Research Proposal / Progress Report – Tren Urbano

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| Title |

Using IT to Facilitate Technology Transfer for Tren Urbano

| Background |

Tren Urbano is designed to alleviate traffic congestion for the 1.3 million people who reside in the 13 municipalities of the San Juan metropolitan region. Its goals are to improve the quality of life and competitiveness of the San Jan metropolitan region as a residential, commercial, and tourism center.

In February 1993 the Federal Transit Administration designated Tren Urbano as one of four turnkey demonstration projects in the Nation. The Puerto Rico DTPW/HTA later adopted a hybrid design-build-operate-maintain (DBOM) approach to the billion-dollar transit project in order to facilitate its development. This approach altered the way in which traditional turnkey projects are facilitated by emphasizing local control, technology transfer, and accelerated start-up, thus utilizing advantages of both traditional turn-key (DBOM) and design-build strategies.

The Technology Transfer Program, directed by Ms. Lydia Mercado, enables students in engineering, architecture, and planning at UPR and MIT to engage Tren Urbano as a "living laboratory" by applying their own research to the project. There are approximately 60 interns working for the Tren Urbano Offices and for Tren Urbano contractors; a total of 120+ interns to date.

The goals of the Technology Transfer Program are now changing. As Phase 1 alignment of Tren Urbano nears completion (linking the western community of Bayamón with Guaynabo and Rio Piedras, then turning north toward Hato Rey and Sagrado Corazon), greater emphasis will be placed on mobilizing and training the workers who will operate and maintain the Tren Urbano system. The Technology Transfer Program aims to assist general contractors in their efforts to transfer knowledge to this new generation of transit operators.

| Introduction |

The Spatial Database research project developed in 1999 made it possible for users to experience Tren Urbano — Puerto Rico's first rail transit system — as a virtual space and to explore spatial information pertaining to Tren Urbano through an organized system of multimedia and images. The primary goal of the project was to develop a web-based, multimedia environment for delivering geographic information about Tren Urbano. According to its

initial developer, Adrienn Jancovics, MCP '99, a multimedia approach was to serve as a platform for interactive exploration, inquiry and creative application by its users. Furthermore, the ability to visualize information would allow for greater understanding of Tren Urbano's planning process, as well as serve as an aid to organizing, analyzing, and communicating complex ideas about the engineering and technical requirements of Tren Urbano. Michael Shiffer, academic advisor to both Adrienn and myself, and one of the principal designers of the original Spatial Database, writes that in order to facilitate collaboration and group participation in the decision-making process, "we need to integrate visualization tools such as multimedia into a comprehensive online-resource system that can access and filter a large amount of information from a variety of sources (Shiffer, 1992)." This has been the overarching theme of the Spatial Database research project to date: how to provide access to large amounts of spatial data in ways that are meaningful to users and that serve the fundamental purpose of knowledge transfer.

In many ways the project was a success and its usefulness to Tren Urbano was confirmed by members of the TUO Professional Development Program (consisting mainly of graduate and undergraduate students in architecture, planning and engineering at UPR and MIT, as well as professors from both universities). The overall usefulness of the project was diminished, however, because it was not integrated on-line as a web-based multimedia environment, and further, by software complications which prevented it from displaying on all types of computers. In the end, the Spatial Database was distributed to only a few members of the TUO Professional Development Program via CD-ROM, and was demonstrated only periodically by participants in Tren Urbano at MIT.

As a potential application of the Spatial Database, its users could upload contributions to the database, allowing for future expansion (and relevance) of the site on-line. The resulting collaborative environment would help facilitate technology transfer in an urban transit context by using Information Technology as a catalyst among professionals, academics, government officials and the public (Jancovics, 1999). Part of my own research involves developing and implementing this application, as well as testing its usability in the field.

| Objectives |

My objectives are to show how information technologies can be used to enhance the transfer of knowledge during Phase 1 of the Tren Urbano Technology Transfer Program by creating a networked, multimedia knowledge transfer system that builds upon the Spatial Database that was developed in 1999. The system will allow dynamic linking of student and professional research reports relevant to developments in Tren Urbano on an ongoing basis. The Spatial Database as it stands today is non-collaborative and allows only for passive browsing of images and multimedia. I would like to design a more collaborative system whereby users are responsible for uploading their own research, which in turn is linked to images and multimedia. Research developed in Phase 1 of the TUO Technology Transfer Program loses value if it is not broadly accessible, both to faculty and students as well as to participating transfer organizations. Linking research to a web-delivered Spatial Database will facilitate the knowledge transfer process during Phase 1 and establish an effective and useful knowledge-base for moving to Phase 2 of the TUO Technology

