The Central Artery/Tunnel Project

Theresa Burianek

Serena Chan

Saurabh Khemka

Ming Maa

Joseph Rozier

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Abstract

The Central Artery/Tunnel (CA/T) Project is the largest public works project in the history of the United States. In the early 1990's, MIT and Lincoln Laboratory collaborated in a joint effort to create novel technologies for application in CA/T. A history of this collaboration and the fruits of their work are presented within the theoretical contexts of Donald MacKenzie and Thomas Kuhn. We identify the existence of heterogeneous engineers and their unique role in the success of this joint effort. Furthermore, we develop a two-level model of technological trajectories, analyzing the influences of both internal and external social, political, economic, and technological forces. Finally, we synthesize our analysis with the theories of MacKenzie and Kuhn and reinterpret their work within the context of modern large-scale engineering projects.

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1 Introduction

The Central Artery/Tunnel (CA/T) Project is the largest public works project in the history of the United States. Scheduled for completion in 2004, the project known as "The Big Dig" is expected to cost a nominal $10 billion. The project involves the creation of 161 miles of highway in a 7.5 mile highway construction corridor within the city of Boston. The harbor tunnel portion of CA/T will facilitate the movement of traffic to Boston's Logan Airport, while the underground Central Artery will improve the movement of interstate highway traffic through the Boston region. In addition, the project also calls for the construction of a new bridge across the Charles River from Cambridge into Boston. CA/T promises to enhance the existing traffic capacity, separate regional highway traffic from local residential throughways, and, after the removal of the elevated highway, provide twenty-seven acres of new open park space in downtown Boston.[1] Figures 1 and 2 provide two different views of the CA/T project.

In this paper, we focus on the involvement of a group of researchers from MIT Civil Engineering and Lincoln Laboratory in the Central Artery/Tunnel project. The MIT-Lincoln Laboratory involvement in CA/T confirms the importance of systems engineering in large technological projects as suggested by Thomas Kuhn, Donald MacKenzie, and Thomas Hughes. We present the motivations of these MIT researchers and Lincoln Laboratory engineers, as well as the technical, political, and social issues that had to be addressed before and during the MIT-Lincoln Laboratory involvement. After performing an analysis of these issues, it is our contention that this joint collaboration exemplifies the ideas of heterogeneous engineering and technological trajectories as presented by Donald MacKenzie in his seminal work *Inventing Accuracy*.

To begin our analysis, we first present a brief history of Lincoln Laboratory and the Intelligent Transportations Systems group at MIT in Section 2. We then, in Section 3, describe in detail the Microscopic Transportation Simulator (MITSIM), the most significant product developed from this venture. We continue with a discussion of the importance of heterogeneous engineering from a MacKenzian perspective in Section 4. Once we have laid this groundwork, we present in Section 5 an analysis of a two-level model of technological trajectories and look at the influence of both internal and external social, political, economic,

[1] http://www.bigdig.com/, Thomas P. Hughes, "Coping with Complexity: Central Artery and Tunnel," Rescuing Prometheus, (New York: Pantheon Books, 1998.)

Figure 1: Schematic Diagram of the CA/T Project

Figure 2: Stylized Diagram of the CA/T Project

and technological forces. Finally, in Section 6, we will re-iterate the importance of systems engineering in large technological projects in terms of their social, political, and economic impacts.

2 The MIT-Lincoln Laboratory Collaboration

Beginning in the early 1990's, Lincoln Laboratory and the Intelligent Transportation Systems (ITS) group of MIT's Civil Engineering Department collaborated in a joint effort to develop technologies for application in the Central Artery/Tunnel (CA/T) project. In this section, we present the story of these two groups, their motivation for collaboration, how they joined forces, and how they ultimately won their contract with CA/T.

2.1 Lincoln Laboratory

Lincoln Laboratory was founded in 1951 with the stated goal of applying, "science and advanced technology to critical problems of national security."[2] Throughout the Cold War, Lincoln Laboratory worked on projects for the United States Department of Defense. Continuing this tradition, in the early 1980s, under the increased military spending of the Reagan and Bush administrations, Lincoln Laboratory was able to secure funding for a large number of defense projects. In the late 1980s, however, the Cold War came to an end. The defense budget began to wane, and national defense research facilities like Lincoln Laboratory faced an uncertain future. According to Carl Much, the division director of the Control Systems Engineering Group at Lincoln Laboratory,

> During the Star Wars days of the 80's, with a lot of optical work, we had as many as 22 engineers [within our division] at that time. Then, with the taking down of the Berlin Wall and the drop-off in the interest in defense, the Lab, it's funding was a little tighter then. And, of course, we saw that coming. That's when we, as well as other groups in the lab, got interested in other work beyond the Department of Defense.[3]

Unfortunately, securing funding from non-military sectors was not easy. Lincoln Laboratory was founded as a Federally Funded Research and Development Center (FFRDC). As such, the federal government

[2] http://www.ll.mit.edu/
[3] Much Interview, 1999.

prohibited Lincoln Laboratory from competing with industry. Instead, FFRDCs were established for sole-source funding programs without any of the complicated and time-consuming bidding processes normally attendant with competitive bidding. As a result, when defense funding was reduced by the end of the 1980's, Lincoln Laboratory was inexperienced and unprepared for the process of obtaining funds through competitive bidding systems.

An additional problem facing Lincoln Laboratory in this new environment was competition from other FFRDCs also entering the non-military funding space. For example, prior to Lincoln Laboratory's involvement with CA/T, the Department of Transportation sponsored a similar contract for the management of the National Intelligent Transportation Systems effort. Despite the fact that Lincoln lacked any experience in large-scale project management, the overwhelming need for diversification drove Lincoln Laboratory to bid under the hope that, "well, this was what was being offered, and we'll try this to get started."[4] Tony Hotz, a Lincoln Laboratory engineer, remarked "we responded, as did JPL [Jet Propulsion Laboratory], as did other labs, and JPL won the contract."[5]

The fact that JPL, another FFRDC, won the contract points to the fact that Lincoln Laboratory could not simply rely on the notion that, "we are a government agency that has excellent skill in advanced areas," because they were not the only ones to fit that description. Indeed, numerous FFRDCs were by this time peddling various military technologies for non-military applications. Sergiu Luchian, from the Massachusetts Highway Authority, describes the "plethora of weird [people and products] coming in and offering their fares to us. I tremendously enjoyed the...transportation vocabulary they used, i.e. 'target acquisition'." Referring to an FFRDC which offered CA/T the ability to acquire 20,000 independent moving targets through a geostationary satellite, Luchian jokingly continues, "See that car speeding? You acquire the target and blow it up off the screen."[6]

To become competitive in this new market place, Lincoln Laboratory needed to refocus on private-sector applications of its core competencies. An example of this is the work of the Control Systems Engineering Group, under the leadership of Dr. Carl Much. Originally focused on designing and building feedback

[4]Hotz Interview, 1999.
[5]Ibid.
[6]Luchian Interview, 1999.

control and sensor systems, the group saw an opportunity in the developing area of Intelligent Vehicle Highway Systems (IVHS). According to Much, this was a natural extension of the work already being done at Lincoln Laboratory because, "if you're sensing vehicles on some city streets and then controlling the lights and other devices based on what you see there, that's a big feedback control system."[7]

The realization that ITS could play an important role in the future of Lincoln Laboratory, however, was not exclusive to Much's group. Rather, it was a concerted effort by the directors of Lincoln Laboratory to involve various groups within Lincoln Laboratory in ITS. According to Tony Hotz, a project manager within the Control Systems Engineering group,

> We got into ITS in the early 90's...a time when the lab had a very strong involvement with the FAA and air traffic control, and the director of the lab at the time, or the assistant director, felt that intelligent transportation systems was a natural thing to include in this FAA project or group...and so they asked several people in the lab to get involved in a study project to see if there indeed is a role that Lincoln can play.[8]

With a compelling need for diversification in funding sources, Lincoln Laboratory had an uncertain future. New non-military projects were needed to refocus the different divisions of Lincoln Laboratory. Yet, most private-sector projects were unavailable to Lincoln Laboratory due to FFRDC constraints. Soon, however, the Control Systems Engineering group at Lincoln Laboratory had an answer.

2.2 MIT

Around the same time, the Intelligent Transportation System group (ITS) in the MIT Civil Engineering Department faced a different problem from the ones faced by Lincoln Laboratory. Although funding was certainly an issue, as it is with most research institutions around the world, it was not the central concern. With the support of MIT, ITS was not in danger of extinction from lack of funds. Rather, the danger would come from lack of new projects.

The primary character driving the development of ITS at MIT was Professor Moshe Ben-Akiva. Beginning his career at MIT with a M.S. and Ph.D. in Civil Engineering, he had become interested in

[7]Much Interview, 1999.
[8]Hotz Interview, 1999.

the fields of dynamic traffic management and modeling by the late 1980's. The goal of dynamic traffic management is, "in real time to try to manage a network in the most efficient way to influence the supply side and the demand side."[9] With the goal of creating simulation tools for dynamic traffic management, Ben-Akiva launched the ITS program at MIT. With the launching of ITS, however, a need arose for real-world projects. Fortuitously, they would not need to look far, for CA/T was already underway in their own backyard.

2.3 The Collaboration

By the early 1990s, Lincoln Laboratory was facing a crisis with funding, and the newly formed Intelligent Transportation Systems group at MIT was searching for projects on which to work. It seemed clear that through collaboration, each group could achieve its own goals. But how did this relationship start, and why was it attractive to CA/T?

According to Carl Much at Lincoln Laboratory, "we got interested in this area and then we started to look at some of the literature. We saw the names of professors on campus were popping up in some of the reports and articles" including Professor Ben-Akiva. Much requested a meeting with several Civil Engineering professors at MIT. Eventually, ITS presented Lincoln Laboratory with seminars on ITS and its current projects. These talks and seminars, "just sort of blossomed into us and them talking about working together on something. We didn't know what at first."[10]

With the desire for collaboration, but without any idea about exactly what project they should focus their attention, Lincoln Laboratory formally joined the ITS venture and the team headed to Washington, DC, to present to the Federal Highway Administration (FHA). While the team proposed several projects, it soon became clear that the funding structure created by the FHA would preclude the involvement of Lincoln Laboratory. According to Much, this discovery "was kind of a bummer."[11]

ITS, however, was not discouraged for long. Instead, they refocused on finding ways around the bureaucratic regulations. The team soon began conversations with people involved in CA/T and discovered

[9] Ben-Akiva Interview, 1999.
[10] Much Interview, 1999.
[11] Ibid.

that the project was being overseen by the management team Bechtel & Parsons-Brinckerhoff (hereafter referred to as "Bechtel"). This firm, which controlled much of the project's funding, provided an important layer between the federal government and ITS. By negotiating with Bechtel, ITS could eventually secure direct funding. In time, the ITS group approached Bechtel and its client, the Massachusetts Highway Authority. Project engineer Sergiu Luchian of the Massachusetts Highway Authority recalls that,

> I was approached in 1991 by Tom Humphrey, who was director of Transportation Studies at MIT...He said "we can do some research. We can develop, as a research program, a traffic simulator...We would like some funding, we would like some real-life applications, and would you like to participate with that." I thought it was a good idea...[testing the devices and logic control design] on the MIT simulator before we even took the design and purchased the component and installed them [was] very advantageous on our side.[12]

After meeting with the ITS, Luchian went to the Research Board and Project Director at Bechtel and convinced them that adding ITS to the CA/T project would be beneficial. Bechtel agreed. ITS had finally achieved the funding and the project that they needed.

2.4 The Contract

Initially, the contract between Bechtel and ITS focused on three distinct areas: (1) sensor technologies, (2) human factors, and (3) dynamic traffic simulation and traffic management strategies. Within the human factors project, Professor Tom Sheridan of MIT's Mechanical Engineering department would eventually provide the expertise. Human factors becomes important in the control centers of CA/T, which collect sensor information from across the CA/T network. Eventually, the human factors research would focus on how to effectively display and parse complex sets of information to the human monitors who facilitate decision making in the control centers.

In contrast, the dynamic traffic simulations program grew naturally out of existing work at ITS. Since its inception, much of the effort at ITS had been focused on developing traffic simulations as an important tool for Intelligent Transportation Systems in general. This effort grew into the Microscopic Transportation

[12] Luchian Interview, 1999.

Simulator (MITSIM), which would eventually become the core of the ITS contract with CA/T.

3 MITSIM

3.1 Background

While the MIcroscopic Transportation SIMulator (MITSIM) eventually became a key component of the ITS-CA/T collaboration, its origins far predated this effort. Initially proposed to Professor Ben-Akiva in the early 1990s, MITSIM was the brainchild of graduate student Qi Yang, who proposed the creation of a traffic simulator as a way to fulfill his Master's thesis requirement. Yang's project, "A Microscopic Traffic Simulation Model for IVHS Applications," complemented the overall ITS effort by providing an in-house simulation tool that could be used to evaluate pre-existing transportation management strategies and algorithms.

3.2 Microscopic vs. Macroscopic Simulators

Prior to MITSIM, most traffic simulators modeled macroscopic relationships and laws of conservation, simulating homogeneous flows of bulk traffic volume through road networks. To make the analogy with fluid dynamics, macroscopic simulators are akin to analyzing the bulk flow of fluids through pipe networks. Traffic dynamics are derived from conservation laws, which equate the total volume of vehicles entering a network segment with the total volume of vehicles leaving the network segment. These networks, however, were often, "analyzed in a vacuum, without regard for the interactions between the components."[13]

In contrast, microscopic simulators attempt to model the dynamic interactions between each and every vehicle in a road network by modeling individual driver behaviors. Rather than looking at bulk fluid flow, therefore, microscopic simulators attempt to model the dynamics of each fluid particle. Indeed, it is common knowledge that driver behavior characteristics vary widely both between individual drivers as well as between geographic locations. This can especially be observed in Boston, with its national reputation for bad driving. The Boston Globe classifies local drivers as "far from being undifferentiated molecules. Some are grandparents. Some are cabbies. Some are truckers. And altogether too many are lane-hopping,

[13]Kenneth R. Howard, "Unjamming Traffic with Computers," Scientific American, October 1997.

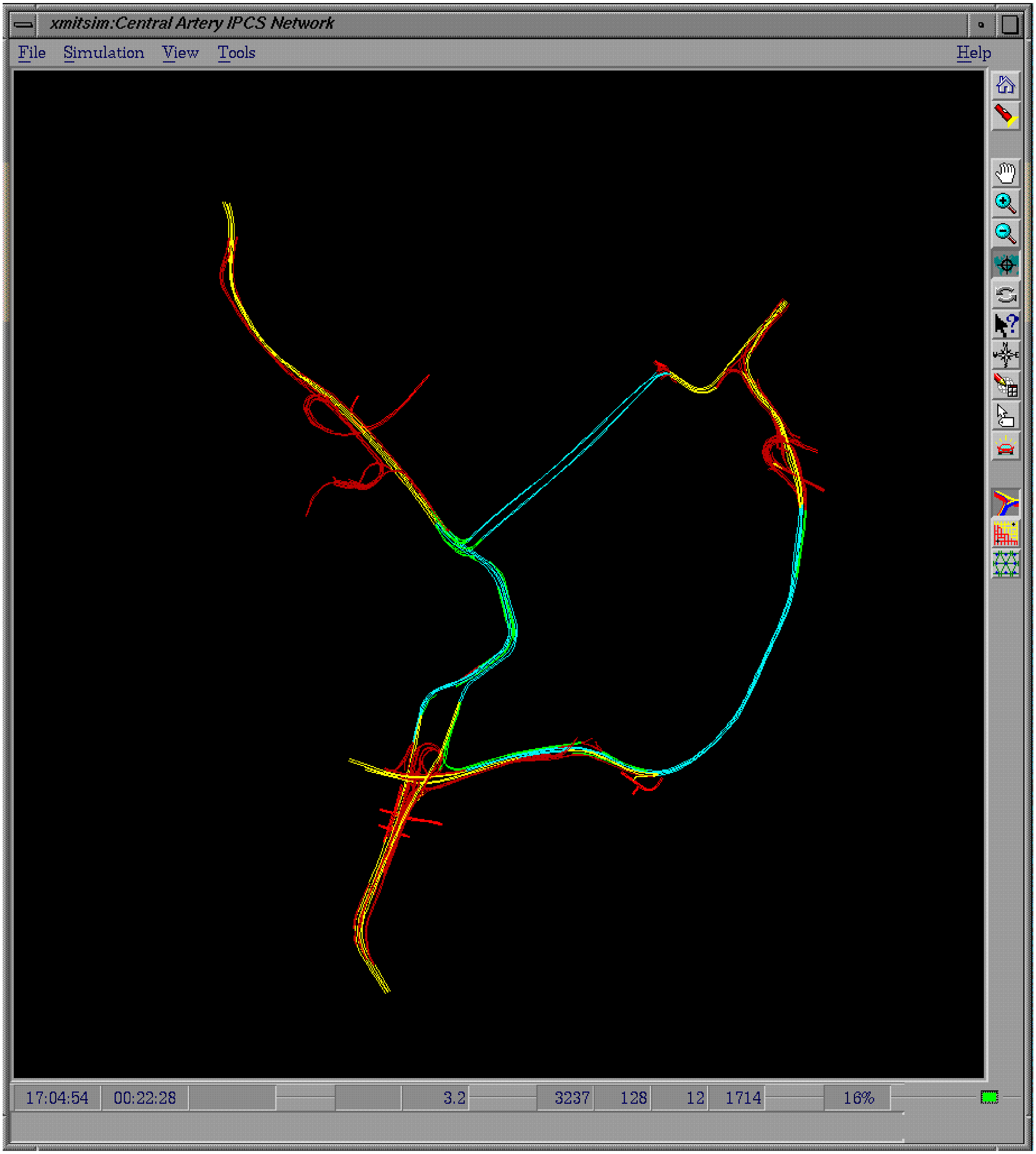


Figure 3: CA/T Road Network in MITSIM.

finger-flipping, stoplight-running, tailgating speeders."[14] Because MITSIM and microscopic simulators in general can model individual driver behaviors, they can simulate a larger variety of traffic situations than macroscopic simulators, which was a key selling point for CA/T.

To implement individual driver behaviors within MITSIM, each vehicle is assigned a specific origin and destination location. The dynamics with which a particular vehicle travels from origin to destination is then determined by the driver's "personality" as quantified by six key statistics: acceleration rate, deceleration rate, desired speed, reaction time, car following behavior, and lane changing behavior. Every vehicle in the simulation is assigned a set of behaviors based on a Gaussian probability distribution function for each statistic. The mean and standard deviation for these Gaussian curves are then determined by analyzing video-recorded images of Boston traffic. Figure 4 displays a typical CA/T traffic network along with the individually modeled vehicles.

3.3 Traffic Management Strategies

In addition, MITSIM is also capable of simulating the effectiveness of various traffic management controls on different types of driver personalities. These controls include ramp metering, variable-message signs, lane-use signs, variable-speed limit signs, toll plazas, and traffic signals. Indeed, this capability was extremely important to CA/T as the completed highway system will include the world's first large-scale implementation of traffic management strategies. Figure 5 displays one particular road network implementing both lane-use signs and traffic sensors. By implementing these controls in MITSIM, engineers can manipulate these management variables to determine the optimal scheme for managing traffic inefficiencies in real time. For example, upon detection of a vehicular breakdown, traffic engineers can mitigate the ensuing congestion by closing certain lanes via local lane-use signs to smoothly and efficiently divert traffic away from the incident.

Indeed, one specific lesson learned from MITSIM was the correct timing of variable lane-use signs during vehicular accidents. Upon incidents like vehicular accidents, affected road lanes are typically closed via variable lane-use signs. MITSIM demonstrated, however, that if the affected lane is prematurely reopened, a traffic bottleneck will ensue as new cars rush in to meet previously congested traffic. Rather, traffic

[14] The Boston Globe, Jan. 21, 19996.

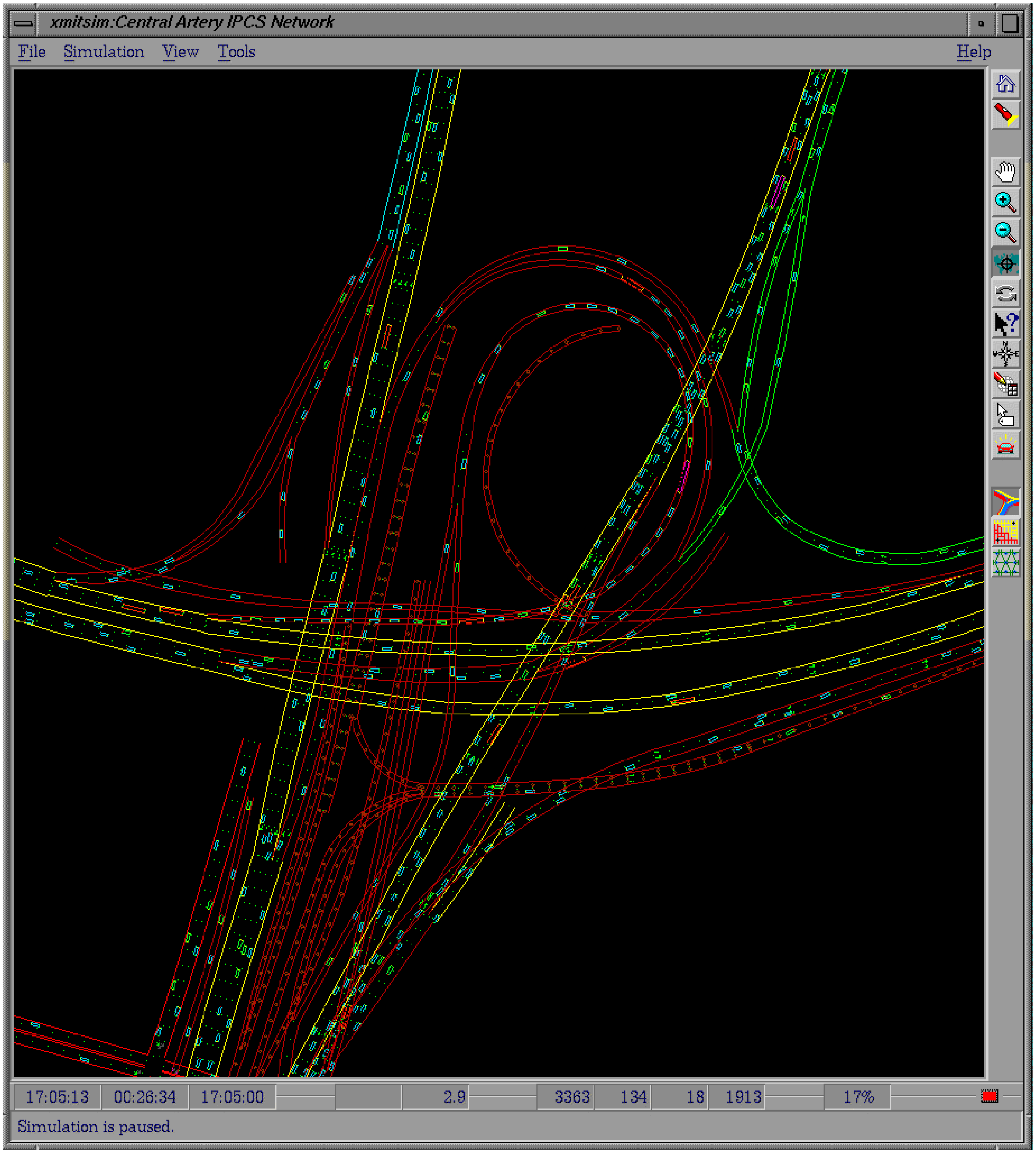
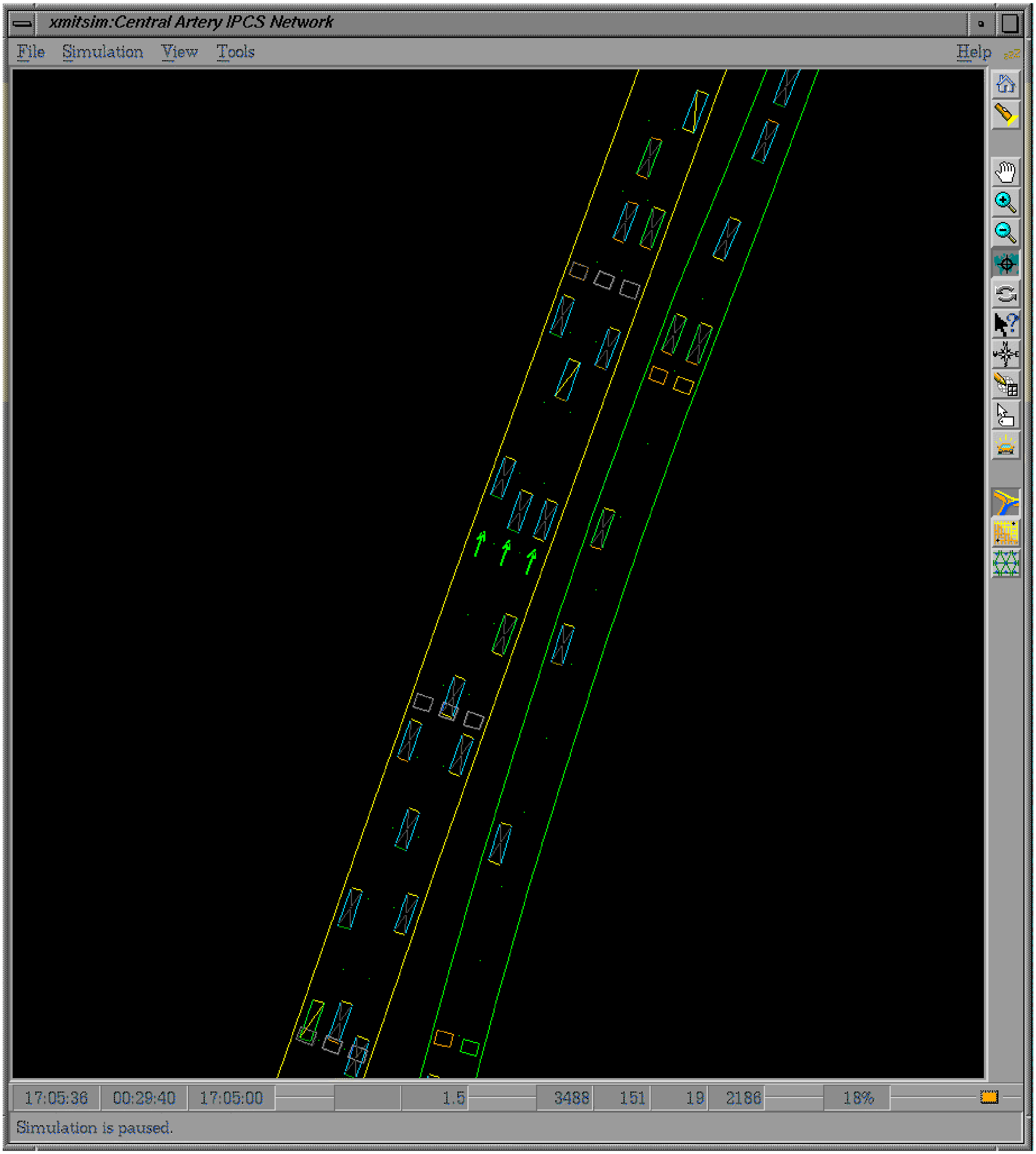


Figure 4: Microscopic Simulation Capabilities of MITSIM.



The three green arrows represent permitted lane use. The groups of three squares across the lanes represent traffic sensors.

Figure 5: Traffic Management Tools within MITSIM

management strategies must first dissipate the previous congestion before allowing new vehicles into the affected lane. As Professor Ben-Akiva summarizes, MITSIM teaches us, "to alleviate traffic congestion by designing a physical system that guides drivers toward better choices."[15]

4 Heterogeneous Engineering

The ITS collaboration with CA/T would not have been possible, however, without the efforts of project managers such as Tony Hotz, a member of the Control Systems Engineering group at Lincoln Laboratory. Responsible for the day-to-day management of ITS, Hotz exemplifies heterogeneous engineering as presented in Donald MacKenzie's work *Inventing Accuracy*. According to MacKenzie, a heterogeneous engineer is someone who is not only skilled in a technical field, but also able to manage the political and social qualities that surround an engineering project. Furthermore, as MacKenzie argues, there are several key attributes that define successful heterogeneous engineers. These include the ability to manage diverse peoples and personalities, the ability to shield information and people within black boxes, and the ability to sell. In addition to these attributes, however, the ITS and Bechtel venture demonstrates that in practical engineering projects, there are often two additional factors: (1) an evolution in the people that assume the role of heterogeneous engineer and (2) the personal sacrifice that each makes upon their assumption of this role.

4.1 Managing People

One of the most important skills required by Heterogeneous Engineers is the ability to manage a diverse spectrum of people and personalities. A summary of this spectrum is displayed in Figure 6. For example, in *Inventing Accuracy*, MacKenzie describes at length Doc Draper's people skills. Not only did he manage and oversee the technical efforts of his laboratory, but he also created and nurtured effective relationships with government and military officials. Working with technicians, engineers, support staff, politicians, and generals, his ability to focus on all aspects of a project coupled with his ability to hide the internal workings of each of the two spheres from the eyes of the other, resulted in a hugely successful outcome despite the

[15]Ibid.

