AN IMAGE AND MULTIMEDIA DATABASE FOR TREN URBANO:

APPLICATION TO TECHNOLOGY TRANSFER PROGRAMS

by

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Submitted to the Department of Urban Studies and Planning
in Partial Fulfillment of the Requirements for the Degree of
Master in City Planning

at the

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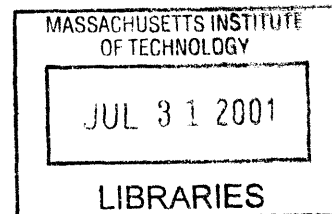May 17, 2001

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Abstract

Information systems can be expected to play a major role in urban infrastructure projects
that require technology transfer. The volume of information that is addressed and the
greatly increased accessibility to that information via the Internet make information systems
many times more desirable than traditional forms of paper exchange or hard-copy ware-
housing. As technologies continue to grow and expand, it is becoming more feasible for lay-
persons to switch to database management solutions for handling vast stores of informa-
tion. These solutions have become much easier to manage, more intuitive to design, and less
costly and burdensome to implement. With a minimum of expertise these days, anyone can
learn to manage a database and operate an information system over the Internet.

The subject of this thesis is a simple database management system - called a "Spatial Data-
base" - designed to support the Tren Urbano Technology Transfer Program. The Spatial
Database allows instant publishing of spatial information (images and multimedia) and stu-
dent research reports over the Internet. Its objectives are to improve communications and
information exchange between Tren Urbano and the community; students at the University
of Puerto Rico and MIT in the Professional Development Program; and students from both
universities and Tren Urbano contractors and consultants. Open distribution benefits each
group by providing immediate access to valuable information as it is captured and recorded
about the Project in the field. This information is necessary to understanding Tren Urbano's
unique history and set of issues involving its construction and daily operations. Freely dis-
tributed information over the Internet is of more use to the Technology Transfer Program in
its efforts to transfer knowledge than if it were to remain undistributed (or distributed to a
much lesser extent).

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For Gina

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CHAPTER 1

INTRODUCTION

"Nothing derails a train of thought more effectively than listening to a person with a one-track mind."

—*Anonymous*

1.1 Background

Tren Urbano is a light-rail transit system 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 (FTA) designated Tren Urbano as one of four turnkey mass transit demonstration projects in the nation. The Puerto Rico Department of Transportation and Public Works (PRDTPW) and the Puerto Rico Highway and Transportation Authority (PRHTA) 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 executed by emphasizing local control, technology transfer, and accelerated start-up; thus utilizing advantages of both traditional turn-key (DBOM) and design-build strategies of rail transit construction (Tren Urbano Office, 1998).

The hybrid turnkey approach is to divide construction of Phase 1 of the alignment among seven contractors, with the largest and dominant contractor, Siemens Transit Team (STT), serving as systems operator for the first 5 years.[1] Once Phase 1 of the alignment is completed, Siemens is committed by contract to providing a specified level of service at a specified cost.[2] It is believed this approach will stabilize the uncertainty of operating a rail transit system where no prior system exists and where the work force needed to operate and maintain the system is being developed.

An advantage of the hybrid turnkey approach is that human capacity building and construction activities occur simultaneously, providing hands-on experience for the Puerto Ricans who inherit the system. This is the main goal of the Technology Transfer Program, which seeks to develop a native generation of rail transit professionals with the necessary skills to operate and maintain the Tren Urbano system, as well as compete for transit-oriented jobs in the U.S. and Latin America.

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1. Tren Urbano has the option of extending this contract another 5 years pending a favorable review of Siemens' performance. Phase 1 of the alignment links the western community of Bayamón with Guaynabo and Rio Piedras, then turns north toward Hato Rey and Sagrado Corazon.
2. In addition to the systems operator contract, Siemens is responsible for the design and installation of all Phase 1 trackwork, the supply of vehicles, the design and construction of two inter-modal stations, an operations control center and a vehicle maintenance facility and storage yard.

1.2 Technology Transfer Program

The Technology Transfer Program enables students in engineering,
architecture, and planning at UPR and MIT to engage Tren Urbano as
a "living laboratory" by applying their own skills and research to the
project. Students and faculty from both universities participate in the
UPR/MIT Professional Development Program, currently in its eighth
year. The Professional Development Program emphasizes the impor-
tance of multi-cultural, multi-disciplinary collaboration between edu-
cators, practitioners, and students. Students are offered a two-year
education with the program, and receive training through course-
work, internships, and independent research projects. There are
approximately 60 interns working for the Tren Urbano Offices and for
Tren Urbano contractors (a total of 120+ interns to date). Students
who complete the program are offered employment with one Tren
Urbano's contractors or consultants.

As Phase 1 of the alignment nears completion, the goals of the Tech-
nology Transfer Program are changing. Greater emphasis is being
placed on mobilizing and training the workers who will operate and
maintain the system. The Technology Transfer Program will assist
general contractors in their efforts to transfer knowledge to this new
generation of transit operators, as part of an effort to monitor compli-
ance with DTPW/HTA provisions requiring a proactive effort by
contractors to transfer knowledge.

1.3 Information Exchange In a Learning Economy

The Technology Transfer Program relies on information exchange much like a "learning economy" in which knowledge is considered a valuable resource. The effectiveness of the program depends on the interactive distribution of information for producing value. Students in the Professional Development Program who contribute research to the learning economy are considered a valuable resource. Members of the community relations group who contribute spatial information about the project's history are also a valuable resource. Information exchange, which determines the effectiveness of the learning economy, can either bolster the value of student participation and spatial information or it can devalue them both depending on the nature of the exchange. The goals of this thesis are to illustrate how information exchange can be improved to facilitate knowledge transfer by adopting a system for distributing images and multimedia about the Project over the Internet.

Information exchange poses a unique problem for the Technology Transfer Program: how to coordinate knowledge transfer between Tren Urbano and the community; students at UPR and MIT in the Professional Development Program; and students from both universities and the Tren Urbano contractors and consultants. Knowledge, as the medium of the exchange, cannot exist in isolation; rather, it should be distributed openly and with no barriers to access (assuming, of course, that it is beneficial to participants of the Technology Transfer Program).

Sharing information is the key to effective knowledge transfer. Identifying the 'right' kinds of information to distribute openly is an important consideration. The right kinds of information should serve the interests of the program and act to strengthen a set of relationships through which information or knowledge developed in one place by one group is transferred to another group in another place to produce value. [Refer to Section 2.1.1 Components of Knowledge Transfer]

The right kinds of information to share in this context are spatial information (images and multimedia, including navigational and panoramic video, 3D models, etc.) as well as student research reports. This information is of considerable value for understanding the development of a major urban infrastructure project in Puerto Rico. Images and graphical representations about Tren Urbano's development are especially important to building strong community relations and soliciting informed feedback about the project from community groups; while student research reports are an invaluable resource to participants of the Technology Transfer Program and transferring agencies, as they exhibit real world problem-solving techniques and issues relevant to the phased development of the train. Both kinds of information should be distributed openly and with no barriers to access, to facilitate the Program's learning economy in which knowledge is considered a valuable resource.

Certainly, spatial information and student research are not the only 'right' kinds of information to exchange in the learning economy context. Forms of 'tacit' information, such as personal experiences and opinions, or 'codified' information, such as technical documents or specifications, may be of equal or greater value depending on the audience and the goals of the program (Marcotte & Niosi, 2000). The types of spatial information considered in this thesis are limited to photographs, ortho-photographs, videos, CAD, graphics, animations, and 3D models. These were selected based on 'perceptions of need' within the Tren Urbano community for an improved system of spatial information management and delivery (of the types mentioned).

1.4 Perceptions of Need – Reasons for Thesis

Perceptions of need for an improved system of spatial information management and delivery are as follows.

1. Greater access to spatial information: Tren Urbano generates a multitude of images and graphical representations to convey its history and progress in Puerto Rico, but it lacks the resources to distribute this media efficiently to the public (most importantly to native Puerto Ricans whose communities are impacted by the project). Despite a well-coordinated effort to photograph and distribute construction images of Phase 1 of the alignment, many people are denied access to this information because it is not widely distributed (for instance, over the Internet). Public access to spatial information is limited to the Community Relations Office in Rio Piedras.

2. Program Philosophy: The hybrid turnkey approach to building the system has allowed for greater community participation in

the design and review process, and the public has been well informed on all aspects of the construction process. It is possible, however, to reach a wider audience than is currently being addressed by distributing up-to-date spatial information about the project over the Internet. Restricting spatial information to the Rio Piedras office is not satisfactory to addressing as wide an audience as is desired for effective community participation and public relations.

3. Greater access to student research: access to student research reports generated for the Professional Development Program has traditionally been limited to the Tren Urbano Office and common rooms at either university. It is difficult to gain an understanding of the types of research available and their relevance to the phased development of the train under the current system. These reports, if they are to be of use to Project developers, students, and interested public, should be distributed over the Internet (preferably alongside relevant spatial information of phased development). It may be argued that limited accessibility to these reports has devalued their importance to the Project and under-mined core goals of the Technology Transfer Program.

4. Broader application of resources: there are currently no plans to use spatial information and student research in training seminars offered by civil contractors, though this information is relevant to ongoing developments with Tren Urbano. The Technology Transfer Program, in its efforts to monitor compliance with DTPW/HTA provisions, should endeavor to incorporate this information into training seminars.

1.5 Proposed Solution – a "Spatial Database"

Information systems can be expected to play a major role in urban infrastructure projects that require technology transfer. The volume of information that is addressed and the greatly increased accessibility to that information via the Internet make information systems

more desirable than traditional forms of paper exchange or hard-copy warehousing. As technologies continue to grow and expand, it is becoming more feasible for lay-persons to switch to database-management solutions for handling vast stores of information. These solutions have become much easier to manage, more intuitive to design, and less costly and burdensome to implement. With a minimum of expertise these days, anyone can learn to manage a database and operate an information system over the Internet.

This thesis proposes a simple database management system – called a "Spatial Database" – for improved communications and information exchange for Tren Urbano's Technology Transfer Program. The Spatial Database allows instant publishing of spatial information (images and multimedia) and student research reports over the Internet. Its objectives are to improve communications and information exchange between Tren Urbano and the community; students at UPR and MIT in the Professional Development Program; and students from both universities and Tren Urbano contractors and consultants. Open distribution benefits each group by providing immediate access to valuable information as it is captured and recorded about the Project in the field. This information is necessary to understanding Tren Urbano's unique history and set of issues involving its construction and daily operations. Freely distributed information over the Internet is of more use to the Technology Transfer Program in its efforts to transfer knowledge than if it were to remain undistributed (or distributed to a much lesser extent).

The Spatial Database uses Lasso's Web Data Engine™ and FileMaker Pro™ databases to store and deliver its spatial information over the Internet. Its design and interface are discussed in this thesis, as are guidelines for how to update and maintain the system. The Spatial Database will be maintained and operated by Tren Urbano staff in Puerto Rico.

1.6 Outline of Thesis

Chapter 1 provides a brief introduction to the Tren Urbano Project, the Technology Transfer Program, and issues relating to information exchange, knowledge transfer, and the creation of this thesis.

Chapter 2 provides a more detailed look at the Technology Transfer Program, as well as an introduction to effective systems of information flow within the program's context.

Chapter 3 provides a more candid look at the community relations group for Tren Urbano, its importance to knowledge transfer, and its practice of collecting and distributing images about the Project. Most of the images used in the Spatial Database were created for the community relations group to interface with the public during community meetings.

Chapter 4 provides a general introduction to database design and implementation, a discussion of institutional barriers to adopting new technologies, and an account of the technologies used to create the Spatial Database for Tren Urbano.

Chapter 5 provides the methodology used to create the Spatial Database, a discussion of image collection techniques, and a guided tour of the Spatial Database on-line.

Chapter 6 provides a discussion of potential applications for the Spatial Database and concludes the context, theory, and implementation part of the thesis.

Appendices A and B provide guidelines for updating and maintaining the Spatial Database.

1.7 A Note About the Spatial Database

The image and multimedia database referenced in this thesis is called a "Spatial Database" because it enables users to access a wide array of spatial information for purposes of analysis and presentation. It is not to be confused with a Geographic Information System (GIS), which in database parlance is often called a "Spatial Database," meaning a computer-based information system that enables capture, modeling, manipulation, retrieval, analysis and presentation of geographically referenced data. The Spatial Database of this thesis allows access to spatial information (in the form of images and multimedia) but does not provide a means for direct manipulation or modeling of the spatial information. This point is developed further in Chapter 4: Database Implementation.

TECHNOLOGY TRANSFER PROGRAM

In this chapter: knowledge transfer; the Professional Development Program; the Technology Transfer Program; types of information flow.

"One of the most important innovations of our project is not about turnkey or design-build procurement; nor does it have anything to do with the latest rail transit technology. This innovation concerns what some economists like to call *human capital*. I prefer the ordinary word: people. The Tren Urbano Professional Development Program is about investing in people, the people whose knowledge and skills Puerto Rico will need in order to operate and maintain our Phase I line successfully, and to design and build the rest of the system."[1]

(Pesquera, 1997)

2.1 Knowledge Transfer

Knowledge transfer, as defined in this thesis, is the act of sharing information to produce value. It can occur between two people sitting in the same room or across continents and oceans via an elaborate information network. The process of knowledge transfer, whether informal (face-to-face) or elaborate (via institutional policies and practices), is essentially collaborative and entered into willingly by both the transferring agent or agencies and the recipient(s) of knowledge or training.