Transfer Process - in which greater emphasis is placed on training and mobilizing a workforce to operate and maintain the Tren Urbano system. *For more information on enhancements to the existing Spatial Database, please refer to the Deliverables section of this document. For a visual representation of Phase 1 and Phase 2 technology transfer, please refer to the Attachments.*

Phase 2 of the Technology Transfer Program involves oversight of the General Management and Architectural and Engineering Consultant (GMAEC) contracts, which include provisions requiring a pro-active effort in technology transfer on the part of its civil contractors. The Tren Urbano Technology Transfer Program is responsible for monitoring compliance with these provisions. It is my hypothesis that a networked, multimedia knowledge transfer database can facilitate Phase 2 of the technology transfer process by serving as a comprehensive, on-line learning center. Under the guidance of the Technology Transfer Program, students and contractors might send and receive valuable information (such as "codified" information: instructions, blueprints, designs; or "tacit" information: such as valuable experience or issues) via an on-line Spatial Database, in effect archiving for ease of distribution the process through which knowledge is transferred for a major infrastructure project. As part of my thesis, I would like to discern the usefulness of a Spatial Database to transfer organizations and the institutional barriers that might prevent on-line transfer of knowledge from occurring. I plan to conduct interviews with transfer organizations while in Puerto Rico in January.

| Institutional Barriers |

Technology and information systems can be expected to play an important role in major infrastructure projects that require technology transfer. But the success of information systems like the Spatial Database, both in terms of broad acceptance and usefulness to a multitude of users, is hampered by institutional barriers. It is necessary to understand these institutional barriers in order to design a system that is both practical and implementable, and that addresses any concerns of the participants involved.

I have begun to study the various kinds of institutional barriers with respect to technology transfer, specifically, the adoption of new technology by industry and the reasons why collaboration occurs and why it is vital to the success of the TUO Technology Transfer Program. The various kinds of institutional barriers are given below.

The following is a general model for institutional barriers to implementing new technologies.

<u>Privacy</u>

- The main concern is over what sort of data is generated by the technology, who has access to it, and for what purposes is the data collected and stored.

Perception of Need

- The extent of perception of need will influence the development of information systems, as well as use of the information systems. Perception of need is a barrier if the technology is not accepted by its users, but it can also be an incentive, if its users perceive the need for the technology to solve an existing problem.

Legal

- Liability can be a significant barrier if the information system is not reliable or if the information can be used to assign blame or responsibility.

Policies and Regulations

- Organizational policies and regulations can be a significant barrier to adopting new technologies. Concern may arise that the new technologies will (a) not really increase productivity; (b) not be cost effective; (c) result in data that will be used to assign blame or responsibility; or (d) prove to be less efficient than existing practices.

The following is a model for institutional barriers in the technological sciences (De Vore, 1999), or factors that influence the context in which technological sciences are developed. This model relates to factors that influence the development and/or acceptance of the Spatial Database by members of the Technology Transfer Program as well as transfer organizations.

Factors that influence the context of technological sciences

- Size of information and knowledge reservoir
- Intellectual and social climate in which the technologist lives and works
- Level of technical talent and expertise available
- Level of development of associated and related technical elements, components, devices, and systems
- Social acceptance and compatibility of the technological effort
- Economic capability and desire of the society to support the technological development

The following model for institutional barriers is from an assessment of University-Industry research collaboration published in the Journal of Technology Transfer (Lee, Y.S., 1996). This model will be useful in determining transfer organizations' preference for an on-line knowledge transfer system.

