database Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XCOORD</td>
<td>Longitude of residential location [degrees]</td>
</tr>
<tr>
<td>YCOORD</td>
<td>Latitude of residential location [degrees]</td>
</tr>
<tr>
<td>PID</td>
<td>Individual's Unique Identifier</td>
</tr>
<tr>
<td>AFFILIATION</td>
<td>MIT affiliation</td>
</tr>
<tr>
<td>AREA</td>
<td>MIT area/department association</td>
</tr>
<tr>
<td>COMMUTE_TYPE</td>
<td>Commuter modality/modalities</td>
</tr>
<tr>
<td>FIPS</td>
<td>12-digit census block group of residence</td>
</tr>
<tr>
<td>DIST_TO/MIT_KM</td>
<td>distance from campus, in kilometers</td>
</tr>
</tbody>
</table>

For a more detailed listing of the nature of these fields, refer to section 7.
4.2 The Mobility Footprint

By linking individuals’ residential geolocation to their primary commute type, we can produce a visual of MIT’s mobility footprint (Fig 4.2).

The visualization and legend is actually a simplification of a more complex code (Section 7) that describes individual travel behavior.

4.3 Variability in Internal Demographics

The database also takes advantage of the fact that demographics can be filtered according to individuals’ affiliations and associations within the institute.
Because of the nature of MIT’s HR system, every individual fits “neatly” into discrete categories that roughly describe their socio-economics. In the first prototype of the database’s graphical user interface (GUI), the user is able to display individuals based upon these demographics (Fig 4.3).

Fig 4.3 Snapshot of GUI configured to display local MIT population’s affiliation vs. residential location. (red dots are graduate students, purple dots are undergraduate students, green dots are faculty, blue dots are administrators, and brown dots are staff).

4.3.1 Affiliation

Every affiliate within the MIT community is a member of either the student body, the faculty, the administration, or the staff. Student and staff categories are notably diverse within themselves, and as such have subcategories. Students are broken down into graduate and undergraduate subcategories, while the staff is broken down into support, services, medical, research, and academic subcategories.
4.3.2 Area/School

Individuals are also associated with discretely defined areas or departments within the institute. These do not necessarily correlate with affiliation, since students, staff, faculty, and administrators may be part of a particular area, such as the School of Engineering.

4.4 Dynamic aggregation

An important feature of the Commuter Common database is the ability of the user to dynamically aggregate data into demographic groups of their choosing. For instance, let's say a graduate student administrator wanted to lobby for better

Fig 4.4a GUI configured to display only the 626 graduate students who are known to cycle.
bicycle safety in Cambridge, and needed to know where graduate students cyclists were coming from. They could filter the database as shown in Fig 4.4a.

Alternatively, an administrator in the School of Engineering might want to make an estimate of mass transportation utilization by its graduate students, adjusting the search accordingly (Fig 4.4b).

Fig 4.4b GUI configured to display only the 568 graduate students in the School of Engineering who are known to use mass transit.
4.5 Variability Among Internal Demographics

Attention to internal demographic information becomes important if we wish to understand how individual differences correlate with different transportation behavior. These differences can be observed by viewing the mobility profiles of different groups side by side (Fig 4.5a). For instance, a faculty member is more likely to only drive than any other demographic. Furthermore, different internal demographic groups are organized by different self-governing bodies. One such example is the Graduate Student Council. These internal bodies serve as platforms for debate, discussion, and even change among their respective constituents.

![MIT Community Mode Choice by Affiliation](image)

**Fig 4.5a** Frequency[\%] of primary modality for faculty in each of MIT's primary schools.

Even among only faculty, though, transportation behavior differs between departments. For instance, we see that a random faculty member chosen from the School of Humanities and Social Sciences (HASS) is more likely to use mass transit than a random faculty member from the Sloan Business School (Fig 4.5b).
Fig 4.5b Frequency[\%] of primary modality for each of MIT's primary affiliate groups. The data show that all of MIT's primary affiliate categories have unique distributions with regard to their primary choice of transportation.