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1. From a speech by Carlos I. Pesquera, Ph.D., Secretary of the Puerto Rico Department of Transportation and Public Works, as prepared for delivery at the FTA conference on technology sharing, Baltimore, MD, 1997.

Knowledge transfer may be thought of in terms of distribution, relationships, and strategic planning. The Technology Transfer Program is an excellent case study for how these components interrelate to form an effective transfer process. As this thesis attempts to build the case for an improved system of information exchange for Tren Urbano's spatial information and research, it is necessary to explore this process so that a set of recommendations for better knowledge management can be made.

2.1.1 Components of Knowledge Transfer

1. Distribution: 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. Participants in the UPR/MIT Professional Development Program with knowledge to share rely on systems of distribution to transfer and receive such knowledge. Effective systems of distribution convey that knowledge is shared freely, without barriers to access or understanding (for instance, language or institutional barriers). Distribution occurs through interpersonal contact, such as meetings and lectures, or through extrapersonal contact, via an information system or other means to distribute knowledge and learning to produce value.

2. Relationships: a set of relationships by which information or knowledge developed in one place by one organization is transferred to another organization in another place. Strong relationships encourage and facilitate the process of knowledge distribution mentioned above. For the Technology Transfer Program, relationships span both language and cultural barriers, as they occur between students and professionals at the University of Puerto Rico (Spanish speaking) and MIT.

3. Strategic Planning: strategic planning involves planning for new

developments as they occur on a cooperative basis. This involves identifying the right kinds of information or knowledge to transfer to participants in the Technology Transfer Program. This may also be thought of as 'filtering' so that relationships are not strained by too much information, or irrelevant information, and systems of distribution are not stressed. In Phase 1 of the Technology Transfer Program, strategic planning accounts for skills-training needed to operate and maintain the Tren Urbano system. Strategic planning helps to prepare students for employment during Phase 2 of the Technology Transfer Program.

The behavior of distribution, relationships, and strategic planning in the Tren Urbano context is explored in the remainder of this chapter.

2.2 A Graphical Representation
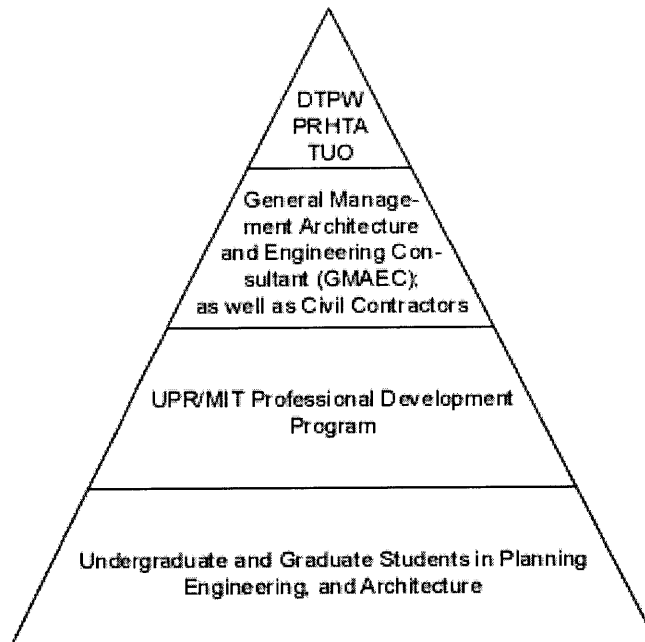
Figure 2-1 Technology Transfer Pyramid

The Technology Transfer Pyramid (Fig. 2-1) is a graphical representation of the Technology Transfer Program. It is like a typical government business pyramid with policy-related functions at top, management-related functions in the middle, and operations- and labor-related functions at the bottom (Huxhold, 1991). The shape of the pyramid suggests that information is free to travel horizontally - within each stratum – as well as vertically. Figure 2-2 represents successful information flow throughout all organizations of the Technology Transfer Program.

INFORMATION

Pyramid diagram with the following levels from top to bottom:

- DTPW PRHTA TUO
- General Management Architecture and Engineering Consultant (GMAEC); as well as Civil Contractors
- UPR/MIT Professional Development Program
- Undergraduate and Graduate Students in Planning, Engineering, and Architecture

Left vertical label: INFORMATION
Right vertical label: INFORMATION

Figure 2-2 Successful Information Flow

An example of successful information flow occurs when one level of the pyramid in need of data or resources receives it through interacting with another level of the pyramid where the data or resources are generated. This might occur when students who are trained to operate and maintain the Tren Urbano system benefit from meeting with and interviewing top officials at PRHTA (the Puerto Rico Highway and Transportation Authority). Likewise, PRHTA and the GMAEC

(General Management Architecture and Engineering Consultants) benefit from successful information flow when students at the bottom level of the pyramid, through involvement with the Professional Development Program, are able to develop the skills needed to acquire top management jobs or assist with construction in the field. A well-established system of technology transfer allows for meaningful interactions to occur between all levels of the pyramid - without barriers to knowledge and practical experience. For this reason the pyramid is an effective graphical aid for illustrating the effectiveness of information flow and skills-training for Tren Urbano.

At the top of the Technology Transfer Pyramid are the Department of Transportation and Public Works in Puerto Rico (DTPW), the Puerto Rico Highway and Transportation Authority (PRHTA), and the Tren Urbano Office (TUO). The second level is composed of the General Management and Architecture and Engineering Consultant (GMAEC), as well as the various civil contractors responsible for building the Tren Urbano system. The third level consists of the UPR/MIT Professional Development Program, which is managed through the Tren Urbano Office. At the base of the technology transfer pyramid are students from universities in Puerto Rico and the U.S. who are selected to participate in the Tren Urbano Technology Transfer Program.

2.2.1 Top Level – DTPW/HTA/TUO

The top level of the knowledge transfer pyramid is where policy makers initiate plans and programs, budgets are approved, and new departments are established. Decisions made at the top level affect the course of the project over multiple years and give it its unique vision. The DTPW/HTA, for instance, advocated a hybrid turnkey approach for Tren Urbano's procurement and accelerated construction schedule, which now characterizes the project's unique vision for capacity building and local development control in Puerto Rico. The DTPW/HTA and its consultants also established a set of goals for the project in general: to become a model of advanced rail-transit design, community participation, technology transfer, and innovative project management.

Because policy makers at the top level cannot achieve these goals alone, they must create new departments and delegate responsibilities to lower levels of the pyramid. In 1994 the HTA created the Tren Urbano Office to manage the planning, design, and procurement phases of the project. This decision freed the DTPW/HTA to focus again on policy-related issues, and led to subsequent new plans and programs. For instance, during the early stages of Phase 1 of the Tren Urbano alignment, the TUO assembled the four prime consulting firms that make up the GMAEC to assist in developing the hybrid turnkey approach to the project.[2]

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2. The four prime consulting firms are Frederic R. Harris, Inc.; Daniel Mann Johnson and Mendenhall, Inc.; Barrett and Hale; and Eduardo Molinari y Asociados. In addition to the four prime consulting firms the GMAEC is composed of more than 20 subcontractors.

The role of the PRHTA in the Tren Urbano Technology Transfer Program is as follows:

1. To oversee all training and technology transfer activities;
2. To coordinate the university program;
3. To oversee the compliance of mentoring, peer partnering, and other local employee development;
4. To monitor the availability of construction workers;
5. To coordinate TU training efforts with other agencies and departments;
6. To review and approve TU system operator's training course outlines, the trainee selection plan, and the training plan for operations start-up.

2.2.2 Middle Level – GMAEC and Civil Contractors

The General Management Architectural and Engineering Consultant (GMAEC) is composed of four prime consulting firms and is responsible for managing work internships with the participating universities and for coordinating and assisting in training and technology transfer programs. The GMAEC is also responsible for monitoring and evaluating the Technology Transfer Program under the direction of the Tren Urbano Office.

In addition to coordinating work activities with both universities, the GMAEC is responsible, through its contract with PRHTA, for performing environmental studies, preliminary engineering for Phase 1, community participation efforts, technical services, and project management and administration.

The GMAEC contract also stipulates that 83% of the work on the project done by civil contractors be carried out in Puerto Rico. This includes a percentage of work to be carried out by Puerto Ricans (50%) and by companies owned by Puerto Ricans (30%). These stipulations are representative of DTPW/HTA's commitment to training a new generation of transit operators and to developing the human capital in Puerto Rico.

2.2.3 Middle Level – UPR/MIT Professional Development Program

The UPR/MIT Professional Development Program was initiated as part of the overall GMAEC contract with PRHTA in August 1994. Its goal is to develop a native generation of rail transit professionals with the necessary skills to operate and maintain the Tren Urbano system, and to compete for transit-oriented jobs in the U.S. and Latin America. The program emphasizes the multi-cultural and multi-disciplinary nature of most major infrastructure projects today.

The Professional Development Program enables university students to engage Tren Urbano as a "living laboratory" through intensive exposure to developments in the project as they occur and by encouraging research projects that are relevant to these developments. It is the major focus of the Technology Transfer Program at the TUO.

The principle objectives of the Professional Development Program, as stated by the Program's main coordinators at TUO, UPR, and MIT, are as follows (Antonio A. Gonzalez-Quevedo, et al):

1. To develop a cadre of local professionals in transit system planning, design, construction and operation, whose expertise can become a valuable high-technology service with a ready export market in Latin America.

2. To strengthen the educational and research programs in the most important infrastructure-related disciplines at the University of Puerto Rico.

3. To establish a model for cross-disciplinary cooperation among UPR faculty in engineering, architecture, and planning, working together with experts from government and industry to apply an integrated systems approach to the development of a major urban infrastructure project.

4. To develop a collaborative relationship between the University of Puerto Rico and the Massachusetts Institute of Technology through this educational program which can serve as a model for other programs involving joint efforts between educational institutions.

2.2.4 Bottom Level – Undergraduate and Graduate Students

The UPR/MIT Professional Development Program is composed of undergraduate and graduate students at both universities, as well as students at Northeastern and Boston University, and faculty advisors who help guide and evaluate the program in addition to assisting students with research. Students are recruited by each university and are eligible for financial assistance through their participation in the program. At the University of Puerto Rico, three schools are involved in the program: the School of Engineering (Mayaguez campus), the Graduate School of Planning (Rio Piedras campus) and the School of

Architecture (also Rio Piedras campus). At the Massachusetts Insti-
tute of Technology, students are recruited from the Center for Trans-
portation Studies, the Department of Civil and Environmental
Engineering, and the Department of Urban Studies and Planning.
Students and faculty from all participating universities are brought
together for a week-long orientation and seminar series occurring
twice a year, once in Boston and once in San Juan. Students from MIT
and UPR are typically involved in the program for a total of 2 years,
though participation frequently extends beyond this timeframe.

An undergraduate's and graduate's experience in the Professional
Development Program has five (5) main elements:

1. An intensive course on public transportation hosted by MIT dur-
    ing the month of June. Field trips are scheduled of Boston's Com-
    muter Rail, MBTA operations and yards, South Station, the Big
    Dig, and historic points of interest. Students work in teams to
    research and present lessons learned from the course and from
    field trips, both positive and negative, for application to Tren
    Urbano in San Juan. Special emphasis is placed on developing
    research skills and ways of thinking critically about transporta-
    tion and commuter-related issues.

2. An intensive course on public transportation in San Juan hosted
    by the Tren Urbano Office during the month of January. Speakers
    include distinguished scholars and urban planning officials from
    around the world, as well as those closer to home including the
    Secretary of Transportation and Public Works in Puerto Rico and
    civil engineers involved in daily construction of the Tren Urbano
    system. Students participate in site tours and are given transit-
    related assignments, which encourage teamwork and investiga-
    tive skills, such as "depart by bus to Bayamón, take publicos to
    Catano, Rio Piedras, or San Turce, then transfer to ferry or AMA

bus to arrive in San Juan." The course ends with poster presentations that were prepared by each student in advance of the course, outlining their research agendas for the term. Special emphasis during the January conference is placed on familiarizing students with all aspects of Tren Urbano and with aiding them in their research by establishing contacts with Tren Urbano officials and other students.

3. A summer internship (full-time) with Tren Urbano contractors and consultants or part-time for one semester or equivalent. The purpose of the student internship program is to provide students in the UPR/MIT Professional Development Program with real project work experience and definable job responsibilities. Students in the program are exposed to areas of research, development, technology and administration, which help them to make informed career choices while in school and to encourage them to pursue opportunities with Tren Urbano following graduation.

4. A student research project on a topic relevant to Tren Urbano. Masters students in the Professional Development program complete a thesis fulfilling the requirements for their degree, while undergraduate students typically write a report in conjunction with another transit-related class or as an independent study project. A research project is required of every student who participates in the program, and the reports are archived at MIT, UPR, and the TUO, and made available to students, faculty, and appropriate TUO/GMAEC staff. One of the objectives of the Tren Urbano Spatial Database is to make these reports available over the Internet and to associate them with images and multimedia about the project related to their research.

5. An employment opportunity with a Tren Urbano contractor or consultant after completing the program. The agreed upon target set by Siemens and the TUO is that 100% of graduate students seeking employment that fits STT's needs will be hired.