Reasons for Firms Collaborating with Academics

- To solve specific technical or design problems
- To develop new products and processes
- To conduct research leading to new patents
- To improve product quality

- To reorient R&D agenda
- To have access to new research (via seminars and workshops)
- To maintain an ongoing relationship and network with the university
- To conduct "blue sky" research in search of new technology
- To conduct fundamental research with no specific applications in mind
- To recruit university graduates

Reasons for Academics Collaborating with Industry

- To supplement funds for one's own academic research
- To test the practical application of one's own research and theory
- To gain insight into the area of one's own research
- To further the university's outreach mission
- To look for business opportunity
- To gain knowledge about practical problems useful to teaching
- To create student internships and job placement opportunities
- To secure funding for research assistants and lab equipment
- To look for business opportunity

| Knowledge Transfer |

Knowledge Transfer is an important and well-documented component of any technology transfer process. For the purposes of my research, I divide knowledge transfer into three categories: Distribution, Relationships, and Strategic Planning. I plan to use these categories to describe the institutional framework for technology transfer characterized by expanding technological markets and competitive strategies, and to describe the Technology Transfer Program for Tren Urbano in terms of a broader institutional model. *For an illustration of an Institutional Model for Technology Transfer, please refer to the Attachments.*

Distribution

- This involves the interactive distribution of information or knowledge for producing value. Distribution is based on the assumption of a "learning economy" in which knowledge is considered a valuable resource. Information technologies can serve to facilitate the distribution of knowledge in Phase 1 and Phase 2 technology transfer.

Relationships

- Knowledge transfer is a set of business relationships by which technology developed in one place by one organization is turned into a commercial product or process by another organization. For Tren Urbano, these relationships represent an interesting challenge as they span both language and cultural barriers.

Information technologies can serve as an effective "bridging organization" between players in the UPR/MIT Professional Development Program and transfer organizations.

Strategic Planning

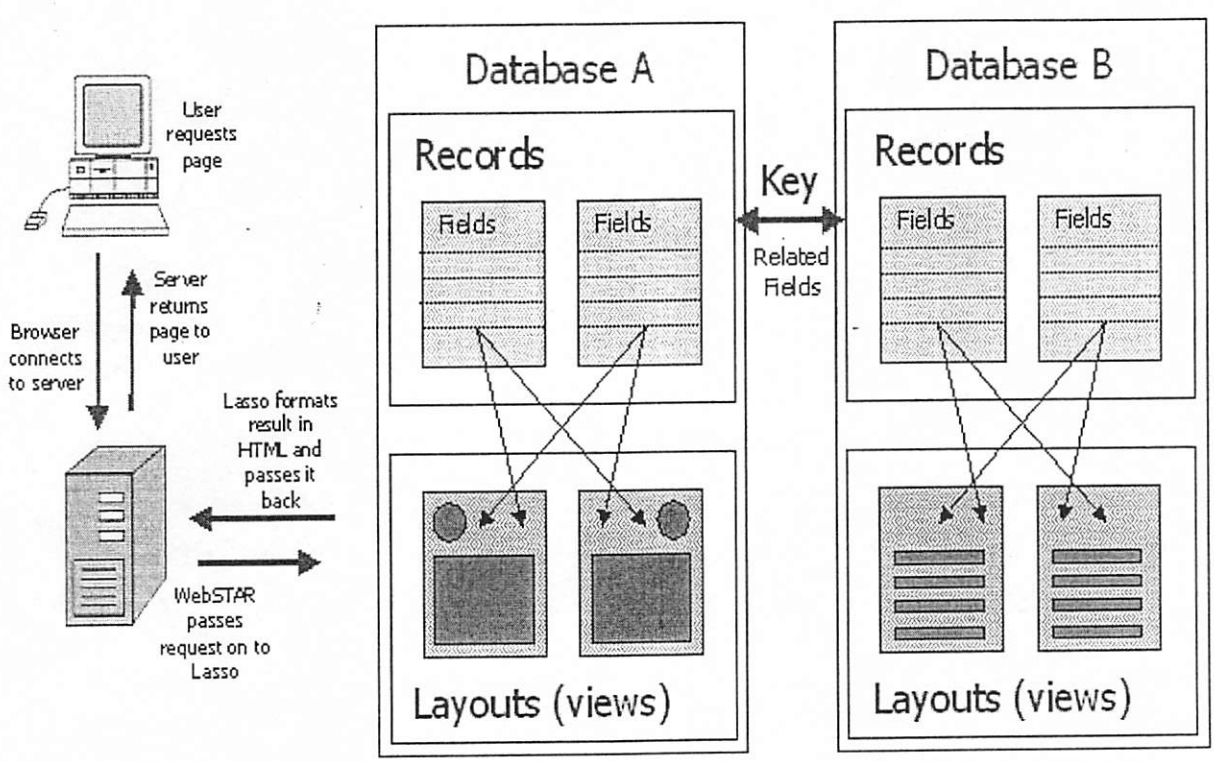
- Strategic planning involves planning for rapidly changing technologies on a cooperative basis. In the initial phases of technology transfer, strategic planning is usually facilitated by bridging organizations or "spanners" (e.g., the FLC, NTTC, and NIST). Regarding Phase 1 of the TUO Technology Transfer Program, strategic planning means being able to identify the 'right' kinds of information and people for transfer partnerships. Information technologies can serve this need by targeting a specific community of users and their information needs, collecting and organizing the information in an intelligent manner, and providing the ability to clone a set of skills to maximize efficiency.