Note that this research does not make any claims to causality, and presents the data only to demonstrate how variation in transportation behavior among different groups can be observed.

4.6 Generalizability

While MIT may be unique in the particular way it chooses to categorize its affiliates internally, we might generalize that all suitably large social institutions are capable of doing so. The practice of operationalizing internal demographics becomes important when we wish to control for socio-economics and mechanisms for internal governance.
5.0 COMMUTER FOOTPRINT: SECONDARY PERFORMANCE METRICS

The commuter "footprint" is a set of deductions derived from the base set of record level data in the commuter common. In other words, the footprint consists of secondary statistics that are inferred from the primary data at our disposal.

5.1 User Frequencies

Perhaps the most straight-forward metric to derive is a count of the individuals associated with various aggregations of demographic and behavior data.

Fig 5.1 GUI tailored to display frequencies of dynamically aggregated demographics. In this instance, the display has been customized to display only counts of known bicyclists.
Fig 5.1 shows how the GUI has been designed to dynamically calculate the number of people known to bicycle in each major affiliate group, for instance.

5.2 Distances Travelled

The geospatial aspect of our database – namely, the geolocation of each individual's home - allows us to deduce the distance of each person's home from MIT campus. In essence, we can understand how far each person travels for...

![Fig 5.2a A purely conceptual distribution of modality as a function of distance from MIT.](image)

![Fig 5.2b A realistic distribution of mobility behavior with actual MIT data.](image)
his or her respective commute. In this case, such calculations were performed using ArchGIS software, but that is one of many methods. Conceptually, we can visualize such information as a stacked frequency curve (Fig 5.2a and 5.2b).

By aggregating the results, we can then know very plainly the cumulative impact of everyone’s behavior in terms of travel distance. In other words, we know the sum of all distances travelled to MIT. For instance, the October 2012 dataset reveals that MIT affiliates travel a combined 202,272 kilometers during a particular commute day, nearly five times the length of the equator (Fig 6.2)!

5.3 Time Travelled

We can also deduce the amount of time spent (or wasted) due to commuting every day. This can be achieved by applying a time/km coefficient to each distance that varies by modality. For instance, a kilometer of bicycle travel might take longer than a kilometer of driving. Using this methodology, we can estimate that MIT’s population spends about 6,360 man hours (265 man days) commuting each day!

5.4 Economic impacts

While monetary incentives are not the only factor influencing mode choice (Dill et al, 2007), it goes without saying that economics plays a large role in transportation behavior. However, it’s important to point out that the burden of travel cost for a social institution is hardly limited to the individual. It is suggested that any economic metrics derived from the data consider at least three important
stakeholders: the individual, the social institution, and the municipality. These stakeholders are conceptually distinct, but practically intertwined by their shared desire to minimize the travel cost. By applying per person modal costs, such as those in figure 5.4, we could use the base dataset to estimate the cost of a population of commuters.

**Estimated Cost to MIT for an Individual with a Given Mode Type**

![Table of Estimated Costs](image)

Fig. 5.4 Itemized per person cost to MIT for various commuter categories (MIT Commuter Connections, 2012)

5.5 Pollution, GHGs, and Energy

Perhaps the most promising performance metrics are those of energy use or green house gas emissions. Energy, GHG, and other pollution metrics can be deduced by applying coefficients to commute distance data in much the same way that commute time is calculated. In fact, MIT’s Office for Sustainability is already using the data for this very purpose.
6.0 POTENTIAL APPLICATIONS

6.1 Mobility Dynamics Console

The first step to utilizing newly available commuter data is to create a robust console that incorporates dynamic aggregation and deductive metrics as presented in Sections 4 and 5. Such a console may look something like Fig 6.1 or 6.2.

---

Welcome! You are logged in as Larry Bruti. Access Level: Gold.