2.3 Phase 1 of the Technology Transfer Program

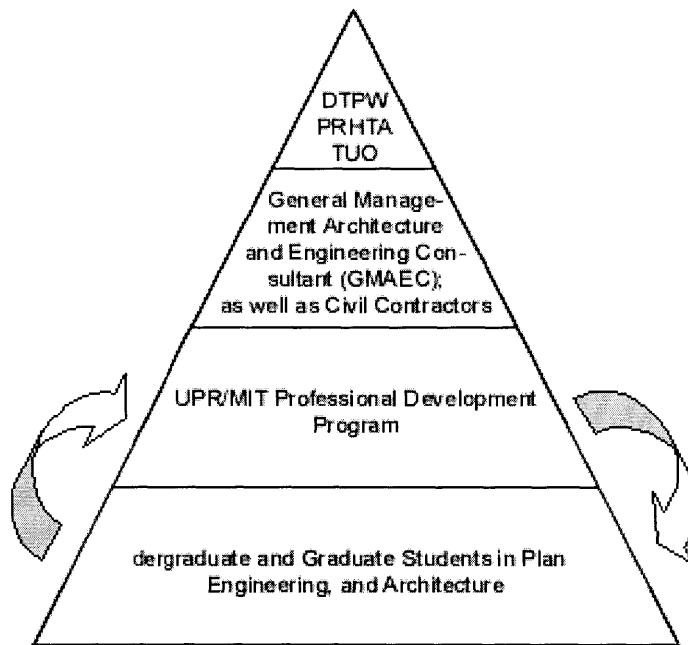

Figure 2-3 Phase 1 of the Technology Transfer Program

2.3.1 Information Exchange

Phase 1 of the Technology Transfer Program is viewed as a multi-cultural, multi-disciplinary learning environment, or as a "living laboratory," in which students engage Tren Urbano through coursework at their universities, site visits, and individual research projects about a topic relevant to current developments in Tren Urbano. Students work closely with faculty advisors to complete this research phase of

their involvement with the Professional Development Program. Phase 1 for the typical student lasts 2 years (four semesters and one summer) [see Table 2-1].

Year 1	June conference at MIT	First semester - student research begins	January conference at TUO in Puerto Rico	Second semester - student research continued
Year 2	Summer internships (optional)	Third semester - student research continued	Fourth semester - student research completed	

Table 2-1 Professional Development Program Time Table

The chance for collaborative information exchange between students at UPR and MIT is limited, with the exception of a biannual meeting to bring the universities together. It is during this time that crossover relationships and knowledge spill-over occur between students and faculty from both universities. Students from MIT who attend the January conference in Puerto Rico collect the bulk of their research during the conference through interviews and independent field studies. Codified information related to the project (such as site plans, maintenance schedules, traffic analyses, etc.) is made available for the first time to many of these students through professional relationships developed with contact persons. These relationships are not easily built without the conference atmosphere in which information is freely exchanged. The same may be said of the June conference at MIT: that it is a collaborative activity in which students benefit from increased access to information, cross-over relationships, and knowl-

edge spill-over.

2.3.2 *Improved Information Exchange*

An improved system of information exchange might allow students during the academic year to develop cross-over relationships without having to rely on the biannual conference to collect and receive valuable information. Codified information could be passed in electronic form at any time during the year by accessing the Spatial Database. As previously mentioned, this would require the knowledge to identify the 'right' kinds of information to transfer, as well as personnel to digitize the information and to distribute it via electronic means.

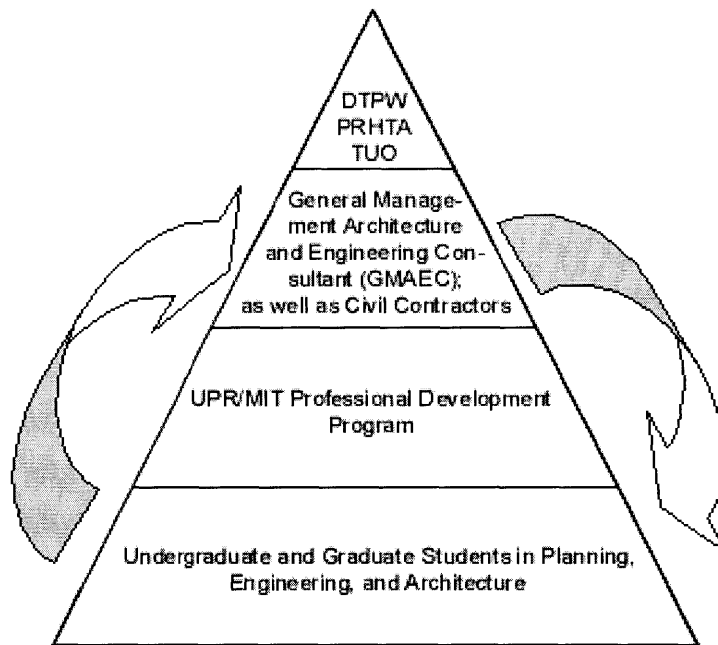## 2.4 Phase 2 of the Technology Transfer Program

Figure 2-4 Phase 2 of the Technology Transfer Program

Phase 2 of the Technology Transfer Program involves expanding the human resources capacity in Puerto Rico and Tren Urbano by offering employment opportunities to the participants of the UPR/MIT Professional Development Program. The Technology Transfer Program has exposed hundreds of young Puerto Rican professionals to the experience of designing and building a major urban infrastructure project from the ground up, and the task remains to find meaningful

employment for them within the Tren Urbano organization. These opportunities will stem from exposure to the GMAEC and civil contractors and consultants. Phase 2 of the Technology Transfer Program moves students from the Professional Development Program and paid internships into the field as bilingual transit experts.

As part of Phase 2, the Technology Transfer Program is responsible for overseeing GMAEC contracts requiring a proactive effort by civil contractors to transfer knowledge to this new work force. The role that civil contractors play in training these workers is vital to the success of the Technology Transfer Program, as it represents a tangible measure of whether the program has achieved its goals for human capacity building in Puerto Rico.

The role that a Spatial Database can play in the training process, as an improved system of information exchange, is discussed in Chapter 6: Applications and Conclusions. It is believed that spatial information and access to student research reports can facilitate the training process in Puerto Rico.

The process of collecting spatial information for the Tren Urbano Project is discussed in the following chapter.

In this chapter: the Tren Urbano Office, The Community Relations Office, the Community Relations Department of HTA; the image collection process for Tren Urbano.

"The use of information in [city planning settings] frequently involves recollections about the past, descriptions of the present, and speculation about the future. This is most often conveyed using the cognitive information provided by the meeting participants and may be augmented using various media and tools. Spatial representations such as maps, typically provide a central organizing metaphor."
(Shiffer, 1995)

3.1 Community Relations and Spatial Representations

The community relations group for Tren Urbano relies upon spatial representations such as maps, aerial photographs, and videos to communicate effectively and openly with the public during community meetings. These discussions are frequently augmented with up-to-date images about a particular subject that serve to dramatically alter the way in which participants in community meetings recollect the subject or relate to new ideas about the subject. Without spatial representations around which our thoughts can be organized, dependence upon memory alone can lead to problems based in the inconsistency of individual memories (Shiffer).

For example, someone might believe there is a well-travelled pedestrian path near the site of new construction in Rio Piedras, while another person believes the path starts further down the street. Small differences of opinion are bound to be resolved sooner rather than later, but they can interrupt the continuity of the meeting and distract

participants from the subject at hand. Spatial representations such as maps often help to focus group discussion and resolve discrepancies related to individuals' memories of a place or situation. It should be recognized, however, that maps are not always the surest means of arriving at the truth of a place or situation, as graphical information is easily manipulation or misrepresented. Indeed it is sometimes easier to agree without the use of maps or graphical representations than it is to acquire accurate and true spatial representations. Hence, the issue of what information is 'needed', 'useful' or 'distracting' is not always so easy to determine (Ferreira, in conversation).

In another example, suppose the misunderstandings over a place or situation are more severe, causing a rift between presenters at the meeting and members of the community. As a result construction is delayed for a couple of days or even halted indefinitely. Spatial representations are important to community relations because they help minimize these misunderstandings (to a degree) and provide participants at community meetings with a more or less accurate depiction of reality.

The community relations group for Tren Urbano is responsible for the task of collecting, processing, archiving, and distributing spatial information for use in public meetings and by staff and professionals throughout all organizations of the Project. Spatial information includes photographs, ortho-photographs, videos, CAD, graphics, animations, and 3D models. The organizations of Tren Urbano, which rely on spatial information, include the Office of the Secretary of

Transportation, all top-level organizations of the Tren Urbano Office, contractual partners composing the TUO, and other organizations that rely on spatial information to perform specific job functions. The community relations group is assigned this task of collecting and maintaining spatial information, which is foremost a communication tool used by people to help others understand and relate to complex or extraordinary events. As such a tool it empowers its users with visual knowledge of a subject.

> "Visual knowledge may be expressed through the filling in of the incomplete, the interpretation of the ambiguous, and the reassembling of 'memory images' which may be recognized in graphic images." (Oxman, 1995)

Spatial information serves other purposes as well, which I hope to illustrate in the remainder of this chapter.

3.2 Tren Urbano's Community Relations Group

The task of collecting, processing, archiving, and distributing spatial information about the Tren Urbano Project is a collaborative effort by three (3) groups. These groups interact to form a process of image handling with application to other large infrastructure projects involving diverse partnerships and federal assistance.

The three groups are:

1. The Communications Department of the PRHTA under the authority of the Secretary of Transportation.
2. The Community Relations Office in Rio Piedras, which is a joint effort between the Tren Urbano Office and the HTA.
3. The Community Relations Group of the Tren Urbano Office.

3.2.1 The Community Relations Department of the PRHTA

The Community Relations Department of the PRHTA is responsible for photographic documentation of all HTA/DTOP projects. It employs three staff photographers to shoot "fly-overs" from inside a helicopter and "walk-throughs" of the alignment according to contract. All projects are documented the same way, for instance, the process used to shoot Tren Urbano is no different than the one used to shoot PR-10, the road between Arecibo and Ponce in Puerto Rico. The images are maintained at the HTA and organized according to project, date, and subject (whether aerial or ground level - *alineaciones aereas y terrestres*).

PRHTA images are processed and maintained in a small graphics and audio-visual department. The department consists of a light table, a plotter, and several staff with computers and equipment to digitize the images. Because it is small, the department relies heavily on the graphics department of the TUO for large jobs (i.e., brochure and magazine work, CAD, and map-making). Hand-painted graphics for use on buses or other means of public display are completed 'in-

house.' Against the walls of the small department are several large fil-
ing cabinets used to store photographs and negatives, and a small
room dedicated to video archives.

The main purpose of the Community Relations Department is to pro-
vide an accurate history of each HTA project for use by HTA profes-
sionals in dealing with the community. The HTA collects images for
use at community meetings (taller informativo) when it wishes to
announce its plans to start a new project or to update the public on an
existing project. For instance, once the authority wished to build a
bypass (En Sanche Antigua Via) over a busy intersection in Agua-
dilla, but to do so had to knock down a row of houses. The HTA
arranged a meeting with the owners of those houses, at which large
images of the busy intersection were displayed alongside graphics of
the proposed bypass (Figures 3-1 and 3-2). After much discussion and
theorizing over the visual aids, the owners grew convinced that a
bypass was necessary for the good of the community and they
accepted fair market prices for their houses.[1,2]

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1. Three stands of graphics are used to orient the community during the
   discussion. This meeting is being held in a local gymnasium owned
   by the government and is therefore free of charge for the day.
2. Questions to consider: could the presentation have been delivered as
   effectively using a computer and a projector screen in the gymna-
   sium? What about the daylight streaming in through the windows in
   back and the apparent lack of electrical outlets? Would the technology
   serve to distance the community from the HTA in unforeseen ways?
   Are stand-alone graphics easier to relate to, even if less interactive
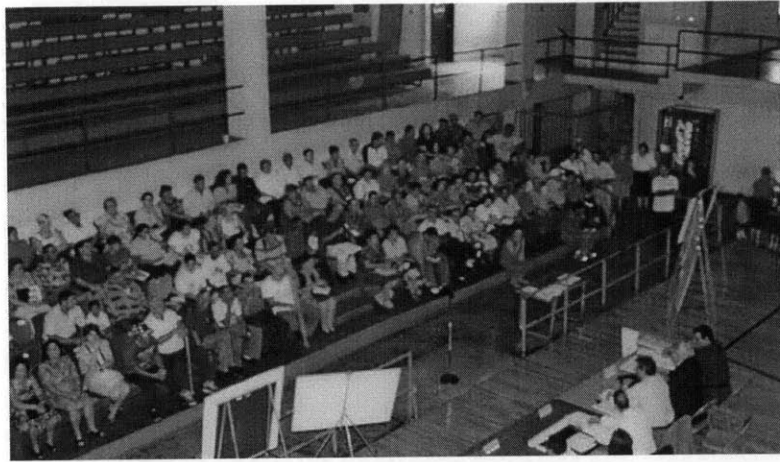   than computer generated images?