| Deliverable |

The deliverable aspect of my thesis research will be a networked, multimedia knowledge transfer system that builds upon the existing Spatial Database. Users of the system will be able to upload and append their own research (after conversion to Adobe PDF) to dynamic maps and images that are stored in databases on a server. Uploaded research will be immediately searchable to users of the system.

The system will rely on web-delivered, relational databases to serve dynamically generated HTML pages to the user. For example, a user accesses the Spatial Database and requests information about Bayamón Station. The request is sent to a server at MIT (running WebSTAR™ v4.0 software) which then passes the request to a "middleware" program (Lasso Publisher™). The program queries a set of relational databases on the server for information about Bayamón Station and formats the results into HTML. The formatted results are passed back to the sever, and then "served" to the user. What the user sees is a web page about Bayamón Station containing spatial imagery and links to relevant uploaded research.

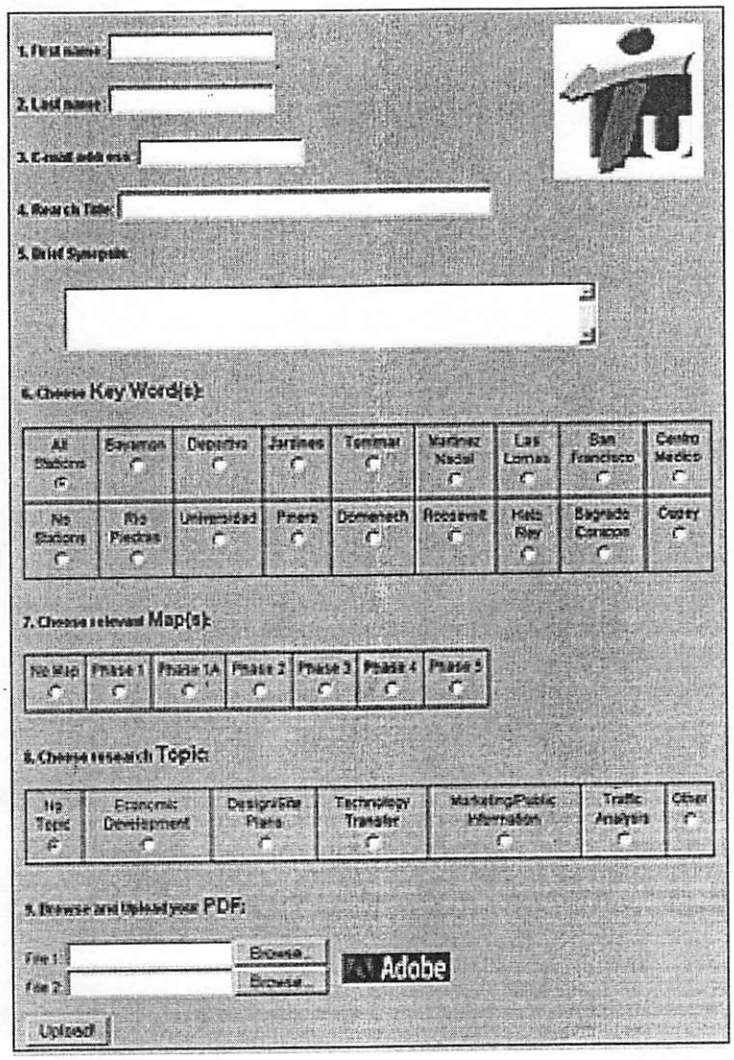
An example of relational databases is given in the Figure below.



Research will be uploaded to the Spatial Database via a secure Common Gateway Interface (CGI). The user will be asked to complete a form with questions about their research. The answers will be used to "populate" fields in the

databases on the server. These fields of information are shared between all of the databases and are used to generate HTML pages as described above.