MIT Mobility Dynamics Page

Data History 14 December 2011

MODE VIEWS

T-Stops: ON

Commuter 002494

Affiliation: Professor
Department: Architecture & Planning
Permits Held: Full Time Parking Pass

Avg. Daily Commute: 20.2 miles, 43 min
Monthly Parking Frequency: 21/31 days

% by S.O.V: 94.3%
% by MBTA: 5.7%
% by Carpool: 0%
% by Bicycle: 0%

Monthly CO2 Contribution: 1.2 tons
Est. Personal Commuting Expenses: $423/mo
Est. Contribution to related MIT infrastructure: $205/mo

Fig. 6.1 Concept for a "Mobility Dynamics" page that allows users to view and understand MIT’s transportation footprint metrics at both an aggregated and disaggregated level.
Just in a day, 12 598 MIT community members spent 381 621 minutes traveling a total distance of 20 237 2 KM, which is about five times as long as the equator.

Fig 6.2 Online GUI tailored to display commuter frequencies and commute distance as a function of modality, developed in conjunction with Media Lab students Amy Yu and Chunglin Wen.

6.2 Annual Reporting

Now that the hard work of creating the first Commuter Common dataset is finished, MIT will now be able to update the database annually. The major benefit of this will be a new ability to compare consecutive years of data, and observe trends over time with perhaps greater resolution than before. Indeed, an established database with years of data will become an impressive tool for visualizing and communicating change over time. It will allow an institution to collectively understand where they came from and where they are going with regard to transportation.
6.3 Controlled “Living Lab” Experiments

Up and coming concepts from the field of human dynamics suggests that human behavior observed with ubiquitous digital technologies can be used to inform feedback and incentives, such to improve conditions over time. This Commuter Common dataset becomes the first step in what could be an annual feedback loop of controlled experiments in the style of a “living laboratory.” First, the data is used to inform potential subpopulations within the community that might respond to an intervention. Secondly, an experiment is designed to test whether a certain incentive can change behavior. Finally, by updating the commuter footprint database, one can see whether or not an intervention had an effect, and the feedback loop continues.

6.3.1 Experiment Requisites

Step 1. Define population (i.e. which subset of MIT population and why)
Step 2. Propose intervention (i.e. new infrastructure, social app, email campaign)
Step 3. Establish quantitative/qualitative indicators of performance metrics
Step 4. Hypothesize potential benefits
Step 5. Design experiment methodology and timescale

6.3.2 Potential Interventions for Exploration

- Housing Incentives for New Hires
- Housing Incentives for Existing Hires
- Provision of Park and Ride Facilities
- New BikeShare Infrastructure
- Real-time Carpooling Application
- Construction of On-Campus Housing
- New shuttle/parking services
- Modal-specific subsidies
- Phone applications with real-time rewards and cost notification
## 7.0 APPENDIX OF COMMUTER COMMON DATABASE STRUCTURE AND FIELDS

<table>
<thead>
<tr>
<th>Database Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XCOORD</td>
<td>Longitude of residential location [degrees]</td>
</tr>
<tr>
<td>YCOORD</td>
<td>Latitude of residential location [degrees]</td>
</tr>
<tr>
<td>PID</td>
<td>Individual's Unique Identifier</td>
</tr>
</tbody>
</table>

### AFFILIATION
- MIT affiliation
  - 1: Undergrad: Freshmen
  - 2: Undergrad: Sophomores
  - 3: Undergrad: Juniors
  - 4: Undergrad: Seniors
  - U: Undergrad: Other
  - G: Graduate Students
- FAC: Faculty
- ADM: Administration
- OTA: Staff: Other Academic
- RES: Staff: Research
- MED: Staff: Medical
- SER: Staff: Services
- SUP: Staff: Support