Figure 3-1 Community Members Meet with Officials From the HTA to Discuss a Proposed Bridge in a Busy Intersection of Aguadilla, Puerto Rico

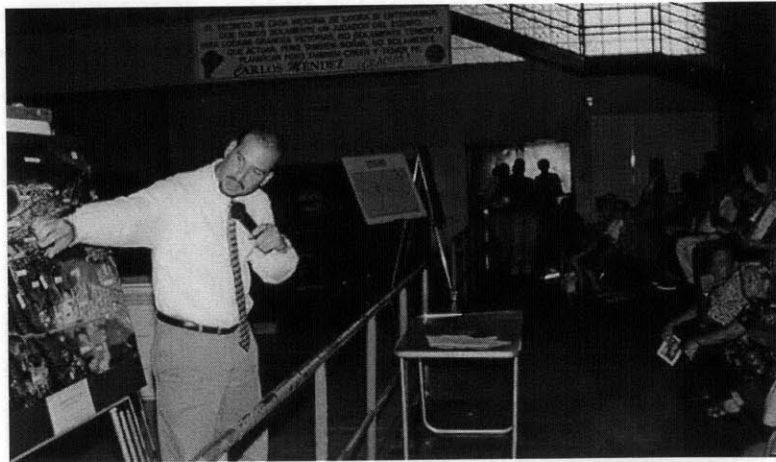Figure 3-2 Effective Use of Graphics to Communicate Spatial Information to the Community in Aguadilla, Puerto Rico

In addition to providing an accurate history of each HTA/DTOP
project, the Community Relations Department is responsible for
approving all photographs before they are made available to the pub-
lic. This is necessary for legal reasons, in case a photograph can later
be used against the authority as evidence of wrongdoing or shoddy
construction (which is not to suggest these cases are common). Occa-
sionally, something unexpected will result in the need for careful
photographic documentation, as with the discovery of Taino Indian
remains along the construction site of PR-22 (a highway in Vega Baja,
Puerto Rico). The discovery forced an excavation of the site that
lasted 2 years (at a cost of 2.5 million dollars). Community Relations
was eager to spin the situation around for anyone inconvenienced by
the affair and arranged for high school students to routinely visit the
site and learn about archaeology and Puerto Rico's history. Ulti-
mately, a bridge was built over the site (Passo Del Indio), and HTA
received an award from the National Geographic Society for its
efforts in cultural preservation and education.

In addition to the aforementioned community and legal uses, many
of the images are used in reports to the chamber of commerce, in pre-
sentations to groups of engineers, to colleges in Puerto Rico, and to
the press.

3.2.2 The Community Relations Office in Rio Piedras

The Community Relations Office is situated in a well-trafficked area of Rio Piedras and is organized to allow the community a place to meet to discuss issues regarding the building of Tren Urbano and to engage the project as it develops through up-to-date images of construction and construction techniques. The Office is the most direct link between the community and Tren Urbano, where it is possible to simply walk in off the streets and browse the latest collection of photographs along the walls, or ask questions of Tren Urbano personnel who routinely pass through, or study architectural models of each of the stations. Construction of the Rio Piedras station has literally turned the area outside the Office upside-down, and it is impossible not to be absorbed by what is happening with Tren Urbano as one walks through town. At times during the day there are easily as many men in yellow vests and hard hats walking to and from the station's construction site as there are students walking to and from the neighboring University of Puerto Rico at Rio Piedras. The Community Relations Office is able to provide a friendly buffer between these two contrasting worlds.

The shared philosophy of those who work at the Community Relations Office, indeed, of everyone who works on Tren Urbano, is that Tren Urbano is "history in the making" and should be regarded as a source of great pride for native Puerto Ricans. This philosophy goes back to the original expectations for Tren Urbano set in place by Carlos Pesquera, former Secretary of Transportation in Puerto Rico (1993-1999): that the success of the project depends on public interest and participation, and that every effort should be made to keep the public

informed of developments with Tren Urbano as they occur. What this has meant for the Community Relations Office in Rio Piedras is that in order to keep the public informed of new developments, all aspects of the project must be continuously recorded and efforts made to allow the public easy access to the information generated. Photographs from construction sites and video fly-overs of the alignment have naturally provided the most accessible way for the public to engage and understand developments with Tren Urbano as they occur, as well as to witness how the alignment is reshaping the look and feel of their neighborhoods. This kind of understanding would not be possible without the use of constantly updated images and video.
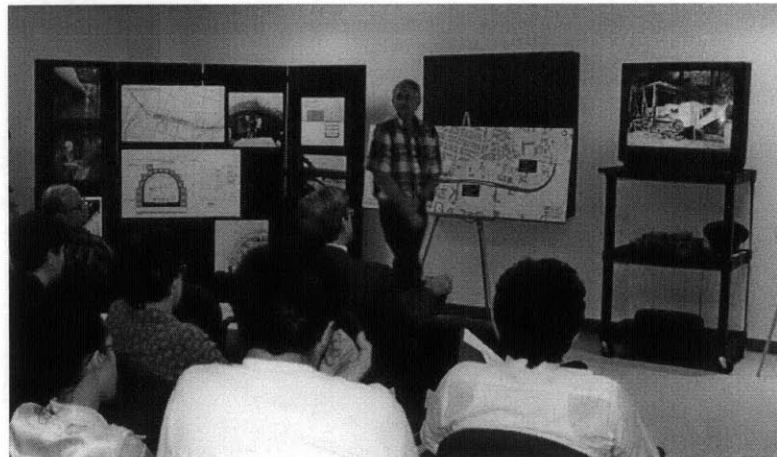
Figure 3-3 Using Video to Demonstrate Tunneling Techniques to Community Members in Rio Piedras

In addition to providing a popular meeting place, the Community Relations Office has planned local events such as a street fair and outdoor information session (Feria de Rio Piedras, November 8, 1997). In a press release announcing the event, Dr. Carlos I. Pesquera, Secretary of the Department of Transportation and Public Works, remarked "the fair will offer Río Piedras residents and visitors an opportunity to learn more about the Tren Urbano project and, at the same time, will give area businesses a chance to promote themselves to a wider public." It is clear that Dr. Pesquera, speaking for the DTPW, wishes to relate that area businesses will prosper as a result of being within service range of Tren Urbano, and that that prosperity will result from Tren Urbano's continued acceptance and public approval.
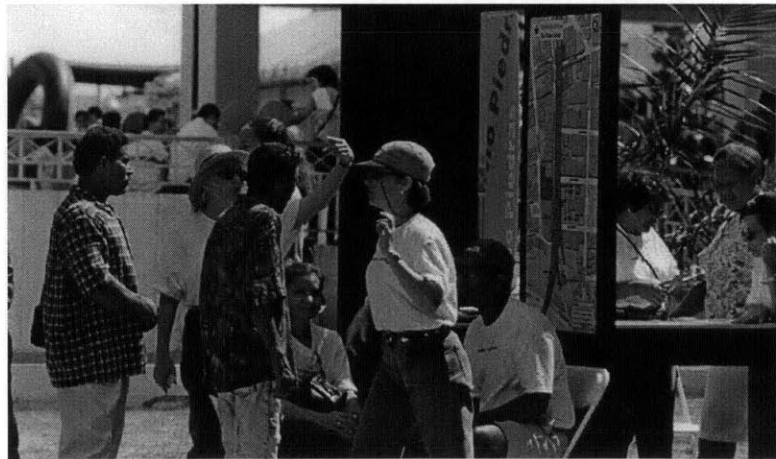

Figure 3-4 Feria de Rio Piedras Information Booth

During Feria de Rio Piedras, visitors to the Office were given a punch card (called a "boarding pass"), which they then presented at information booths set up around downtown Rio Piedras to represent station stops along the alignment. After listening to details about a particular station, their cards were punched and they could proceed to the next booth (one stop further down the alignment). A full tour of the alignment brought them back to the Office where they were given a reward (a candy-filled paper train) and asked to provide feedback on their experiences. In addition to the tour, games were set up for children, local artisans sold their arts and crafts, and Jaileen Cintrón, a popular meringue star, gave an enthusiastic mid-afternoon performance to future 'Tren Urbaners'.
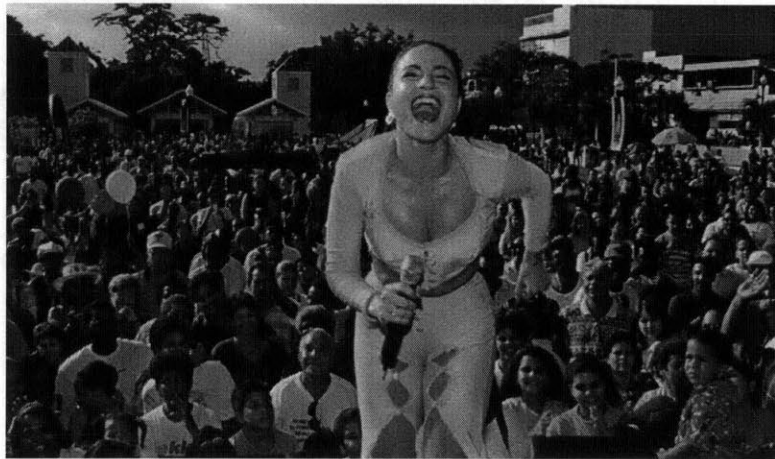

Figure 3-5 Jaileen Cintrón Performs for Future 'Tren Urbaners' at the Fair

This is just one example of how images and graphical representations have been used to interact with the community. The majority of inter-actions involve ongoing developments with the project itself, as demonstrated in one meeting with the community in which the design of the facade of the Rio Piedras station came under attack. It was believed the facade did not express the real character of the Rio Piedras neighborhood, and that furthermore, it looked like nothing else in Puerto Rico (it was believed to have looked "more Miami than Puerto Rico"). The community decided it could do better and sought design assistance from the School of Architecture at UPR. The reworked designs were then submitted at another meeting with Tren Urbano officials, where it was decided that an earlier version of the facade – meeting more of the criteria the community had established – could be used instead.

Figure 3-6 Discussing the Rio Piedras Station Facade at the CRO

3.2.3 The Community Relations Group at the TUO

The Community Relations group at the Tren Urbano Office is com-
prised of a Community Relations Department and a Graphics
Department, and is responsible for staffing the Community Relations
Office in Rio Piedras. The two departments at the TUO work as a
team to provide written and graphical material for use in presenta-
tions at community meetings, local events, internal meetings, and
other events such as presentations to APTA (American Public Trans-
portation Association), the FTA and other governmental and non-
governmental assemblies. Official publications about Tren Urbano
are all prepared at the TUO. As of early 1999, over 300 meetings had
been arranged through the Community Relations group to bring
community and professional groups into direct personal dialogue
with the DTPW/HTA executive team and professionals at the TUO.
The department is committed to providing a level of community out-
reach and public involvement never before realized in Puerto Rico. To
some this comes as no surprise considering that the manager of Com-
munity Relations is the former Commissioner of the Massachusetts
Department of Public Welfare (1989-1991) and managed a $3.6 billion
budget and 4,000 employees serving 550,000 clients (Source: An orga-
nizational Report of the Tren Urbano Office).

The Community Relations group is well-outfitted with the latest com-
puter graphics software, a knowledgeable and highly professional
staff, and the resources needed to generate most of the maps and

graphical representations that have characterized the look and feel of the Tren Urbano project in the public domain (and moreover, the rest of the world). Most, if not all, of the graphics presented in the Tren Urbano Spatial Database (site plans, orthographic photos, and renderings) originated in the Graphics Department of the TUO.

3.3 Tren Urbano's Image Collection Process

As previously mentioned, the three groups involved in image collection, processing, archival and distribution for Tren Urbano are:

1. The Puerto Rico Highway and Transportation Authority (HTA)

2. The Community Relations Office in Rio Piedras (CRO)

3. The Community Relations group of the Tren Urbano Office (TUO)

The following diagram illustrates how these groups interact to generate spatial information about the Tren Urbano Project:

Figure 3-7 Spatial Information Collection Process for Tren Urbano
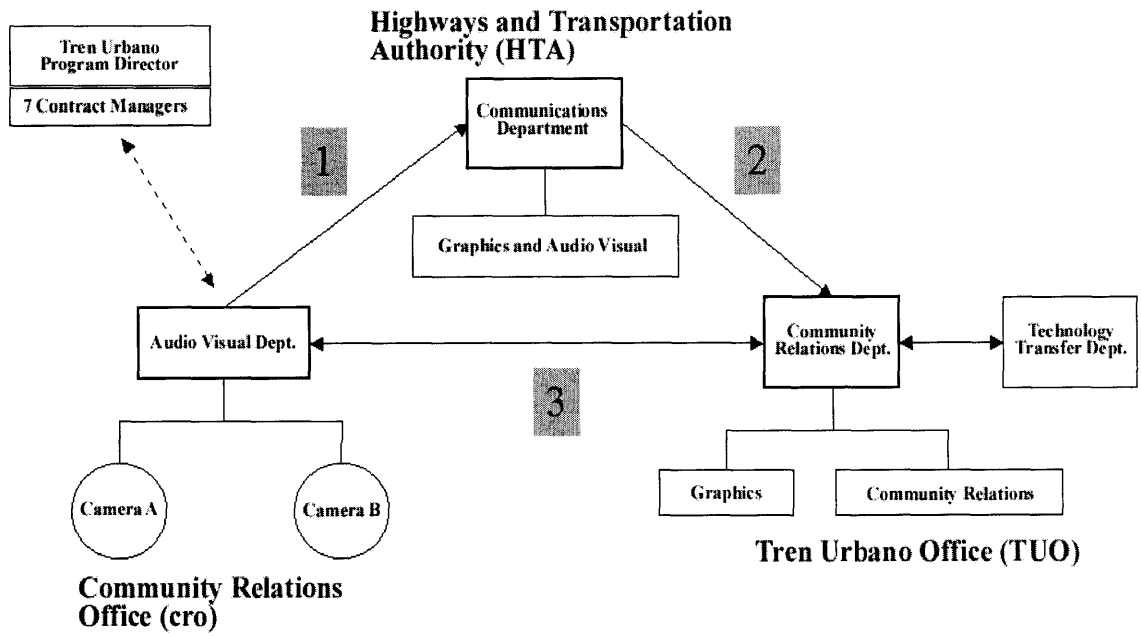
3.3.1 Step 1

Step 1 of the diagram (Fig. 3-7) illustrates the process through which spatial information (construction photographs, video) is sent from the Community Relations Office to the Highway and Transportation Authority on a formal monthly basis. The information is captured by two photographers from the HTA, along with personnel from the CRO, by videotaping the alignment from the air and later by walking through the stations and station segments. The photographs and video are then sent to the HTA for processing and approval, whereupon hardcopies are returned to the CRO for archival. The HTA keeps another set of hardcopies filed away in its Graphics and Audio-Visual Department, including all negatives, videos, and digitized material. The HTA is considered the owner of all spatial information collected in this manner.