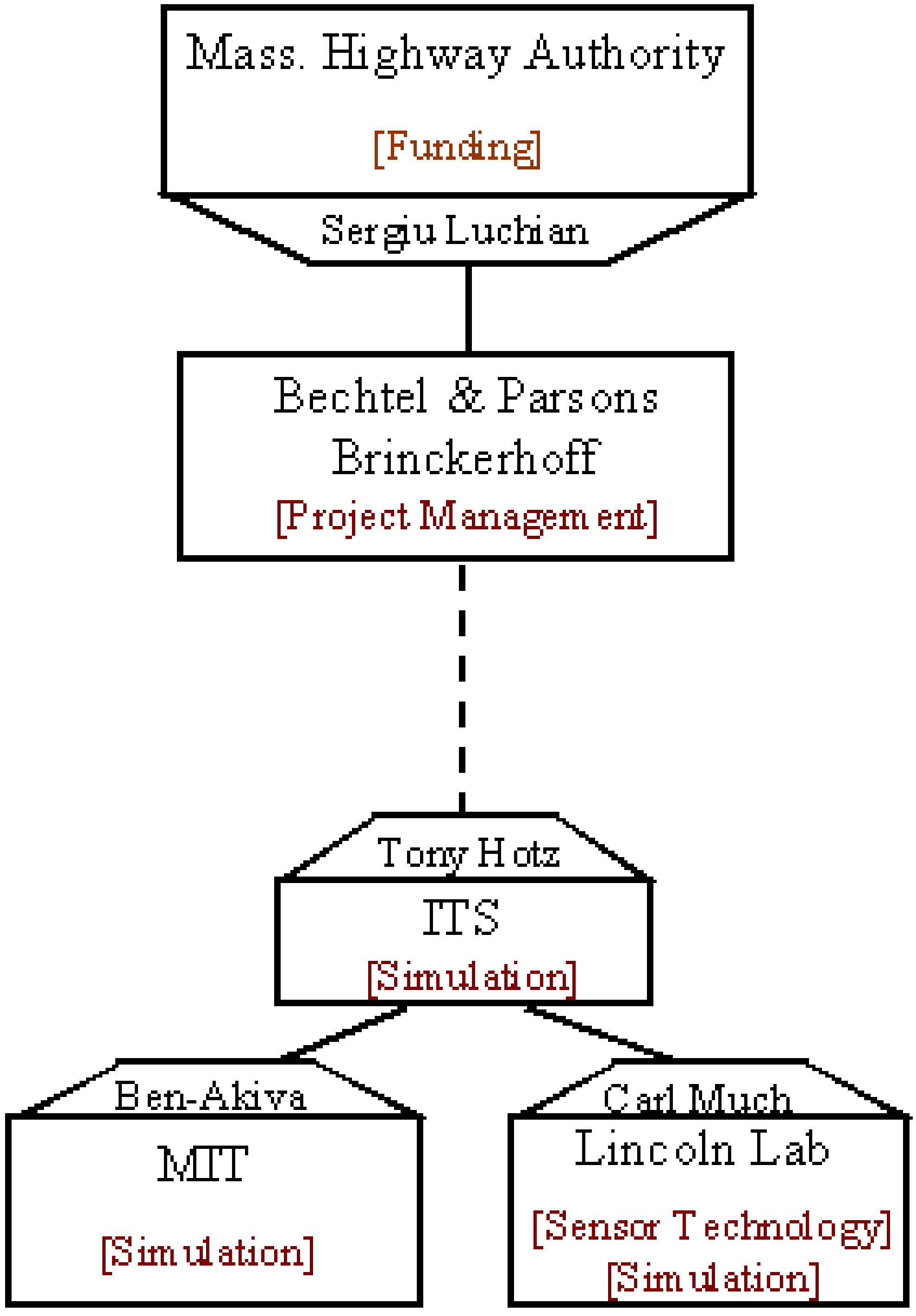


Figure 6: Relationships of Major Parties Involved

often-conflicting agendas set by each of the major players. In the case of CA/T, these same people skills can be seen in the work of Tony Hotz. As Tony describes,

> When you're managing a project, you realize that you're not just managing technology or a program, but you're managing people, and when you're managing people, you're not just managing technical expertise. Everyone has a different agenda. Everyone needs a different emotional support, intellectual support ... The technical stuff is actually quite easy. Dealing with the personalities and the human aspect in projects like this are as important as dealing with all of the technical aspects. And this goes all the way to the level of the faculty. You have to know how much they want to know, what they want to know, and what they don't want to be burdened with.[16]

Along with the management of divergent personalities, however, is the management of divergent goals and agendas held by those personalities. In Draper Laboratory, Doc Draper had to manage a number of divergent interests held by the various branches of the United States military, the manufacturing contractors, and the academic gyroculture, each of whom held different underlying motivations for the advancement of gyroscopic technologies. In this environment, the success of Doc Draper can largely be attributed to his ability to manage all of these divergent interests by convincing each party of a unified goal.

Similarly, in the case of CA/T, Tony Hotz successfully managed the divergent interests of MIT, Lincoln Laboratory, and Bechtel. As Tony Hotz explained,

> While the goal of the people at ITS was to build a simulator, that of [Bechtel] was to evaluate traffic control strategies, and further down the goal of the students working on the simulator was to get a degree, and sometimes that work is different from the work that we needed to get done and hence sometimes they found it difficult to separate what they needed to do for the project and what they needed to do to get their degrees, as also was the problem with the staff at MIT which was more interested with publications and doing theoretical things which was not what they needed to do for the project.

The long-term effects of these differences in priority will be further discussed in Section 5. The short-term effects, however, manifested themselves in numerous day-to-day management challenges. For example, because graduate students were often focused on completing their theses rather than producing reports for

[16] Hotz Interview, 1999

Bechtel, they often modified MITSIM in order to test various algorithmic optimizations and changes. As Tony Hotz explains, however,

> If you're trying to use a tool to evaluate a project and the tool is constantly being changed, you can never guarantee that the tool you're using today is the same one you were using yesterday. You may get very different results. So managing that turned out to be very difficult. Even though we tried very hard to put things in place. We had version control software in place called Clearcase. Students were suppose to check software in and out. But many students bypassed this because at the time, it was inconvenient. So that became a problem.[17]

4.2 Creating Black Boxes

Critical to the success of managing and bridging the gap between these divergent interests, however, was Hotz's ability to create and maintain black boxes around the individual activities of Bechtel and the ITS collaboration. In *Inventing Accuracy*, MacKenzie defines the metaphorical "black box" as, "a technical artifact – or more loosely, any process or program – that is regarded as just performing its function without any need for, or perhaps any possibly of, awareness of its internal workings on the part of the user."[18]

In the case of CA/T, Hotz explains that, "most of [the communication between Bechtel and ITS] was through me. It became very evident that you really needed someone to manage the project overall, day-to-day. [Professor] Moshe [Ben-Akiva] didn't want to get involved in the day-to-day details."[19] Indeed, the extent to which Hotz shielded the politics of Bechtel from researchers within the ITS-Lincoln Laboratory venture was so complete that Professor Ben-Akiva explains,

> There are a lot of controversial issues at CA/T but not for us. No our mission is very simple, very clear. We don't want to get involved with it and as I said I always had a person who was a liaison with CA/T for day-to-day contacts so I was never involved with them and certainly not the students.[20]

[17] Hotz Interview, 1999
[18] Donald MacKenzie, *Inventing Accuracy,* MIT Press, 1990, p. 26.
[19] Hotz Interview, 1999.
[20] Ben-Akiva Interview, 1999.

4.3 The Ability to Sell

Equally important to the management of such a joint venture is the ability to sell the venture to others. Doc Draper achieved this through his famous Doc Dollar bills and the contacts he built through graduates of the MIT Aeronautical Engineering Department. Like Doc Draper, a primary function that consumed Hotz in his role as heterogeneous engineer was the incessant need to sell the capabilities of ITS to Bechtel. Hotz explained that,

> We would always sell the different capabilities of the simulator. I don't know how many demonstrations we had on the different aspects of the simulator where we would invite a ton of people from the different organizations from the Mass Port to Mass Turnpike and the state and Bechtel to come over.[21]

Some of the strategies that Doc Draper used to sell Draper Laboratories included populating the military ranks with Draper graduates to bias those on the other side of the black box. Similarly, some of the strategies that Hotz used to sell MITSIM included populating the buy side with a sympathetic audience. As he explains,

> Most of the people that we have presentations with were a combination of people with whom we had solid relations with. They knew our work. We were working directly with them so they had a lot of knowledge on what our capabilities were. On top of that you would add in people that you had never seen before but were in a high positions. It was usually not a case where we would talk to a group of people that were completely cold. Those were very difficult sells. Our approach was always to blend the two.[22]

Yet, not only did Hotz need to sell the capabilities of ITS to Bechtel, but he also had to sell the ITS collaboration to MIT. Hotz explains that,

> If you needed to get a professor involved and some of his students, you would ask to have a meeting with them, and they would decide whether this is something that I want to spend my time on or would I rather pursue funding from another resource. Is this in mind with the kind of research that I'm doing, do I have any students that I can use on a project on this, and would I supervise? So it's always a sell, on both sides.[23]

[21] Hotz Interview, 1999.
[22] Ibid.
[23] Ibid.

The need to sell the ITS collaboration was therefore a two-edged sword that Tony Hotz was able to successfully wield.

4.4 Building Trust

Part of the reason that Hotz successfully wielded this sword was due to his ability to foster trust among those with whom he interacted. In the case of Draper's Laboratory, Doc Draper was ultimately able to sell the capabilities of his research to the United States military by the strength of his past accomplishments and his ability to deliver results. In essence, his clients were able to trust his word. Similarly, in the CA/T venture, Hotz was ultimately able to sell the capabilities of ITS to both MIT and Bechtel by fostering a sense of genuine trust. As he explains, "A lot of this was based on the fact that they felt that they could trust us. We weren't doing anything covert. We were there when they needed us. When they needed us to go to a meeting, someone was there. If they requested that we do something, we did it. Our results were good."[24] Likewise, Sergiu Luchian, the project engineer in charge of CA/T for the Massachusetts Highway Authority reiterates, "Tony's reputation? I like him a lot. I think he was a very competent, very good professional. I never had a disappointment in MIT and what they did."[25]

4.5 Multiple Heterogeneous Engineers

One important difference between this project and Doc Draper's Laboratory, however, is the number of heterogeneous engineers involved. As the head of the Draper Laboratory, Draper can be singled out as *the* heterogeneous engineer. Although there were likely other heterogeneous engineers working within Draper Laboratory, their importance is dwarfed by that of Draper.

In the ITS-CA/T project, however, the person assuming the role of the heterogeneous engineer changed over time. First, Tony Hotz filled the role for the first couple of years before returning to Lincoln Laboratory. His role was then filled by Alan Chachich, another ITS engineer originally from Lincoln Laboratory. Later, as funding diminished, Alan Chachich voluntarily left ITS as head of the project, remaining

[24] Ibid.
[25] Luchian Interview, 1999.

on as a consultant.

While it is remarkable that the ITS-Bechtel collaboration continued successfully throughout these changes in leadership, their success only points to the skill of heterogeneous engineers in project management. Furthermore, the fact that such changes in personnel occurred only points to the sensitivity of leadership roles to the vicissitudes of modern politics and economics.

4.6 Personal Sacrifice

What MacKenzie and others often fail to discuss are the personal sacrifices that accompany the role of the heterogeneous engineer. For example, heterogeneous engineers are oftentimes derived from technical backgrounds. Certainly MacKenzie's Doc Draper ascended to the role of heterogeneous engineer from technical venues. Likewise, ITS's Tony Hotz was originally a theorist in Applied Mathematics and Control Systems theory while Alan Chachich was originally a theorist in plasma physics. Unfortunately, however, donning the role of heterogeneous engineer is typically a lasting one-way street. Relinquishing this role is oftentimes more difficult than accepting. As Tony Hotz explains,

> Before I went into this, I was pretty much a control theorist and I had to put that all on hold for 3 years, and as I come back, I have a lot of catching up to do. But trying to cram 4 years back in is a difficult thing to do. So it depends on what your goal is, if my goal was to get into management, then it was a perfect thing to do. But if my goal was to stay a technologist, then it wasn't a very good thing to do. There were benefits on both sides. But there were things about it that weren't so great. If I had to do it all over again, [I'd do] part of it.[26]

Carl Much, division director of the Control Systems Engineering Group at Lincoln Laboratory adds that accepting the role of heterogeneous engineer is,

> a real handicap to doing some good work. Tony's spent probably most of his time on administrative stuff, garbage you might say, more than half his time was in administrative quagmire instead of theoretical or technical stuff.[27]

[26] Hotz Interview, 1999.
[27] Much Interview, 1999.

5 Shifting Technological Foci/Trajectories

In the course of most engineering projects, priorities and technologies naturally shift and evolve through time, with certain engineering technologies and processes being adopted while others are dropped. Thomas Kuhn modeled these shifts in priorities and technologies as shifts in paradigms catalyzed by scientific revolutions. In contrast, Donald Mackenzie modeled these shifts as changes in technological trajectories. For example, in the case of Draper's laboratory, advances in gas bearing technologies eventually forced Draper's research staff to eliminate their program in ball bearings in favor for redirected research into gas bearings. In looking at CA/T, however, we can also see elements of both Kuhn and Mackenzie in play. Moreover, in this particular story of MIT and Lincoln Laboratory, these shifts in priorities and technologies appear to work on two distinct levels. On one level, we will examine how various organizations with different interests, goals, and agendas can influence the technological trajectory of a single project. Following this, we will examine on a higher level, the interplay and evolution of the various projects within ITS and how each of these project's trajectories reacted to political and economic influences.

5.1 CA/T's Influence on MITSIM's Technological Trajectory

While Bechtel funding allowed students and researchers to develop better algorithms and interfaces to MITSIM, it also allowed Bechtel to drive the capabilities of MITSIM toward certain directions. One such direction was the incorporation of electronic toll plazas into MITSIM, which gave Bechtel the much needed and critical ability to determine both the placement and the relative numbers of manual versus electronic toll plazas within the CA/T network. Another such direction was the development of MITSIM for laptop PC's, which would have allowed Bechtel to independently run simulations without relying on ITS. While this direction was never fully implemented, possibly due to intellectual property and licensing rights, Bechtel was able to direct ITS's attention and human resources toward this direction.

On the other side of this coin, moreover, Bechtel was also able to eliminate certain capabilities from MITSIM through budget cuts. As Alan Chachich explains,

> When we originally did the simulator, and planned it and all that, there

> was a whole bunch of things in the work plan. And the artery's been cutting money all along. They come back after they'd signed it and want to chop $50,000 out of it. And the whole time, whatever money we thought we had to work with for whatever period it was, every seven months they were coming back and saying, you've got to reduce it, you've got to cut something out because they were under such pressure ... So there were a lot of capabilities that we had planned on doing that we had to drop.[28]

For example, one of the original capabilities planned into MITSIM by ITS was the ability to model carbon monoxide emissions from each car. By modeling emission rates, which are dependant on car acceleration and deceleration rates, ITS had hoped to reduce CO emissions through the effective use of traffic management strategies. Indeed, this is especially important for CA/T which contain numerous tunnels that must meet stringent federal regulations for environmental conditions. Unfortunately, however, emissions modeling capabilities were eventually removed by Bechtel due to budget restrictions.

Other areas that were desired by ITS but eventually eliminated include both local street modeling and ramp metering. Currently, MITSIM only models the major interstate roadways associated with CA/T. Local neighborhood roads are not modeled. Likewise, ramp metering, which is a management strategy of placing controlled traffic lights on on-ramps to better direct merging traffic with throughfare traffic, was also eliminated. Yet, before it was discontinued, Masroor Hasan, a Ph.D. candidate in ITS, had already finished nearly half of his thesis on this topic. Having already made considerable progress, Masroor chose to complete his thesis in ramp metering while at the same time implementing other features for CA/T in order to meet the contractual agreements for funding. This episode demonstrates, therefore, the need to balance the divergent goals of the parties involved. Students had to struggle to complete their thesis work even while facing the changing needs of Bechtel. As Alan Chachich summarizes,

> There was a faction there that wanted ramp metering. There was another faction that didn't want it. And so the circumstances we were working in kept changing. So, we were working on ramp metering. So, Masroor, you get him going on ramp metering, and all of the sudden, the project decides it's not going to do ramp metering. This is one of the cultural differences I said. MIT was not a contractor. And Bechtel wants to treat us as a contractor. So there's a constant tension.[29]

[28] Chachich Interview, 1999.
[29] Ibid.

5.2 ITS Project Trajectories

On a higher level, however, we may also analyze the impact of changing technological trajectories on the various programs within ITS as a whole. Initially, ITS was charged with three programs that leveraged MIT's and Lincoln Laboratory's expertise in sensor technologies, human factors and dynamic simulations (MITSIM). As the relationship between ITS and Bechtel matured, however, the technological charge of ITS shifted away from sensor technologies and human factors and toward dynamic modeling (MITSIM). As Hotz explained, "sensor technologies was probably the first [project] to be pushed to the wayside. I think that funding was getting a little tight, so they wanted to channel their resources into an area in which they thought would most benefit them."[30] Similarly, the human factors program was also marginalized over time. In contrast, however, the importance of MITSIM only increased with time. As Hotz explained,

> Ultimately, as is the case with most of these things, as we evolve, they discover what we can really do to help them, and it became clear that our primary support eventually would be modeling, dynamical modeling. Developing a very large scale simulation capability for them so they could test a lot of the traffic management strategies that they had envisioned. At that time, there were other simulators available, but they really weren't designed to accommodate the kinds of problems that they had. They were mostly designed to accommodate very different and specific kinds of problems.[31]

Figure 7 summarizes the evolution of ITS's initial contracts with Bechtel. To understand these shifts in priority, however, we must first examine the underlying political and economic currents that either carried or marginalized these programs.

5.2.1 The Decline of Sensor Technologies and Human Factors

From the onset, there were three fundamental forces marginalizing the sensor technologies program. First, there was a fundamental difference in the expectations of ITS held by ITS and Bechtel. While ITS was interested in creating and experimenting with novel state-of-the-art sensor technologies, Bechtel was only interested in correctly implementing existing off-the-shelf sensor technologies. As Carl Much explains, ITS believed that,

[30] Hotz Interview, 1999.
[31] Ibid.

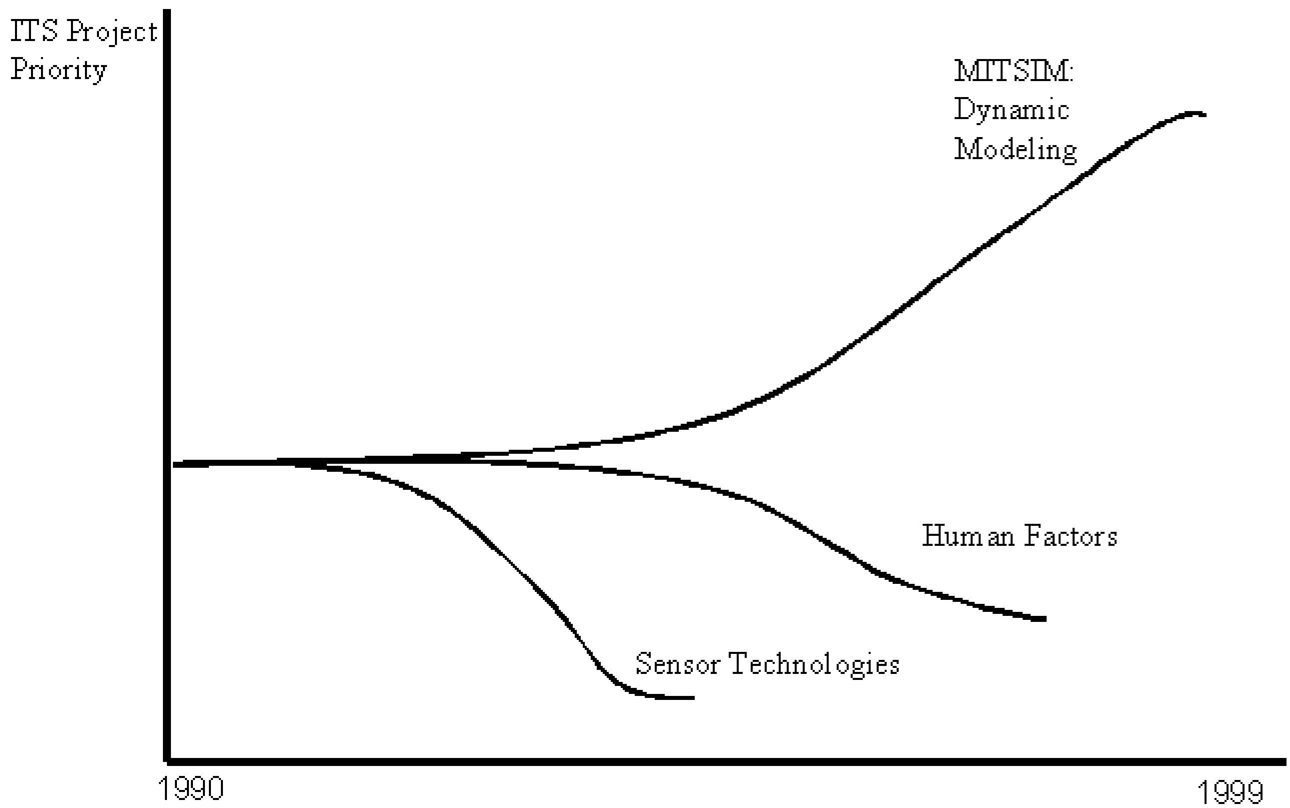


Figure 7: ITS Project Trajectories

> because CA/T is still always from being implemented, it was time to do some upfront R&D to come up with some experience on new things that might really work well there, but that just never resonated with [Bechtel].The whole intelligent transportation systems society was always saying "We're not inventing new technology here, we're just applying existing technology to a new application." See, and that's quite different than what we do here at Lincoln with DoD, we're inventing new technology to be applied in the future. So philosophically, this was a pretty big mismatch. As we came to learn this, that became kind of a big disappointment to us.[32]

In addition to mismatches in expectations, however, there was also a fundamental non-uniqueness of ITS's sensor expertise. Indeed, ITS was not the only contractor with expertise in sensor technologies or human factors. Bechtel themselves, employed engineers with extensive sensor design experience. As Professor Ben-Akiva elaborates, "human factors and incident detection [a.k.a sensor technologies] fell out of favor because of internal competition [with Bechtel]. [Bechtel] had technology groups. They had human factors people but they did not have MITSIM. MITSIM provided a tool that nobody had."[33] Over time, therefore, Bechtel began to reevaluate this redundancy in expertise and the real value that the ITS sensor technologies program could bring to the table.

Finally, compounding these two factors was the fact that, as the cost of CA/T ballooned to over $12 billion, political pressure mounted from both grass-roots organizations and the Senate floor to eliminate any non-essential research programs. Cost containment projects encouraged "penny-wise, pound-foolish" policies that would short numerous projects with future potential but of no immediate value. As Luchian explains, "At some point, about six years ago, we stopped design. For us, to look again at new [sensor] technologies, I mean it makes sense, but to change specifications mid-stream, would cost zillions, because the programs are already awarded. So, at some point, we had to cut it."[34] The end-result of these three factors would eventually be the marginalization of the sensor technologies and human factors programs.

5.2.2 The Rise of MITSIM

In contrast, MITSIM witnessed a vastly different developmental curve due to two primary reasons: (1) its potential ability to reduce capital expenditures and (2) its ability to provide construction-stage mitigation

[32]Much Interview, 1999

[33]Ben-Akiva Interview, 1999.

[34]Luchian Interview, 1999.

modeling.

In examining the role of MITSIM, Bechtel quickly realized that of all of the projects initially charged to ITS, MITSIM was the only project that dealt specifically with reducing capital expenditures. In contrast, both the sensor technologies project and the human factors program were concerned with implementing technologies or algorithms at a capital cost. Indeed, one of the main motivations for the marginalization of sensor technologies was the high capital expense that it would have incurred. In contrast, MITSIM provided Bechtel with an inexpensive software laboratory from which it could test various sensor types and location placements before any actual and expensive implementation. Bechtel would be able to determine the ideal characteristics of their sensors before these expensive sensors were purchased. In the eyes of Bechtel, therefore, MITSIM represented an ideal opportunity for cost-control. As Sergiu Luchian, managing engineer at the Massachusetts Highway Authority explains,

> I realized that it (MITSIM) was going to very useful very early, because otherwise I wouldn't have proposed it even as a research program, because we are pretty tight with money. I realized that it was going to be very useful when I saw how fast it was going to be turned into a [cost-saving] tool. I was impressed. I was really impressed. And from there on, when we made a clear decision, that it was going to be a tool, let's introduce it as a tool in our design, it was going to be very useful.[35]

Yet, MITSIM provided not only an economic motivation to Bechtel, but also a political motivation. In the original design phases of CA/T, one of the universally agreed-upon prerequisites for support was the fact that there would be no loss of jobs, homes, or commercial businesses as a result of CA/T. In part, this sentiment was the repercussion of previous Massachusetts highway projects that had proposed to bulldoze numerous local homes and businesses for the sake of improving area transportation. For example, in the case of the Inner Beltway Project, the predecessor of the CA/T Project, former Massachusetts Secretary of Transportation Fred Salvucci explains, "A lot of the reason for opposing the Inner Belt was that it was very destructive. It would have knocked out 2000 dwelling units within Cambridge alone, 3000 jobs. You know, pretty massive environmental impact."[36] By the end of the 1980's, therefore, a significant portion of the

[35]Ibid.
[36]Salvucci Interview, 1999.

CA/T budget would be earmarked for mitigation efforts to preserve the existing quality of life. As Salvucci explains,

> The depression of the Artery didn't involve the taking of a single residence, practically no jobs. The few jobs that were taken were government jobs that are inherently relocated within the region, so the region didn't lose a singe housing unit and didn't lose a single job. So the negative reasons for opposing the Inner Belt simply weren't present with the Artery project or, for that matter, with the tunnel.[37]

While the end result of CA/T was designed with these mitigation factors in mind, however, Bechtel had no way of guaranteeing that the actual construction stages of CA/T would also be benign. Indeed, during the actual construction phases, temporary construction measures such as temporary on and off-ramps, temporary roadblocks, and temporary roadway diversions would have to be constructed to manage traffic during construction. Yet, Bechtel could not model the effects of these in-situ construction measures on local traffic patterns. As Tony Hotz elaborates,

> it was uncertain for [Bechtel] what impact certain offramps would have in certain locations. If they changed certain roadway structures in certain locations, what impact that would have. So this is what they focused our energy in, in developing this capability in our simulators. It turned out to be quite beneficial to them[38]

Even though MITSIM could not explicitly model local roadways, it could model on and off-ramps, which are the interfaces between local neighborhood networks and the CA/T network. By modeling traffic patterns on these temporary on and off-ramps, MITSIM could predict what effects, if any, temporary construction measures would have on local traffic. In effect, MITSIM complemented Bechtel's long-term mitigation efforts with short-term construction stage mitigation modeling. The capabilities uniquely provided by MITSIM, therefore, were instrumental in validating the political and economic promises made by CA/T to the state of Massachusetts.

Throughout the ITS-Bechtel collaboration, therefore, shifts in paradigms or changes in technological trajectories may be influenced by factors political, social, and economic as well as technological. If we apply

[37] Ibid.
[38] Hotz Interview, 1999.

the lessons learned from this collaboration to the theory of Kuhn, however, then the implicit conclusion is that paradigmatic shifts, whether in science or in engineering, can be caused not only by anomalies arising from the practice of normal engineering and science, but also from political, social, and economic demands. Whereas Kuhn believed that scientific revolutions arise only from scientific anomalies, therefore, the ITS-Bechtel collaboration extends his theories to suggest the possibility that revolutions in scientific and engineering paradigms may also arise from the political, economic, and social sectors. Paradigmatic revolutions, therefore, may be much more responsive to economic and political concerns than previously believed.

6 Conclusions

As MIT's involvement with CA/T through ITS is terminating at the end of December 1999, we can shed some light on the future direction of ITS. Sergiu Luchian has made some Swedish contacts pushing for the support of MITSIM in the evaluation of the traffic systems in Sweden. MITSIM continues to be developed and used for other traffic schemes around the United States. Alan Chachich currently consults for ITS, working on proposals to help MITSIM gain more recognition. After the completion of his PhD at MIT, Qi Yang is now an academic at the University of Washington. The successful ITS program at MIT, still under the direction of Professor Ben-Akiva, serves as a template for other universities to follow, developing applications and working with other organizations in large, complex engineering projects.

This paper illustrates some important points that confirm the importance of systems engineering in large technological projects in terms of social, political, and economic impacts. We have seen the need for heterogeneous engineering and several of the difficulties heterogeneous engineers face. The most enlightening aspect of heterogeneous engineering gleamed from this project is the sense of personal sacrifice among the various leaders involved in the CA/T project. In addition, the existence of multiple heterogeneous engineers and the difficulties they faced supplements the ideas presented in MacKenzie's work.

We have also seen the effects of divergent goals and how technological trajectories are very much influenced by the political and economic aspects. Technological trajectories by no means "natural." For example, Lincoln Laboratory wanted to go way just implementation, but the glacial bureaucracy wanted to do things that had already been tried and true. Subsequently, Lincoln Laboratory was not able to continue researching and developing in the field of sensor technology.

Lastly, the financial constraints heavily influenced ITS and the development of MITSIM. The enormity of the CA/T project requires proper financial management. As inflation rates and costs gradually increased over the years, certain things had to be scaled back. Budget cuts did hamper certain additions to MITSIM, but ITS and MITSIM would not have developed and thrived without help from CA/T. The MIT-Lincoln Laboratory collaboration and contribution to the CA/T project turned out be a win-win situation for all those involved.