Below is an example of the CGI upload form. The necessary fields are name, e-mail address, research title, research topic, synopsis, relevant station names, and relevant maps in the database. Users will be asked to create PDF files of their research before completing and uploading the form.



| Literature Review |

The following list represents a preliminary literature review.

Booz, Robert J., and Laurie K. Lewis, "Facilitating Technology Transfer Among Organizations: An Applied Communication Strategy Concept for Organizational Boundary Spanners," *Journal of Technology Transfer*, Vol. 22 (1): 35-46.

De Vore, Paul W. (1999), "Do No Harm: Technology, Ethics, and Responsibility," *Journal of Technology Transfer*, Vol. 22 (1): 63-74.

Lee, Y.S. (1996), "The Sustainability of University-Industry Research Collaboration: An Empirical Assessment," *Journal of Technology Transfer*, Vol. 25: 111-133.

Marcotte, Claude, and Jorge Niosi, "Technology Transfer to China: The Issues of Knowledge and Learning," *Journal of Technology Transfer*, Vol. 25: 43-57.

Séror, Ann C., "A Model of Institutional Network Dynamics and A Comparative Case Analysis of Information Technology Transfer," *Journal of Technology Transfer*, Vol. 23 (3): 39-50.

Shiffer, Michael (1995), "Environmental Review with Hypermedia Systems," *Environment and Planning B: Planning and Design*, Vol. 22: 359-372.

Shiffer, Michael (1995), "Towards a Collaborative Planning System," *Environment and Planning B: Planning and Design*, Vol. 19: 709-722.

Wigand, Rolf T., et al, "Electronic Commerce and User-Based Design of a Web Site: Targeting the Technology Transfer Audience," *Journal of Technology Transfer*, Vol. 22 (1): 19-28.

Wolek, Francis W., and James W. Klingler, "Apprenticeship and the Transfer of Technical Know-How," *Journal of Technology Transfer*, Vol. 23 (3): 51-57.

| Timeframe |

December 2000 - January 2001

- Develop a prototype of the Spatial Database for demonstration in Puerto Rico. Continue research of multimedia solutions and institutional barriers with respect to Information Technologies. Continue research of the TUO Technology Transfer Program and related transfer programs. Design a strategy for interviews with transfer organizations and staff in Puerto Rico.

January 2001 - Puerto Rico

- Demo on-line prototype of the Spatial Database. Conduct interviews with transfer organizations and members of the TUO Technology Transfer staff. Collect digital imagery from the Tren Urbano offices for integration into the project.

December 2000 - March 2001

- Continue to work on the Spatial Database and to integrate new imagery from Puerto Rico. Begin thesis writing and incorporate results of interviews. Continue theoretical research.

February 2001 - May 2001

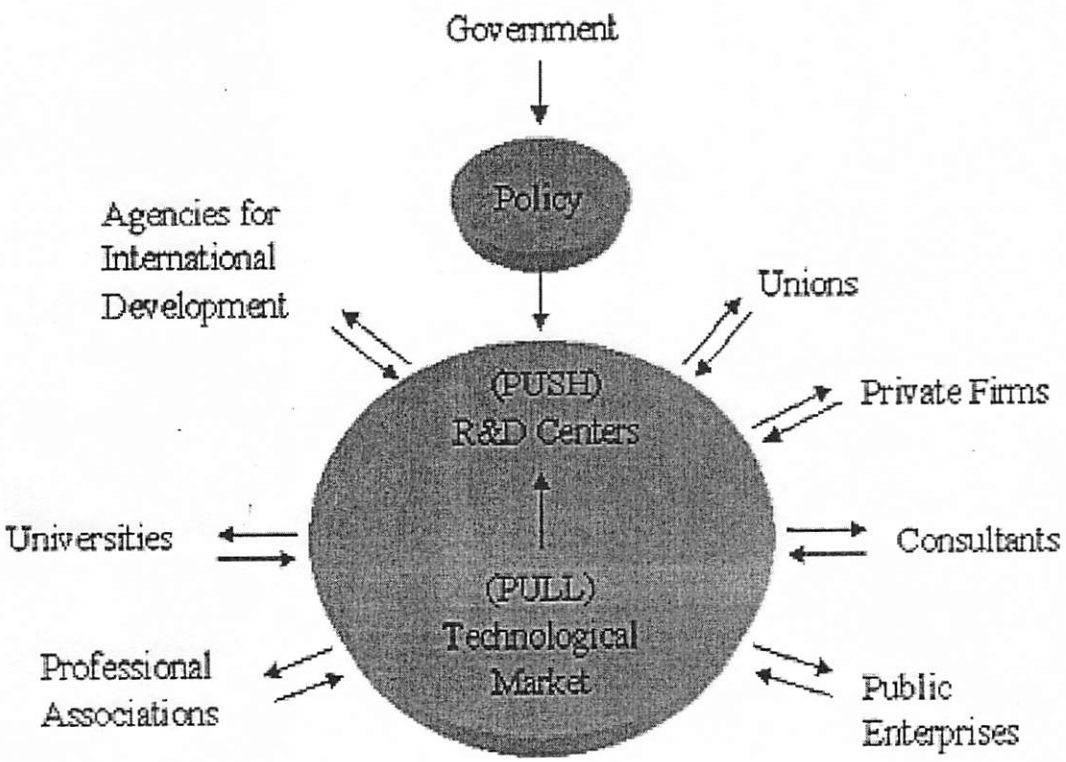
- Continue to work on Spatial Database and thesis writing until the beginning of May.