In addition to this formal approach to gathering spatial information, the project director of the CRO will photograph the alignment independently of the HTA depending on what is happening in the field on any given day. She keeps herself informed of new developments in the field by speaking with the seven contract managers responsible for each of the alignment segments, or if the managers are unavailable to provide updates, she speaks with the field engineers or relies on word-of-mouth. For instance, she may be informed that the first structural segments are being poured at Las Lomas Station and will

rush over with a digital camera. This informal approach to gathering spatial information about the project is well suited to working with unpredictable construction schedules.

3.3.2 Step 2

Digital construction images and fly-over videos are sent to the Community Relations Manager of the TUO. The digital images are indexed electronically on a server called "Graphics" and are available to all departments at the TUO over a local area network (LAN). Efforts are made to periodically create backup tapes of the server and to transfer the images to CD-ROM. This is considered a safeguard in case the server goes down or there is a last minute request for a presentation using the images. Officials from both the HTA and the TUO rely on the Community Relations Department for creating written and graphical support documentation and presentation materials using these electronic images.

3.3.3 Step 3

Step 3 represents an informal dialog between the TUO and the CRO in which images are sent back and forth as needed for a particular project. It is often the case that images needed by the Community Relations Department for creating a presentation are not available in electronic form, and so the Community Relations Director will make a request of the CRO to see if the images are available as hard-copies. This is either accomplished with a phone call or a visit to the office.

But because the CRO is not connected to the local area network used to distribute images at the TUO, this method of image swapping must take place in person.

3.4 Sharing the Images - Spatial Database

The Community Relations Office and Tren Urbano Office both expressed a desire to have the images distributed over the World Wide Web. The Director of Community Relations at the TUO, when asked for her opinion on the future of the images, envisioned a web solution for distributing images to the public. She mentioned the shared philosophy of the Technology Transfer Program, that all material describing Tren Urbano's development be made available to the public. This opinion was shared at the CRO, whose facilitator offered to maintain the Spatial Database once it was ready to go on-line.

In this chapter: types of DBMS and applications; general institutional barriers; when to implement a database management system.

"Database management is the quick search and retrieval of needed information from a collection of data. At the most basic level, data management software provides automated tools for data entry, storage, and retrieval...the choices of how to organize and retrieve data involve a rich set of trade-offs that include questions of flexibility, ease of learning, and knowledge representation as well as speed, efficiency, and cost." (Ferreira, 1990)

4.1 Decision to Use a Database Management System (DBMS)

The description of a simple database management system presented by Ferreira (1990) acknowledges six (6) significant factors that influence one's decision to adopt such a system. First, there are questions of flexibility involved in choosing a systems architecture to operate the database. By 'systems architecture' I am referring to the combination of software and hardware required to operate the system as well as any programming or technical effort required to set up the system. In terms of flexibility, will the chosen software be compatible with existing files and for how long? Will the software and hardware package be robust enough to withstand obsolescence in a few short years, or if the organization for which the database is specifically designed decides to switch to a different operating system? Second, there is the problem of ease of learning. For example, a project manager is concerned that software needed to run a specific type of database might be too time-consuming and too difficult for her staff to learn; furthermore, she is concerned that adequate resources are not available to

invest in training. She is unlikely to consider a database management solution. Conversely, the same project manager implements the database management system, but it is used by only one person rather than by her entire staff. Is the solution a success? The problem with ease of learning is that it is closely related to "institutional barriers" within an organization which prevent new technologies from being adopted. In order for new technologies to be successfully adopted, or rather, "institutionalized" within an organization, it is vital that these barriers be addressed before rather than after the new technology is put in place. [Refer to Section *4.2 Institutional Barriers*] Fourth in the list is concern over speed. Will the system be fast enough to meet expectations of a robust and informative database management system? That depends on what the system is used for (types of data managed and frequency) and on the systems architecture. Fifth, there is the question of whether a database management solution can actually improve efficiency. How can improvements in efficiency be properly measured, will it require additional resources to do so, and how long must one be expected to wait before seeing improvements in efficiency. Lastly, there is cost. There are many different types of database packages available today, each with its own specialized applications, levels of expertise, and cost to an organization. Choosing the right one requires identifying the right kinds of applications in advance, as well as establishing a budget and key staff to help implement the project. A few of the more popular applications are listed below (Worboys, in part).

4.1.1 Different Types of DBMS and Applications

1. <u>A single-user small database</u>: Runs on a single platform, generally for private use; not networked.

2. <u>Corporate database</u>: Runs on different platforms; key issues are privacy, reliability, integrity of the data, performance, and networked access by multiple users in different departments within an organization.

3. <u>Office information system</u>: Useful for exchanging text-based information within an office environment; supports electronic publishing and multiple versions of existing documents in various formats.

4. <u>Engineering database, CAD database</u>: Uses complex queries and data structures to store and manipulate Computer-Aided Design models of 3D photo-realistic visual representations.

5. <u>Visual database</u>: uses a diagram-based visual query scheme to cross-reference and access visual data; each item in the database is indexed diagrammatically and hand-drawn query diagrams are matched against this index; in other cases the user arranges icons spatially to form queries of the database.

6. <u>Bibliographic database</u>: Mostly textual data useful for querying indexes by keyword, subject, author, etc.; non-graphical.

7. <u>Scientific database</u>: Complex data structures; highly specialized.

8. <u>Image and multimedia database</u>: Used to store a wide array of images, video, audio, and other media of various file formats and file sizes; subject of this thesis.

9. <u>Geographic Information System (GIS)</u>: A computer-based infor-

mation system that enables capture, modeling, manipulation, retrieval, analysis and presentation of geographically referenced data (Worboys, 1995). GIS is used to create digital maps, which are linked to tabular databases such as Census data for purposes of spatial analysis.

4.2 Institutional Barriers to Implementing a DBMS

Let us suppose you have decided on a database management system, one that is appropriate to the scope of your information management needs and that acknowledges Ferreira's six influencing factors in adopting such a system, how then do you implement it? The first step is to recognize "institutional barriers" within your organization preventing the immediate and successful adoption of new technology if such technology is not currently in place. An institutional barrier may be defined as any systematic belief existing within an institution, such as an agency or place of work, preventing the adoption of new ideas, such as new technologies, from becoming part of a structured and usually well-established system. The reasons why new technologies are most often subject to institutional barriers are: privacy, the perception of need, legal issues, policies and regulations, complexity, and flexibility.

1. Privacy: The main concerns over privacy are with the kinds of data that are being generated by the technology, the security of the data (who has access to it and in what manner – over a LAN, the Internet?), and the purposes for which the data are being collected and stored. Will that data be used to incriminate people, or lead to embarrassing situations in some unforeseeable way?

2. Perception of need: The extent of the perception of need for a new technology will greatly influence its implementation, and ultimately its success, within an organization. Perception of need is a formidable barrier if the technology is not accepted by its users prior to its being implemented, or if the technology is not championed by an individual or group of individuals prior to its being implemented. The perception of need can be a great advantage as well to implementing a new technology if its users perceive the need for the technology to solve an existing problem.

3. Legal issues: 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.

4. Policies and regulations: Organizational policies and regulations can be a significant barrier to adopting new technologies, as concerns may arise that the new technologies will (a) not really increase productivity within the organization; (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. It takes a strong perception of need for a new technology to be adopted in spite of existing policies and regulations that would ordinarily prevent its being adopted.

5. Complexity and sustainability: A system that is too complex for its users, one that poses too steep a learning curve, can be a significant barrier. Likewise, a complex system requiring additional hardware and software to operate can be a significant barrier. A complex system may not be sustainable within an organization if the funds needed to maintain it and the personnel required to manage it are not available (or available for a limited while). Another form of sustainability, when comparing paper-based storage to electronic storage, advocates for a database management system based on the fact that paper decays slowly and that it requires a lot of space. However, it is easily readable and familiar for most people. For these reasons, complexity and sustainability can be a plus or a minus when deciding to implement a database management system.

6. Flexibility: Once you decide on a particular systems architecture and framework for the database management system, you may be stuck with it even if a better system is discovered. Generally speaking, the more complex it is, the less likely it will be to easily adapt or replace outright.

4.3 When To Implement a Database Management System

Let us then suppose your organization has identified a database management system for storing and delivering a wide array of images, video, audio, and other media of various file formats and file sizes to users over the Internet (Type 8 in Section 4.1.2). When is such a system practical to implement? A decision to implement an image and multimedia database for a large-scale infrastructure project like Tren Urbano may come before, during, or at the end of the life cycle of the project. The following three scenarios will illustrate a few practical reasons for implementing a database-driven system during each of the project cycles.

1. Before the project begins: a database-driven system is thought to be necessary to connect organizational branches of the project that rely on up-to-date images to communicate effectively within the general organization and with the public. The project also involves participation by individuals and agencies who are dislocated by time and place and who rely on up-to-date images to perform their jobs. Furthermore, it is the philosophy of the project to make available to the public all images and multimedia about the project, and to keep that information up-to-date and as accurate a record of the project as possible.

2. During the project: a database-driven system is a good idea if and when a traditional filing system is already in place. A networked

database system is needed to solve existing problems that occur in the traditional filing system, such as lack of physical space needed to store images or loss of image integrity due to poor storage standards. It may be that the traditional filing system has grown redundant and has led to duplication of effort by different branches of the organization. Furthermore, the traditional filing system is costly to manage and employs more people than necessary.

3. After the project has ended: a database-driven system is suitable to creating a visual history of the project for purposes of educating the public or as a demonstration of technical innovations used during the project. There is no expressed need for image and multimedia management beyond the life of the project other than to provide these services.

The Spatial Database research project grew out of a combination of circumstances mentioned above. Its successful implementation will result from Tren Urbano's commitment to knowledge transfer, human capacity building, and strong community relations. Some of the typical institutional barriers, such as legal issues and questions regarding data privacy, are not applicable.

In this chapter: method-
ological approach and a
guided tour of the Spatial
Database.

5.1 Methodology

The methodological approach used to design the Spatial Database
arose from decisions made in its early development phase: (1) it must
be web-delivered as opposed to stand-alone, (2) it must be database-
driven and provide its facilitators at Tren Urbano with a simple
DBMS for handling dynamic multimedia content over the web, (3) it
must consider its audience. This third decision, while seeming obvi-
ous, is by far the most important (as well as the most difficult to pre-
dict). While not always the case, it is usually the audience for whom a
project is specifically designed that ultimately decides the success of
the project. The audience for this project was believed to consist
solely of the UPR/MIT Professional Development Program, the Tren
Urbano Office, and various 'transferring organizations' involved
with the Technology Transfer Program. It was not apparent at first (to
the author) the role that community relations plays in the need for
collecting and distributing images and multimedia about Tren
Urbano, nor the philosophy that all spatial information collected
about Tren Urbano be made available to the public.

5.1.1 Web-Delivered as Opposed to Stand-Alone

One of the primary goals of the Spatial Database research project begun in 1999 and ending in 2000 – the predecessor to this research effort – was to develop a web-based, multimedia system for delivering geographic information about Tren Urbano. According to its developer, Adrienn Jankovic (MCP '99), this approach would enable interactive exploration, inquiry, and creative application by its users. The ability to visualize information would allow for greater understanding of Tren Urbano's planning process and serve as an aid to organizing, analyzing, and communicating complex ideas governing the engineering and technical requirements needed to build the alignment. According to Michael Shiffer of the Department of Urban Studies and Planning at MIT, such a system might be used to encourage collaboration and group participation in decision-making processes. He has written that in order to do so, "we need to integrate visualization tools such as multimedia into a comprehensive on-line 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 a large amount of visual data in ways that are meaningful to the user, and ultimately, that serve the fundamental purpose of knowledge transfer and collaboration.

The original Spatial Database fell short of providing meaningful access to all of its users. Because it was unable to move from being a stand-alone system to being a web-delivered system, its users in Puerto Rico (on whom the success of the project depended) were unable to access its rich multimedia content. One solution proffered

was to distribute the project on CD-ROM to key persons at the TUO and to faculty members of the UPR/MIT Professional Development Program, but due to technical complications and time constraints the solution had to be abandoned.