7 Appendix A

7.1 Interview with Moshe Ben-Akiva

Serena Chan, Ming Maa, and Saurabh Khemka Thursday November 4, 1999

MING: I think we want to start off by giving you sort of a background about what we are trying to do, the project we are doing is trying to look at a holistic view of a project sort of how social, economic, political factors play out in a technological project and see the interrelationships between these different types of players, so that's kind of the framework we are looking at and we decided to do the big dig because it was interesting to us, and we are trying to tease out some of the interrelationships in the big dig .. Ok .so.. actually we emailed you some questions.. but I think we are going to start by asking what your background is

MOSHE: OK.. I am a professor in the civil and environmental engineering department, my area is transportation, my area of specialization is transportation demand modeling and network modeling and demand

modeling is sort of the behavioral side of transportation the user side, understanding how users of transportation make decisions, how they make choices between public transport and highways, so we develop models, mathematical models that predict of people make this choices as a function of conditions on the network as a function of traffic congestion and that that is the simple explanation of the demand side..and then on the supply side you model the performance of the network so users interact together on a transportation network and produce the performance of the network which we try to improve that's what transportation planning is all about, so ..eeh I have been a professor at MIT, I have been a student I did my PHD here

MING: Oh Wow so you have been a lifer

MOSHE: I didn't do my bachelors here, I did it elsewhere but I did my masters and Ph.D. and then stayed on as a professor

MING: You just couldn't leave!

MOSHE: Or couldn't finish maybe... I don't know

MING: How did you get involved with the CA/t when and why?

MOSHE: I had an interest in what is known as dynamic traffic management, in the past in the beginning of my career I was primarily working on transportation planning, transportation planning you do kind of slowly, in the office and you do all these large scale surveys and modeling, simulations, develop different alternatives and evaluate different alternatives and so on but then I became also interested in dynamic traffic management, primarily I was beginning to get interested in it maybe about 10 yrs. ago, dynamic traffic management also nowadays comes under the name of Intelligent Traffics Systems (ITS) and it stands for use of advances in information technology, sensor technology, computation, communication for ground transportation, ITS has different things for different people, some people work on automated highway systems I don't, my interest is in Dynamic traffic Management. Dynamic traffic management the idea is in real time to try to manage a network in the most efficient way to influence the supply side and demand side. My research interest are in has been modeling and simulation in traffic so I started to develop tools, modeling and simulation tools for dynamic traffic management, that's why we decided to start the ITS program at MIT and we started in the early 90 we got some publicity and the people from the CAT project heard about the ITS program that we started here and they came to find out what we are doing and that's how the contact began.

MING: I see so ITS was began before the CAT people came ...

MOSHE: Oh yes the ITS name sort of started form people organizing, initially people called it IVHS (Intelligent Vehicle Highway System) it was sort of grassroots coalition of transportation professional formed together came up with the name IVHS America now called ITS America and so and this led to large projects being allocated at the federal level to ITS initially the research and development and also demonstration projects and so at the same time we began to do research in that area and decided to start an ITS program at MIT and ITS research program at MIT so this preceded us getting involved with the CAT project

MING: When CAT approached did they have a specific charter

MOSHE: kind of complicated, you know the relationship between a large organization and MIT in the beginning were very unclear it was not a clear cut black and white we are going to form a relationship with you and there was all kinds of contact and MIT is also not the single point of contact you know .. there was There was another person at MIT at that time called Tom Humphrey, he is no longer at MIT he had had more of political contacts, he had more contacts with the state with the Mass Highway department and the people at CA/T and I was more of a technical person that they were interested in. So the initial contact was kind of Ya we are interested in what you are doing we have some issues we have some issues that we need some help on lets talk about them, initially they were interested in incident detection. Incident detection the idea is to try to automate the detection of an incident, an incident is any kind of event that causes a reduction in capacity. Somebody running out of gas, a crash, somebody just stopping the car in the breakdown lane any kind of thing you want to detect it and then you have an incident management system that tries to clear the incident as quickly as possible, which is very important in Tunnels because in tunnels you need to detect incidents as quickly as possible otherwise the cars that are stuck behind get exposed to [carbon monoxide] CO and there are some safety levels of CO. So, initially they talked to us about incident detection, innovation in incident detection algorithm, but nothing came out of that, we ended up doing some work on the incident detection algorithm but we are doing it now in 1999, when they come to us with the question it was probably late 1992. So the people at CAT are well aware of MIT and what MIT can do but I think the interest was because of the ITS program, and they came up first with this question about can you do some work for incident detection algorithm, but nothing came out of it and there then there was a long period of back and forth and at the same time we started to develop a microscopic MITSIM. you saw a demo of MITSIM lab, so we started to develop before the project began and they said that we are developing for the Central Artery a very complicated they call it IPCS (Integrated Project Control System) and they have Allied Signal as a contractor who is developing it, and so they say we are doing we have spreadsheet calculations, seems like we really need to do a detailed simulation to make sure this control system functions properly, is robust behaves well under unusual conditions and so we need a simulator, that's what we proposed to do. So they forgot about incident detection and we started to talk about simulation. At that point they were interested in talking to us about simulation but it was a question how to fund it how can we give a contract to MIT, and then the more higher people in and then they saw that it has to be competitive procurement, competitive procurement eliminates Lincoln Lab, because it is an FFRDC its (Federally Funded Research & Development Center) because it is an FFRDC it cannot compete against other organizations that are not FFRDC, they have an advantage, MIT manages Lincoln Lab, but MIT doesn't own Lincoln Lab it is owned by the Airforce, so its funded by the Airforce but it is managed by MIT, the employees of Lincoln Lab are employees of MIT, so they cannot compete so this eliminated Lincoln, so Lincoln was out of the picture, in the beginning when we talked to them the idea was to work together with Lincoln lab and then I don't remember exactly how it evolved but then Lincoln came in again it moved to a more higher level (people) at CA/T and they became interested in this whole idea of University and Lincoln lab the combination of Lincoln lab and MIT suddenly became very attractive as way of sort of making sure the technology that they are implementing is up to date and is not going to be outdated when the project they are investing so much money , we are talking today of 11 billion dollar and but also if you take just a small percentage of it which is being invested in the IPCS, so here is the IPCS technology that we are going to spend so much money on lets make sure let somebody objective take a look at it to make sure that we are not investing in obsolete technology etc. so that's what the role of Lincoln and MIT at a higher level and that's how the sole source of justification of to give a project to MIT came about with this philosophy and that's why the role of Lincoln Lab was important and because they are an advanced electronic laboratory that maintains knowledge of related technology and so that's how the project began and there was also another element in it and they said we are also interested in Human factors, so Professor Tom Sheridan from Mechanical Engineering was also involved, so there was essentially three parts to it the simulation part, initially when we started with the simulation after it was my work, the technology electronic technology sensor technology which was Lincoln and the human factor which was Tom Sheridan but Lincoln was also involved in the simulation initially.

MING: Why do you think the incident detection fall out

MOSHE: I don't know it came back in 1998-1999, there was again so it may have been in the work program initially but it was not a priority work area so it may have been in a work program in already when we started and I don't know when we started it was 1993 -1994 do you guys know ..

SERENA: Carl Much had said 1993

MOSHE: 93 so probably mid 93 so probably it was in the work program but it was part of the simulation area it became a minor problem remember initially when they came to us this was the single question can you help us with incident detection but a year later or less than a year later it was the whole technology sort evaluation and monitoring with Lincoln Lab and so incident detection was just one element of a fairly large program so when we started it was large program and Karl Much was involved in it he was like the project manager..

SERENA: I think Tony was the project manager, but Karl was like the group leader

MOSHE: Wait a minute .. it was always, the contact was always at MIT Initially when we started there were... MIT for every project has a principal investigator it was two when we started a younger professor, a lot younger his name was David Bernstein, he was here and he was an assistant professor and me..

SERENA: Oh so he is not..

MOSHE: He is no longer here, he is at Princeton, so we were co PI and Karl Much was really the project manager I don't know what's his title in Lincoln Lab but he was the project manager and it was a big project and Tony was the assistant project manager or deputy project manager or just worked on the project I don't what was his title was and then Karl phased out and Tony became the project manager and David left MIT and so for many years it was me as PI as far as MIT is concerned PI is the one who is responsible and Tony was the project manager and as far as the budget included the part for Lincoln Lab and to Lincoln Lab staff but the work was always done here at MIT so we had LL staff members assigned to us at MIT so we had Karl Much part time, Tony full time and then we had some others and we also hired a full time researcher by the name of Alan Chachich and he worked for us for a while.. and so I mean he knows a lot about, a lot about everything you should talk to him, he will know the dates, he is a walking encyclopedia , you can interview him as well, but if you are interested more in the big picture I really suggested you talk to people like Salvucci and people at CA/T like Sergiu Luchian have you talked to Sergiu Luchian ..

SERENA: Actually we didn't have his last name, Tony didn't remember it

MOSHE: Aah..Luchian. I wrote an email to somebody, what's his name

SERENA: Joey maybe??

MING: Yes check with him I gave him the telephone number and everything so it is Sergiu Luchian, a Romanian name and he is the best person to talk to in terms of the CAT, he was the on who first came to us he was the one who first came with the question of incident detection, he initiated the contact and that's why and Fred Salvucci is the one who initiated the CA/T period so you should definitely talk to him

SERENA: We are interviewing him next week..

MOSHE: Oh great .. that will be your best interview and so Sergiu ,,,. Luchian so its 946-3050.

SERENA: And this is at the Central Artery

MOSHE: Yes Central Artery, he is a engineer responsible for the they have also a traffic management center and he may invite you to see and you can take a look it is near the entrance of the Ted Williams tunnel, so anyhow

MING: Actually do you have to leave ...

MOSHE: I have.. I have until 5:30 so we have 30 minutes

MING: Oh good because we have lots of questions

MING: Sort of explain the relationship with the Boston people, how they interacted...

MOSHE: Let me just quickly finish though, We started with these different areas and the other areas were sort of phased out so we were left only with simulation, so the simulation, the MITSIM is what started in the beginning and continued until today, so this is still ongoing project

SERENA: What were the other things that were phased out, sensor detection...

MOSHE: The sensor they did, they worked on it for a while and the human factors the work that Tom Sheridan did and really the simulation became the central focus

SERENA: Why did the other things phased out was it lack of funding, lack of interest

MOSHE: And competition, internal competition, the MITSIM provides like a tool that nobody internally, the CAT is a big organization and has consultants, its joint venture with Bechtel and Parsons and so they had technology groups inside these companies, they had human factors people and so I think they probably said why do we need MIT but they did not have MITSIM, I think that's my hypothesis nobody told me and that's what where we are today and so also this work is being now phased out beginning of 200 this contract will expire .. Just for a while maybe it will be revived our most recent work the last task we are doing for them is on incident detection algorithm So the next question was.. how was the relation between us

MING: How did they interact (Boston people) and MIT.. the interface between the organization

MOSHE: Well it wasn't me, the interface was not me, it was Tony, that was the role of the project managers the role of the full time project manager person from Lincoln Lab was to serve as the Interface with the CA/T and to shield the people who are doing research from this kind of the day to day the kind of more working level interactions with the CAT. And when Tony left to go back to Lincoln lab, then Alan Chachich played this role and when he left I had another project manager his name was Mithilesh Jha so there was always a full time research associate, research engineer, all this title are interchangeable with MIT that served as a liaison with the CAT and the basically from time to time we agreed on problems that we are going to work on or , case studies and they provided us the data and we enhanced the simulations to be able to address the question and ran the simulation and from time to time they would have people come over here to look at the demonstration and relation to simulation and later on we would put it in a laptop and take it over there so

MING: So did the liaison changed periodically

MOSHE: Initially when we started we had this person Tom Humphrey, Tom Humphrey was very effective, when we started the project was very large, over the years it kind of shrank in size became smaller and smaller in terms of dollar, initially it was huge , I forget over 2 million dollars when we started Karl March will know the figure better than I do . So Tom Humphrey at that time was very effective his background was in state transportation, he worked for State of Mass before he came to MIT so he was very good at being the liaison to state agencies to explain what we are doing, I didn't do it. So he was the most effective liaison, Tom Humphrey and he was involved in getting us started getting the project off the ground in the beginning.

(Tape being changed. We lost a small part of the interview but I think he was just talking about the Masters Student Qi Yang)

MOSHE: ..he said, he was working as a RA for me actually I was co supervising with a professor another professor by the name of Harris Koutsopoulos. So Harris was an Assistant professor here and at some point he left and moved on to another university and now he is actually working for the Volpe center so Harris and I co supervised Qi Yang, Qi Yang and came to us one day and said I would like to develop a microscopic traffic simulator and we checked his temperature and he was serious about it and we knew that if somebody could do it would be him and he wanted to do it for his Masters thesis and he did it so this was the subject of his Masters thesis at that time we had research funding from a program called the University Transportation center (UTC), its a federally funded transportation research program and we also had some funding on a related topic from the Draper Lab, Draper Lab has an internal R & D program where they fund researchers at MIT who work with them so they gave us some money and that's it that's how we started, that's why we started to be honest and my motivation that time was what it has become that if you wanted to do advanced research on methods for dynamic traffic management we need a lab we need a lab which would be our own and at about the same time we also received some research funding from a we had in the civil engineering department called the Intelligent Engineering systems Lab and they had some funding from Japan from what is the largest telephone company in Japan,

MING: Nippon??

MOSHE: Nippon something.. NT...

MING: NTT

MOSHE: Ya.. NTT of course they had a large research grant from NTT so we began to work on a precursor of what we now call DynaMIT, I don't know if they gave you a ..DYNAMIT, it is another ITS program we have 2 major project one is, 2 major project areas one is related to MITSIM another one is related to another system called DYNAMIT, its unrelated to the CAT so . so what was the question that was asked.

Ming Sort of I think we are asking what

So it was developed and it was viewed as a very detailed simulation that would allow us to use it as a lab and that's the way . that's how that what lead to the CAT project they realized this capability and they become interested. Really the success of our CAT project was that very shortly after we started we had all of them come to MIT took then to one of the very first electronic classrooms, now we have many electronic classroom, took them to electronic classroom right here in the corner of Building 1 and there was a big screen and we ran simulations of the Ted Williams tunnel and it was very early version of the MITSIM and they were impressed because when we started the project they gave us boxes and boxes with specs of this IPCS so we did just took one part of this IPCS and actually we uncovered a mistake in the IPCS.

What mistake was that ?

It was a trivial mistake it was when there was an incident in the tunnel and when you detect the incidence then you lock the entrance to the tunnel and so at the portal there will be a red light and then once the incidence is cleared you will change it to green, so what we have shown in our simulation is that if you do it as is planned then the cars from the portal will be rushing in to the tunnel and hitting the queue that is still in the tunnel and has not cleared out .. so If there is an incidence in the tunnel and you have queue inside the tunnel then what you need to do is to first let this queue start moving and clearing because if you don't do that then what happens is cars some rushing in, driving at 50 miles an hour and then suddenly they see a stationary queue they start to slow down and it can create secondary incidents but that's not we necessarily simulate but what we can see is a shockwave you know how traffic congestion, that's what you usually observe when you drive on a freeway you have suddenly stop and go traffic and then suddenly its open again that's a shockwave that sort of moves backwards along the freeway so what we have shown that will happen you need to do is to delay the cars at the portal a few seconds, let the queue move so there is no stationery queue inside the tunnel and then you have a smooth flow of traffic when you open the tunnel that's all .. but we showed it .. engineers worked on it and wrote down detailed specs and here modeling and simulation can be useful

MING: Was it right in the beginning of the project

MOSHE: Yes, I think so very shortly after we started the project.. ya late

MING: So what event do you think convinced them

MOSHE: Before that they had apprehensions, they thought t we are developing a very complicated controlled system and we are kind of apprehensive our spreadsheets we are running here maybe some simulators are indicating its ok but there are lot of it's a fairly involved control system with different objectives, different control measures, how do we know that how do they work together and so that's what their motivation and when we gave them the demo they were convinced that this was a useful tool. It was demo to 20 people we really called everybody to see what MIT can do

MING: This is very nice Around what time was the what phase was this ....

MOSHE: So, in terms of the geometry it was done, but we had, we had never, we don't, our involvement was only in relation to the IPCS, not to the concrete and asphalt, there was another MIT project, there were people in GeoTechnical worked with them on issues on foundations and tunneling, our work with them was strictly related to the technologies involved in the IPCS So

SERENA: Because we were wondering because one aspect of the MITSIM was the ramp metering and

MOSHE: Yes , that's part of the traffic surveillance and control

SERENA: And the student had said, I guess some of the questions there was asked was how many ramps to put in and we were wondering if Boston already decided the number to put in and we were just to see if we should change it or not

MOSHE: We actually there were some questions as I said from time to time questions came up during and there were questions about ramps, location of ramps and number of ramps most of them were concerned with construction staging, like because they are opening different sections at different times and they are so it was interim solutions like what's going on right now

SERENA: Oh Ok right when they like just move the traffic lanes while they are building the other lane

MOSHE: Exactly something like that and there may have been some sort of configuration that relates to the final design so maybe the issue was do we need this ramp here or if we have a ramp here and it will be moved in this way what are the implications, so we did some analysis study I don't remember the details, the person who will know all the details about these kind of ramp studies will be either Masroor Hassan that you met or Mithilesh Jha, again I am not familiar with the detail, but ya there was at some point there was a discussion between the city of Boston and Central Artery Organization, the city of Boston was advocating a most expensive interim solution and the central artery was trying to save money and so they said ok do us a simulation show us how it will operate under the two solution and again if you are interested to know hoe it effected the decisions that they made met talk to Sergiu Luchian and he can tell you and what you hear from me is just I don't know I just know what the kind of work we did but how it actually influenced the decision I know based on what Sergiu told me you know you know and its better to go to the source

SERENA: Do you know which area of the tunnel or in which the ramp metering is used which section project

MOSHE: Well, there are 2 things one is the Location and number of ramps Location and second is ramp metering .. so when we talk about ramps we talk about exits and entrances .. and ramp metering is something right now its a taboo, they are not interested in ramp metering they were interested earlier on and then they become totally disinterested in ramp metering ramp metering , is where you position traffic lights .. it is practiced in many countries, ya this country, in Europe but City Of Boston objected now why do they object to ramp meter because the idea of ramp metering as perceived by a n uninformed person is that it penalizes local traffic because you give advantage to the mainline freeway traffic and then you sort of store people on the on ramp and and if the storage space on the online ramp if you run out of space on the online ramp it spills over the local street causing local congestion , so though one can show that ramp metering if it is operated effectively can benefit everybody but the perception of ramp metering and that too If its designed badly it can really cause problems to the local traffic, anyway so central artery as a project is not considering ramp metering they can install them if they wanted to but they are not planning to.

MING: Were the simulations changed at anytime ??

MOSHE: I don't, I mean I don't remember its like there were ,. we have done we have used MITSIM for many different things, some of them were funded by Central artery some were not.. and some of the work that students do was requested by them some we do ourselves as far as I remember ramp metering was an issue at the beginning of the project but some of the work that Masroor did systematic analysis of the various algorithms was not requested by them so you know when you do when you work at a place like MIT you don't do what they tell use to do .. right.. MITSIM belongs to us its our lab and we have and will use it for many things some of them are not sponsored and any student I mean we have students who are interested in transportation it has been used in the Media lab for other projects, so any student who wants to use it do some research in traffic is welcome to use it

SERENA: For the location and the number of ramps do you know where

MOSHE: No no you know you asked me before talk to Sergiu, Mithilesh or to John Chlebeck .

SERENA: I tried he is still at the company I am trying to call

MOSHE: . He would be a good source of information he would be good source for information , let me speak for the research and what we did at MIT how we do and how it effected the project you have to get it from Sergio Luchian from John Chlebeck,

SAURABH: Were there any critical issues any major controversies that you remember?

MOSHE: There are a lot of controversial issue at the CAT but not for us no our mission is very simple, very clear, we don't want to get involved with it ... and as I said I always had a person who was a liaison with CAT for day to day contacts so I was never involved with them and certainly not the students..as far as controversy for us ..it would be friction with other consultants it's a huge organization with consultants . there was one consultant who was trying to criticize our work saying .. I don't remember . ask Tony maybe he knows so that's kind of criticism of MIT.

MING:

MOSHE: No No it's a great opportunity for us oh yes for us it was a fantastic opportunity it gave us an opportunity to be involved in and fully develop the MITSIM.. we had a shell of a program in the beginning , like it was a masters thesis that Qi Yang did .but it was funded the full development of MITSIM was funded all by the CAT .a lot of people worked on MITSIM .. it was programmers sometimes don't work well together so at different point we had different programmers but usually Qi Yang was the final, he was overall architect., it was his baby .not everything that was developed by others was actually used but there was still lot of work done on developing on MITSIM and related software and there was one software which we called RNE Road Network Editor it was actually developed by someone from Lincoln Lab auto ..a program used to develop input to MITSIM.. so it was a great opportunity for us there is no question about it it got us involved with a real world project .. gave us a opportunity to develop a tool which is extremely useful not only for our research but for an important project like the Big Dig.. gave us a lot of credibility for the research we are doing and so it gave us funding to get involved in a big way in traffic management research to characterize it as you know ..no no ..as we did them a favor .. it was ofcourse . they benefited.. it was beneficial for both sides

MING: Future of MITSIM

MOSHE: Ya I mean its as I said we had research project in Stockholm, we are using in other federally funded project called DYNAMIT, students using for their own research like you are interested in traffic management and you want to test a new ramp metering algorithm then it's a lab we have students doing research on incident detection algorithm and students doing masters thesis on developing new incident detection algorithm and in order to test them they use MITSIM. That's our tool .. exactly actually we have a meeting in Washington in month from now where we are going to present to the Federal Highway administration

MING: Congrats!

MOSHE: Well we don't know its just a they invited us to come down and maybe they will adopt it they have old simulation which has outlived its useful life and they are looking into alternatives and they are considering adopting MITSIM. So ya I .. it does have a future

I have a meeting at 5:30 but anyhow I will be away for the next one and half actually 2 week But you can reach me by email

SERENA: To access the files who do we contact

MOSHE: You don't , you don't access the files, there are no files that will be useful , we talked about it there was also email exchanges I mean any kind publications, the students can give you, the files doesn't have anything useful for you, but if you have any kind of document that something will mention to you in the interview that will be useful for you then email me, it has to be something specific, I cannot give you access there is financial information the project is ongoing so its better I really don't think you will find anything but somebody tells you then let me know OK

Thank you

7.2 Interview with Carl Much

Serena Chan and Ming Maa Friday November 5, 1999

MING: I think we sort of wanted to give you a framework for what weare doing, why we are doing this. The class we are taking is really...taking a look at past engineering projects, looking at some of the factors that affect the course of the project like the political factors, social and economic, as well as the technological.

CARL: OK

MING: And we are trying to see the connections between these players, um, as they affect the project and uh, we picked the big dig...

CARL: Yeah, big project, yeah.

MING: Yeah, big project and very interesting project.

CARL: Yeah. This course, is this in the EE department, or course 6, is that what you said?

SERENA: It's a joint EE and STS-Science, Technology, and Society.

CARL: Oh, from, is that from the Sloan School, or is that...?

MING: Uh, no.

CARL: No, it's another department I guess that does that.

MING: Right. I think it's closely related to the Technology and Policy Program.

CARL: Yeah.

MING: That you were... Very interesting program.

CARL: Yeah, it's really something quite different for engineering students to take. Yeah.

MING: I guess we were hoping to start by maybe asking about your background.

CARL: Sure. Okay, um. Well, I've been at Lincoln Lab 36 years. Pretty long time. [laughs] Came here in 1963. Uh, I uh got a Bachelor's Degree in Electrical Engineering at University of Wisconsin 1960, worked a couple of years, and um, went back to school and got a Master's Degree in EE at Stanford. And then came here from there. And, um. I've been in this group my whole career. Our group is called Control System Engineering and, uh, what that means a little more precisely is, our primary work is designing and building feedback control systems. And, uh, there's a need for that here at the lab because of, uh, well starting all the way back in the Lab's early days, because of all the antennas. Some of them quite large, that are required for the radar systems that Lincoln has built through the years. So our group has been involved in pointing those radar antennas, big dishes, some of them as big as 150 feet in diameter like at Haystack and down at Quadulun (sp?) and all sizes smaller than that. But it turns out along the way in the Lab's history that there is a continuing need for pointing and positioning things. We got into laser work heavily in the 1980's and there, there's a requirement for positioning and pointing mirrors for directing laser beams. Generally much smaller things than these big radar dishes, small little mirrors, bigger mirrors, all kinds of mirrors. [laughs] But generally require high speed, high precision positioning and, um, our group has continued to work in this feedback control area ever since. So, we like to think that everything at the lab that has to move and be controlled, that we get involved in it.

MING: So you...

CARL: Yeah, it's very interesting. We've done a wide variety of things. We've done satellite attitude control systems when the lab was building complete satellites, that's eight and nine. Which we worked on with division six. You're working with division six? Yeah. In the 70's, at most were launched three-axis attitude control system that we built there. So we've worked on quite a variety of things. We're more of a real hardware building and implementing group than we are theoretical. Many groups in the Lab are quite theoretical. They do theoretical studies and system analysis and so forth. And, uh,never actually build some piece of hardware. We're on the other end of the spectrum. We're always building things and, not necessarily inventing new theories, but we use all the latest theories in, you know, hardware devices, and our work. So, I guess it was about 1988 that I became the leader of this group, and we, uh, just continue on like we always have. We're not a very large group. We have 11 engineers, or technicians. That's varied over the years. During the Star Wars days of the 80's, with a lot of optical work, and we had as many as 22 engineers at that time. Then, with the taking down of the Berlin Wall and the drop-off in the interest in defense, the Lab, it's funding was a little tighter then. [laughs]. And, of course, we saw that coming. That's when we, as well as other groups in the lab got interested in other work beyond the Department of Defense. And there was quite a big push here, and at other national labs, to expand into other areas, even trying to work with industry. So, we came upon this, came to learn about the IVHS work that was going on, Intelligent Vehicle Highway Systems that was starting up at that time. That sounded really attracted to us because, if you're sensing vehicles on some city streets and then controlling the lights and other devices based on what you see there, that's a big feedback control system. Very complicated and non-linear one with people involved. [laughs]. So that really fascinated us. We thought this might be a good match. We're also quite strong in our group in building and implementing electronics in general, so all the new sensors that were being talked about being used was really interesting to us too, and how they might work. So, that's what led us to pursue, you know, this new intelligent transportation systems arena and eventually get involved with the Central Artery/Tunnel

MING: Could you talk a little bit more about how you became involved in the project, as in whether you were approached by Boston whether it was an independent project that started...

CARL: You know, we sort of, uh, it just sort of happened that we got interested in this area and then as we started to look at some of the literature, we saw the names of professors on campus were popping up in some of the reports and articles, and especially Professor Ben-Akiva and Professor Sussman in the Civil/Environmental Engineering Department on campus. So, we contacted them to see what they were doing in that area. We had meeting with them, they gave some seminars to us, combined with some of their students about things they were interested in and, what this whole IVHS arena was about. And, so, based on that, it just sort of blossomed into us and them talking about working together on something. We didn't know what at first. We actually went down to the Federal Highway Administration in Washington and, I think a couple day meeting with various people down there, and talked about various things we might do. And, so we struggled with that-how could we work with the Federal Highway Administration to do some project and we actually, you know, proposed some things to them and, but we soon discovered there that the way the Federal Highway Administration funds programs was not compatible with how the Lincoln Lab needs to be funded. We're a federally funded research and development center, and we had some very specific regulations applied to us as to how we can be funded. And, we cannot compete with industry or anyone else for that matter. We have to be funded on a sole source contract. I guess the reason for that is that the government set up labs like us and Sandia, other similar labs, to work on specific, well not specific, but in general areas for the government. And, they have essentially funded us, they have essentially built Lincoln Lab you might say, because of their funding we have all of the people and equipment that we have. It's kind of unfair for us to use that, say, against industry that didn't have a similar advantage of getting all this done for them, you might say. So, in a sense we'd have an unfair advantage if we compete with industry, so I think that's one reason we're restricted from being able to do that. The other is that, it's sort of like a two-edged sword. On one hand, we cannot compete with industry, but on the other hand Department of Defense agencies are allowed to fund us on a sole-source way at will. So, to have that privilege of them being able to come to us and just give us money without going out on a competitive bid, we have the other side of the coin where we cannot compete. And this is a big advantage for the Department of Defense. Say they have a problem that's pretty far out there as far as having never been solved and so forth. They don't have to try to write a spec to figure out how to formulate this into a real program. They just come to Lincoln and say "We want you to work on this. Let's get it a little more solved before we go out and buy something to solve that problem." So, because there is a thing in the federal acquisition regulations that's very clear about everything the government buying being done competitively, except for this little thing with FFRDCs.

So, anyway, Federal Highway Administration does not operate that way. They only [want] competitive bids. So that was a real stumbling block for us to try to get any kind of funding from them to do something. And, so that was kind of a bummer, you might say, to find that out and discover that. But then we got talking with the people on the Central Artery and that is run by the managing team there is a combination of Bechtel and Parson Brinckerhoff. And, it became clear that they could use some of our help and that they wanted it. And we got talking early on about this sole-source business, and they said "Well, maybe we can do that, because we're running this project on our own and we think we can probably do that if you can make a strong enough case of why you're unique." So we did that as part of our proposal, we spent a lot of time pointing out why we were unique, not only compared to industry, but compared to similar groups that might be formed. Like Sandia might work with Berkeley or maybe some other school closer to home like the University of New Mexico or something like that, and could also try to do the same work. But the fact that they are located so far away would be a big disadvantage. We're right here. We can have a lot more contact with the project and all that.