### AREA
- MIT area/department association
  - SAP: Sch. of Architecture and Planning
  - ENG: Sch. of Engineering
  - HAS: Sch. of Humanities, Arts, and Soc. Sci.
  - SCI: Sch. of Science
  - SSM: Sloan Sch. of Management
  - UNDEC: Undeclared
  - LL: Lincoln Labs
  - AAA: Alumni Association Area
  - APA: Assoc. Provost for the Arts Area
  - CHA: Chancellor's Area
  - DSL: Dep. of Student Life
  - DUE: Dep. of Undergraduate Education
  - DGE: Dep. of Graduate Education
  - DF: Dep. of Facilities
  - EHS: Environment, Health, and Safety HQ
  - EVP: Executive VP Area
  - LIB: Libraries, MIT Press, Tech Review
  - MAJ: Major Agreements Area
  - OEVP: Off. of Executive VP
  - OPV: Off. of Provost
  - PCC: President & Chairman of the Corp. Area
  - VPC: VP and Secretary of Corp. Area
VPF  VP Finance Area
VPHR VP Human Resources Area
VPIST VP IS&T Area
VPRD VP Resource Development Area
VPRES VP Research Area
WHTKR Whitaker
OTH Other

**COMMUTE_TYPE**  Commuter modality/modalities
  WLK  Walk Only
  BIC  Bicycle Only
  WLK_PUB Walk and Transit
  BIC_PUB Bicycle and Transit
  VAN  Vanpool (with 7+ others)
  CRP_PUB Carpool/Vanpool and Transit
  BIC_DRV Bicycle and Drive
  BIC_DRV_PUB Bicycle, Transit, and Drive
  DRV  Drive Only
  DRV_PUB Drive and Transit
  DRV_HOM Drive and Work from Home
  CRP2 Carpool (with 1 other)
  CRP6 Carpool (with 2-6 others)
  DRP  Get Dropped Off
  TAX  Taxi
  HOM  Work from Home
  UNK  Unknown

**FIPS**  12-digit census block group of residence

**DIST_TO_MIT_KM**  Distance from campus, in kilometers
8.0 BIBLIOGRAPHY

8.1 Electronic Journals


*This recent thesis focuses on a new multi-mobility employer-based incentive at MIT, and also provides extensive research of existing transportation behavior and demand management strategies at MIT.*


*Dill and Wardell explore non-monetary incentives to influence transportation mode choice for travel to the workplace.*


*Traditional transportation planning models are rooted in what David, Zheng, and Walker calls a "microeconomic paradigm of rationality." Their thesis describes how the relatively young field of behavioral economics can be applied to certain contemporary transportation decisions.*


*Since the 1970s in America, it has been recognized that employers can have an important influence on individual travel behavior. Kearney's work provides a comprehensive collection of contemporary employer incentive programs that emphasize rational penalties and alternatives.*

_McFadden theorizes that transportation behavior is significantly informed by individuals' voluntarily affiliation with social networks. The MIT Commuter Common might be an important laboratory to test this theory._


_Shoup makes a report on the folly of trusting statistically insignificant transportation models. Through a case study, he shows how precise numbers generated from parking demand models are misused._


_Zeid develops a transportation model that incorporates the utility of happiness and some social factors in the 'discrete choice' of transportation decisions. While her social factors do not include geospatial proximity of peers, her work includes a broader understanding of the variables informing overall "commute satisfaction."_

### 8.2 Books


_Ison provides a rather comprehensive study of the complicated parking policy at UCLA campus. Parking policy is heavily dependent on one's socioeconomic status within the university, to some peoples' delight but to others' dismay._


_Shoup makes the case that free parking creates numerous externalities. By most economic models, this implies that the management of such transportation infrastructure should be a more shared concern, supporting the idea of an inclusive "Commuter Common" that transcends parking needs._
8.3 Data


8.4 Articles


“collaborative community reduces countless transaction costs in the innovation process... Human networks like this... needs freedom from the informal social constraints caused by distrust, fear, miscommunication, and distance.”


With unique demands for transportation and infrastructure, and an unprecedented aversion to private car ownership, transportation policy must quickly adapt to such new attitudes.


A unique aspect of millennials is their aversion to large, expensive material capital goods, especially automobiles and homes.