In defence of the stand-alone approach, however, the system could easily be adapted for delivery using a portable computer, for instance, for use in face-to-face demonstrations in Puerto Rico or in conjunction with a projector and screen at MIT. This approach was used to great effect by Dr. Shiffer at MIT and later by myself in demonstrations about Tren Urbano to students in the Professional Development Program.

5.1.2 Visual Interpretation

Images and multimedia collected over the life of a project can be used to form a temporal structure with a fixed scale – a clear beginning and end – allowing for visual interpretation. From images we create a sense of place in the making, and are thus able to manipulate a place in time by freezing its duration at one particular view, or at one particular day, or at one particular phase of its development. Similarly, it is possible to undo or augment a sense of place by manipulating its duration in time. This may be accomplished by choosing to exclude some events entirely from interpretation, or to dwell at length over others. Depending upon the goals and preferences of the image controller, the number of ways a project can be interpreted is, like the number of ways in which matter occupies space, limitless.

Because of this potential for limitless interpretation, it is advisable to create a temporal structure of fixed scale and equal parts. This is to say that duration should be measured in continuity with calendar days or some other fixed measure of time across the entire project at once.

For a very large project spanning many years, it may be wise to collect visual imagery only every month, or every two months, to ensure adequate progress from month to month and to conserve energy and resources needed to collect, process and maintain the images. This can be complicated, indeed, as with the case of a major infrastructure project where lots of indirectly related events are happening at the same time and in different locations and at varying degrees of intensity. For instance, developments at Site A may be advancing at twice the speed of Site B, and valuable spatial information will be lost if one waits until the end of the month to collect it at Site A. In this case, it may be wise to alter the continuity with which images are collected at Site A while leaving the original continuity in place at Site B. Such a decision may be necessary from time to time and should not effect the overall interpretation of the duration of the project; rather, considerations should be made by the image controller to indicate speed of development at Site A in relation to speed of development at Site B.

The Spatial Database is designed to express these differences in duration by visual means; to see from one month to the next changes in the project as they occur. Spatial information is used to fill in the gaps

in our memory. It empowers us with visual knowledge. "Visual knowledge may be expressed through the filling in of the incomplete, the interpretation of the ambiguous, and the reassembling of 'memory images' which may be recognized in graphic images." (Oxman, 1995)

As for our visual interpretation of duration, we are faced with the paradox of two events occurring at the same time within the same fixed scale but presented at different intervals of time. It may be clear enough to say construction at Site A is progressing twice as fast as Site B, but how does one, years later, make the case when both the sites are completed? Again, it may be clear enough to say that construction at Site B took twice as long as Site A, but without adequate means to interpret this duration we are left with only vague assurances and a paper (or digital) trail of requisition invoices, signatures and important dates. Again, the Spatial Database is designed to express these differences in duration by visual means.

5.2 Accessing the Spatial Database

The Spatial Database is accessed over the World Wide Web (WWW) using a standard web browser and a connection to the Internet. A Web browser is a client program that uses the Hypertext Transfer Protocol (HTTP) to make requests of Web servers throughout the Internet on behalf of the browser user. The Spatial Database is configured for both Internet Explorer (Versions 3 and above) and Netscape Navigator (Versions 3 and above) but displays fine in other commercial browsers as well.

5.2.1 Home Page

The home page is the main page of a website, which serves as an index or table of contents to other pages stored at the site. It is the first page the users see when they enter the site.

5.2.2 Frames

The Spatial Database uses "frames" to divide the browser window into three sections. Frames are a feature supported by most modern web browsers, which allow the contents of each frame to display different web pages. Each frame contains links, or hypertext, to other pages and multimedia content stored at the site. The user navigates the Spatial Database by clicking on links and loading content into the frames.
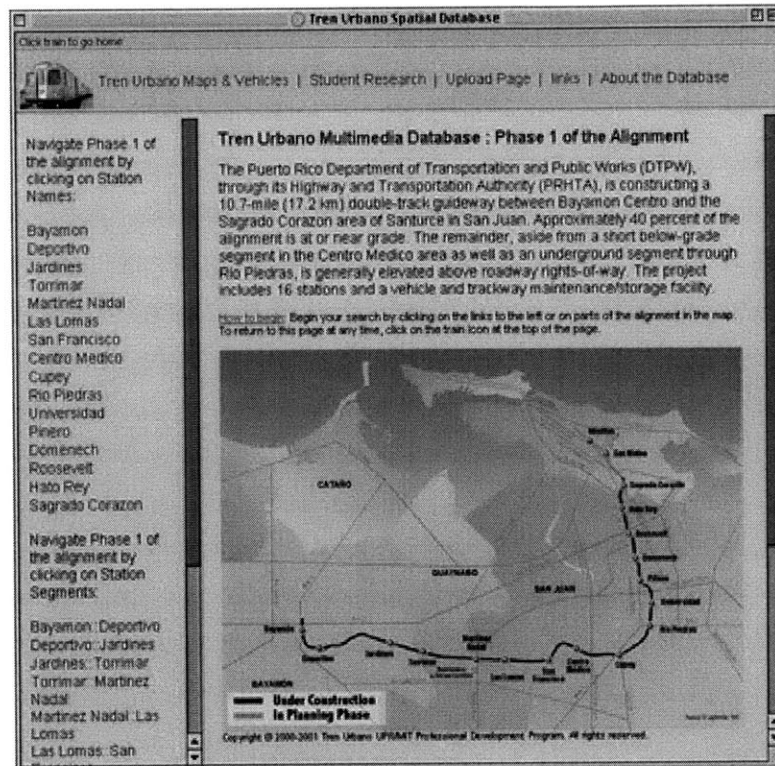
Figure 5-1 Spatial Database: Home Page

The middle and largest frame in the frameset briefly describes the Tren Urbano project and presents an interactive map of Phase 1 of the alignment. The alignment begins at Bayamón Station and extends through Sagrado Corazon Station – the last station of Phase 1 – into the proposed development of Phase 1A. Phase 1A is shown for reference purposes only and is not yet interactive. The user is able to click

on stations and station segments along Phase 1 of the alignment for spatial information. By clicking on the map, the user initiates a Lasso request for multimedia contained in the databases.

Another way to begin navigating the Spatial Database is by clicking on hyperlinks to stations and station segments in the left frame. As with the interactive map, these links will initiate a Lasso request for spatial information from the databases. The left frame of the home page is dynamically generated HTML based on Lasso commands to display all of the station names and station segments contained in the databases. If, for instance, another station name were added to the databases, it would be reflected on the homepage in the left frame. These links provide access to the same multimedia as displayed by clicking on the interactive map: the difference being the map provides visual access to the spatial information in the databases and the hyperlinks in the left frame provide textual or 'read' access. The user is free to choose either method of navigating that is most intuitive.

The top frame offers the third set of options for navigating the Spatial Database. This is a fixed frame and will not change its content as the user explores the database beyond the home page. The top frame provides access to maps and vehicle images, student research, links to other related websites, and technical information about the Spatial Database. In the upper left-hand corner of the top frame is a clickable image icon to be used for returning to the home page at any time.

5.2.3 Navigating the Spatial Database

An intuitive way to begin navigating the Spatial Database is by clicking on Bayamón Station – the first station of the alignment – using either the interactive map or the textual links in the left frame. This initiates a Lasso request to query the databases and load different media types for Bayamón Station in the left frame and display the site plan for Bayamón Station in the middle frame.
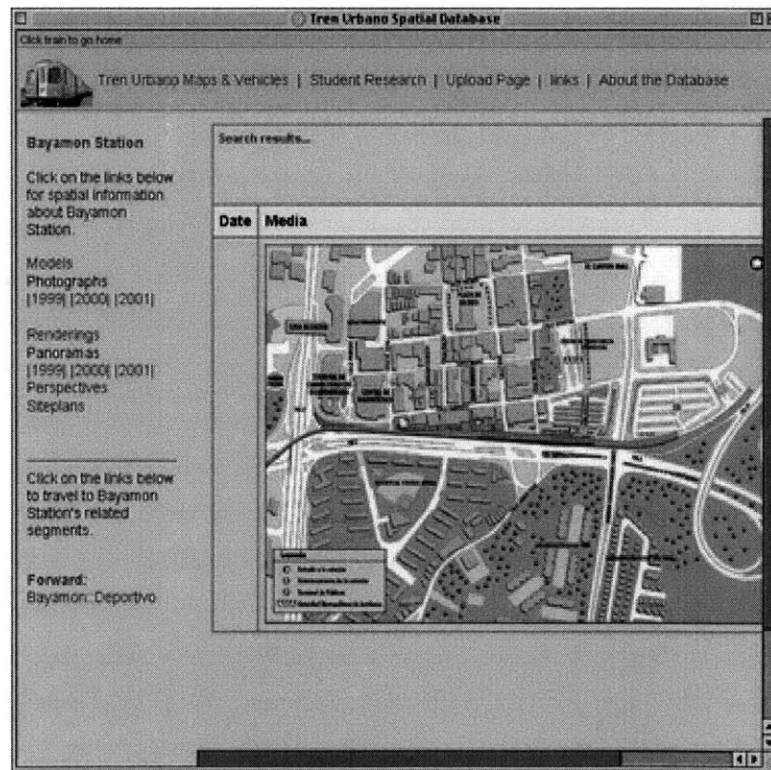

Figure 5-2 Spatial Database: Bayamón Station

The left frame now displays dynamically generated hyperlinks to all of the multimedia in the database for Bayamón Station. This includes 3D models, construction photographs arranged by year, architectural renderings, interactive panoramas also arranged by year, perspectives, and site plans. The site plan(s) loads into the middle frame automatically in order to provide the user with an informative visual starting point before accessing some of the other media types.

At the bottom of the left frame is a dynamically generated hyperlink to the station segment following Bayamón Station, in this case it is "Bayamón::Deportivo." This link represents linear (left to right, or West to East) travel along Phase 1 of the alignment, moving from station to station segment, until one reaches the end of the line at Sagrado Corazon. It is also possible to travel backwards along the alignment (right to left, or East to West) from any point in the alignment (except of course the starting point at Bayamón Station). In order to jump from station to station, or from one station to a station segment that does not directly follow or come in advance of that station, the user should return to the home page and use the image map or text links. The user returns to the home page by clicking on the image icon in the upper left portion of the top frame.

Information displayed in the middle frame is arranged in a table under column headings of Date, Media, Type, and Version (the last column should be considered a 'free' column and could be used for other applications of the database in the future). A date will appear

only for media types that are useful to sort by date, such as construction images that span the course of the project and panoramas that can be constructed from photographs from any given year. It may be interesting for the user to notice differences between the images from different years. For all other media types the Date column will appear blank. The Media column is used to display the various media types, while the Type column is used to affix the associated name of that media type contained in the databases.

At the top right of the middle frame is the phrase "Search results..." which indicates that the database has been successfully queried for spatial information. To the right of this is a display of the number of records found in the database for each query as well as the total number of records being displayed on the page at one time. The phrase "Displaying records 1 through 1" means there is only 1 such record in the database for this query. Other media types, such as construction images, will have many records in the database – more than is practical to display at one time. The middle frame will only display 10 such records at a time, however, giving the user the option to click a link for "Next 10 records," or however many records the case may be, at the bottom of the page.

The user is given the option to select other types of media to display in the middle frame, or travel to the station segment following Bayamón Station. If the user wishes to display other types of media, he may choose to start by clicking "Models" in the left frame. This

sends a Lasso command to the databases asking for all records of models associated with Bayamón Station. The results of this query are displayed in the middle frame as shown.
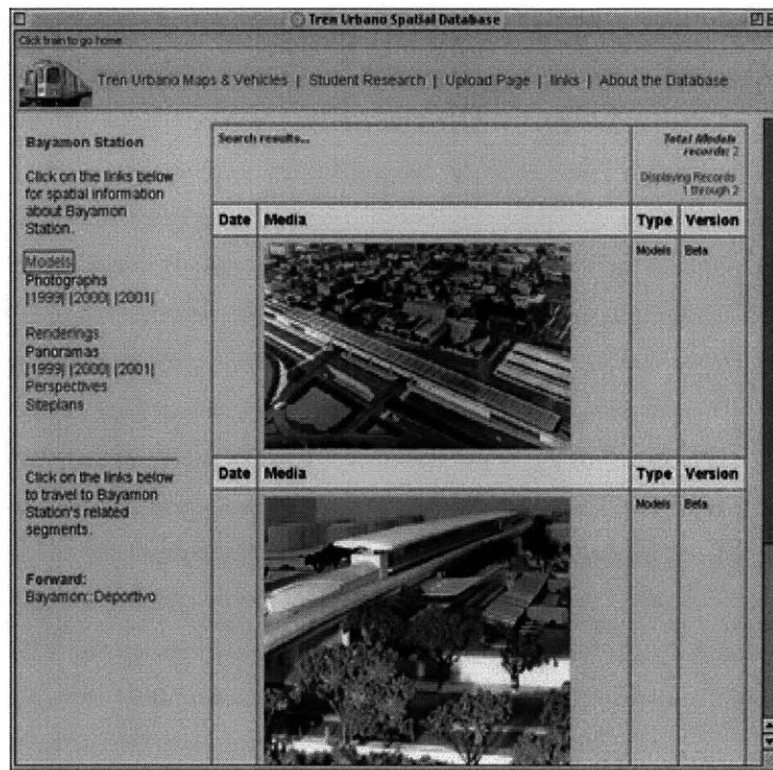
Figure 5-3 Spatial Database: 3D Models

For Bayamón Station there are only 2 records of models in the database. The left frame still shows the other media types for Bayamón Station, but the middle frame has been replaced to display the mod-

els. The text at the top of the middle frame confirms there are only 2 records of models in the database for this station, and that both records are displayed.