So we eventually convinced them that that would be a workable thing. So then we proposed...well we proposed a number of things. One being the simulation, the traffic simulator, which we really did, but we also proposed working on testing sensors, traffic sensors, and just any new electronic devices they were planning to use in the project. We would buy these from suppliers and test them, maybe here at the lab, on roadways here at the base, or down there at the project. They have this South Boston haul road that they built to allow the vehicles to come into the construction areas primarily during the building of the new tunnel. And it's like a perfect place now to do testing because on the sides of the highway it has some open grassy areas where you could set stuff up and try all kinds of things. So at first they seemed pretty interested in that as well. But then, they said "Well, let's begin on the simulator." So we did, we started on that in 1993, and along the way we kept bringing up this other thing too, but it never really became part of our work. And that turned out to be quite a disappointment for us here in this group because that's what we really wanted to do, whereas campus was very interested in the simulation, and they had already done a lot of things, a lot of preliminary work in that area. It was very useful as a starting point.

MING: Actually, taking a step back. When you approached Ben-Akiva and the MIT professors, had Boston already contacted them at that point.

CARL: Um, they knew the people over there. I think there might have been some earlier discussions with them. No, they didn't have a program per se, they were not being funded at that point. I think there had been discussions with some of the people on the Central Artery project. But, yeah, no, there was no real program, at least of this type. I think some of the, there were other professors on campus that had programs with them as well, more on the construction techniques area rather than, not on this arena of intelligent transportation systems, but some other aspects of the construction project.

MING: We actually talked to Ben-Akiva yesterday...

CARL: Oh, did you!

MING: ...about some of the simulation...

CARL: Yeah, good.

MING: The way he approached it was that there were really three focuses that were given to MIT and Lincoln Labs. There were simulations, human factors there was also these sensors. We're sort of interested in why you think the incident detection and sensor project sort of fell by the wayside.

CARL: Yeah, okay. Yeah, that's right. I forgot about the human factors. Let me just mention that first. We didn't do too much work in that although we have a group here in the lab that has human factors people in it, part of the FAA groups. It's over in, well they were in Division 4 at the time, now they're in Division 9. They have at least a couple human factors people, and they were involved a little bit on it, just a little bit, but that was primarily Professor Sheridan in the ME department that did that part of it.

Okay, and on the sensors part, I think this was another place where our feelings about the sensors and how these advanced electronic devices, how you would approach deciding on what to use and put in the project was quite different from Bechtel and Parsons Brinkerhoff's, and probably the whole transportation industry's approach to a thing like that. When they want to implement something on a roadway like this, even though this is a new, brand-new underground roadway with the ultimate use, the latest and greatest thing, they approach that by going on a bid saying what the problem is, what we're trying to do here, and they have companies bid on that, contractors. And these companies will propose devices to be used in here and everything. Generally they'll be pretty conservative in what they propose, it'll be something that's been used before. Matter of fact, I think we heard at one point Bechtel Parsons Brinkerhoff saying that part of their specification these things is something had to be used at least six months or more somewhere else before being applied here. So, even though the impression we're going to use the latest and greatest thing here, it's not necessarily going to be the first time it's been used. [laughs] And, so the companies will propose these things. If they choose to propose something that's pretty advanced and hasn't been used before, it's going to be their responsibility to make this work, and they aren't going to get paid until it's made to work, so they put the burden on the contractor to get this thing to work one way or another, even if they have to tear out everything they put in and go back to something else, at their expense. So that's the approach they use, rather than the approach we were thinking of where prior to even getting this, and it was a lot of time, we were working on this in the early 90s, and a lot of this stuff, still, of course is not, we're talking about an underground of Boston still aways away from being implemented, so it was time to do some upfront R&D to come up with some experience on new things that might really work well there, but that just never resonated with these folks. They just don't envision it that way. And really the whole intelligent transportation systems society was always saying "We're not inventing new technology here, we're just applying existing technology to a new application. See, and that's quite different than what, like, we do here at Lincoln with DoD, we're inventing new technology to be applied in the future. [laughs] So philisophically, this was a pretty big mismatch. As we came to learn this, that became kind of a big disappointment to us. We were eager to try things, I mean we came up with all kinds of crazy ideas like that [laughs]. Why don't we try this for ya, try that for ya.

MING: When you realized there was a discrepancy, did Lincoln Labs try to shift it's focus more on just implementing technology versus...

CARL: Yeah, yeah, we said "Okay, well that's...", you know, yeah, we did, and I mean we when we realized what they really wanted to do, we started looking at some of their early proposals. I don't know if.. yeah, it was proposals they received from companies and started reviewing those and helping them there with a few things. But it was, kind of minor work, in terms of both size and technical content, and not what we hoped for. But we at Lincoln here did contributed pretty significantly, I think, to the simulation. Some people from here, well we had a team down there, really, of students and some professional software people here from the Lab working together for quite a while.

MING: At ITS?

CARL: Yeah, over there at Kendall Square. Yeah. And again, these people primarily came from the FAA group, because they do similar big simulations for the Federal Aviation Administration and particularly at the time they were working on simulating aircraft traffic on the ground, on runways, which was a little simpler, but they have other more complicated simulations. They simulate in three-dimensional space all the aircraft coming in the vicinity of an airport, how you stack them up, get them in order for landing and all that stuff. And they include, you know, weather affects and everything in their simulation so they get some pretty complex simulations of their own.

So we used some of those people, I think we had about three at one time, three of their people involved and two or three people from our group were working down there at Kendall Square. Now that became a little bit of a problem for some of our people working down at Kendall Square because we're located here, and we have people that live west of here, west of the suburbs. So, for them to come, they're used to coming here to work, and the traffic patterns [laughs] and everything, the commuting has been worked out from their years of working here but then to go from here on down to campus was pretty painful commuting wise.

MING: Must have been a long drive.

CARL: Yeah. And then the parking is tough down there. So, it would have been better in retrospect, if we could have found a place halfway in between but, you know, that would involve... And that probably could have been done. We probably could have found some places in the Alewife region for example that might have been a little more convenient for us and students still could have gotten there on the T for example, so that might have been a good idea. But it worked out pretty well, but that was one thing that was kind of painful from the Lincoln side, going down there.

From a management standpoint, when I was trying to get people to work down there, they were always saying, you know, after they were down there a while, "could you get someone else?" You know, because of the difficulty getting down there. But they were very interested in the problem, that was very challenging simulation to write to make it realistic.

MING That's interesting, because it seems like Lincoln Labs is more interested in the sensor side, more than *** simulations. You would have expected a big rift...

CARL: Well, I think it's just a matter of the ability of personnel more than anything. You know, when you look at the two teams, the campus team is comprised of professors and students primarily. They didn't have one full-time person, well, and that grew as it went along. They had Alan Chachich who used to work at Lincoln and then got a position with campus to work on this project, so he was a full-time non-academic person. But we had Tony Holtz who was involved with this whole thing right from the beginning. I think in their view, and certainly in ours, that he seemed like the right person to lead this effort on a full-time basis. Really, none of the professors could really do it because they're busy with other academic duties teaching classes and so forth. It wouldn't really be a good match for one of them to really be full time running this thing.

I guess when I first started, Tony was sort of the most natural person so he became the full-time leader down their at Kendall Square and the campus did add some more people along the way. They had, well I think there's a fellow down their Mithilesh I think is still there. Tony would know better who's really still there. But they hired other people full time to sort of fill in the gaps. [laughs]

So that would be the reason I can think of, is just that we were very eager in the beginning to get working on this, and we had people available to work on it, so it just started out that way. In the beginning, it was mostly Lincoln staff members, two or three professors from campus, and students.

MING: That's interesting. I'm sort of interested in why Lincoln Labs was so interested in pursuing this project because you obviously didn't need funding.

CARL: Well, we did at that time. Yeah, things were getting really snug and tight funding wise. This was in the early 90s.

MING: So it provided a *** away from defense.

CARL: Yeah, which we really needed. We had another project we also did at that time for similar reasons, for the same reason, we needed more work. There's a mechanism, I don't know if you've heard of, called CRADA. It's a Cooperative Research and Development Agreement. It's a way for labs like ours to work with industry. This was mainly developed by, well, the government came up with this aproach because the Department of Energy labs, Sandia, Los Alamos particularly were even harder hit than we Department of Defense labs, and it almost came to a halt as far as working with nuclear weapons and so forth.

So, they needed, they really needed some other sources of work. And this Cooperative Research and Development Agreement is a way you can work with an industrial company and the purpose of it is to transfer technology you have to them with the intent of them turning it into a commercial project. They cannot use this technology on a government project, because the government has already paid for it, but they can use it to come up with a commercial product. So, we had such an agreement with Ford Motor Company, and we had a couple of people who were working on developing hardware and a test facility for them out in Michigan with the intent that this would allow them to do a lot more testing instead of building prototypes. When you come up with a new model... I'm digressing now [laughs], just briefly... when they come out with a new model they build like 1000 cars and test the heck out of them on test tracks and everything like that to subject them to all kinds of, in some cases destructive testing, just to make sure everything is okay. What they were interested in is if hardware loop testing could eliminate some of that-building of 1000 and doing it sort of brute force. So that was interesting to work with out there. It was a little, I guess for the people that went out there it was a little strange because you're working in a lab that has thousands of engineers and PhD's and they have all kinds of technical horsepower of their own, but they wanted a different viewpoint on things, and a new approach.

So, anyway, we're doing that too, just as an example that it was just a lull really in defense funding for a while there. Now this bothered, really, folks in the intelligent transportation arena. This came up in discussions, "why are you interested in this, how come you haven't been around before and so on and so forth." And it became clear to them that we were doing this because funding was a little down at the time, and the DoD, and they expressed that concern "Are you just going to abandon us, then?" So that was a concern on their part. No we wouldn't have, but if we could have developed this into really interesting work for us, I'm sure we wish we were still working in it today, and could be working with sensors and more hardware. It would still be an excellent project that would be very interesting.

There was that, and this sole-source business. Those two things combined really put the damper on it being an ongoing project ***

MING: Can you talk a little more about the relationship between the Boston people and the MIT/Lincoln Lab. Was there a lot of interaction between the two...

CARL: Yeah. No, there was a lot of interaction. That was a reason for locating in Kendall Square. That way you could get on the Red Line, and get off the Red Line at South Station, and their offices were right near there. We had many contacts with them every day, not necessarily in person, but phone calls and so forth. Real tight coupling to them which we really fostered that from the beginning. We felt that was really important because we were new and working with them, we were kind of working in a whole new arena for them. We wanted to be in close contact with them, so...

MING: When you say we, who does that indicate.

CARL: Well, that would be mainly Tony. Tony was the main person. He was down there at Kendall Square. He had a lot of contact with them. But for a lot of the meetings... and I was still out here. Moshe was still over in Civil/Environmental engineering in his office over there. Neither one of us resided over there at Kendall Square, but we went over there a lot for meetings in Kendall Square and also with Tony over to Bechtel Parsons Brinckerhoff for many of the meetings. I'd say more than half of them, we were there with them, and especially in the earlier parts when we were developing follow-on work and so forth. So we really got to know the path between Kendall Square and South Station. [laugh]

MING: Do you think Tony shielded some of the members here and at MIT from some of the politics within the Central Artery project.

CARL: Well, yeah, he absorbed some of that, and sometimes we all got involved. It was kind of significant.

MING: Eventually you took over Tony's role...

CARL: Ah, no. Tony stayed there the whole time, and if anything I sort of decreased my effort on it later on when it became clear we weren't going to do much in the sensor arena and it was going to be mainly finishing the simulation and applying it to the case studies there then I guess my role sort of diminished at that point. I think Moshe stayed pretty constant throughout, it may have even picked up later on. But he came over there to Kendall Square quite a bit to meet with Tony and his students to discuss various things that were going on with the simulation.

SERENA: I wanted to know if you knew the documentation of the proposals that you had written if they're located somewhere we might have access to?

CARL: Yeah, you had asked about that before. Those are all down in Kendall Square in the files there. Did you ask Moshe about that?

SERENA: Yeah, but we needed to *** so that we can ask him for it, specify a document. *** CARL: Yeah, probably Tony would be the best to give you that. Yeah, but there were a number or proposals. A lot of proposals. A lot of reports on things we did, significant advances we made in the simulation, and other things.

MING: Do you think that the simulations affected some of the policies.

CARL: Yeah, I think one of the most significant things that the simulation accomplished was that at one point, prior to, as part of the construction phase, Central Artery has to build a lot of temporary ramps and things like that to move traffic while they're working on the project. And there was one particular ramp (and Tony and Ben-Akiva would know the streets that are involved) down in Boston that Project wanted to build and the City of Boston wasn't happy with that solution. They felt that it was going to back up traffic more severely than it had to be, and they wanted a different solution. See, the way the project works, it's really a federal project, but they do have to interface with the city because they're doing a lot of this on their turf, but the city is not involved on the day-to-day basis with the design and all that. But anyway, the way the city wanted it done was going to cost something like $2.5 million more than the way the Project wanted to do it.

And so both parties agreed that we would run this simulation and see what the difference would be on the neighboring streets due to the different approaches. The simulation showed that they were essentially the same. So, based on that, they were able to proceed with the less expensive method. So, you can look at that as pretty directly, the simulator saved some $2.5 million right there in that one application.

Now, it was also used to analyze what was going to happen out at the airport with the various roads there when the third harbor tunnel was really opened as fully as it is now, and a lot of the other roads are built out there now at the airport. We were able to show where there was going to be some significant buildup on one of the access roads I think over the area where the rental cars are located. We could show that that was going to be pretty severe congestion over there. I'm not sure whether they changed anything to try to accommodate that, or if they could even at that point, but it turns out now that it's really an operation, that that's really happening. [laughs] So it's really a good case of validating the simulation just for that instance.

It was also used in a pretty significant study as to how many variable message signs they were going to need on this new bridge that's going over the Charles River that's presently coming up right now. And it showed that sure it made a difference if you left one of them out, each back of these is pretty expensive, but that it wasn't too bad, so I think based on that they left one of those out.

So it's been used for a number of things, probably a lot more other things that I'm not even aware of in the interim because this was two or three years ago and we're ***

MING: And Tony would probably be the best person to...

CARL: Yeah, yeah, he knows the details of all those runs.

MING: Do you think the role of the simulation program ever changed?

CARL: Yeah, not that I know of. I don't know about that. It sort of depends on what's happened down there since we were involved I think, but yeah, it could play a more active role in the original design. I think in this case, a lot of it was at least to a first order had been designed already. They have a model, they still have this model of the whole project probably down there at South Station somewhere, it'd be a good thing to see. But a whole model of the whole project, showing how many lanes in each area and all that. A lot of that initial design was done before we got involved. The interest in the simulation was when they began to realize it really wasn't going to work that well the way it was designed. They discovered this one way or another, and applied the simulation to see how it might be changed to work better.

So I guess it didn't really take part in the initial design because it was already done. But you could use it that way, you know some other project perhaps, or like I say whenever they realized something wasn't going to work, they can use it to figure out a better way to solve it or a way to modify it to solve that problem.

SERENA: Was it Bechtel Parsons Brinckerhoff who did the initial designs?

CARL: Yeah... [tape switches sides]

CARL: I might mention one other difficulty, kind of a major one, that we had in this program and not technical, but it's how we actually got paid for the work. [laughs] Both Lincoln Labs and at campus, most of the projects, all of the projects we work on, we normally get funding, a lump of funding, up front. And we start working on the program, and we report, you know, very carefully how we use that money in terms of who worked on it, their salaries, the overhead, and all that stuff, and we deduct it from this lump that we got up front and as we get low, we ask for more money, maybe get it, maybe don't, depending on how the project's going. And that's the way, like I said, both Lincoln Labs and campus are used to working. Well, this program was not done that way. This was treated like a real construction...as if we were hauling in concrete to build the road. [laughs] And the way that works is you do the work first, and then you bill for it, and then you send in an invoice, and then you get paid.

Maybe at first that doesn't sound like too much of a difference, but that was quite a hassle.

SERENA: ***

CARL: Yeah, and we had to have excruciating detail. We had to have documentation like the receipts and everything, anything more than $20 [laughs] so it was really tough. And we'd send in these big invoices with all this supporting evidence and it'd be quite a long time before, you know, we'd get an answer back from them, and there'd be thinks that weren't right. In the beginning, it was pretty big delays before we actually got...

SERENA: Who was it sent to?

CARL: It was sent to Bechtel Parsons Brinckerhoff, but it had to be approved by both I guess the, it had to be approved by the Federal Highway Administration and probably the state office was involved with the federal office. So, a lot of approvals required, very strict format, content, and all of that stuff. [laughs] It was a lot bigger administrative task than we expected, so we had to have an administrative assistant full time on our staff just to handle all that and that's added expense that we didn't expect at the beginning. And, plus the delay in receiving the funds was worrisome-are you going to get it, you know, already spent the money, are we going to get reimbursed. And so, that was just an administrative thing that was quite a burden in the project.

MING: ***

CARL: No, once we got used to this, it was okay. It was just getting used to it, getting the whole structure there and the people to do all of this administrative work was the tough thing, the hassle that we didn't anticipate from the beginning.

SERENA: Is Lincoln doing any more related work, because the Project on campus is still under contract...

CARL: Not that I know of. We are in our group, I don't think so. I don't think there's anything going on. We had tried some other things along the way, that was primarily spearheaded by this FAA group I mentioned. We got interested in the Boston city traffic control system. They have a computerized traffic light control system down at city hall. We got interested. We did a little work for them in trying to do some better, more elaborate displays of what was happening in the grid of lights and sort of leading toward eventually working on control algorithms to operate the lights. The other control algorithms beyond what they already have.

We actually did that with funding, internal R&D funding that we had here at the lab to try and develop that and then get funding from them and it just, it really came down to this sole-source thing again. It just came down to the fact that the city could not sole-source us either because a lot of this money is from the Federal Highway Administration. They get money for this purpose comes from the Federal Highway Administration to them and then they can use it, so they are subject to the same federal acquisition regulations. Just couldn't make it happen. [laughs]

SERENA: Were you *** constricted by the restraint I know Lincoln is, but I don't know about MIT...

MING: No, MIT is not, but MIT has sort of an internal policy that they will not compete with industry. They compete with other universities, they do that really all the time. But they choose not to compete with industry, for probably a lot of different reasons. They're getting funding from a lot of different industrial companies, and this could jeopardize that relationship if they're going to turn around and compete. You know, there are a lot of industrial consortiums and all those kind of things, and Civil and Environmental Engineering have industrial affiliates program that's quite strong.

But yeah, they're not really restricted. Nor is Draper. We also at one time were going to do some things with Draper. They can compete if they want, but they choose not to compete with industry either. It's their own local rule.

SERENA: But Draper wasn't in general involved ***

CARL: We did have, there was a professor from Umass-Lowell that was involved in this as well. Nathan Gardener. He was just there part-time. He's an expert in the area of signal light control, controlling traffic in urban areas.

MING: ***

CARL: As far as I know, this is, I'm sure it is, this is the biggest joint thing Lincoln and campus ever did. There have been a lot of little things between a professor and a group out here, but nothing of this magnitude where we really tried to work together. You know, and it was interesting to see. It wasn't easy. Two very different places, different goals and ways of operating that make it pretty difficult.

We have another little project with campus right now in our group on micro air vehicles. Real small airplanes. We have one of our staff members here working full time with the aero/astro department to, we're doing the electronics and avionics control system for this little micro air vehicle. And the aero/astro department professor is actually building the model and doing all the aerodynamic work on it. And it's worked out well because this particular guy is a graduate of the aero/astro department so he's very familiar with it, and he lives in Arlington, so it's not so hard for him to get down to campus. So it's worked out. A lot of these problems we had here, on that scale, one-on-one, are not really problems. And they're being funded by DARPA so they're not having the problems we had with FHWA.

MING: It's amazing how these mundane issues ***

CARL: Yeah, that's a real handicap to doing some good work. Tony's been probably most of his time on administrative stuff, garbage you might say, more than half his time was in administrative quagmire instead of theoretical or technical stuff.

MING: *** u CARL: We have contacts with campus like yours, Serena, you know we have students out here. And that's always good. We've had a quite a few students in our group over the years. We don't have one right at the moment. So there's been that, and there are quite a few professors that work out here. You probably see Professor Roberge out here. There've been others. We've worked with professor Jeff Lange from EE here, and Dave Trumper in Mechanical has worked with us. So we have some contact, but not as intense as this was, so it was quite interesting. [laughs] People wondering about all the sneaky places to park down there.

MING: Maybe you should share that with me.

CARL: [laughs]

MING: Great, well thank you very much for your time.

CARL: You're welcome. If you have any more questions you can, yeah, sure, e-mail or we can talk on the phone. Okay, good.

7.3 Interview with Anthony Hotz

Serena Chan and Ming Maa Friday November 5, 1999

MING: Tell us about your background

TONY: My background is in applied mathematics and control systems. I've done a lot of work in dynamical modeling of systems. Mostly from a control systems point of view. I have several degrees for Boeing, McDonnell Douglas, Lincoln for the past 13 years, doing just that, modeling dynamic systems. We got into ITS about early 90's, 90 or 91 and it was a time when the lab had a very strong involvement with the FAA and air traffic control, and the director of the lab at the time, or the assistant director, felt that intelligent transportation systems was a natural thing to include in this FAA project or group or was a natural extension of it, and so they asked several people in the lab to get involved in a study project to see if there indeed is a role that Lincoln can play. And this is what we did. We had several study projects and we looked at the overall nature of ITS, what kinds of technologies were being anticipated, what were being used, and if there were any expertise in the laboratory that we thought that could be directly applied and would be beneficial. In the back of our mind, the caveat that we knew that we would have to encounter at some time is that we're an FFRDC and therefore we cannot support proposals. We can only be funded directly, and so we knew that this was going to be an obstacle for us. Nonetheless we thought that this was an ideal fit for a place like Lincoln and we decided to pursue it. We did so by talking to several people in Washington in the dept of transportation. So, our first approach was really 2 pronged. Well, I should back and say that in the study projects that we did, we included the expertise on campus, the civil engineering dept, Ben Akiva. And so they were included in some degree in the study programs and we went to the DOT to try and propose to them something that we could do. I think the response was pretty much the normal response, you know, that's interesting, let's see what we can do, and of course there was really nothing that we could do except that I think the DOT felt that there was a role that the national labs could play. They didn't quite know what that was because they haven't worked that much with the national labs. So they did find a place for the national labs. They defined a scope of work that only the national labs could respond to, and this was in managing the national architecture of ITS, not in performing the work, but in doing the contractual oversight and technical oversite of it. We responded, as did JPL as did a number of labs, and JPL won the contract. They had much more experience in managing large contracts. We just don't do that sort of thing here. It really wasn't what we had in mind, but we thought that well, this was what was being offered and we'll try this to get started. So that didn't work out. But we realized at the time that maybe our approach was wrong. Maybe we need to look at our own back yard and we contacted a number of sources. We contacted Mass Port in various degrees to determine if there was anything we could do that would be beneficial to them. And at the time, they were interested in electronic toll collection, so we wrote a couple of proposals on how we could benefit them because the lab has so much experience with sensor technology and testing. And at the time, they were more unsure of how well this technology would work. What they didn't want to do was spend a lot of money on infrastructure and find out that it wouldn't work. However, they really weren't prepared to spend money. They were really coming to grips on how they were going to fund such things and how much money people were going to have to spend. So those didn't really go over very well. And our final tries was to contact mass high way to see if there was anything we could do for the central artery project, and our 1st contact was received as expected, 'we don't have any funding, but we're willing to hear what it is that you could do for us, and we did chat with them and I think they agreed that there was a lot of expertise in campus and in the lab. But they weren't prepared to fund anyone either. So it turns out several weeks later, they actually called, Bechtel Parsons had called us and wanted to have a meeting. So we went to the meeting. And the problem that they had was that they were going to be putting thousands of sensors in the road and all of this data was going to be connected by fiber optics to a central control center, and I think it dawned on them that this was going to be a tremendous amount of data. And they knew that we had a lot of experience in handling sensors and lots of data and they wanted to know if we could look at this problem and help them, to define how to handle this data, what do with it, and we told them we would write up a small proposal. A direct application was incidence application and they thought it was good idea to get us involved, and so funded this, and it just grew from there. And we started interacting with them, and I think they thought our involvement was quite beneficial. Ultimately, as is the case with most of these things, as they evolve, they discover what we can really do to help them, and it became that our primary support eventually would be modeling, dynamical modeling. Developing a very large scale simulation capability for them so they could test a lot of the traffic management strategies that they had envisioned. At that time, there were other simulators available, but they really weren't designed to accommodate the kinds of problems that they had. They were mostly designed to accommodate on very different and specific kinds of problems. And this is why they decided to go into the development of a new simulator.

We made the first contact with them, and they reciprocated after that.

MING: Why did LL become interested in ITS.

We tried the federal highway dept and found that this was going to be a difficult thing to do because most of the funding coming out of the DOT is based on competitive bidding. They really didn't have a structure setup to accommodate national labs. Additionally, since we wanted to get into the ITS, we thought that perhaps if we went locally, it would not only benefit the state and the local state by having local expertise involved but it would also be an opportunity for us to get into this, so it seemed like a natural thing to do. You try as many different sources as you can when you're trying to get into a new area of work, usually in a hierarchical sense you start with the highest governing body, which was the DOT and you sort of go down. And if fact, the DOT recommended that we contact the mass highway dept b/c as you know 80% of that project is funded by the DOT anyways. And in fact, we were steered that way.

We had human factors, sensor technologies, model simulations, and the development of traffic management strategies. These were our 4 prongs. I think that the state was less state at the time in testing sensor technologies, and I think it's because they have a lot of experience in sensors, and I think also they put a lot of that burden on the manufacturer themselves. And it makes a lot of sense from a funding point of view because hey, if you're sensor says it's going to do a certain thing and we pay you money to do and it doesn't work then you're responsible to get it to work, and so therefore, we don't need Lincoln to spend a lot of time testing. However, they did want us to spend some time identifying technologies that we would use and we wrote several reports on that. The human factors actually was quite active throughout the entire project, mostly in the ergonomics in the control center, and the displays in particular. Traffic operators are going to be sitting in front of these displays all day and you wanted to make sure that the data was presented in a way that they could easily handle it. The sensor technology was probably the first to get waysided. I think that after we had done some initial work, they were satisfied that we had identified the technology that would take them to the next 15 years. And I think that funding was getting a little tight, so they wanted to channel their resources into an area in which they thought would most benefit them and they were mostly worried about developing traffic management strategies for a couple of things, first for traffic mitigation during construction and also it was uncertain for them what impact certain offramps would have in certain locations. If they changed certain the roadway structure in certain locations, what impact that would have. So this is what they focused our energy in, in developing this capability in our simulators. It turned out to be quite beneficial to them.

So sensor technology opened the door for Lincoln and simulation opened the door for campus.

Well I think the first one that we had was that they were building the Ted Williams tunnel and it was going to be regulated by an electronic tolling system. And they wanted to see the effect of toll tags. So we did that study, varying the penetration of toll tags. You see, when the ted Williams tunnel was opened, only authorized traffic was allowed, so they also design a new intersection and they were worried about what traffic patterns would results. So this was really a two pronged problem. So we modeled that intersection as well. And as it turned out, when they actually opened the tunnel, the results that we predicted were very close to what actually occurred. Which was very impressive because this validated their design of the intersection before they actually implemented it. So our simulation helped them in that design. We showed them that there are ways to do and ways not to do it. So they were all very impressed by it. And so were we because we really weren't sure how well the simulation would work. So that opened up a lot of eyes, that wow, this simulation capability is something that could really be beneficial I throughout a large number of areas on the project. We used it for a number of areas. I think the study that we did gave them confidence that this was something that was useful. There were a lot of skeptics, and that study did validate it, to some extent. It gave them enough encouragement where they wished to apply it somewhere else.

MING: Did funding structure affect the work that was produced?

It actually affected campus more that Lincoln and I'll tell you why. The engineers that were working down there were actually badly needed back here to do other projects, and in fact, if you look at the staffing over time, ITS engineers did tend to migrate back over time. But campus was worried about funding for students. And so instead of having a nice block that was available for 3 or 4 years, they had to make sure they had enough year by year.

MING: Can you talk about the relationship between the Boston and MIT people?

Most of it was through me. Moshe had less contact with them. Of course he always had the technical oversight. He helped write the proposals. But most of the contact was done through me. I was originally pegged to be the technical lead, the day to day details, but it became very evident that you really needed someone to manage the project overall, day to day. Moshe didn't want to get involved in the day -to-day details. It doesn't mean that I stayed away from the technical stuff. I managed a lot of the technical stuff in house, but there was a lot of administrative stuff.

Some of the failures that I saw was that I was trying to manage the day to day activities of many students. It's a difficult thing to do because they're all on different schedules. Many of them, their primary goal is to get a degree, so they're trying to get Master's degree, Doctoral theses, and sometimes, that work is different from the work that we needed to get done. And they sometimes found it difficult to separate what they needed to do for the project and what they needed to do to get their degrees. So there was sometimes an incompatibility there. For example, a change would be made to the simulators. But if you're going to make a change to the simulator, make sure you inform us first before you touch the simulator so we can decide if this is something we really want to do. If you're trying to use a tool to evaluate a project and the tool is constantly being changed, you can never guarantee that the tool you're using today is the same one you were using yesterday. You may get very different results. So managing that turned out to be very difficult. Even though we tried very hard to put things in place. We had version control software in place called Clearcase. Students were suppose to check software in and out. But many students bypassed this because at the time, it was inconvenient. There were only so many licenses. So that became a problem. Another challenge that we faced was some of the staff that was working on the MIT side, just by the nature of their work was very concerned with publications and doing theoretical things, and sometimes, these efforts were incongruous with what we had to do for the project, which were more mundane. We had to get results. We had to do a study.