| Advisor |

My academic and thesis advisor is Michael Shiffer, PhD.

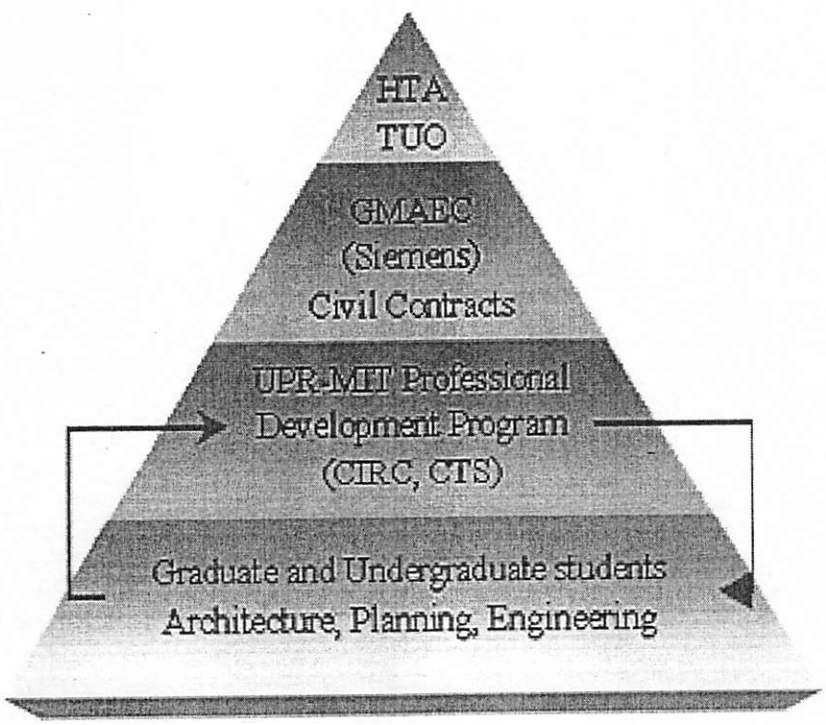
| Attachment A |

An Institutional Model for Technology Transfer. Technological markets act as a "pull" for various organizations wishing to take advantage of new technologies. R & D Centers, academic research centers, and Federal ORTAs act as a "push" – pushing new technologies to various organizations. The government, through development of policy, informs the entire process.



| Attachment B |

Phase 1 of the Technology Transfer Program. The diagram below represents the relationship between the UPR-MIT Professional Development Program (CIRC, CTS) and the graduate and undergraduate students in architecture, planning, and engineering at both universities. Phase 1 is characterized as being a "living laboratory." The focus is on research and collaborative learning experiences.



| Attachment C |

Phase 2 of the Technology Transfer Program. The diagram below represents the relationship between GMAEC and civil contractors and the graduate and undergraduate students in architecture, planning, and engineering at MIT and UPR. Greater emphasis is placed on training and mobilizing a workforce to operate and maintain the Tren Urbano system.