The user may then wish to explore the construction photographs for Bayamón Station from 1999. By clicking on the year 1999, a Lasso command is sent to the databases asking for all records of construction images for Bayamón station from 1999. The results of this query are displayed in the middle frame as shown.
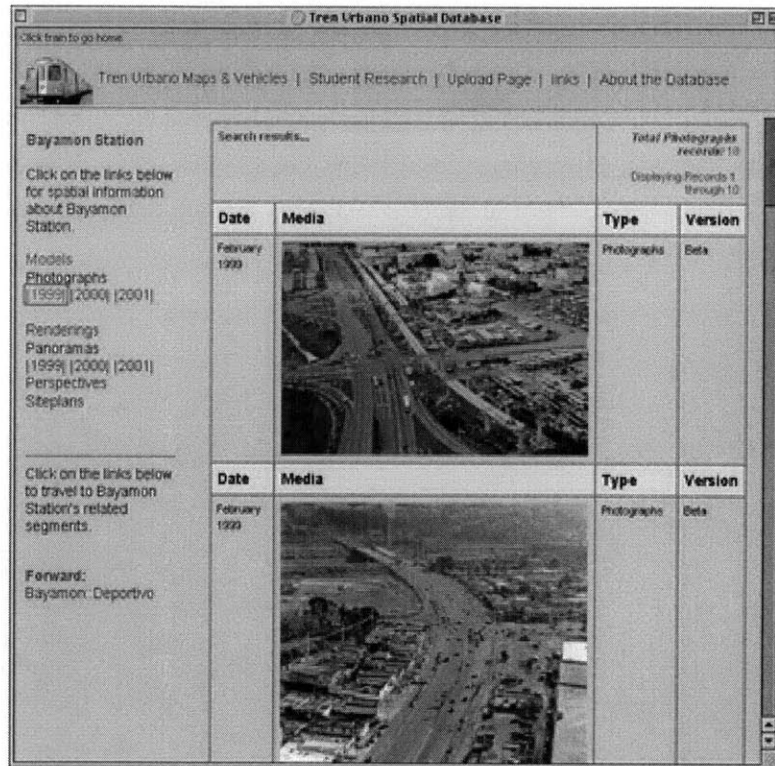
Figure 5-4 Spatial Database: Construction Photographs

Construction images are arranged on the page according to month, beginning with January and ending with December (earliest to latest). In this case there are no construction images for Bayamón Station from January 1999, meaning either the database is incomplete for this particular station and year (and should be updated by the database facilitator) or there simply are no construction images for this station

and month. According to the text at the top of the page, there are a total of 18 records of construction images for Bayamón Station from 1999. Since the page will display a maximum of 10 records, the user will view the remaining 8 records by clicking on the link at the bottom of the page.

Next, the user decides to display all renderings for Bayamón Station and clicks on the link in the left frame. The resulting text in the middle frame tells the user a successful search of the database occurred, ("Search results...") however, nothing is displayed. According to the page, the total number of renderings in the database for Bayamón Station is zero. The page is even polite enough to say it is displaying records "0 though 0!" While this may look like a mistake to the user, it is really an accurate display of the contents of the database. There are zero records of renderings for Bayamón Station in the database, and rather than return an error page as the result of the user's query, Lasso has generated the same page it would for records which are in the database — only this time without the media.

At this point the user may be ready to travel from Bayamón Station to the following station segment ("Bayamón::Deportivo") by clicking the link for it at the bottom of the left frame. The results of this action call fourth a new dynamically generated left frame with media types pertaining to travel as well as a new middle frame. The middle frame automatically loads a QuickTime navigational video showing air travel between the station of origin and the next station along the line. This is what is referred to as a station segment: the area between

two stations of the alignment. In addition to the navigational video in the middle frame, an ortho-photo showing the station segment is automatically loaded.
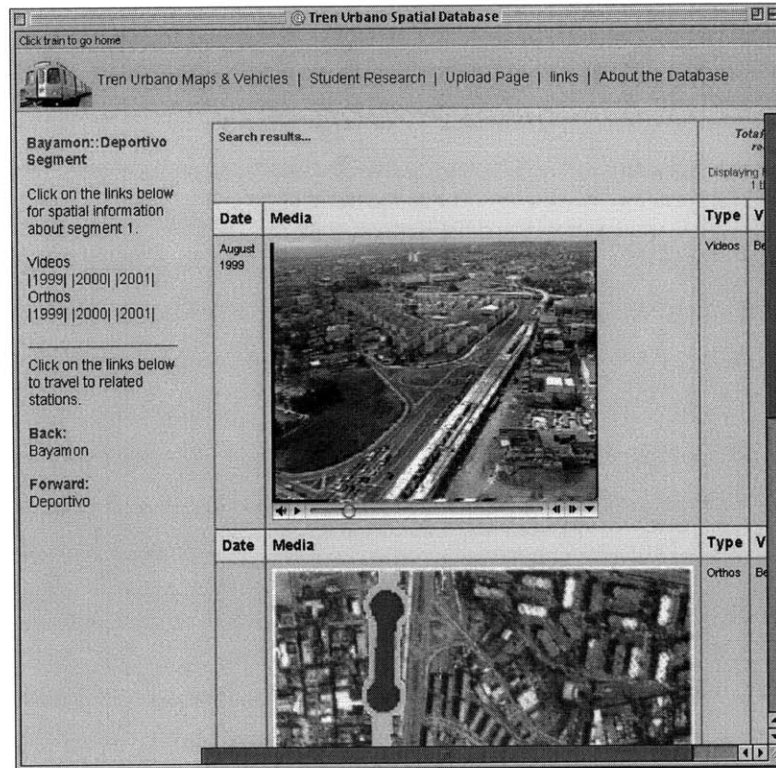

Figure 5-5 Spatial Database: Station Segment

The QuickTime navigational video may take some time to load depending on the user's connection speed to the Internet and the performance power (RAM) of his computer. A slow connection to the

Internet means the video will load slowly, and a fast connection
means the video will load relatively fast. In some cases the user may
be prompted to download the latest version of QuickTime in order to
play the video. If this happens, the software need only be down-
loaded once and installed to view all of the video media on the site.
Most of the videos should be viewable with Versions 3 and above of
QuickTime player. This software is available free over the Internet
and is easily downloaded.

The new left frame displays links to other video and ortho-photos
pertaining to the station segment. These are arranged according to
year. At the bottom of the frame are dynamically generated links
enabling the user to travel back to Bayamón Station (the station of ori-
gin) or forward to Deportivo Station. If the user chooses to travel for-
ward to Deportivo Station, a new left and middle frame will be
generated similar to the ones for Bayamón Station with links to rele-
vant multimedia and options to navigate back or forward again.

5.2.4 Student Research

Student research is contained in a separate database from the multi-
media but its navigation is similar to that of multimedia pages
described above. The user begins by clicking the link for "Student
Research" in the top frame. This link may be clicked at any time while
navigating the Spatial Database, even while perusing the multimedia
pages. What it does is load a new dynamically generated left frame
and a new middle frame. To return to browsing the stations and sta-

tion segments at this point, it would be necessary to return to the home page first by clicking on the image icon at the upper left of the top frame.
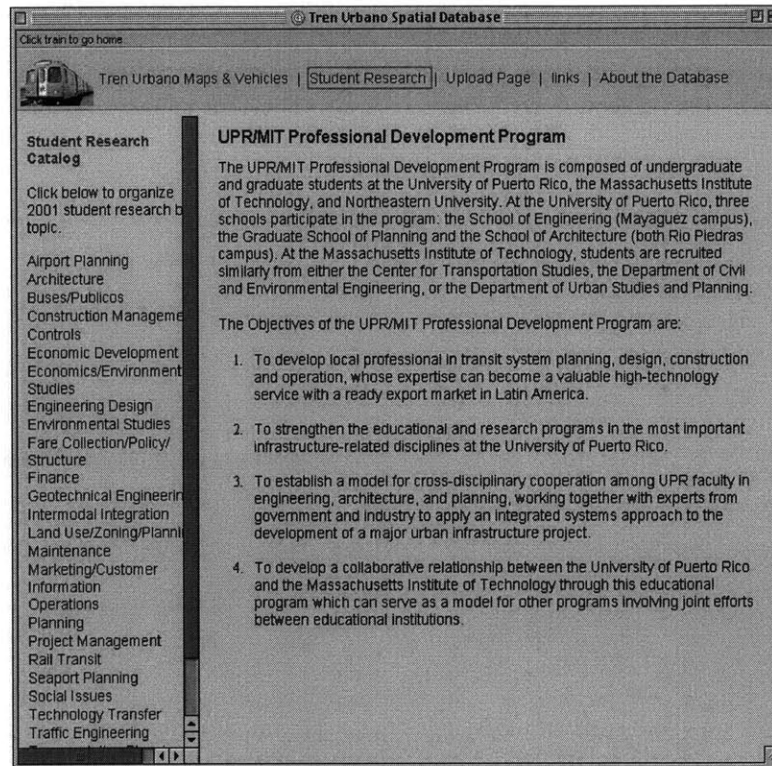
Figure 5-6 Spatial Database: Student Research Section

The left frame represents an accurate picture of all research topics contained in the research database on the server. The links are generated automatically using Lasso commands to query the database and

format the results into HTML. These formatted results are displayed in the left frame and contain hyperlinks to research records that exist in the database. Clicking on any of the topics will load a page with all associated records in the middle frame. The default page displayed in the middle frame – displayed only before the user selects a research topic to view – contains a short description of the UPR/MIT Professional Development Program and its goals. It is hoped that the user will read these goals for a better understanding of the importance of student research to the building of Tren Urbano, as well as the importance of making this research available on-line. To return to this default page at any time, simply click on the link for "Student Research" again in the top frame.

By clicking on the link for "Architecture" in the left frame, a Lasso command is issued that queries the research database for all records matching this topic. The results are displayed in the middle frame inside a formatted table as shown.

Figure 5-7 Spatial Database: Student Research Profile

Each research report is arranged in the table according to Title, Abstract, Author, Advisor, Relevant Phase(s), Relevant Station(s), and PDF. "Title" is the actual title of the student's research report; "Abstract" is a brief description of the student's research report; "Author" is the name of the student; "Advisor" is the name of the student's university advisor; "Relevant Phase(s)" tells which phase of

the alignment (there are six phases including Phase 1A) the student's research pertains to; "Relevant Station(s)" tells which stations the student's research pertains to (in most cases the research is relevant to all stations); and "PDF" provides a link to the student's research report only if a report exists in PDF format on the server for that student. If a PDF does not exist on the server for a particular student, the phrase "Not available" appears instead of a hyperlink.
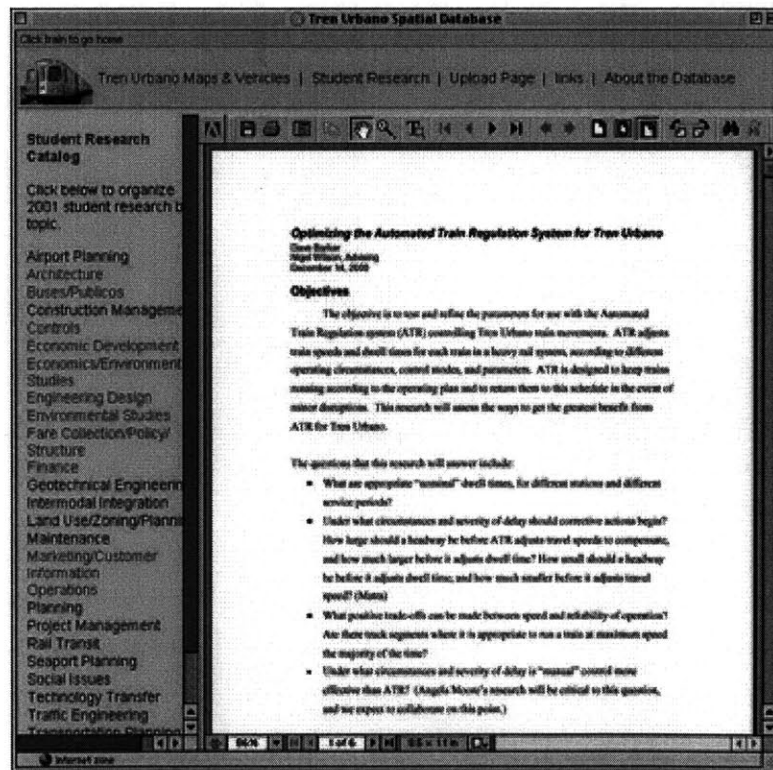

Figure 5-8 Spatial Database: Student Research Report (PDF)

5.3 Further Developments

Further developments for the Spatial Database are discussed in Chapter 6: Applications and Conclusions.

CHAPTER 6

APPLICATIONS AND CONCLUSIONS

In this chapter: address-
ing institutional barriers;
limitations of a database
management system; new
directions for the Spatial
Database.