Some of the successes that we had was that we had a very cooperative and working relationship between campus and Lincoln. We also had a very fluid contact with Bechtel. We were all on the same page and there really wasn't much resistance or friction. And a lot of this was based on the fact that they felt that they could trust us. We weren't doing anything covert. We were there when they needed us. When they needed us to go to a meeting, someone was there. They requested that we do something. We did it. Our results were good.

Most of my interactions was with the Bechtel Partners since they were the lead contractor so we were on contract to the Mass Highway dept but it was through Bechtel partners. The contract was actually with Bechtel partners who of course was funded by the Mass Highway dept.

MING: did you have to sell.

Of course. I don't know how many demonstrations we had on the different aspects of the simulator where we would invite a ton of people from the different organizations from the mass Port to Mass turnpike and the state and Bechtel to come over. You have a room bigger than this with a row of chairs and a screen bigger than this and we would have our computer displaying the traffic scenarios setup to show what it could do. It was an ongoing thing because we knew that as projects came to an end, the extension was going to require us to do an amendment to our scope of work (this is what effect of payment scheme had). So we would be defining what extensions we could do in order to convince them that these were valid things to do and important things to do. We would always sell the different capabilities of the simulators. We had a lot of simulations. Most people usually went away quite impressed with what it could do, but I think it still always boiled down to the fact that yeah, that's really nice, that's really very interesting, but where's the money? We would love to do it. I heard that a number of times. But we don't have any funding.

MING: Did the role of simulations ever change?

Absolutely, I would say it was half and half. A lot of times, they would come to us with a problem to solve and on the other hand we would come to them to show what problems we have already solved or things that we have done that might be of interest to them. For example, the ramp metering systems, that we did a lot of studies on weren't just for one or two ramps. We were looking at a holistic approach. You have in a segment of road 12 to 14 ramps. We would coordinate them, measuring traffic in different locations and using this knowledge in an algorithm that would monitor and then meter the ramps. This was something that they weren't necessarily thinking at the time. But we presented it to them and sparked their Interest. There were camps in bechtel that didn't believe in ramp metering at all, and there were others that were highly supportive. That was one example. We approached them a number of times on incident detection algorithms that we could be involved with which they were very concerned and interested in. So definitely, it was a two way process there. We certainly weren't just stooges that sat around waiting for them to come to us with problems. We were always trying to ask new questions and also from our perspective we were trying to educate them to what questions were important and things they should be asking. And they were very receptive to it, and highly appreciative of it. Everyone has their strength. Bechctel parsons has an incredible amount of, the work that their working down there is just amazing, putting an entire interstate highway under a city that's already there. No one has ever done this before, so you have to give them an awful amount of credit for what they're doing. You might hear a lot of complains on overruns and overspending, of course its there. But nevertheless, it's an incredibly complicated project, lots of technologies. But their real strengths wasn't in simulation and modeling. Their real strengths weren't in the kind of things that MIT is very good. So one role that we did play, and this is something they asked of us, was to educate them, on the new technologies. This is what we did.

MING: Did MIT's results ever affect policy?

Well that one didn't, the ramp metering certainly didn't. And neither did another technology that we really stressed was all vehicles exchanging information by transponders on the vehicle. You could have roadside readers and roadside transmitters that could be transmitting traffic information to every vehicle that passed by it on what the road conditions were on various parts of the city. Of course, this is all very futuristic, and the fact that it's not in the roadway right now doesn't mean it won't be in the future. Certain kinds of things that did come to fruition: A lot of the stuff we used was on the use of lane signs. We did a lot of studies on how best to manage traffic around incidents. And the Central Artery at the time they were going to put up a tremendous number of lane signs, they were going to be every 200 ft. so if you have an incident blocking a lot of traffic, what you would like to do is in a very efficient way move the traffic from 4 lanes to 3 to 2 lanes. I think we showed them a number of different ways of doing this, through phasing, spacing of the lane signs. And it was my understanding at the time that they were going to implement some of these ideas.

Most of the people that we have presentations with were a combination of people with whom we had solid relations with. They knew our work. We were working directly with them so they had a lot of knowledge on what our capabilities were. On top of that you would add in people that you had never seen before but were in a high positions. It was usually not a case where we would talk to a group of people that were completely cold. Those were very difficult sells. Our approach was always to blend the two. Because there's always a hierarchy. I know you, but I don't know your friend, but you know your friend. So if you want to talk to my friend, it helps if I'm there. Otherwise, you're friend might think you're crazy. Additionally, our sells approach was always to try to do something that was always one step ahead what they could get from a normal traffic engineering firm. Traffic engineering firms serve a very useful role, but it's always very implementation and get the job done based. If we couldn't provide anything more than what they could provide, then why would they need Lincoln. So were always in a selling process, always. Always encouraging technologies that were not currently in use. And part of this whole process was to justify why these things were useful and why they should be used anyways. You can't just say, this is a new technology. Use it.

MING: Did you every have to sell to MIT?

In any organization like Lincoln and campus, there's going to be a group of people that are going to say, we have a limited amount of resources, resources being people power, staffing. You are going to go off and in my mind, do something that will never be a big project for the laboratory. So I don't know that its really a productive use of our resources to be sending our engineers to do a project that really isn't leading to anything. So of course, in order to keep this thing vibrant and alive, we had to sell this. If you needed to get a professor involved and some of his students, you would ask to have a meeting with them, and they would decide whether this is something that I want to spend my time on or would I rather pursue funding from another resource. Is this in mind with the kind of research that I'm doing, do I have any students that I can use on a project on this, and would I supervise? So it's always a sell, on both sides.

MING: was selling to Boston harder?

Of course, if you sell it here, and you sell it, then it doesn't really make a difference except that you have their ok to do this. If they say ok, you can do and Boston says, well ok, it would be nice but we have no money, then well...

MING: why did you become the heterogeneous engineer?

I think it's pretty simple. Dave and I were the ones to write the first proposal. I was on the study project. Dave was very interested in the incident management at the time. That was the focus of the first proposal. And we got the funding, so we were the natural people to lead this up.

When you're managing a project, you realize that you're not just managing technology or a program, but you're managing people, and when you're managing people, you're not just managing technical expertise. Everyone has a different agenda. Everyone needs a different emotional support, intellectual support. People need different resources. People do things in different ways, so one of my greatest challenges in managing was all of these issues. The technical stuff is actually quite easy. Dealing with the personalities and the human aspect in projects like this are as important as dealing with all of the technical aspects, the bureaucracy. And this goes all the way to the level of the faculty. You have know what how much they want to know, what they want to know, and what they don't want to be burdened with. And it's perfectly understandable. They don't want to be burdened with ordering paper for the copy machine. But they do want to be burdened if there's an extra task that's going to be in the proposal. They want to know why it's in there, how we're going to do it, if it's correct, etc. It's about who to tell what, when to tell them, and why. It's not political. It's trying to use people's time efficiently. And sometimes when people are under a lot of pressure, you might have what people consider a difficult personality, but that's the wrong way to look at it. It's not a difficult personality. It's a person has a certain kind of need. You have to be understanding of that. If it's a difficult personality, you probably made it that way.

MING: would you do it over again?

In a way, I would and in a way I wouldn't. Before I went into this, I was pretty much a control theorist and I had to put that all on hold for 3 years, and as I come back, I have a lot of catching up to do. But trying to cram 4 years back in is a difficult thing to do. So it depends on what your goal is, if my goal was to get into management, then it was a perfect thing to do. But if my goal was to stay a technologist, then it wasn't a very good thing to do. There were benefits on both sides. But there were things about it that weren't so great. If I had to do it all over again, part of it.

SERENA: has DOT fixed the contracting to allow national labs?

I don't think so. I think they made an attempt to do this when they invited only the national labs to propose. I don't think there's any program in place. I don't think they were ever convinced that it was required. All the national laboratories are heavily funded by DOD, DARPA, DOE.

7.4 Interview with Fred Salvucci

Joey Rozier Monday November 8, 1999

JOEY: This is an interview with professor Fred Salvucci on November 8, 1999. It's Monday.

So, just to give you some background about what we're doing, why we wanted to contact you. I'm in a class called 6.933, The Structure of Engineering Revolutions. As a final project in this class, we are looking at an engineering project. My group is working on the Big Dig. Of course, that's a very big topic, so we've actually narrowed our focus for our project on MIT's connection to the Big Dig. A lot of that is the simulations that's been done over at ITS for the Big Dig, but some of it also is how MIT got involved in the first place, how the Lincoln Labs got involved, that type of thing, that type of issue. We're more than interested in just the technical details, we don't just want to know how the simulation worked, that type of thing. We want to know a lot about the process. How MIT got involved. How things worked between the city and a research institution and the state. That's the major thing that we're focused on here. But our focus is on the MIT side. I have a series of questions that we came up with and would like to run them by you and get your responses.

FRED: I may not be able to be that helpful, because this largely happened after I left the state and was at MIT, and since my relations with the state are quite bad...

JOEY: Okay, well we can go into that actually. [laughs]

FRED: I deliberately stayed away from this process because my presence would have probably poisoned it, so...

JOEY: Actually, if you don't mind talking about it, that would be a very interesting topic to discuss how that happened.

FRED: Yeah, sure...

JOEY: I have a series of questions that I've written down, and if you don't feel like you're qualified to answer, fine, just go ahead and let me know. So, just to start with, I'd like to know a very general question, a little bit about your background so we have some idea of where you're coming from.

FRED: Well, I got a Bachelor's Degree from MIT in Civil Engineering with an emphasis in Transportation. Then I stayed and got a Master's with an emphasis in Transportation. That was before the CTS program was sort of formally set up.

From there, I went to work with the city essentially, the Boston Redevelopment Authority which is a city planning agency, and I did a Fulbright in Italy for a year at the University of Naples. I was basically interested in the relationship between transportation and economic development. Went back to work at the BRA. I helped establish the Little City Hall program. I opened the first one in the city which was East Boston, and later I became deputy director of the program.

The mayor, Mayor White, then reorganized his staff and set up functional specialists and I became the transportation advisor to the mayor. And, then later in 1975 when Mike Dukakis was elected governor, I went with him to be state secretary of transportation and construction. 1978, we lost the election. I came back to MIT in a position similar to what I have now, working on research and teaching. Four years later, Dukakis got back in, I went back in with him. I was in there for eight years because he was re-elected. In 1988 he ran for president and didn't make it. In 1990 he didn't run, the Republicans won so I left the government and came back to MIT and been here since.

The other significant thing is that in the late 60s and early 70s, I worked as a volunteer sort of providing technical assistance to community groups opposed to the construction of the Interstate highways in Cambridge, Jamaica Plain, East Boston, Roxbury. So, I was active as a volunteer in a successful effort to stop some highway construction and shift the focus toward public transportation.

JOEY: Does that have anything to do with the Inner Belt?

FRED: Yeah, it was the process to stop the Inner Belt.

JOEY: Okay. I saw a picture of that over the BU bridge, the proposed three-level bridge over the BU bridge. And I was like, that's such a bad idea! I can look, just looking at the picture it seemed like a bad idea. I guess I'm glad that didn't happen, because I've lived in Brookline and now I live in Cambridge, so I'm really glad it didn't happen I guess.

So, I'm wondering when you were Secretary of Transportation, and you started, how did the process of the Central Artery start just very general terms, when did this start.

FRED: Well, it was an extremely long process. During the so called Boston Transportation Planning Review in the early 70s when I was working for the city, and MIT graduate actually, named Bill Reynolds, who was representing the contractors...

There's a working committee that met every week with the Boston Transportation Planning Review which was the process that the Sargent administration set up to decide what to do with the Inner Belt. I had started out as a volunteer working against the highways. I then became the City of Boston's designee with the same position; Mayor White opposed the highway construction and favored a shift to transit.

So I was going to these meetings each week in a coalition between the municipalities and the citizens and environmentalists proposing to end the Inner Belt and shift money to transit. At the same meetings, Bill Reynolds, also an MIT graduate, represented the contractors and wanted to build everything. Reynolds had this idea about depressing the artery which, when I first heard about it I thought it was crazy. Then as I got thinking about it, I kind of got the bug and ultimately the two of us went to then Secretary of Transportation Altschuler [sp?] and proposed that this idea was worth a study. Altschuler was very nervous to begin and insisted that we get a written indication from the mayor, Mayor White, that he supported this. Mayor White in fact did support it, so we produced a letter and the state basically contracted the Boston Redevelopment Authority to do a study on the feasibility of depressing the artery. The feasibility study came in positive, and when Sargent made his decisions to basically kill the Inner Belt and shift most funds to transit, the only exceptions... Basically stopped all highway construction inside of 128 except depressing the artery and the tunnel to Logan were seen as exceptions that deserved further consideration and that decision I think was November of 71 if I remember the date correctly. So it kind of got launched from the city. It was initially not my idea, it was an idea I came to support and Mayor White supported it. We got good support out of the Boston Globe.

And then, when I became Secretary of Transportation, I was able to push it more aggressively in the first Dukakis administration. Between 78 and 82, the years that Dukakis was out, the artery did not move at all. The tunnel was looked at... I had a hard time to keep the two projects intertwined. The King administration wanted to do the tunnel and not the artery so they separated it and just advanced the tunnel. When Dukakis got back in in 83, I reconnected them and we processed a final Environmental Impact Statement in 1983. Federal Highway gave us a very hard time on it, I think essentially for political reasons. It was during the Reagan Administration and everybody in Massachusetts was a Democrat. It took us four years and a lot of lobbying and ultimately winning the inclusion of some language in the National Suface Transportation Act of 1987 to clarify our eligibility for federal interstate money for this project. They required us to do a supplementary Environmental Impact Statement that was finally completed in 1991, and the construction began. I had left the state government in early 91, just before the final approval came from the feds, the day after the state final approval occurred. So I was basically very active in the sort of formulative stages up to the point of environmental approval and then I left the government. It's been largely constructed since then.

JOEY: You said that when people were opposed to the Inner Belt, but then some people were supporting, like you, were supporting the tunnel. Why would you see that as something to support. If you want to go for mass transit, it seems like...

FRED: There were basically four different reasons. One is that the, a lot of the reason for opposing the Inner Belt was that it was very destructive. It would have knocked out 2000 dwelling units within Cambridge alone, 3000 jobs. You know, pretty massive environmental impact. The legislation here is very complicated, but basically we believed and then succeeded in getting that amount of money shifted into transit.

The depression of the Artery didn't involve the taking of a single residence, practically no jobs. The few jobs that were taken were government jobs that are inherently relocated within the region, so the region didn't lose a single housing unit and didn't lose a single job. So the negative reasons for opposing the Inner Belt simply weren't present with the Artery project or, for that matter, with the tunnel.

In addition, the reconstruction of the artery below grade was, I believe, eligible for 90% interstate highway funds. For very sort of fortuitous accident of history, the original Central Artery was built with 100% state and some city funds before the Interstate highway program, but it constituted part of the Interstate system, so we had never gotten Interstate funds, and had built this monstrosity all by ourselves with our own money. Consequently, I argued that the reconstruction of it, to meet reasonable environmental standards, should be eligibile for 90% federal money. We could not, under the structure of the so-called Interstate transfer language, we could not access that money for transit. So we had to wait for the money to depress the artery, or we didn't go for the money.

So, all of the financial reasons were there to do it. None of the environmental reasons to oppose the other highways were present. And, finally, the structure that holds up the old artery was clearly having problems, which are worse today. The thing was basically going to fall down if we didn't fix it.

JOEY: I remember last year you were talking about the grates that you put under to prevent the concrete from falling down.

FRED: Yeah, we had four incidents of concrete falling on the sidewalk the last year I was secretary, until we figured out that this wasn't an accident. The deterioration was more advanced than we believed.

So, all of those reasons were reasons to proceed, to go for the project, and none of the reasons to oppose the Inner Belt were present here.

The other thing is from a network point of view. This doesn't quite apply to the Inner Belt [I think he means CA/T], but the Inner Belt was going to be accompanied two major radial highways, an extension of route two and so-called I-95 up the SouthWest Corridor. Those radial highways would have brought more cars into the city than the Inner Built would bring around it, so the net effect was to bring more cars into a city that couldn't handle what it already had.

The depression and widening of the artery and the construction of the tunnel to the airport are in many ways decongesting highways because they expand the capacity at the very center of the system. And they actually allow the city to better handle what it's already got.

So the radials were seen as bringing extra cars, which was environmentally damaging. This was seen as a way of just managing what we already had and therefore environmentally benign. So there was a network rationale.

The network rationale was important to me because I'm a transportation planner in terms of the real political discussions that took place, probably the strongest single reason that the project was able to gain support... well there's two. One, there were people who hated the elevated, and thought it would be wonderful to put it underground. I was one of those. But then secondly, the idea that this thing was just going to fall, and we had to do something, and no one else had an alternate plan that was credible. The physical fact that it was going to fall down was probably the strongest ally that I had in building support for doing something.

JOEY: When you mentioned the network issue of how, if the Inner Belt had been built it would have brought more cars in. How did you determine this? Were they done in simulations? I know computers were around, were there computer simulations?

FRED: No, I had done some analysis, just paper analysis as a traffic engineer of the number of lanes of traffic that were coming in, and some reasonable estimates of what share would go around and what share would come into the city, but you could construct almost a geometric proof that based on the width of the roads there was an excess of traffic capacity at least coming in. Now, if you then assume that that capacity were filled, which was an assumption I made, there was simply no room for it on the Inner Belt. There was more net radial capacity than there was capacity around, so the net effect had to be an increase of traffic through the center, unless you believe that the radials were going to operate below capacity which I had no reason to believe because we haven't seen one of those yet.

But it wasn't a computer simulation, it was just sort of a hand analysis. I did that when I worked for the city of Boston as a traffic engineer.

JOEY: Do you know when computer simulations became important to the project? Or, are they important today?

FRED: There are different kinds of computer simulations. They were important to the project in convincing federal highway that it was useful. They were not particularly important to anyone in Boston. I mean, the physical fact that it was going to fall down, again, was sort of the most vivid argument locally. But, the computer simulations were undoubtedly helpful in convincing the feds who were adversary to the idea. And, they held us up for about two years. We ran several simulations and in those simulations we demonstrated that... Even though Interstate highways don't legally have to do benefit cost analyses, it's not part of the normal process, we did one, a comparitive one on the Central Artery and, I think there were four other big projects that federal highway was funding at that time. And the analysis showed that the artery tunnel was more cost effective than any of the other projects, and federal highway was funding all of the other projects, so we sort of did it as an advocacy piece to say, you know, "you owe us this." The reality is, that as a legal matter, our case was very solid. This is part of the interstate highway network, we had never gotten federal money, and the legal arguments were really quite strong. Benefit cost analysis isn't part of federal law, but in terms of convincing the federal highway officials, the computer simulations were useful. So, it helped to soften a negative attitude and ultimately they withdrew their objection and approved the Environmental Impact Statement. So, the computer simulation at the planning level turned out to be very important even though theoretically they shouldn't have been.

Later in the project...

JOEY: I'm sorry, before you continue... What time frame was that?

FRED: Probably 85, 86 that that work was going on.

JOEY: And do you know who was doing the simulations?

FRED: The CTPS, Central Transportation Planning Staff was doing the work. Tom Lisco was involved, who's still over at CTPS. [I clarify spelling.] And, a fellow who was undersecretary to me, named Matt Kugen, really managed all this work. Matt was, you know, essentially full time on about all the processing on the artery tunnel stuff.

Now, the traffic simulations became important again at the tail end of the supplementary environmental process in 1990 when there was a threat of litigation from the Conservation Law Foundation and I negotiated an agreement with them whereby they would not sue in exchange for some environmental commitments I made on behalf of the project. Part of that process was to identify what the most important initiatives would be to assure that the road would lead to better levels of service for the same amount of traffic rather than continued lousy levels of service for ever larger amounts of traffic. And, we looked at a number of different initiatives. And the strengthening of the parking limitations in downtown Boston and at Logan airport emerged as clearly the most important element in a number of elements that we looked at. I think the second most important was maintaining a moderate fare strategy for transit. [I look questioningly.] Not letting transit fares get too high, maintaining them at a moderate level.

There were a number of other transit initiatives tested in that, you know, extend this line or build that transit line, but these broader policies were clearly the strongest. There was some computer analysis that was useful in getting agreement with Conservation Law Foundation on a list of items that should go into the agreement.

Another use of the computer simulations was to predict the amount of traffic that various ramps would have to handle. That's helpful in designing exactly where the ramps should go, and how they should be configured. So that aspect of the simulation was important during the design process. And I think that's continued to be important through the construction because the construction process involves an almost continuous process of deleting certain moves and building in detours, so you're always looking for analysis on how much traffic to expect with which detour route. So I assume they've continued to use those traffic assignment models for that purpose.

Then, after I left, and you'd have to get the specific details from Moshe Ben-Akiva, you probably already have because you've already met him. MIT got this contract to do simulations that you've talked to Moshe about. I wasn't part of that process deliberately because my relationship with the Weld administration, particularly with Karasiotis. [sp?] was quite bad. And any sense that I was part of an MIT proposal would have made it more difficult to get it funded. In addition to which I'm not a modeler, so on the substantive merits I didn't belong to that process, and I would have been a problem politically so it made no sense for me to be involved, you know, either way, so I wasn't.

I think, I could be wrong on this, I think that the contract may have emerged because there was a lot of discussion of ITS at the time and the feds were looking at funding things, and it was generally seen, I think correctly, that universities that got funding from their state highway departments, or their state transportation departments, were more likely to be recognized by federal highways having something to over. The presumption was if you couldn't convince your own state highway department that what you were proposing was useful, you'd have a harder time in Washington. And I think it was in that context that the Lincoln Lab and MIT... Lincoln Lab was also looking for a role because of the cutback in defense spending. So I think it was a natural context that the strategy was "okay, let's target the state" and try to come up with something that will be useful for the needs the state has during this construction progress and after. But again, I wasn't really very involved in that at all.

JOEY: So MIT had had previous contracts with the state? Is that what you're saying, on the state transportation?

FRED: No, well, over the years, from time to time MIT had had some contracts with the state. But in the context of Intelligent Transportation Systems, there was a lot of excitement nationally that there might be a new opportunity for university involvement in transportation. So, I think what was proposed was of a bigger scale than anything that had happened before.

JOEY: So, when you were involved with the project, when you were actually on board, had you ever, was MIT involved in any way? Not so much with the simulations, or with simulations, did you ever bring them in? Or was this the first major involvement.

FRED: No, it was the first major involvement. It's sort of anecdotal and not on point. I had attempted to start a relationship between the state and university, particularly MIT but also other universities, and had gotten legislative approval to go forward. And then there was a lot of, I think, total nonsense out of the State Inspector General that I had a conflict of interest, which I didn't, because I had no contract with MIT or any assurance that I was going to come back. And, I think the inspector general was a fool.

They misapplied in my view a bunch of private sector notions of conflict of interest to, in competition, and they wanted a process whereby universities doing university based research would compete with private consultants, which ethically the universities can't do, and it's stupid. I mean, it's an apple and an orange. And, in my view, there's a strong public interest in supporting university involvement in this area and what I was proposing was that we earmark certain research funds for university based research and that if it was important to assure some level of competition, that it should be university-university competition within an academic... so you'd get the best proposals funded, but it should not be university-private consultant competition. It was a mess, the inspector general was a royal pain, and I think at the end of the day, I don't know if we ever let any contracts, because he made the process impossible. Fortunately he had gone by the time I went. And, there was a different inspector general in place. And again, I don't know the details of how MIT/Lincoln Lab ended up working this out, but the earlier problem with the IG I think had gone away because the IG had retired.

JOEY: That's actually a very interesting story. It'll probably find it's way into our report because we're very interested in how MIT got involved and knowing that beforehand, for sort of a personal reason almost, prevented it from getting involved before, is very interesting. It's anecdotal, but it's very interesting, and it's quite telling about the atmosphere of the politics.

Another question that we have sort of developed as we've looked at these simulations, and I thought that it might interest you, knowing how you care about houses getting torn down and that type of thing, how much did the perception of how people drive, how much did that really affect the design of the Central Artery versus the Green Monster, or whatever it's called, the old clunky... the one that's up now. When they were designing that, did they really consider the fact that people would be driving on this?

FRED: When they originally built it, it was built with really terrible standards. And, you know, I worked on some construction when I was 16 years old, but I was certainly not part of the planning process, but from what I can tell, there's always politics, but that was a totally political design process. And people's brains are usually out of date by a generation or two with current reality. So the perception of the politics of the time was that you really wanted a ramp right near your store, or your bar, or your whatever. So they put in at least twice as many ramps as there should have been because everybody with a political connection wanted a ramp.

Consequently, the distances between on-ramps and off-ramps on the Central Artery was about 600 feet. The handbook will tell you you need 3000 feet. A sort of practical, urban traffic engineer would tell you, "well, maybe you could live with 1200, 1400 feet. You'll be somewhat uncomfortable but you can kind of survive."

600 feet's a disaster and 600 was the dominant mode, they just jammed one in every place they could. They were so bad that they later chopped them off, because they had very high accident rates, and, you know, a lot of fatalities at one particular intersection in Charlestown.

JOEY: So they actually closed ramps?

FRED: Yeah, over time, some of these ramps actually got closed, but, you know, some of them are still up there today causing very dangerous short weaves. Dangerous is the wrong term. Well, I don't think anybody gets killed because you can't move fast enough to hurt yourself. There are a lot of fender benders. But it operates slowly enough that it's not actually dangerous to, you know, to cause serious physical harm to people. But it is very badly designed.

The newer design, you know, went through a lot of iterations because there were a set of on and off ramps that we thought would work optimally, sort of a blended average of the desire for frequency versus too frequent means the whole thing doesn't work. The Artery Business Committee which is a business funded organization kind of looking out for the interest of its members, questioned that plan, and the city questioned that plan, and we ended up sort of redoing the planning of all the ramps. And they pretty much stayed where they were, although a couple of changes came out of that. And computer simulations of traffic were involved in evaluating you know, some of the modifications that various interest groups propose be considered. And some of them turned out to look better, so they got changed. So there was kind of an interactive process.

It was somewhat kind of traditional standards based, you know, the handbook says there should be so many feet and there's just not enough room here, and so *** simulation based. It's certainly much less bad than the original elevated...

On the other hand, I think some of those ramps are too close together. I think some of the modifications that were made after I left because of the Scheme Z controversy are not well thought through, and I think they're going to reintroduce... they're not going to put 600 foot weaving sections in, but they are putting in 1200, you know marginal weaving sections where there could have been 3000, 2000 foot separations of on ramps from off ramps. So, there is always a political process that goes along with the planning, and there are judgments to be made, I think they made some wrong ones. But it's going to be a lot better than it was.

And in that sense, I think the simulations actually hurt. Because, depending on how you structure the simulation... Engineering rules of thumb tend to take the form "thou shalt not have an on ramp after an off ramp within so many feet," and it's kind of clear then you can kind of have a gray zone that compromise into, whereas a simulation creates the illusion that you could have an off ramp two feet after the onramp, and if it's not used very often, it doesn't matter very much, because the simulation's too smart, it takes a lot of factors into account. I believe that the simulation for somebody who's not technical can lead to the perception that it's okay to have on and off ramps closer together than it actually makes sense to do. It isn't only the fault of the simulation, it's the fault of people wanting to ignore information who are able to use the simulation, or abuse the simulation, to make a decision that I think shouldn't have been made.

JOEY: So you think that's been done on the Central Artery?

FRED: I think it's been done near the river crossing, yeah, in one case. The southbound ramp from Leverett Circle headed southbound comes too close to the off ramp going to the tunnel in my judment, I think it's going to cause problems, particularly since those moves occur in tunnel and with curves, and it's very hard... Maybe still more simulation would have helped, I mean there are people who do human factors engineering, but I don't think there was adequate thought given to what the driver's experience would actually be, coming around a curve in a tunnel being joined by another movement in a tunnel, then having a conflict move where you had to get across because some of the people in the original stream of traffic were trying to get off to the right.

JOEY: So you think that the simulations don't really take into account the human perception?

FRED: Those particular simulations were not designed to, that's why you need a good professional that can exercise some judgment, looking at the simulations. If you just do the simulation, it's very easy to misinterpret that data. And I think there was a very strong political desire to make the move from Leveret Circle southbound on the artery direct rather than indirect. I think that was a mistake. I think they... I don't want to say willfully misinterpreted the simulation because I think the people who were pressing for this didn't really have the training to understand the simulations, but they kind of waved the simulation around as evidence, quote unquote, that they could do this.

And they were dealing with a state that had... At that time, the state officials were equally anxious to put in the direct movement so they were kind of... The city, the business leaders, and the state were all looking to do something that I think was a mistake, and none of them were particularly technically oriented and all of them were willing to misinterpret, in my view, the data. [Interrupted by delivery man.]

JOEY: So, in your view, thinking about these simulations and how people used them. And we're talking about the MIT simulations at this point...

FRED: Well, the ones that I think were misinterpreted were not the MIT simulations, these were simulations done by Central Transportation Planning Staff.

JOEY: Oh, okay. Did these simulations overlap? Or what was the different purposes?

FRED: The CTPS simulations were more for sort of project evaluation purposes at the kind of macro level, and ramp design at the more micro level. The MIT simulations were more traffic management related.

JOEY: Okay. So, how do you mean traffic management, just to clarify.

FRED: Well, again I haven't been directly involved but I've sort of gone over and looked at the simulations, and I think the primary purpose for the current contract is to simulate the way the road will actually function and ways to identify where congestion is likely to build up so you can adapt strategies to sort of diffuse it before it happens. So it's more of a traffic management tool rather than a design tool.

You know, in the first instance you are trying to decide, you know, what are the general benefits of doing the project at all, that was very useful to us when we had, you know, an adversary attitude out at federal highway, we had to turn it around, we were able to show at a kind of a macro level that the benefits exceeded the cost to a greater degree than other projects that federal highway was funding, so the basic argument was, if you're funding those four big projects, and this one has better merits, then, you know, why are you funding this one? So that was kind of a strategic planning use of the models.

Then there was kind of this ramp design issue. During the initial planning process, there were predicted levels of traffic for automobiles leaving the central business district headed to the north that indicated it would overload certain intersections. So the specific detail design of the ramp was changed to avoid those intersections in order to avoid that. But those were sort of... The function of the model was to anticipate problems so you could design the concrete ramp in a different way.

Then, once it's a given, and for better or worse this is the piece of concrete that we're going to put in place, you are interested in simulation to say "Okay, we're not going to move the ramp after it's built, but we can do ramp metering, or you know, some kind of intervention to affect the management of how we use what we got. And I think it's the third process the MIT group has been involved in.

JOEY: So in your view, the CTPS that you were talking about, and the simulations that they did, were those very much politically driven?

FRED: No, no, they do good work. It's a question of how you interpret, and I think the interpretation was political by political people, which it should be. But, you know, there's a balance, I think the political people struck the wrong balance. But I think the CTPS is very professional and does good work.

JOEY: And they are a public institution?

FRED: They're a public organization, and a lot of graduates of MIT work there. It's a very high quality place. The people there are professional, they know what they are doing, but they can't be held accountable for what other people interpret from their work.

JOEY: So that's really interesting. I never realized that there were the two levels of simulation there. I just thought that MIT was involved in all of it, so it's interesting to get that view on it.

So, I know that you obviously, you say you don't get along very well with the people running the project now. What is your opinion on how it is turning out? Do you think that you set enough of a groundwork that it is going to succeed still?

FRED: Yeah, I think it's going to be okay. I think that they have done a good job on the construction management. The management of traffic during construction has been good, better than people expected, as good as what I expected. I mean I always, I always thought that there was a somewhat exaggerated fear of the amount of disruption that the construction would cause, and that that was a manageable problem. But it's one think to believe that, or hypothesize that, it's another thing to do it, and I think they've done a good job at managing the traffic and managing the construction. They've had a very good safety record so far. I believe they've had one fatality. That's one too many, but ten years of tunneling, that's an incredibly good record on safety. So I give them credit for doing a good job on that.

I don't respect that they have made some decisions that were political that I think were very bad judgments early on, they added a huge amount of cost to the project, and, in my view, the project will work less well because of some of those decisions they made around the river crossing. And then later, as they become to recognize that they are way over budget, they've been cutting some things out without paying attention to the fact that they're cutting out more value than they're cutting out cost. They're claiming to save cost, I think they're actually being penny wise and pound foolish.

The most extreme example of that is that the fact that they cut off the ramp that would allow you to gain access to the Back Bay, so they are in the position of spending $12 billion or so on this project. You're not going to be able to get from Logan Airport to the Back Bay except by using a lot of city streets. That's ridiculous. I mean it's an absurd outcome. While it's true that the ramp in question would have been expensive to build, it was an absolutely essential ramp. It's crazy to cut it out.

The description anybody gives, I think they've done a reasonably good job on the construction management. I think their judgment is consistently bad on the tradeoffs between the environmental functioning, the social functions the road has to play, and it's cost.

JOEY: So the question... It's obvious that there are a lot of influences based on these politics. How do you feel a project like this can work when you have a government like we have set up, where every four years or every two years or whatever, the government's changing, and the people are changing? This is a long term project that's gone on for a very long time, how does it work? How does it stay past that?

FRED: Well, I think it's inevitable in any big project that it's going to... That you've got to design it anticipating that it's going to go through several administrations. And, different people are going to get to make judgments. And, you know, that's the way it's got to be in a democracy.

The best insurance against bad decisions being made in my view is a lot of public involvement, and then you hope that the public that's involved in the planning process will then demand that the most important features get respected. I think that we've been unlucky in the fact that Karasiotis, who's a very strong-minded guy, a very skillful guy at the politics of things, has been able through his skill to drive some very bad decisions through a process and kind of ignore public opinion when he felt like it. On the one hand he's very skillful, on the other hand I think the skill has got a bad outcome because he's ignoring feedback that's important. And at the end of the day, it is very difficult on a project of this size to get public scrutiny on minute details. You know, if there are 100 people in this city who understand that when this is all over you're not going to be able to get to the Back Bay, you know, I'm surprised. You know, when it's done, people are going to say "Oh my God! They left it out! How could they have done that?" You know, the best you can do is, you know, you write this stuff down you do all of this documentation and environmental impact studies, you try to involve the public so there's some ongoing constituency that survives an individual government that will press for, you know, this particular ramp to not be deleted. It doesn't always work.

On balance, it's still going to be a good project, you know, the city's going to be better off. The artery's not going to fall with all the cars on it, the city'll look better. But there will be some features that aren't working as well as they should because of some penny-wise pound-foolish decisions. I don't think the public's going to particularly notice the difference between, you know, 12.6 billion and 12.7 billion, I think they will notice certain functions can't be performed.

JOEY: So, how hard will it be to add features later, for example, to add a ramp to the Back Bay?

FRED: Right now, there's some chance that there's enough people in the Back Bay and the city are beginning to realize that's a problem.

[The recorder stopped here for a brief time. Summarizing what was discussed, I asked if the system was designed to be flexible enough to add features like the ramp afterward, and he replied that anything could be done, but because of the expense, they most likely would not be done. In the case of the Back Bay ramp, if it is not included, there is going to be an awful lot of concrete to dig through to make the ramp, and it will probably never get done.

I then asked him a question about his role in the Administration, and how much he was involved in the political/administrative side versus the technical side.]

FRED: Yeah, I was personally involved in both, partly because of my own proclivities, I was interested in the technical stuff, but partly also because the ability to get this project funded through a maze of regulations when the federal government didn't want to fund it, required that we have a very strong base of local support. And, understanding the technical aspects of the job were really essential to ensuring that we continued to have that strong base of local support. If we hadn't maintained... We did opinion surveys from time to time, and the popularity of the project was always at least 70%, sort of 70% for, 20% against, and 10% don't know, on a bad day, and on a good day, we were up in the high 70s, low 80s in terms of favorability: 80% for, 10% against, and 10% don't know. And, you know, you can't get a big project built on 51-49. There are too many ways to stop a project, and there ought to be. If people are that unsure they want something you shouldn't go spend $10 billion on it. You've got to be, you know, pretty damn sure this is a good thing, you know, to put that kind of money into it. So I think it is reasonable that the process require, not unanimity, but a reasonably broad consensus. And you can't maintain that kind of consensus without keeping a careful eye on the actual functioning of the facility, because otherwise you're going to gore somebody's ox without even knowing it, and you're going to have a political problem. And, typically there's a lead time between when a decision is made, and the consequences of that decision become understood, and that translated to political opposition, and by then it's too late to fix sometimes, so to me, staying on top of the technical side was really essential to being able to do a reasonable job on the political side.

During that period of time. Now, once you got all the approvals, it does change character. Now it's a construction job. The money is no longer in question, you can't ignore it, you've got to go chase appropriations every year, you got to do your homework, but, you know, you're into a different phase of the project. You're not constantly posed with the question of existence. I mean, it's a fact, it's happening, it's being built, and you try to optimize. So, regardless of who's running the government, the nature of the process post-January 1991 is different than the nature of the process up to that point. And, one could pay less attention to the technical details in the post-91 environment. To sort of not confuse the example by personality changes, I was very personally involved in the technical as well as the political and financial processing of the Red Line extension out of Harvard Square and the relocation of the Orange Line in Jamaica Plain, and then was I out of the government because we lost the election. But in any case, once it got it's approvals, I would have been largely out of the day-to-day management of that job. It was in the hands of the MBTA Construction Division. They're very good at what they do. When I got back into the government, those projects were in full construction. I did not get involved in any substantive way in the construction management of either of those projects.

And it came out, I think, quite well. And I think that if I had become more involved, it's likely that I would have lessened their value because the construction environment... There's so many actors and it is so complicated that it requires a reasonably, almost sort-of military kind-of chain of command, and it was under the Director of Construction at the T. You got contractors coming and going, not all contractors are good, you got conflict, you've got change orders, you've got lawsuits, and interventions from the policy slash political level are more likely to be counter productive than productive, in my view, and I pretty much tried to stay out of things. Even if you see an individual decision that you think you might second guess the Director of Construction and do better, that may be true once in ten times, but you'll screw up the other nine, I mean you're just better off delegating that and letting the process happen.

So, if I had stayed as Secretary, I don't believe I would have been anything like the level... I had a huge level of involvement up to the approval of the permits. I hope I would have had the good sense to cut way back in my involvement and let the project get constructed had I stayed, the fact that I left made it easier. And the guys that took my place, I think... where they intervened, they messed up. And, it's not necessarily because their intervention was less good than my intervention, it's because once you're at a certain point, political intervention tends to screw these things up. And I think the river crossing thing, which reopened some issues, caused a lot of delay, a lot of increased costs, and some bad decisions technically. And if they had simply done nothing, and just let the guys build it, it would have been a better project, it would have cost less money. As I said before, I disagree with these guys philosophically, but if it was you know, my twin clone running the project, those interventions would have been a mistake, I think. At a certain point you got to say, okay, it's not a thing and it's getting constructed. You don't want to be stupid, if there's major new information you have an obligation to reexamine it. But you don't, you don't keep going back or you really disrupt the construction process. And it is so complicated and so interrelated that you, you know, turn this screw a little here and something a half a mile down pops up on you.

JOEY: It's very, very difficult, though, because it's been your project for so long, to be able to say "Okay, now you take it."

FRED: Well, on the other hand, it's a relief too. I mean, you know, I love the project, but, you know, it was like twenty years. It's long enough. [laughs]

JOEY: You get sick of talking about it, people interviewing you? [laughs]

FRED: Nah, it's fine. I like the project. But I think at a certain point... and in that sense it's healthy that there's change every four to eight years. I mean, you know, I don't happen to agree with some of the decisions that were made but, you know, this... projects like this are way too big to be one person's project. They've got to reflect a broader point of view than that, and they ought to be able to sustain changes in administration. It doesn't mean you're perfectly happy with every single detail, but I think on balance that's a good thing.

JOEY: I was wondering, just sort of leading towards the final questions, if you could give me a view of what your day would be like, a typical day, if you ever had a typical day, when you were working on this project so I can get a sense of what type of things you were involved in.

FRED: I was Secretary of Transportation, so in Massachusetts that means that I had a responsibility for the statewide highway program, I was chairman of the board for the MBTA, I was sort of responsible for the... well there's an independent board of directors at the port authority. I really felt responsible for airport and seaport policy. And there are small transit authorities in twelve other metropolitan areas around the state.

So there are a lot of other things that you're responsible for, and you've got annual budgets that you have to get approval from the legislature, and typically every two years you've got a capital program, a transportation bond authorization that you really need to continue the program.

The way my week used to line up, on Monday, I would have policy meetings with every agency head to get a sense of critical issues, what was expected to happen that week, what was coming up over the next month. You know, just an ongoing weekly review of where we were in each agency.

On Tuesdays, we always had an artery tunnel meeting that would last four, five, six, seven hours depending on how complicated things were, and it typically would go into the night, we'd send out for pizza or something, and that was to try to create a weekly forum so the project got timely decisions, and didn't sort of sit around waiting... because you get into a place where you need a decision, you don't provide that decision, the thing gets all backed up. So, Tuesday was sort of artery tunnel day. I think the meeting was supposed to start at 2 o'clock in the afternoon, it probably typically started at 4 and just kept going.

JOEY: So who would typically be at these meetings?

FRED: Well, I would go down to South Station where the work was going on. Matt Kugen [sp?], the undersecretary would be there, Bill Toome [sp?] the project director for Mass Highway would be there, Jane Garvey [sp?] who was commissioner of public works would be there, the Bechtel Parsons key people would be there, the project director changed a couple of times, but whoever the project director was, he'd be there, and usually one or two specialists depending on what issues were coming up. Typically, there was a community affairs person from the artery who would be there, and there was a press person who worked directly for me would keep an eye on what was happening. And, uh, depending on the issue there'd be some specialists on whatever the issue's being discussed, so there's maybe ten people in the room. And a lot of that was around environmental permitting and where the various issues were.

Every other Wednesday, the MBTA had a board of director's meeting, and that typically would knock the whole day out for me, because those tended to be long, and you'd have to get ready for it. I don't even remember what Thursdays and Fridays were, but it wasn't that need. But the week had a flow to it, and Tuesday tended to be the day when I could really focus on the artery, but then things would come up every day. I mean, you don't control the environment. The legislature would decide that they were going to discuss something a certain day, you had to get up there for a hearing. If it happened to be Monday, you couldn't say "I'm sorry, that's my meeting day." You had to move your schedule around.

So there tended to be some basic structure to the week which got modified depending on what was coming up that week, but I kind of set aside a chunk of time every week just for the artery, you know, kind of in the back room focused, and then there were always night meetings and public presentations and other things that you did that were related to the artery.

JOEY: So were those meetings, did they tend to be more politics type stuff or more technical stuff ?

FRED: They were more technical. It was sort of stuff relating to the... You know, we were desperate to get this project into construction. We had been held up for years by the federal highway foot dragging, and you know, we had to get language in the 1987 Surface Transportation Act. We finally got the language, and we were still not into construction because now we had to get approval on the supplementary environmental impact statement, so I was really pushing to get that wrapped up, and it's a very complicated environmental document.

And, I made a decision that was pretty fundamental, and I don't know if it was the right decision or not. There was an original approval on the environmental impact statement subject to fourteen points that further work was needed on. I could have proceeded on the strength of that, and it had somewhere between fourteen and twenty supplementary environmental impact statements on each other issue, and try to keep... get into construction on some pieces.

I thought that would be extremely confusing for the public, and that there was a risk that the project would get to be really confusing, you know "What the hell's going on, I thought they had their approval, why are they doing another hearing?" You know, fourteen environmental impact reports floating around probably inconsistent with each other because, you know, Murphy's Law says something's going to go wrong. I ended up deciding it's too complicated, we've got to do one big document to incorporate all of these modifications that they required us to incorporate. The problem with that... And I'm sure that was right from a coherence point of view. The problem with that is, you know, whichever of the fourteen items takes the longest time to resolve controls everything, because now it's one document, so you can't start until the whole damn thing's done! [laughs]

And, you know, my theory was, it's more understandable to the public, and we've got to do it that way because public understanding is essential to the project, and it's sort of the only way we'll really get through this process because we know we've got to get it done. I mean, it's always going to be tempting if you break it up into little pieces, to sort of let some things that are complicated lag. So, you know, I decided it as, we've got to do one big supplementary. I think it was a more coherent process than it would have been, I mean it was confusing enough as it was.

But it did have a downside, because it delayed us getting into construction on some pieces, and it also created an incentive, which I hadn't anticipated, for wiseguys like Goldberg and Kontos [sp?], the two characters who were in last weeks paper... [I look questioningly.] Well, if you... last Saturday there was an article that a woman named Anne Epert [sp?] who worked for Congressman Schuster [sp?] had done some kind of plea bargain and agreed to some wrong-doing and paid $1000 fine, but the people who had tried to buy their way around the process were both Boston characters who had issues with the artery. And the game both of them were playing was a belief that by finding a way to cause delay on the supplementary environmental impact statement because they were holding up the whole project. I mean inflation was so high at one point we calculated that it was a million dollars... no it was more than that... it was like ten million dollars a month for delay. So their calculation was "well, if we can threaten to delay, then we can extort something out of the project because it's worth money to them to make us go away. And, you know, my attitude was, I love the project, but I ain't going to jail for it. I'm not going to play that game. We're going to settle these issues on the merits, and we're not going to play that game. Had I not made the decision to link everything together, there would have been less leverage for characters like them, which is not something I had anticipated.

I mean you can argue it either way, you know, at this point, I decided it one way and that's the way it played out. I think it was more coherent, but it did have that downside.

JOEY: This is the final question, thanks very much for your time. The final question is, would you do it again? If you knew twenty years ago that it was going to be a twenty-year long project and you were going to be involved, and people were going to come interview you twenty years later, would you do it again? Do you think it's worth it, in terms of Boston? [both laugh]

FRED: Oh, yeah. I think it's worth it for the city. If someone had told me it was going to take twenty years, I don't think I would have believed them, I would have said NAH! [laughs]

JOEY: When you first started, when did you envision it...

FRED: Well, I can tell you with precision one very unrealistic estimate I made. When I went back into the state government in 1982, Dukakis won and went back in, my game plan was... I had figured out the basic way of approaching this thing, which I think turned out to be successful of going with both the artery and the tunnel and relocating the tunnel path so that it was benign instead of adverse in South Boston, and I had the game plan figured out, because I had four years out of the government to sort of reflect, what did we do right, what did we do wrong?

A good clear gameplan, in my calculation was, okay... The legislation required that we get a final EIS filed by September 30, 1983, so I knew we had a helluva year to meet that deadline. And my calculation was, okay, I go like hell, I think I figured out how to do it, we make the deadline, then I pull back and I got three more years to go back and focus on transit. Eight years later [laughs], it's my last day as Secretary, after eight years, you know, we got the approval the day before that, so I was off by exactly a factor of eight! That one I remember with precision.

JOEY: So, thank you very much for your time.

FRED: OK, well you're welcome. It's great to talk about it. Yeah, send me a copy of the report if you get the chance.

JOEY: Yeah, I will, definitely. Actually, we present it at the end of the term, and we invite everybody.

FRED: Oh, thanks, let me know, I'll try to be there if I'm in town.

JOEY: We'll send you everything that we do, and actually, as we develop the project, would you mind us interviewing you again with more focused questions?

FRED: Oh, sure. Yeah.

7.5 Interview with Phyllis Hassiotou

Serena Chan, Joey Rozier, and Ming Maa Friday November 12, 1999

JOEY: This is an interview on Friday, November 12, 1999 with Phyllis Hassiotou.

Ok, so we'll give you some background. We're in a class at MIT called The Structure of Engineering Revolutions. We're interested in, basically, how engineering projects develop over time, not so much the technical details, although that is part of it, but also on the processes that go into it, the political decisions, the decisions on what you are going to pursue, and that type of thing. We decided to do our project on The Big Dig. And The Big Dig is a very big issue and so to focus on it, we decided on MIT and MIT's role in it. We found the biggest involvement with the simulations here at ITS. So, we want to get a lot of perspectives on how MIT got involved. And obviously Bechtel is one of the big players and that's why we want to get the perspective from that side. We've got other perspectives from this side. We've interviewed Professor Ben-Akiva at ITS, some people over at Lincoln Labs...

SERENA: Tony Hotz and Carl Much

JOEY: And we've interviewed Professor Salvucci, who was involved with the Big Dig before 1991. So, we've interviewed a lot of people around here and we're also interested in people outside of MIT, to get their perspective. So, I guess to start off, the way we normally start, is to get an idea of who you are, a little bit about your background, just your education and also how you got involved with Bechtel.

PHYLLIS: Well, actually, I'm not Bechtel, I'm a Parsons person.

JOEY: Sorry, I just think of it as a whole big...

PHYLLIS: It's a joint venture - Bechtel, Parsons, Brinckerhoff.

[Laughter]

PHYLLIS: Well, as I told you, I'm from Greece. I have my BS in civil engineering from Greece and then I cam here to Michigan State to get my masters degree in traffic engineering. I'm doing my Ph.D and never finished. [Laugh] I'm still in the process of finishing it. But I've been away some and with this project for six years. I was in the Traffic Department for 3 years and with the Operations Department for another 3 years.

JOEY: What was the difference between those two departments?

PHYLLIS: Well, it's hard to distinguish between the two departments. The Traffic Department is more involved with the assigned elements of roadways, the number of lanes, the assignment of the intersection, the assignment of the traffic lights, analysis of capacity, things like that. The Operations Department focused on the operation of the main line basically, not so much as the surface roadways as the main line.

JOEY: The main line?

PHYLLIS: The freeway, I-93, I-90. not the surface roadways.

JOEY: Ok. How would you say MIT's role fits in?

PHYLLIS: Well, MIT's simulation doesn't include surface roadways, just basically, I-93, I-90 and the interchanges.

JOEY: So, do you know how Parsons and Brinckerhoff got involved in the project? How they were brought in?

PHYLLIS: Well, they are the management consultants. You know, the conception of the Big Dig, has been like, 20 years. Finally, it went through Congress and was approved. There was a bid process that Betchel and Parsons, as a joint venture, won the project.

JOEY: Ok. Do you know anything about that process?

PHYLLIS: No, I don't. It was back in the '80s.

JOEY: Ok. So that was before you were...

PHYLLIS: Yah, that was before. I was hired by the project in '93 and it was well under way.

JOEY: So, you were around at the time when MIT got involved.

PHYLLIS: Not really. I was around but I wasn't involved. So, I really don't know how MIT got involved and the reasoning behind hiring MIT in the beginning. That's a question that probably John would answer if you give him a call.

SERENA: Yes, I will be giving him a call.

PHYLLIS: He'll give you some background information about how MIT was involved.

SERENA: Were you already in the Operations Department when you got started on this project?

PHYLLIS: When I started working with MIT, it was with the Operations Department.

JOEY: What was it like working with MIT as a contractor? Did you have to come over to MIT and work with these researchers? Was there a big difference?

PHYLLIS: That's why we hired MIT. We are impressed with their background, with everything that they do. The major difference is the consulting compared to the academic area. You have to deal with students, who have their classes, who have everything..., they operate in a different mode from the corporate mode. In a corporation, it's like 'we need that', 'we have a specific deadline.' But they have been very good with meeting deadlines for us.

JOEY: Was there a lot of day-to-day contact between...?

PHYLLIS: In the beginning, sure. I wasn't involved with that, but I know John was basically here, almost everyday for several hours, when they were doing the calibration of the model.

JOEY: Um...you say the beginning, did it change over time?

PHYLLIS: As things got under way, they had a better understanding of what we were expecting and how things had to be done. Our involvement had not been as much lately. We just meet once a month or twice a month and we specify what we need and when we have the deliverables, then we can meet again and talk about the issues that we see.

SERENA: So was John the only one who came out here a lot?

PHYLLIS: John was pretty much the person who managed day-to-day activities with MIT.

SERENA: Did anybody else come out to this site?

PHYLLIS: No.

SERENA: I'm trying to figure our who was at ITS.

PHYLLIS: It was just John in the beginning and then I was coming too. Not all the people.

JOEY: So, you did come over later?

PHYLLIS: Yes, about '97.

JOEY: What was it like interacting with the people here? Professor Ben-Akiva? Tony?

PHYLLIS: Well, actually at that time it was Mithilesh Jha, the person who was in charge of the students. So, the interaction was more with Mithilesh directly. He was directing the students. So with Professor Ben-Akiva, it was more indirect, to discuss basically financial issues, things like that.

JOEY: Were there usually a lot of debates? Was it you telling them 'this is what we want' and they said 'ok'?

PHYLLIS: No, it was discussion-based - how to to do what we want you to do. We were explaining from our perspective what we wanted and all the time it was 'yah, we can do this and we can do that.' So, it was a discussion-based.

JOEY: So, you were the group that was initiating?

PHYLLIS: It was based on real needs of CA/T.

JOEY: Did MIT ever come to you saying 'this is an idea that we have and can you use it in some way?'

PHYLLIS: As far as I know, no.

JOEY: What does a typical day or week look like for you? You were at Parsons, was the Big Dig your main focus? Over the week how much time would you spend here?

PHYLLIS: Physically? or just working?

JOEY: Just working.

PHYLLIS: It will vary. Sometimes no time at all. Sometimes, when we had to review some deliverables, it was 90% of the time. It varies. Because it's not constant interaction.

JOEY: So, when you weren't working on the Big Dig, what kinds of other projects were you working on? Or were you working on the Big Dig all the time?

PHYLLIS: It's just the Big Dig all the time. Everybody works full time on the Big Dig. Just different components.

JOEY: So, when you said that it varied, that was the MIT component?

PHYLLIS: Exactly.

JOEY: Ok. Gotcha. So, how much do you know about the technical aspects of the simulation? What type of components went into the simulations? the outcomes they got?

PHYLLIS: Well, I can answer all the questions, but if you talk to the students...I am pretty familiar with what is happening.

JOEY: One thing about simulations, how much of an impact do you think the simulations had in the Big Dig?

PHYLLIS: Well, it was very useful information.

JOEY: Do you have any specific examples of where it came in handy?

PHYLLIS: Well, for example, I don't know how familiar you are with the Central Artery. One of the first big components that opened in December '95 was the Ted Williams Tunnel, which carries at this point, only commercial traffic from the airport to South Boston. And for designing the toll plaza, MIT was heavily involved in that, assuming different penetration levels for the electronic toll collection. They gave us very good information about the design of the toll plaza, how many booths you are going to have based on percentage of penetration level.

JOEY: So that way, the simulation that MIT did had impact on the design?

PHYLLIS: Yah, sure. On the roadway of the toll plaza, how manual booths and how many electronic ones.

JOEY: So, MIT's role was mostly after the design of how you are going to put down..

PHYLLIS: The roadway design was done based on volumes that came from a different model, run by a different sub-contract, Cambridge Systematic [?], which uses trip-tables, based on lane uses. That's how they designed how many lanes you need. Now, the role that MIT had was how to design the toll plaza.

MING: From your perspective, what were some of the gripes of the deliverables? What were some of the bad things?

PHYLLIS: Well, it's not necessarily bad. Sometimes the format was different from what we expected. The information was there but we wanted to see it in a different form. So, we basically asked them to reformat the information.

JOEY: What type of format did the information normally come in? Was it tables of numbers or drawings?

PHYLLIS: No drawings, it would be tables basically and brief reports summarizing the tables of information.

JOEY: One of the things that has come up is that simulation is very open to interpretation. So, would MIT just provide raw data and you would interpret it?

PHYLLIS: No, MIT would do a lot of the interpretation.

JOEY: So, to you, how important was the data versus the interpretation they gave?

PHYLLIS: Well, when we are talking about 20 hours of run for each run times I don't know how many runs, we are talking about a lot of raw data. So, we most of the time were not even exposed to the raw data. We always had MIT summarize the data and present us the outcome.

JOEY: How much of your role had to deal with politics? with the government and also MIT?

PHYLLIS: Well, every big project is 50% politics and 50% engineering, or whatever you want to call it. I don't think MIT was involved in politics too much. We tried to keep our relations with MIT at a technical level than a more political level.

JOEY: So, do you see yourself as a buffer between the politics of the Big Dig and MIT?

PHYLLIS: Umm...well, again, we are only the management consultants. We are not the client. So, our role is to present the client, the Turnpike, with the information that is important and to present the options. Find out the options, the pros and cons of each option. The client, bascially, comes up with the decision. So, the client, being a political entity, ...

JOEY: In your own experience, did the politics ever affect the decision that was made in a negative way? For example, you presented them a number of options and you thought this one was better than that one, but they went with the worst one?

PHYLLIS: In terms of engineering again...[laughter]... but first we don't have the picture of just component...You know, I don't want to say anything that is not true. From our perspective, that's what we think is correct. Now, the client has to take input from other disciplines, it has to take the cost, which is a big issue. So, they have to make a decision based on all those aspects. [Laughter] You know, if we way 'yes, we like this engineering...its more sound, but it costs a couple of million more', the client has to consider our decision, but it may not be the best engineering decision. There are so many different aspects when are you talking about this kind of project. So, I don't say that they are making the right decision or the wrong decision. We have to consider all the aspects bascially. While we are only talking about things in black and white, in an engineering perspective.

MING: Was there ever an instance where MIT gave an interpretation of the data and there were questions about the results? In terms of whether it was valid.

PHYLLIS: Well, when you are dealing with simulations, you always have to question how valid the results are. Simulation is one thing and then you have real life. But based on the calibrations of the model and everything that was done, we feel confident about the information that we get from MIT. We know, still, when everything will be implemented in the real field, things may be different, but that's the best tool we have so far to predict how the future is going to be. So as far as I know, things have been working so far, for example, the toll plaza that has been implemented...things have been working well of there. Still, we are talking with MIT right now about incident detection algorithms and how those are going to be calibrated. The results we are getting from simulation are very good. Now, when it will be implemented in the field, nobody knows. And it will be several years, before we can say 'yes, the simulation was very good and the results are similar' or 'no, the simulation was really varying.'

SERENA: So, since the Ted Williams Tunnel has been implemented, did you guys go back and validate the simulation results with what is actually happening in the area?

PHYLLIS: I'm not sure. I know we did a lot of data collection for the model. I'm not sure to what extent. You have to talk to the students who are basically doing that.

SERENA: So, you are now working with the students on incident detection?

PHYLLIS: Yes. Actually, they are pretty much finalizing the whole effort.

JOEY: I know MIT's contract runs out at the end of this year. Is there another company that is going to do simulations after this? Or is there no need for simulations anymore?

PHYLLIS: Well, the project is pretty much complete and the client is interested in cost containment.

JOEY: So, no more simulations are going to be done?

PHYLLIS: No, as far as I know. No.

JOEY: I notice that you refer to Boston as the client. Do you normally work with agencies like that? Does Parsons? Or do they work with private companies?

PHYLLIS: Well, most of the big projects are through government agencies, the cities, or towns. As far as I know, Parsons have been also been involved with private companies.

JOEY: What about you personally?

PHYLLIS: Well, that was my first job. [Laughter] Pretty much my first real job.

[Talk about Bechtel Hall at MIT]

PHYLLIS: Well, Bechtel is huge, much much bigger than Parsons. Bechtel is a construction company. Parsons is, until recently, more of a design company. And now, getting more involved in construction.

JOEY: Do you know how Parsons and Bechtel got involved with each other?

SERENA: How it became a joint venture...

PHYLLIS: Well, I know they worked as a joint venture in other projects also. They are both big in their respective areas, probably the biggest companies, so it made sense, I guess.

SERENA: So, is John also from Parsons?

PHYLLIS: Well, the way that things worked actually...in the office, it's pretty much integrated. Sometimes you don't know if the person next to you is Bechtel or Parsons Brinckerhoff. The only difference is the individual company, the benefits of the individual company, in terms of your role, the way you are treated, your promotion, and things like that. Everybody else is pretty much the same.

SERENA: Well, the other intervees though he was from Bechtel, so that why we though you were from Bechtel.

PHYLLIS: Oh, no. He is Parsons. Anything else? I hope I helped you. Again, if you have any questions, John is the one who's been with the project and with MIT much longer. He'll probably give you some background information about how MIT was involved in the beginning, who came with the idea, and the simulation work.

JOEY: Well, thank you very much. Thank you for your time.

7.6 Interview with Masroor Hasan

Serena Chan, Ming Maa, and Joey Rozier Friday November 12, 1999

JOEY: Ok so it is November 12th 1999 and this is an interview with Masroor Hassan. Did I pronounce it right?

MASROOR: Ya, ok so.. one of the very few times

JOEY: Mind if I shut the door

MASROOR: Oh no , that's fine

JOEY: Do you want to start out Ming or ?

MING: Oh! Ok so right..so figure you like to get some background on the project.. what we are doing and that will help you sort of understand the questions we are asking.. so the project is really trying to find trying to look at the different aspects that various players have in engineering projects, these players could social, political , economic or technological players, but we are really looking at the interactions between these players and how they each contribute to the projects, demise or success, that's sort of the background

MASROOR: OK!

MING: You Guys want to start out

SERENA: Well I guess you can first give us your background.

MASROOR: My background, I came here as a Masters student in 96 Fall, I finished my masters and now I am a Ph.D. Student, that's about it and I have been working on this project for from the very first day

I came here it was my first RA appointment and I have been working as an RA on this project since then continuosly, its basically I was initially working on the data collection part of the project not of the project of the simulator later on I worked on some of the assignments the CA/T people wanted us to do in the mean time I also worked on my Masters thesis and completed that and now I am working on the Ph.D.

JOEY: So what get you interested in simulation at the beginning?

MASROOR: In the beginning I did not know much about simulation, Ya if you ask me if you want a forthright answer, I did not have funding when I came here but I got my funding within 5 days so even if I was not interested in simulation I would have done because it was were my funding was coming from, no but it is fun, I am in transportation, so its really close to real life that you are looking at real life situations you are trying to model real life situations driver movements , vehicle movements control and all the things so I think this is the future, it has to be the future, all the evaluations you have to do and all the new ITS controls that are coming you have to evaluate them and the best thing to do is simulation because field testing is not feasible with the limited budget and constraints that they have.

JOEY: So have you been involved in traffic before as an undergrad?

MASROOR: Ya Ya in Bangladesh, I was ..in my undergrad .. I actually .. maybe not much but I did a Masters degree in Bangladesh too and my masters thesis in Bangladesh was with traffic signals and the unique feature in that part of the world is that you have non motorized and motorized vehicles on the same road so which makes it more complicated the traffic modeling so I was doing traffic signal modeling for that kind of system where you have both the motorized and non-motorized vehicles at the same time which makes some of the models more intricate and you have to change the parameters and things like that because it does not apply the models you are doing for this country for the western world the developed world doesn't work if you are applying to the third world country, maybe the basic structure applies but maybe you have to format some of the parameters of the equations and things like that so I have been involved with traffic modeling and transportation modeling

JOEY: So why did you come to MIT? Do they have a good reputation over there or?

MASROOR: It's the best institution in the world, you know the Visa officer in the US consulate in Bangladesh asked me just this question why are you going to MIT and I said "Why shouldn't I "

(Some jokes ....)

JOEY: So about the simulations was it something the bigdig needed and they said they were looking for someone to do the simulations or MIT had it and they said oh we can use that?

MASROOR: I don't know the history exactly, but as far as I know we didn't have the simulation at that time I think it fell into place at the same time. My professors and other professors here were thinking about having a tool which they can use for their own purpose for doing all sorts of evaluations without having the bigdig in mind and at the same time they found out that there was an opportunity to be able to get funding from bigdig as this project was going on and I think they were also looking at something like that so I think what they had to do was to convince the bigdig there is something we have in mind which might help you , I think its like that I am not 100

JOEY: So simulator is a MIT property

MASROOR: Oh Ya.. it is an MIT property but they can use it they have unrestricted access to it but it is out and out a MIT property.

JOEY: So when you were working on your masters thesis did you feel like I am doing this for my thesis that was the main focus or did you feel like I am doing it as part of the bigdig.

MASROOR: My masters thesis part you can say when I explicitly focused on that then it was not part of the bigdig because the thing that I was doing as my masters thesis is not part of the project anymore, it will not be part in the bigdig, its ramp metering I don't know if you know it will not be there but I started the ramp metering work as an evaluation assignment that hey gave us for the bigdig so I got interested in that when I was doing the evaluation assignment for them but then they decides maybe political or whatever reasons it will not be here but I got interested and here people my supervisor said ya why don't you continue to do something on this so I continued to do that because it helps you because once you are already working on something ,you have a background and things like that and if you want to start fresh again with something else the initial , the inertia time it takes it can take 2-3-4 months you don't know you have to do to literature survey and that to figure out what projects to do , what topics to select so it gave me a little bit of cushion to start on.

Do you know how the other students.. what did they think

There is a time when it comes its just the thesis, because when you are 2 or 3 months away from it you are totally focussed on the thesis, but initially every student work s on different aspects of the project, sometime on some other projects because the simulator is used just not on bigdig, like there is a Sweden Stockholm project that we have and one student will be working on that and he will not be working on the bigdig project anyway the project is ending so it depends, it depends the number of students you have the assignment they want the requirement, they will be working on something else, maybe developing their own models enhancing the models, it has always happened. Although sometimes the project requirements are so high almost all the students have to work on that so it depends from time to time it varies there are sometimes when we had to a lot hard work for the bigdig and there times when there is no work from them so we were working on something else not at all on their project.

JOEY: Was the bigdig the primary project of the ITS?

MASROOR: Initially yes for the last 3 years yes.. ya definitely primary project workwise, moneywise.. maybe not many more.

JOEY: Did you ever feel like that the ITS was just part of bigdig not of MIT

MASROOR: No we didn't have that feeling, we always knew that this was the project we are working on but overall the global picture it's the ITS we are working, we are working on the ITS framework we are doing everything that is included in the ITS and the bigdig is just sort of a byproduct not a byproduct just a subcontract we are doing we are applying ITS technologies for the bigdig requirement but I personally didn't feel the way you mentioned.

SERENA: How did you interact with the CAT.

MASROOR: Definitely first we interact among ourselves, when we agree on results then we present to them, before we give the final result we also talk to people like John Chlebeck he come sin and we discuss with whom and based on all the feedback we give them the final product.

SERENA: Who takes it there? Students?

MASROOR: Usually we are the one who gives the results and there are research associates who help us prepare reports, I haven't given any maybe informal but in their office I haven't gone there to show them the results usually the research associates do that and in some cases you don't even need to give them any presentations the report was enough

JOEY: Was there a lot of debate with the result, what that meant ?

MASROOR: Which one you are talking about?

JOEY: The bigdig..

Initially, I don't know, initially first three years I was not here, the last three years I was here not much debate there are some differences maybe the CA/T want it in a different way that we are showing so we change it and sometimes when we think we are doing it correct we put our foot down and say no we are correct so sometimes they have said ok you are right and sometimes we found out their suggestion is correct but after we came here I haven seen much of debate you are saying no no debate

JOEY: Well even internally

MASROOR: Not yet, it has been a very good association with the CAT people, that hey understand us pretty well and we understand them pretty well , since I came in it has been a pretty fun ride.

JOEY: What was it like working at ITS, fun and hectic?

MASROOR: Any MIT place, it is not a fun place it is a hectic place, no sometimes it is fun

[Discussions on MIT and ITS etc..]

JOEY: Did you feel any pressure directly?

MASROOR: No, not at all, oblivious about the outside world

JOEY: Do you know if your supervisor felt that?

MASROOR: No, even if he felt that I have no idea..

JOEY: Feel the immense bureaucracy around the bigdig

MASROOR:

No, we are totally separated, we don't deal with these things at all we have no idea what's going on there.

JOEY: I have some questions about the simulations..

MASROOR: That's better..

JOEY: How did ITS approach the problem of simulating individual drivers, I know you use microscopic model how did you approach the problem of collecting the data, we read the paper about the video collection ?

MASROOR:

Basically the idea was we needed trajectory data because the way we model it, we model it on individual vehicle and then movements on the road , so requirements were simple so we needed trajectory data as much as possible which was not available, when I came in it was not and still it is very much unavailable, you can have there is lot of aggregated speed, density things like that but if you ask for trajectory data its where you have positions of vehicle each period of time it is still very much unavailable data , so they were looking before I came it was decided they were looking for how to get it I think Alan came up with the software name that I told you before: Viva Traffic so he contacted them and procured it initially it was beta version , they were also developing it so it took us sometime to get it up and running as there were lot of bugs, there was a lot of email exchanges, then they gave a better version so started version then we found out that there was other problem, if the traffic congestion is very congested then the software doesn't work as it cannot differentiate between the road and cars as they are so closely spaced so what we had to do was to collect it manually so me and another student worked on it data collection , we knew what was needed but the difficulty was getting it it was very cumbersome I think it was like for 1 minute data we had to wrok 30hrs, so manually we got about 10 minutes of trajectory data for congested conditions because it was about 350 hours which is more than 2-3 months working I guess then the other part where is is not congested, its not very easy to get the data just run the software, the data needs are very evident but it is not easy to get it so the guy who was doing his Ph.D., needed it very badly and the 10 minutes data we gave him helped a him a lot, still data is a problem.

JOEY: Did you look at simulating the driver's psychology?

MASROOR: Psychology has to be, its no explicit, its implicit, the way you move it's a outcome of my psychology .. the way I drive is depended on my psychology .. I am sure you drive differently from me so it is just we are two different people but you cannot see the psychology , we just look at the outcome and try to model the outcome as closely as possible to the reality.. but explicitly no but implicitly yes you are modeling something close like that because the outcome results you are seeing on the road is an outcome of your psychology

[Discussion on Viva Traffic]

The section that you used the section of the CAT are you comfortable with extrapolating that to generic traffic patterns

We did do it for other places too, at some point you have to do a tradeoff, in this case the student that he used he used he modeled those he just simulated that section of the network, he didn't use it for other selection we did some for drive, some for memorial drive we collected some data and it was explicitly for those cases but if you tell me to use the data for everywhere in Mass then we will not be comfortable but in some cases they are representative, Boston drivers are driving over there and there is a freeway there so there is some transferability, but there are limitations you cannot apply everywhere you want even in Boston or Mass. So we didn't explicitly use it for a lot of places basically this data was used by this Ph.D. student he used it for that section of the freeway for that should be very comfortable.

JOEY: So how will the rest of the network be simulated?

MASROOR: You have to go take the video and process the data, data collection, is the, trajectory data collection is difficult.

JOEY: So what kind of data did you collect for your ramp metering thesis?

MASROOR: For that I didn't need any data because I just developed the algorithm and implemented it and the origin destination so its just the models were there, the models that were already calibrated and validated were there so

MING: So you actually went out to different points in the central artery and got this data?

MASROOR: Alan, ya. I was not present but he got videos from different points, not only central artery but memorial drive also

MING: How many points were there?

MASROOR: Alan might he is the best person, he was supervising us when we were doing this data collection, he is still working part time with the project but he is full time employee someone else.

JOEY: How is MITSIM different from others simulators, TRANSIM, cellular etc.?

MASROOR: TRANSIM is more planning level software so you can use it for transportation planning, day activity scheduling and things, they are different and every simulator has its strong point and weak points so if you ask me personally I'll say ours is the best..

JOEY: Why

MASROOR: One of the reason is the models that goes behind the simulator I think this is academia so we are really focussed on the inherent modeling of the simulator there are other simulators which may look good graphically or might have other advantage but I inherent modeling I am pretty confident our simulator is the best, the most effort was put in modeling so that we can really represent reality, so this will be the best point of our simulators.

JOEY: So when you run the simulations do you get a sense of how the individual will feel like or react to things like accidents, curves or you have to look at the whole system?

MASROOR: You can do it actually, basically our approach is that before we run the scenarios we see if graphically first to see if there are any problems or not to see if the drivers that are behaving are behaving weirdly or not. So it gives you an idea on what's going on whether you are simulating close to reality or not. Sometimes you will see something is wrong and so we will understand we were doing something wrong, that's why the drivers are behaving weirdly, but for final results what we do is when we have to run multiple applications it's a stochastic simulator, once we are confident of the scenario we run it in the background.

JOEY: How long does it take to run it in the background?

MASROOR: It depends in some cases it runs slower than real time and some cases faster than real time, it depends on the scenario of demand, if you have higher demand it is slower then if you have lower demand it runs 50

MING: To determine whether the model is not working you look at the graphics

MASROOR:: That's just one of them, just to look, just to see there might be something wrong in the input file that you did so it gives you an idea if everything is going in right in every direction if you look at it very carefully, so once we setup all the scenarios we just don't run it in the background as it is we just have to usually look at it just to see that it is typical.

[Question on paper and graphs.]

JOEY: One of the people we interviewed was Prof. Salvucci and he had this quote and I wanted to see how you respond to it he said And in that sense, I think the simulations actually hurt. Because, depending on how you structure the simulation... Engineering rules of thumb tend to take the form "thou shalt not have an on ramp after an off ramp within so many feet," and it's kind of clear then you can kind of have a gray zone that compromise into, whereas a simulation creates the illusion that you could have an off ramp two feet after the onramp, and if it's not used very often, it doesn't matter very much, because the simulation's too smart. What do you think about that, the general idea that simulations are over fitting?

MASROOR: Sometimes it may happen, I am not saying it might not happen, but I think it's the answer to a lot of questions that people are having with new technology its not 1940 anymore where you did not have that much technology that much control things available so you could predict a model easily now with traffic demand going high high higher everyday and with the new tech. That are coming I think simulation is a very good tool to test the models you have and definitely there will be some overkill as you said so people should try to minimize that so , it depends on the simulator too , how are you modeling this, if you are models are good so overkill should be less if you are models are way ff you are not representing the real life, there is tradeoff here I think it is useful but simulation which you are using should be good one.

[Questions about a graph and a paper.]

SERENA: Are there any other projects going on

MASROOR: Right now there is no project going on, its almost finishing, we are just wrapping up, for the time being the CA/T will be history for this ITS project, maybe there will be new work later on in the future, not any more as far as I know.

JOEY: Thank you very much in the future if we have any questions do you mind if we contact you.

MASROOR: No No that's ok.

7.7 Interview with Alan Chachich

SERENA Chan, Ming Maa, and Theresa Burianek Tuesday November 16, 1999

ALAN: What is your objective? Are you specifically interested in MITSIM? Or... The reason I ask the question is, Tad [...] did work with us, he was part of this group here, the human factors were one third of what we were doing. There were people in Ocean as I mentioned that were doing something for the artery, related to the tunnel going under water, ships hitting it and all that business. And there were also somebody else that was doing structurally relating things. I don't know. The ocean people and those guys were totally separate contracts from us, so I don't think that anybody could tell you about... So I'm asking what's in your scope? If that's not your scope, then it's no big deal, if it turns out your scope is broader than maybe you don't want to look those guys up.

MING: Right, the class sort of centers around looking at a project from the holistic point of view trying to get the other factors that go into a successful project, sort of the political, economic, and social factors and more importantly how the different players interact with each other. So we decided to do the CA/T project because, you know, obviously in this project, there's a lot of these factors going on. I think in the course of our research, we wanted to do something that was related to MIT, the simulations was a perfect sort of topic. And, I think as we've gone along, we've focused on the simulations more than the other factors, or some of the other projects, just because there's a wealth of information in that area.

ALAN: Well, Moshe's goal was to build a simulator. The project's goal was not to build a simulator. The simulator is just a means to an end. I mean, why the hell would they give a damn about the [...] simulator, right? They wanted help evaluating traffic control strategies. Moshe doesn't give a damn about dumb [...]. Moshe is less concerned about the control strategies as he is in developing the simulator, so you can see it, the kind of questions you are getting at, the right idea, the diversions and the interests which tend to negotiate as you go. There's a tension, pulling opposite directions. That's important. Actually, this class is a good class. I think it's good that they're teaching it while you're still in school. I think it's a great idea. Because I have had one of these eclectic careers where I've done a lot of deep technical work and I've done a lot of, at this point I'm actually looking at more market research oriented things, so again, to a whole realm of this, on a different type of project's important. Discussing these things when you're a student getting your degree in EE, or physics, or whatever will certainly help you open your eyes a little bit. I sort of ran into a lot of this on-the-job training. You know, why you don't say certain things.

SERENA: [background?]

ALAN: I started in plasma physics. IM beam diagnostic probes at RPI. And, while I was doing that, we had a change of presidency. You look at factors that can affect technical things. I never dreamed how that would affect my career, but when I went in Jimmy Carter had the moral equivalent of war. The sultan energy crisis was the quote-unquote moral equivalent of war. In fact, you guys don't even probably remember that...

Anyway, when Ronald Reagan became president, he didn't care, he wasn't interested in this energy business. He was more interested in the evil empire, so the money at the federal level shifted in the hundreds of millions. So the energy programs were cut drastically. The fusion program I was in was cut one-third in one year. The solar energy programs were cut 80%. Lawrence Livermore program went down to 10% one year. So that wasn't a promising relation, so when I left RPI, I worked for a consulting engineering company for a couple years, working on sensor related problems... Well first I was doing communication stuff that was military, then I got into energy work and was working for the railroads and some of the industries in the oil industry. I went from there to the Lincoln Laboratory and did I guess what you'd call sensors or control work. And then came down here as a... I was interested in leaving the defense area. It's not where I started, and this was an opportunity to get back in... Well, I guess the trigger was while I was at Lincoln I contributed to a book called "The Energy Source Book" that was published by the American Institute of Physics, and I wrote the chapter on Energy Transportation. And that got me thinking about transportation more seriously, so when I had the opportunity I came down here and have done some work here.

So my background is a physics degree, electrical engineering degree, and then a lot of everything else. So, my record is technical and broad. I was very deep into the area of microwave integrated circuits, and everything else is kind of big picture...

SERENA: [Why didn't you return to Lincoln after the Big Dig project?]

ALAN: Yeah, actually the ones who went back were in the minority. When we first came down here... You got the dates and all that. May 93 project started, and we were working in Carl's area at Lincoln Laboratory, he made some space available in his group there and we finally moved into this office space something like June or July a couple weeks later. The first interim contract went from May til the end of September. And then, after that, the next contract we signed, it took them half a year to negotiate... it's something I never really understood. It took them several months to negotiate that five month contract, and assuming they worked all those terms out, our next contract, which was then to be for two years, wasn't ready. We started negotiating that one as soon as they got us going. Five months later, they still didn't have that contract ready. In fact, they continued negotiating that thing for like another year, a year and a half. Maybe Tony would remember better than me. So, once we hit the end of that quote-unquote interim period, we never had more than a couple of months [...] The two-year contract was finally signed, I could be wrong about the portion here, I think it was about three-quarters of the way through the period. It was signed and made retroactive. I never understood why they could negotiate the terms of the interim in a certain number of months, and you figure once you've resolved all of that stuff, what's left to do should be easier. Instead, it took at least a year or more to negotiate a two-year contract. I just never understood what the problem was there. That could be interesting to look into. Tony, he might have a little bit more...

It did affect our thinking a little bit. You had to assume the money was going to keep coming. Because at any point, they could have stopped. At any two or three months period, they could have just stopped, and we all would have, you know, been unemployed. Except Moshe. If you're on the academic staff, or the research staff, you got soft money, so...

MING: [How do you think the fact that you were always on hold/on contract affected your work?]

ALAN: I don't know... Do you do anything that's risky? I'm a rock climber, so I could put it in those terms. If you do something and you don't get hurt, then after a while you get sort of complacent, the complacency sort of... You know, I still ride my bike out to Wilmington... I didn't ride this week... You do something like that you got to worry about getting picked off by a car, but after a while not getting hit by a car you start to not worry about it. So, if you thought about it, it could be nerve-racking. Two things. One, it forced you to look at the bigger political picture, so I would essentially make my own judgment that "there's no way they could cut it off." And, it worked, they didn't. And when the money was starting to be cut more seriously, I could tell. But, I don't know, so I don't know that it affected my work per se, but sometimes, instead of riding on a road where there's no shoulder, you kind of get used to it, you keep looking ahead, you don't worry about it but sometimes you look down, and you sometimes feel like you have to have a strong stomach to keep doing this.

I don't know if any of us had actually... I don't think any of us actually had family and kids and things to worry about. Now, for somebody like that, it might have been a more serious issue. You know, I think we all had a lot more flexibility so the personal risk wouldn't be as high if you had a house payment, and you have the wife who's not working, children, I think then it might have been harder for someone to keep doing it. In fact, the first guy to leave, that was the case, he was actually married and had his first kid. I was telling you, when we first came down here, it was Carl, Tony. Carl was the project manager. He actually didn't take an office here, he actually, he stayed at Lincoln, because he's a group leader over there. This was just one of many things that were underneath him. Tony, myself, Rob Gilligan [?], Lisa, and Marilyn who was the secretary, so at least five, if there's somebody else, my apologies to them if they ever see this or hear this. Rob actually took a job... Well, in Wall Street, they have these big boards with the numbers are up there that the trader's look at, he went to work at a company doing electronics for the boards, so he stayed commercial. Lisa did the same thing, she left probably three months later, and then Jaime... Oh, I take it back, maybe the majority didn't split, 50-50. Jaime replaced Rob, Jaime Bernstein [?], and he works in the same group that Tony's in now. He was here for a year or two, then he went back to Lincoln.

THERESA: [Did you have the option to go back to Lincoln at any point?]

ALAN: Well, yes and no. I didn't have the option because I actually changed my employment to here, they didn't. They stayed Lincoln Lab employees, so, as far as the option of going back, it depends on whether there was, whether Carl had something to cover them. I don't know. For some of them, coming down here might have been the only way he could have kept them on board because MIT was going to lay off some things at the time. They had to downsize 400 people over a couple year period. So, I don't know. I know in my case the answer was no. I couldn't go back to the group I was win. I didn't want to.

MING: [Mentions papers about collecting data from video. Would simulator be different if it hadn't been involved in CA/T?]

ALAN: Absolutely. Well, you could say the capabilities that didn't come out. That would actually be more realistic. When we originally did the simulator, and planned it and all that, there was a whole bunch of things in the work plan. And the artery's been cutting money all along. That contract, the two year contract. They come back after they'd signed it and want to chop $50,000 out of it. And the whole time, whatever money we thought we had to work with for whatever period it was, every seven months they were coming back "you've got to reduce it, you've got to cut something out" because they were under such pressure. I don't know if Phyllis could give you a good insight into that end of the project. John Schlect [?] probably could give you a better... John Schwartz was there before we even got on... Those guys could maybe tell you how seriously cross-managed this thing is.

So, there were a lot of capabilities that we had planned on doing that we had to drop. Because when people cut your money, you got to reduce the scope. So one of the things that went away at the very beginning was local streets. If you see the simulator, you'll see it actually has the main artery routes. Eventually we're supposed to have main artery routes and all the local streets in Boston. Everything. So not only could we run the traffic through the artery, we could also see how they might spread out from the exits.

We were working on emissions modeling. And we were going to do emissions modeling in a more sophisticated matter, where we were going to emissions from each individual vehicle, just like the driver behavior parameters are individual. Instead, I think the emissions stuff... Again, I'm not the best person to know this now... is kind of based on mobile 5 or something like that, which is just a macroscopic thing that gives you some general basic parameters. And we may have taken that, and assumed some kind of distribution and throw it in there. And see, that does not allow us then, to deal with the kind of things the simulator could really deal with, which is the microscopic phenomenon. See, if you're looking at things like water flowing in a pipe type level things, a macroscopic simulator will handle that, but if you get into the details of stuff where, you know, macroscopic simulators assumes everybody comes into this segment, next cycles through, these guys all went this way, these all went this way, and these all went this way, according to what it was supposed to be. In real life though, there's something called Cuske Fillback [?] Cuske fillback is when you have traffic building up, when a line of cars gets far enough back that people that want to turn off can't, then they start adding to the queue and growing faster. Macroscopic models don't handle that, because they just assume each time everybody goes to where they needed to go, each cycle. Whereas we are looking at individuals vehicles and lanes. And mesoscopic models can catch this too. Michael Van Erdes [?] model was one of the first to do it. I think it is called integration. He's a professor at a university in Canada. I don't remember which one.

So, one of the issues, we're looking at controlling traffic in the tunnel because emissions is a big problem in a tunnel. Right, the fans are sized such that if you have traffic sitting there too long, it can reach a level that the EPA won't permit, the reason that it could be hazardous. So, how do cars generate emissions.

See, I'm saying so much about it because I actually worked on this. This is one of the things I worked on.

And, an automobile, when it's accelerating, at a certain level of acceleration it starts putting out emissions two-thousand times more emissions than it does just moving along. And it's because the auto-makers... Umm... This may be more technical than you want. Cars are built to go this FTP cycle, right? They test them and say "they only make this many emissions." They designed the car so that it stays clean as long as you follow the cycle, you accelerate. You go this speed, accelerate this much, go this speed. That's it. But if you're really driving a car, you're going to be doing lots of accelerations and speeds that aren't tested in cycle. And to keep the catalytic converter from overheating, the automakers have gone to the strategy where they dump excess gas into the mix. So you have all of these unbroken hydrocarbons running through. Then they reach the catalytic converter, and the heat cracks the molecules. Just like you have in a refinery, it's called cracking. And the breaking of those bonds absorb the energy, the same way having water evaporate over a hot surface cools it rapidly. And that improves the life of the catalytic converter. Unfortunately, you've just made the emissions just go through the roof. And, so, acceleration behavior... That's why a model like Mobile, it's a general thing when you have on-ramps with different geometries, you can get people and in certain traffic conditions, you may be inducing people to drive their vehicles in and out of this condition, which is called open-loop. And, so that's something we could have looked at, but we had to drop that work because they were cutting money. And I thought it would have been quite valuable actually, because... This could be a much bigger help than anything you're going to see using a macro thing, in terms of how do you design the alignment, or, it's actually traffic control. How do you design the lights? Do you want traffic flowing smoothly and slowly, or do you do things that create stop and go issues. A certain amount of stop and go doesn't cause this problem, but when people are going and then stopping, and the going is enough of a going, then their engine goes into that open-loop condition, and all of a sudden the amount of emissions you're getting from the stream of traffic is just much much more. These are the kinds of things we could have actually dealt with which went away.

MING: [Are these things ITS would have pursued?]

ALAN: Yeah, if we had all of the money we wanted, and it was for academic reasons like National Science Foundation, yeah, we would have done that.

SERENA: Did you propose these ideas to them and then they just didn't fund them, or were they actually written into the contract to fund them.

ALAN: They were written into the contract that we were going to do this. When they came back and said "Well, we're going to have to pay you less money." Any good consultant or anybody... You can't do the same work for less money for two reasons. One, because you probably aren't going to be able to do it without working 24 hour days if you really estimated honestly. Second of all, it's not good negotiating. Because they think they'll just keep chopping you and you'll just keep getting everything done, you know what I mean. Anybody ever wants to come back with any less money, you always have to make them give something up. You have to.

In our case, we are already doing, we did an awful lot for them. We went beyond what we were contracted to. We were quite good about it. I mean, there were contractors or consulting companies that were making a stink over every extra thing they had to do, or... we were joking around about this at lunch...

MING: [...]

ALAN: Well, I wouldn't say they added capabilities we didn't want, but they were very much focused on looking at the lane use signs, the green arrow, red x, yellow x. That was of interest to them, [...] but a lot of the things they were asking us to put in there were good things to put in, and especially for them like, well actually lane use signs aren't used everywhere, but you know we focused on those, variable message signs, something they called... some kind of speed signs. As far as I knew, it's a sign that just has a variable speed on the sign. Something called a blankout sign, which is a sign that just comes on or goes off, just a sign with a light bulb in it. And I think those are for something like overheight vehicle or tunnel closed or something like that, and then there were the [...] traffic signals. We probably would have got more into the traffic signals, which is better for local roads types of things earlier, but they needed us to focus more on those. I don't know that they actually... And then they wanted ramp metering, they wanted us to do ramp metering stuff. But see, one of the things that affected us were that inside the project they were having these internal struggles or decisions that they had to wrestle with. One of them was the ramp metering thing. There was a faction there that wanted ramp metering, there was another faction that didn't want it. And so the circumstances we were working in kept changing. So, we were working on ramp metering... So, Masroor, you get him going on ramp metering, and all of the sudden the project decides it's not going to be ramp metering, we don't want this guy to be doing ramp metering. This is one of the cultural differences I said... MIT was not a, we're not a contractor. And Bechtel wants to treat us as a contractor. So there's a constant tension, like I mentioned to you before, Tom Humphrey was instrumental in this contract ever being able to happen. There's very few people who can get two organizations with such different interests to actually do business together.

SERENA: [Tony mentioned the student thesis pressure, etc.]

ALAN: Sometimes we couldn't. Masroor did his work on ramp metering anyway, but then he had to do other work for the deliverables we had to give for the traffic control strategies and lane use signs. But those type of decisions, those would affect us. And that was, I would say, annoying. And think, okay we're going to do this, we're going to do this, and then "no, don't do this." But it's like "you asked for it." But if you understand what's going on, it's like any real engineering project, right, I mean if there was one best way to do it that was obvious to everybody, there would be no question. And, again, a lot of the question was due to the constant money problems. If everyone had unlimited money, it wouldn't be an issue. But then when they're trying to cap the project at whatever billion it was at the time, people re struggling with ways to like "how can we save a billion" or "how can we save a hundred million" and people threw ideas on the table. Let's get rid of this, let's get rid of that. The overhead vehicle thing was another issue that kept coming up, that came up that we worked on. Rob and I were doing it, whenever Rob left I had to finish that by myself. When I went and talked to the people over there, they had sufficiently bright engineers who had really thought the problem through that had good ideas, but the problem was they didn't want to hear them. So we had to come up with something viable to help them out of that decision that was created by, somebody made a decision to make the tunnel six inches shorter than is standard. So that created a risk now, that somebody could drive his truck all the way up 95 from Florida, all the way to here, even though he's overheight. Usually, the rule of thumb is about a foot, right, when the sign says 13' 7", you know, and the bridge is really 14' 7". So, this guy, I can't really remember now... To save money on the cost of the tunnel, some cost engineer in Washington DC said "well, why don't you make the tunnel box six inches shorter, so you save this much in concrete. So I forget what the cost savings was, $50 million or something. They did that. And, as a result now, they have something which may be a gate on the whole Interstate network. So if somebody's overheight but doesn't realized because he's gotten away, he's just driven through five states, he drives into here and he smacks, he's stuck. So that was, they were looking for an answer, and they were constraining the problem in a lot of complicated ways, like "why don't you put a thing in the front of it so that if the guy's too big, it's a physical barrier. But then people were doing calculations that "Well, if you've got an 18-wheeler going 70 miles an hour and he contacts a physical barrier, that's like enough energy to be really damaging.

THERESA: Well, wouldn't it be the same energy if he hit in the tunnel?

ALAN: Well, yeah, except, what I didn't realize until we started working on it, is that the tunnel ceiling itself stays at 17 feet. The stuff that comes down to 14 are the cameras and the variable message signs and all that stuff. Imagine... At any rate, they could gate it [?] We looked at tunnels where they had these things where somebody hits this thing automatically, it sort of flops down, and compresses the truck. We came up with a lot of physical ideas. In terms of that, even their own people had a lot of good ideas as to how to deal with this too. We came up with our own other set of ideas, some other things we came up with to catch the car. [...]

But anyway, you know we run into this problem and they look at me and say... This I've run into beyond the Central Artery, it's a common struggle... Capital costs is upfront costs, it's a big lump sum that nobody has to pay for now, versus the tradeoff in operations cost, which is usually somebody else's problem. You've got the people doing the design, they're under pressure to keep the design cost low. That doesn't come out of their budget or whatever to build the thing in the first place. People have to run the thing, though, it's a different budget. So this guy saved money, but he creates something that's a nightmare for the people who have to operate it. And every time there's an accident in there, they're going to have to pay, it comes out of those budget. You get this tradeoff versus how much money should you spend up front to save in the long term. And yet, that's a struggle beyond the artery. I've seen this commonly comes up in engineering issues.

So, anyway, this is the thing, if the truck goes through and starts cleaning out these expensive electronics, how often can that happen before it would have been cheaper to build the thing higher. I did that calculation actually.

MING: How long would that have taken.

ALAN: I'm not going to say. That's the kind of stuff that you'd have to get the state to tell you.

THERESA: [Truck story.]

ALAN: So there was all of this debate about whether there would be physical attenuators, or even on the ramps where the trucks aren't going so fast, could you have chains there that would hit the truck and make noise. Then there were policy battles about "no, we can't allow anything that has physical contact." So there were constraints on the problem that made it harder to deal with. And, I don't know what... They got this overhead detection system with lights that come on.

MING: [Simulations model the world. It embodies assumptions. Are there assumptions built into the simulations that reflect how people think about Boston drivers?]

ALAN: Yeah, but I wouldn't know. The person that knows the assumptions is [?]. It's his Master's project, and he was our little wizard with the simulator. And he did things in there that he knows how to make a [...] [Says he thinks there are based on statistical models that were chosen, etc.]

That's the reason for doing the validation, the calibration work that you mentioned when I was out taking video data. At some point, you've got to compare your models and assumptions with real life somehow. There's two aspects to that. Calibration is where you take data to help figure out what the parameters of the model should be. Validation is when you take data so that you can say "this data, at the beginning" start the simulator, run it for a while, and see if it gives you the same data at the end that you really had.

MING: [Gives interpretation of paper on video data. Were there any biases? Is time/weather important?]

ALAN: Yeah, those things would bias the data. We took the... Well, we're limited to the locations that we could get that were good. I had a heck of a time trying to get up on a building in Boston, and we did a lot of... The scouting video, you know, I went up with a couple of students and we got kicked off a number of places, so we'd go there and try to film as long as we could until some security person would come after us. And, we'd try to get permission. Sometimes it's difficult. Because these people, you know the building manager's running it for some real estate company down in Florida or something. Everybody looks at it as a liability thing. If you fall off our roof or you drop something on somebody, it's a problem for us. It's easy to say no. So some of that, we just sort of went places and filmed. But the best view we got was from the top of One Financial Center. [...] This is a building that's right over the artery, right downtown. And, I got that video by making a deal with somebody I knew at SmartRoutes because, again, it was easier than getting on top of that building. Now, the artery people eventually let us get on the Wang Building. On Nealon Street where the Central Artery is. But the trouble is, the angles were always a problem. See, the thing is, when you're doing video with cars, when you are doing video at an angle, how can you tell if these are two separate hands. And, that was the hard part, was finding a building that was both high enough and close enough. So, anyways, SmartRoutes has these cameras that they use for their traffic reports on TV, and it turns out they have a number of these in their law offices, I mean their firm that they use as a law firm, and they worked some kind of quid pro quo deal, because they would let us tap in, but they didn't want the law firm to know that we were actually recording the data for another use, because they were afraid that they'd want to charge. So a grad student and I had to go up pretending to be service technicians. I remember telling [?] "just let me do the talking, don't say anything to anybody. Pretend like you don't speak much English."

So, we needed to test their line to see if we could tap into it without causing them trouble here so they could still use the video on the air. It actually did diminish the picture quality a little bit, but not that much so they let us set up. We brought in two VCRs, and recorded two channels at different times of day. And we had to keep going back to change the tapes. The fact that we were having to come several times a day, they had to think we were testing the system for something. We tried 8 o'clock in the morning time, lunch time, traffic, rush hour traffic to get different times. We got traffic in sun, we got traffic in overcast. Now, that was a start. You're right, you maybe would want to get... But see, the way I would build the simulator, if you wanted to simulate the effect of raining and things like that, you could code the model to deal with environmental conditions as part of the scenario, or change the models. But since most of we're doing for the artery is underground, right, we really want good weather data, right?

MING: [Any holes in the modeling?]

ALAN: Oh, I'm sure there are more things that could be added to it. When you say holes, it's like you're making a judgment. Anything like that could be continually refined or made better. I think the most important things are there. You always start with the most fundamental things. Like I said, on this data. We didn't worry about bad weather data, make sure to get good weather data, get a view looking down, and we picked a location to try to meet the requirements that the modelers had, which is, they wanted this much straight, this much ramp, this much distance after the ramp, so they could test the merging models. And lane-changing behavior approaching the ramp. So those are the kind of requirements we had to find the fundamental things out, now you can keep always refining it, but you want to solve the first-order problem first. So, the thing that I was most disappointed to see was the emissions, you know the microscopic emissions model.

SERENA: [Any other projects cut from ITS that came back later? Mentions incident detection.]

ALAN: Same thing with local streets. They had somebody working on that I think here, I think [...] this year. So some of these things came back later in some form. But it's what you can afford. You know, you always pay the rent first. Things have a certain order or priority.

[Ming leaves.]

SERENA: [Why did sensor technology go away?]

ALAN: No, actually, that was my area, sensor technology. Yeah, it was cut out of the budget. But the reason the sensor technology got cut was that there were consulting companies that wanted the work, so they lobbied with Bechtel that MIT shouldn't be doing that...

[Next Tape]

[Talk about other existing technologies.]

SERENA: So, we are winding down now. Another interesting question that was brought up in class is about patentability. Was there any interest in that with the simulation or algorithms?

ALAN: Well, I don't know about the simulator stuff, but papers have been published that give it away. So, how can you patent stuff that has been published in literature?

I did design a sensor for them, that did detect vehicle fire much faster than what they are putting in and I think it was valuable and I think that they needed to show interest in pursuing it. I don't know whatever happened. I think the people over there were overwhelmed. So many documents to read, so much stuff.

SERENA: Is it something you can't pursue on your own? without them?

ALAN: I did the work for them, so I would have to see if they would release it. I don't know. It's not really worth it. I have to say, "Is there a big enough market for this? Is it patentable?"

[Talked about other patentable projects that he worked on but never pursued potential licenses, etc.]

I'm busy managing projects with students and working on projects with the Central Artery. I don't have time to do the market research.

[Talked about patent law class at MIT.]

SERENA: So, are you working with ITS until the end of the year, when the contract runs out?

ALAN: I've been working with ITS as an affiliate.

SERENA: But, the contract runs out at the end of the year...

ALAN: Oh, are you asking me personally? or ITS?

SERENA: You? or ITS?

ALAN: Well, there's a distinction. I was a deputy project director here up until two years ago. When Tony went back to Lincoln, I became the director. The money was getting smaller. So, to make sure that the money would last for Mithilesh, it made more sense for me to move on. And I wanted to at that point. So, I changed my position as a University Scientist to a Research Affiliate. So, I work on a consultanting basis. I draw my salary on the day-time at another job.

So, I changed my status. So, at that point, I no longer work on Artery work. Everything since then has been to help Moshe find other funding and professional activities.

[Talk about project presentations for 6.933]

7.8 Interview with Sergiu Luchian

Serena Chan and Ming Maa Friday November 19, 1999

SERENA: Could you give us a little about your background and how you got involved with MIT ITS?

SERGIU: How long do you want it to be? 'Cause I've been on the project for 18 years, so... Background? I came from Romania in 1980. I'm a structural engineer by profession. Since I was working on the Orange Line Tunnels, they wanted me to start working on this, when we looked at the environmental impact statements. Actually, the Third Harbor Tunnel, that was the first portion of the project that we were suppose to built in 1982. In February of 1982, we started with a team of nine engineers looking at various alternatives to building the Third Harbor Tunnel. And the environmental impact statement, you probably know that, I don't have to tell you, looks at everything, looks at feasibility first of all, how do you do it, where can you do it, and what kind of impacts it will have, both on the environment and the society, economy, traffic of course, whether it will improve traffic or not. We looked at that until 1983 when we finished with our ideas, we looked at 16 original alternatives for the original Third Harbor Tunnel or Third Crossing.

In 1983 the administration changed and the Secretary at the time decided to tie together the Third Harbor Crossing, which had a tremendous chance of passing through Congress, through various legislations. He wanted to tie to that the depression of the Central Artery. The depression of the Central Artery is a very complex project, not just structurally, socially if you want. The need for it, starts from two sides. Side #1, the regional transportation. It was very obvious that when this was built, it was built as a complete region interstate network. But it ended being a local collective, distributive system, too many ramps, smack in the middle of the city, lots of people popping up and wanting to down on the surface. Not a good idea because it became clogged at rush hour, much more over capacity, much more over what it was designed for. The social impact for this, was it cut the city in two. It separated the North End, which is a residential area, for the Italian community. It cut them from the rest of the city. Some of them say, 'well, that's fine.' Some of them say, 'well, that's not a good idea.' That's what it did, it provided a physical barrier to downtown and the waterfront. And that's an important factor.

So, at the time, the Transportation Secretary and the administration decided to tie both of them together and go with one single project. We restarted the project, tying them together, providing the interchange between I-90 and I-93, I-93 and the Third Crossing, the extension of the Turnpike and the airport, and I-93, being the depression of I-93 to downtown Boston. We finished that in August of 1983 which various studies were needed as we developed since we were in the middle of a city, a historical city, its busy and very crowded, urban environment. Things happen and we have to change alignment because things happen...development, new plans. We kept working on the project, refining it, until it got approved by Congress in 1987. In 1987, the project got approved by Congress with an original estimate, which I'm the proud generator, of 2.53

billion dollars. Now, it was 2.53 billion dollars, but it didn't account for any kind of inflation. It was done in 1981 dollars. And also, it was missing several of the features that we now have in the project. Especially one of them, for which I'm very proud of, for which I'm responsible for, is the Intelligent Transportation Systems part of it, the ITS portion, the control center, all the monitoring and control of traffic, the incident management. So not having that, it was 2.53 and Congress approved it. Very dramatic situation with Reagen vetoing it and the veto overwritten within hours by the House by convincing one member to vote in favor of it. We took the project off the map and started building it and start the final design. So, that's the beginning of the project and I've been involved with it since then.

I've done tunnel engineering, bride engineering, geotechnical engineering. I've became the project-wide engineer for the Mass Highway, which is like the engineers without borders. We have the project divided into 5 major regional areas. We have the South Bay interchange, [points to large map in the office] the Central area, which deals with the depression of the central artery up towards Causeway Street, North of Causeway, which is of course all the way there, which towards the limits up to Charlestown, and we have a section in South Boston, including the Third Harbor Tunnel, and a section in East Boston.

As project-wide engineer, I was going all over the place because I was in charge. I'm still in charge, with systems, mechanical, tunnel ventiliation, lights, pump stations, power distributions, and then systems, including safety systems, fire detection protection, environmental security systems, traffic management, and incident managment.

So, since then, the project evolved into the 10.8 billion project you know. It has 3 very notable features that weren't there initially. One of them is the mitigation feature, South Boston's Haul Road, the piece of highway that you see here [points to map]. This didn't exist. It was a very good idea when Bechtel, Parsons and Brinkerhoff came in on the project. One of their planners took a walk along the alignment, we all did, many many times, and saw a railroad track that was used by Conrail, which was coming into the piers of South Boston over here. So, there are four tracks over here and our discussions with them, they told us they only use one. So, we transformed it into one track, we pulled it back way south...this is depressed, so we see all the retaining walls. This is the cross-street and there are bridges over it. So, this is like a roadbed that we built right next to that one railroad track. And that allowed us to do a couple of things. Very very important. One of them, is to redirect all the construction traffic, all the big trucks and big heavy equipment, from South Boston city streets, you know South Boston is a highly residental area, and we didn't want them to be bothered by all that is happening and since we put about 600 to 1,000 trucks a day on the city streets, we decided that this was a perfect mitigation measure to take the trucks off the city streets, and put them in this depressed section, and also provide very quick access to the Southeast Expressway to the South. You see this is what this interchange does.

So, that was a very very good point the project did. So, that added some money to the project because we have this interchange here, this entire lane, plus another interchange here. But, probably the most important factor was this in December 1995, four years ago, we opened the Ted Williams Tunnel. It allowed us to tie the Ted Williams Tunnel with the rest of the city of Boston. Because we had the temporary approach to the airport right now over here, but we didn't have this major connection with Interstate-90, which is the Turnpike. [Map pointing]

[Ted Williams Tunnel] was the fastest and easiest part of the project. Piece of cake. Very easy. You just take 12 submarine like pieces of tunnel, float them, you can fabricate them wherever you want. We did them in Norfolk Virginia, but it doesn't matter. You float them, they were tugged in, outfitted here, line with concrete and reinforcements and brought into place and sunk, and connected to each other like beads on a string. Built in less than two years. No big deal. No traffic disruptions. No problems. The only problems we had with traffic disruptions was in the harbor and we dealt with that. No problem. The other problem was the lobsters that were spawning in this area. So, we had ultrasound devices that would push them away, make pinging noises that would push them and sea/striped bass away. We want to keep them away because we were blasting the rock at the bottom and we didn't want to destroy them but we didn't want to alienate them from that area. We kind of hushed them away when we were working there and we took the sonic devices away back out and they're probably spawning happily over there, they don't know what happened. But, this was the only disruption that we provided. Outside of that, again, piece of cake.

So, this was ready. So, how do you open it? Now, you have the highly touted Third Harbor Crossing and how do you open it for commercial vehicles? We provided this connection which is running very nicely. We have over 10 million vehicles running 4 years from here to here. Very important. Even more important, this allowed us to take a lot very heavy traffic. We allowed commercial vehicles and in weekends, everbody. But with commercial vehicles, this allowed us to take 5-7% of all the bus, trucks, and heavy equipment, that otherwise, if they wanted to go to the airport, would have to go through all this maze and come down to the airport. You're probably aware that 25-30% of the people here don't want to be here [specific points on map]. Because all these people are either probably coming in from the South or West from the Turnpike to get to the airport. They absolutely have no business being in the downtown area nor do they want to, but they have to. So what we did is, we provided this siphon and that allowed us to do construction in here, the depression of the central artery with much less traffic than we would have had otherwise. So, very important piece.

The other very important piece is the crossing of the Charles River. The famous Scheme Z, you probably heard about that. We through about 64 iterations until the community was happy,...the Charlestown community, Cambridge community, Boston community, BRA, MDC, MDC Parks and Recreation, everybody and their brother. Huge bridge design and committee. Design by committee. That's why it took four years and that's why it cost hundreds of millions of dollars in decision making. And it was horrendous. The result, what you see now, is that beautiful bridge, that we have over there, the Cablestate Bridge, which is a portal to Boston, which is going to be as important as the arch is to St. Louis, ...I don't know, what other important cities?

MING: San Francisco.

SERENA: The Golden Gate Brdige.

[Interrupted by a phone call.]

Anyway, so that's another big piece. The third piece is the one closest to my heart, its the operations control center. And that runs all the traffic devices, the traffic management and incident management. And that added to the cost, plus inflation, plus everything.

MING: Can we talk more about your relationships?

SERGIU: Sure. What would you like to know?

MING: Interactions with MIT...

SERGIU: Sure. Well, MIT has been very interested in this project for a long time. The people that I talked to before in my project-wide engineering capacity were the geotechnical engineers there in the departments. MIT has a strong geotechnical department and a lot of geotechnical research was performed by MIT. I'm also in charge of research for the project.

I was approached in 1991 by Tom Humphrey who was Director of Transportation Studies at MIT and who is now working for [HWS & Training]. He approached me with a very interesting proposal. He said, 'we can do some research, we can develop, as a research program, a traffic simulator.' I think the idea was already with MIT. 'We would like some funding, we would like some real-life applqication and would you like to participate with that?' I thought it was a good idea. I thought so because we were implementing in this project, a lot of devices and a logic control design that was never tried before. To us, it was like testing all this in a lab environment on the MIT simulator before we even took the design and purchased the component and installed them. Very advantageous on our side because it was a tool to check out not only the location of our devices but the logic control, how these devices work in an integrated way.

So, since we were working on integrating all our control devices in the 1980s, we started the concept of an operations center. We had to deal first with 8 ventilation buildings and with 4 power distribution points throughout the project. Little by little, a lot of devices were coming and coming. Where are we going to do this? Way back when, in the 1980s, we decided to go into a centralized system, a control center, that would put all these functions under one roof.

Well, ITS didn't exist yet. It was yet coined or invented. Not even IVHS. And, we decided that traffic management and control has to be there. All the information from the loop detectors, all the monitoring from the CCTV cameras, and carbon monoxide detection. Everything has to come under one roof. Well, all these devices had to be design and some logic had to be built to put in there, so information comes in pre-processed, in front of an operator, so that he can act or react.

So, when MIT come in with Lincoln Lab, with...who was there?

SERENA: Carl Much

SERGIU: They came in and said, 'we feel that we have a very good product that we can put together if you give us your network and of course fund the program.' Very important words. And I said, 'ok, let me see what I can do.' I went over to the Research Board and the project director and convinced them that it was a good idea. So, we initiated the project as a research program. We found out real fast that it could be implemented as a took for checking design. Because, not only was it very fast implementation, we found the early stages of MITSIM in its original form running within first 6-8 months.

It took all our network, our engineering drawings, of course electronic database, dropped it in, and built a network. It helped us real early straighten out some design flaws that they found for us. By that time, Tom Humphrey and Moshe Ben-Akiva came in and started MIT ITS program office where Tony Hotz was the manager over there. Great people.

So, little by little, we took the research money out of it and made it a part of of the program, the systems integration program, which deals with ITS. And again, that's happening as ITS emerges. Our planning and our design was way before that. ITS was kind of icing on the cake for us, because it spurred the industry and all the defense industry...at the time, they didn't know where to turn to for funding of their product and the sales point for their products.

I had a plethora of very weird not only people but products coming in and offering their fares to us. I tremendously enjoyed the vocabulary they used, the transportation vocabulary they used, i.e. 'target acquisition.' [Laugh] It was really something. Wow. See that car speeding, you acquire the target and blow it up off the screen. They could do that. I can still remember a guy coming in. He can put something in space and track in real-time up to 35,000 objects. Ok. Anyway. [Laugh] Put a satellite up there. Run a red light and blow them.

But, that's how ITS emerged. Its from the kind of meshing of the interests of the transportation industry, various transportation consultants of the department, with the need for the former defense contractors who needed an outlet for their products. And we were in the middle of that. I'm very happy about it. Our specficiations for what is in the control center and our devices are of military standards because you need the ruggedness and reliability that's built into those standards. So, we're pretty happy that that's happened. And at the same time, we were developing the largest ITS program in the country, without too many people realizing that. We were worth anywhere from 250-300 million dollars, with all the deployed devices and the control centers running them. That's how it started it.

Now, the control center is located in South Boston. [Points to map] Right before the entrance to the Ted Williams Tunnel. That's where it is located, on the 2nd floor. Now, the backup center is located in one of our ventilation buildings, Ventiliation Building 6. Right now, everything that we have is run by a temporary control center while we are testing the final control center. We are taking the devices and debugging them to make sure they all work. Next spring everybody moves into the control center and that's where the brains are going to be.

What else? How is MITSIM applies? Ok, I'm sorry, I'm diverging.

MITSIM has been applied a lot of times. We used it as a tool, as I said. We also use them for verifying. We develop strategies for various incidences. For instance, we address the incidence of where do we dispatch people from. We have 9 emergency stations on the project at various locations, strategically located, where once dispatched, they can come in, dive into the tunnel within their reach within the first few minutes after the incident is detected. Now, in order to do that, we have to have a very clearly orchestrated and controlled system where we have variable message signs, walk entrances, lane control signals, where we have those red X's to make people change lanes, radio rebroadcast, where the radio comes in with the appropriate messages, where the two-way communication is geared toward emergency situations. Ventiliation kicks in automatically and full-exhaust does what it has to do to remove carbon monoxide out of the roadway. So all this has to be done in a fast and logical manner and MITSIM helped us with that. It was used as a tool and as a troubleshooter during our scenario building and it is still doing that.

MING: Did MITSIM propose changes too?

SERGIU: Yes, it proposed changes too. It's not only reactive, it doesn't only verify. You can initiate stuff. You can simulate one incident, two incidents, various incidents, multiple...You can simulate a lot of stuff on it and we checked our design on various construction times and rerouting especially downtown during construction. We have discussions with the city of Boston and with the community, various neighborhoods as the best way to do what. You take a tool like MITSIM and apply the various alignments that are proposed and you draw the traffic figures that are used by everybody, the city of Boston, and you see what is best. MITSIM is graphical and is fast. And we've done that a lot. We've won almost every adverserial case, where consultants from other entities, other companies say, 'no way, your system is not going to work.' I'll give you an example. Take MassPort and the toll plaza. We introduced electronic tolling at the toll plaza. That was the first time it was introduced in Massachusetts. MassPort was adamant that we needed one more manual toll booth because the queueing was going to screw up their network and transportation system. But we told them, 'no, we checked it out.' We had three different consultants coming in and telling us their alternatives. So, we took them down and put them on MITSIM. Beautiful results on ours. Not so good on theirs. With MITSIM, they figured out that they had a problem somewhere else. So, it's been a very very good tool to troubleshoot, a very very good tool to run scenarios and at the same time to verify the design, so that we can change our devices, change our spacings, can change the control logic and so on and so forth.

MING: Were you involved...[How involved with MITSIM were you?]

SERGIU: I'll be very candid with you. I've been involved in the beginning. I've been managing the project. I brought it into the project and I looked it it in the beginning three, four months. I realized that it was going to very useful very early, because otherwise I wouldn't have proposed it even as a research program, because we are pretty tight with money.

I realized that it was going to be very useful when I saw how fast it was going to be turned into a tool. From the time we sent the electronic files to the time that I was told, 'it was running, we already see a couple of places where you can optimize your design,' it was like 6 weeks. And I couldn't believe it, I expected MIT to take like 6 months. But, it was awesome. I was impressed. I was really impressed. And from there on, when we made a clear decision, that it was going to be a tool, let's introduce it as a tool in our design, it was going to be very useful.

SERENA: How different was it to be funded under the research program as opposed to bringing it as tool to the project?

SERGIU: Oh, it was very different. Research money is a different part of federal and state money. It's been administered different. 80% from federal and 20% from state are again from diferent parts. Now, this project is funded by interstate funding. This is the last interstate project.

As a matter of fact, we had a lot of research money on this project. When I'm saying a lot, it was billons of dollars from interstate funding. It's never been heard of before. Like, MITSIM cost 6 million dollars so far. The first half a million dollars was from research. That is a lot of money for research. They're usually under a million dollars, like 60,000 or 80,000, that's research funding.

MING: What did you think of Tony Hotz and his reputation?

SERGIU: Tony's reputation? I like him a lot. I think he was a very competent, very good professional. I never had a disappointment in MIT and what they did.

If I wanted to get into anything, I could. I didn't feel like anybody shielded anything from me. I didn't have time to get into everything. Probably I wasn't told some of the horror stories that I'm sure happened. But, I expect that. I don't tell people horror stories either.

MING: ...

SERGIU: I don't know how they interacted. All I know is that I had a good relationship with both Tony and Moshe.

SERENA: Did you interact with Bechtel Parsons too?

SERGIU: Let me tell you, Mass Highway has a management contract relationship with Bechtel Parsons. Bechtel Parsons are the managers and administrators of everything that we are doing here. So, it's not just ITS, its everything, design, everything. This went under Bechtel Parsons' management very fast because one, I didn't have time to deal with it. As I said, I brought it in and I didn't have time to deal with it on a day-by-day management.

What's the relationship between Bechtel Parsons with MIT? I'll get you down the hall to talk to John Swartz if you want or with John Chlebeck because they much more intimately familiar with the administrative management contract for the last 5-6 years.

MING: ...

SERGIU: I'm sure our Traffic Group had to run and refine the results. But, I'm sure that's when the first two or three iterations of results came in. I know that MITSIM has been refined several times over and updated.

The one gripe, if you want, with MITSIM, was why wasn't it brought up on a computer here, on a PC over here. And I understand that for the last year and a half, Moshe telling me, 'come anytime with your laptop and we'll drop one on your laptop.' And actually, I have a promise that I can go anywhere I want with my laptop and get it on my laptop. It's very user friendly as far as I'm concerned. I can use it although I wasn't trained. So, that came in a little bit late, I think. If it was more available in the beginning couple of years, I think it would have been more successful on the project. But, it probably wasn't possible. The code was too heavy. Also, the operating system is different.

MING: ...

SERGIU: [About having MITSIM on site] You want to have it here as opposed to picking up the phone and talking to Moshe and telling them that this is what we want and blah blah blah. We should have a couple of our engineers over here doing it. I think that's an issue that MIT took that they didn't want to do it without a license. It was probably a commerical issue more than anything. But, this started more or less as a research program. What it developed and what it came out to be, I don't think there is anybody to blame for that.

What I can say is that they should have made it more portable.

MING: Serena mentioned the other projects...why did they phase out?

SERGIU: Well, you can only work so many times on human interface. You see a workstation and you have a human. So, you have a final report. Thank you very much. So, that's an easy one.

Incident detection. I'm not really the one to talk about it. That's John Swartz's.

SERENA: I know that it's being finished now.

SERGIU: It is, right now. MITSIM, actually, I helped Moshe put it on the map in Sweden. Because I have a lot of relationships with the Swedish government and the city of Stockholm government and I convinced them that they should use it for traffic simulations. I'm very glad I did. Not only for MIT but also for the Swedish people because I think it's a tremendous tool. We're all very good champions of MITSIM. I also suggested that they work with Moshe to make it the traffic simulation of choice for their highway.

SERENA: What about the sensor technologies?

SERGIU: Alan Chachich was the one looking in on that side. He gave us his research, his report and that was done. At some point, about six years ago, we stopped design. For us, to look again at new technologies, I mean it makes sense, but to change specifications mid-stream, would cost zillions, because the programs are already awarded. So, you change the specifications, 'no, i want infrared, instead of ultrasonic,' for example...jesus christ, that's already bought. So, it's a waste of money and time. So, at some point, we had to cut it. But, if what we have, doesn't work, you restart it. Don't start it from scratch, you know what function requirements are, but you go look again for something that will work. If it works, that's it.

MING: Ok. Thank you.

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