This chapter explores applications for the Spatial Database designed to strengthen knowledge transfer and information exchange between Tren Urbano and the community; students at UPR and MIT in the Professional Development Program; and new employees and Tren Urbano contractors and consultants. These sum of these applications may be considered the framework for institutionalizing the Spatial Database within the Technology Transfer Program.

6.1 Students and Tren Urbano Contractors and Consultants

6.1.1 Training Sessions

The Siemens Transit Team (STT) is planning to prepare new employ- ees for work by providing two general types of training: (a) an intro- duction to the organization and (b) position-specific training. Under type (a), topics that will be covered include Tren Urbano's mission and history, the goals of the PRHTA, the institutional and legal frame- work of the Tren Urbano Project, and an overview of the transit sys- tem and its capabilities. Under type (b), position-specific training, a hands-on approach will be applied to each job category. It is believed that a combination of both types of training (organizational and posi- tion-specific) is needed to adequately familiarize new hires with the Tren Urbano Project and their own job responsibilities. All employees will be required to participate in training seminars regardless of prior work experience.

Training will be conducted in classrooms and at position-specific locations in the field. Classroom sessions will address organizational policies and procedures and be used to supplement knowledge acquired through field exercises, where appropriate. Sessions will incorporate a combination of visual media (slides, videos, printed materials, models, etc.) and direct demonstration using field equipment. Each session will cover a specific module, designed to gradually build employees' knowledge of complex subjects. Depending on the nature of the module (be it a lecture or an in-class assignment), trainees will be assigned to computers within the Siemens organization.

It is possible to use the Spatial Database to augment the visual media component of Siemens' classroom training sessions. For instance, students could be asked to access the Spatial Database from individual workstations in conjunction with lectures about Tren Urbano's mission and construction history. If there are not enough workstations for this, then the Spatial Database could be projected onto a wall using a digital projector and a single networked computer. In either case, the multimedia content of the Spatial Database can be used to facilitate the transfer and acquisition of knowledge during the training sessions.

6.2 Students in the Professional Development Program

The Professional Development Program seeks to develop a collaborative relationship between the University of Puerto Rico and MIT, as

well as to strengthen important educational and research programs in the most infrastructure-related disciplines at UPR. By providing distributed access to student research reports and up-to-date images and multimedia about the Tren Urbano Project, the Spatial Database will facilitate achieving these goals.

The Spatial Database is designed to reinforce the learning-by-doing acquisition of knowledge that students experience during the conferences in Boston and in Puerto Rico. It is believed that students will find it useful to access up-to-date images and multimedia during the academic year (as opposed to during the biannual conferences only) in order to monitor developments in the field. Access to these developments, as well as to the complete catalog of ongoing student research reports, will assist them in their own research projects and in forming collaborative relationships with other students. In this way the Spatial Database might help to establish a model for cross-disciplinary collaboration between UPR and MIT during the entire academic year [refer Chapter 2, Table 1], as opposed to relying on the conferences alone.

6.3 Community and Tren Urbano

The Spatial Database as designed is a flexible image-management system for connecting organizational branches of the Tren Urbano project that rely on up-to-date spatial information to communicate effectively both within the general organization and with community members. The system proposes to solve existing problems that occur

with traditional media filing systems, such as lack of physical space and limited accessibility by persons outside the organization. A database-driven, image-management approach to delivering spatial information over the Internet is suitable to creating a visual history of the project for purposes of community relations and for demonstrating technical innovations used during the construction of the project.

Suggestions for how to use the Spatial Database to relay spatial information about Tren Urbano to the community are as follows. *A dedicated server, at either the CRO or TUO, must be running Lasso's Web Data Engine to deliver the database-driven multimedia content over the Internet.*

1. As an Internet resource: incorporate the Spatial Database into existing Internet materials describing the Tren Urbano Project, such as the University of Puerto Rico's homepage for the Professional Development Program. Deliver the Spatial Database as an extension of the Community Relations Office in Rio Piedras.

2. Using a portable digital projector and laptop computer: project the Spatial Database onto a wall or screen during public meetings to illustrate developments with the project as they occur in the field. Digital projectors are often used in companies, schools, and public offices to deliver presentations to groups of people assembled in a conference room. Projectors can be used while the lights are still on - thus eliminating the inconvenience of needing to create a dark environment to see the text and images.

3. As a public information kiosk: an information kiosk provides Internet access to the Spatial Database via a remote computer located in a public space (the Community Relations Office in Rio Piedras). People visiting the Community Relations Office are able to sit down in front of the computer and browse spatial information on the Spatial Database via the WWW or from the com-

puter's hard drive. Requirements for a simple information kiosk are: a CPU with 500 Mhz or above processor; 128 Megs of RDRAM (memory) rated at 133Mhz or above, a SVGA 17" .28 dot pitch monitor; and an anti-vandal keyboard and mouse.

6.4 Addressing Institutional Barriers

Institutional barriers as defined in Section 4.1.3 of this thesis are systematic beliefs existing within an organization preventing the adoption of new technologies from becoming part of a structured and usually well-established system. The process of image collection and distribution currently in practice for Tren Urbano poses such a barrier if implementation of the Spatial Database fails to address concerns over privacy, perception of need, legal issues, and internal policies and regulations. Regarding the issue of privacy, all images and graphical representations generated for Tren Urbano through partnership with PRHTA and the CRO are approved for general release to the public. The Spatial Database contains only information that is considered public for the purposes of technology transfer and community relations, and this information is unlikely to incriminate or otherwise embarrass the Tren Urbano organization. Legal issues do not pose a barrier to adoption of the Spatial Database, as the information cannot be used to assign blame or responsibility to the organization. The perception of need for an improved system of information exchange, already determined by members of the Technology Transfer Program, will contribute to the adoption of the Spatial Database. A strong perception of need is a great advantage to implementing new technologies where the technologies are viewed as necessary to

solving an existing problem. Policies and regulations established for Tren Urbano, such that information about the project be made available to the community for purposes of technology transfer and community relations, make adoption of the Spatial Database possible.

6.5 Limitations of the Spatial Database

The Spatial Database is a work in progress and as such it is of limited scope and range of applications. This section addresses several of the key concerns over its design and functionality that may be considered for development in the future.

When designing the Spatial Database, little attention was paid to public review and feedback. Though it may not have been feasible to do so given the small amount of time in which to design the system, more attention should have been paid to soliciting feedback from potential users. Public participation in the design process is critical to designing a system that addresses the needs of its users. The alternative is to assume those needs, which may turn out to be other than expected. Now that the Spatial Database is operational, some time should be invested in public review using either an informal method of feedback or an organized focus/study group.

Designing the interface of the Spatial Database was one of the most challenging aspects of this project. For the most part, the needs of the users had to be assumed. The result was a system of navigation consisting of two modes – visual navigation using the image map and

textual navigation using the hyperlinks. It is yet unclear whether this decision was appropriate based on users' needs. In addition to concerns over the navigation system, it is unclear as to whether there is enough instruction at the site to guide the user through navigating the system. Certainly, not all users require the same level of instruction and so it may be worthwhile to redesign the interface to account for users' varying degree of familiarity with the web and with navigating a visual database.

6.6 Where to Go Next

One solution to the aforementioned is to allow the user to customize his/her experience using the Spatial Database based on his/her needs. The concept of 'adaptable portals' is one in which the user is able to customize the look and feel of a website (also called a portal) based on individual preferences. This may be accomplished by allowing the user the option to select from a list of preferences to adjust the level of instruction at the site. Though a bit more complex, it may be feasible to use 'intelligent agent' programming that anticipates a user's needs and finds ways to support him or her as they navigate through the system.

For example, while exploring the Spatial Database for information about Torrimar Station, a small menu window appears with links to additional resources about Torrimar and its surrounding neighborhoods. The system has anticipated the user's needs by interpreting

his/her patterns of behavior while navigating the system. The option of having these messages appear may be turned on or off depending on the user's preferences.

Regarding the student research component of the Spatial Database, it may be worthwhile to explore an 'upload' feature whereby students transfer their research PDFs to the database using a CGI script (Common Gateway Interface) or other program. This idea was explored during the early developmental stages of the Spatial Database, but was later abandoned due to anticipated complications in moving the system from a server at MIT to one in Puerto Rico. Students would also be given the option to create or revise their profiles in the student research section by completing and submitting a secure on-line form.

There are many interesting new directions for the Spatial Database. It is hoped that the facilitators of the Spatial Database in Puerto Rico continue to explore new materials to transfer, as well as new ways to transfer them.

*Appendix A provides a brief introduction to the software used to create the Spatial Database.*

Almost every major database vendor has a choice of software and configurations for delivering spatial information over the web. The decision to use the database software described in this chapter was based on its availability to the author at the time of designing the Spatial Database. This chapter is not meant to advocate for one particular brand of software over another, since there are many viable and compelling choices in the market to choose from, each with its own array of features and drawbacks. The most important considerations to the author when deciding on the appropriate software choices, were availability, ease of learning, and cost.

7.1 Lasso Web Data Engine

The Lasso Web Data Engine makes it possible to display multimedia files, such as QuickTime Movies, WAV sounds, JPEGs, GIFs and other image files stored in FileMaker Pro databases on a server. These files may be displayed over the World Wide Web using a standard Internet browser. Lasso is called a middleware program because it operates invisibly in between a standard web browser and a server and its databases. Lasso operates by interpreting commands sent through a web browser in order to retrieve information from the databases and complete the commands. The programming language that is used to issue the commands is called LDML (Lasso Dynamic Markup Language). LDML syntax is embedded inside standard HTML pages that are the bread and butter of the Internet.

For example, a person visiting a web page on the Internet clicks on a link for 'more information' about a topic. In doing so that person has issued a command to the server, one that is written in LDML. The server recognizes the command is written in LDML and passes it along to Lasso for interpretation. Lasso interprets the command and queries the FileMaker Pro databases for 'more information' and then formats the results into HTML. These results are passed back to the server, which recognizes them as HTML and thus is able to 'serve' them back to the user. [Refer to Fig. 7-1]

Figure 7-1 Web-Delivered Databases
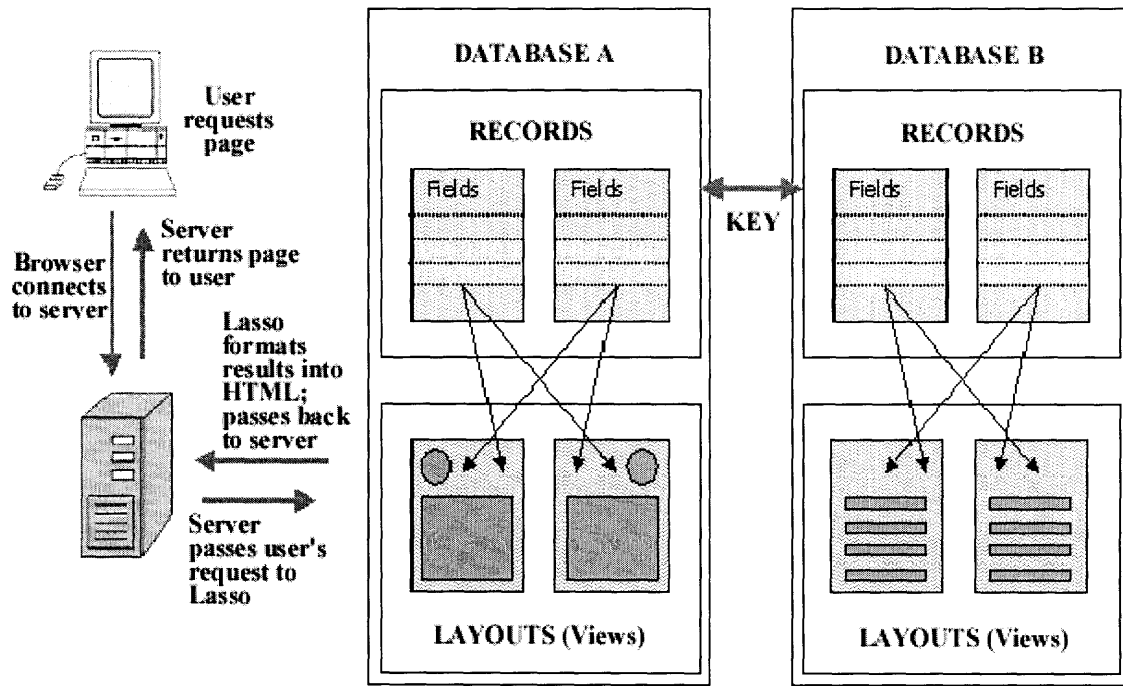
7.1.1 Advantages to Using Lasso

There are many advantages to moving from a stand-alone informa-
tion system in which users are dependent upon a particular comput-
ing platform and tied to one particular location, to a web-delivered
information system supporting multiple connections by multiple
users at once (Shiffer, 1995). By 'stand alone' information system I am
referring to an individual workstations or a group of computers on a
local area network (LAN) independent of the World Wide Web. The
advantages to creating a web-delivered information system with
Lasso, such as the Tren Urbano Spatial Database, are as follows:

1. The data are not 'hard-coded' into static HTML pages, which
    require frequent and time-consuming updates in order to be kept
    up-to-date. Rather, the data are linked to a robust back-end deliv-
    ery system (the Lasso Web Data Engine) that builds HTML pages
    on the fly based on what data currently reside in the databases on
    the server.

2. There are no new demands placed on the user of the system. The
    user is unaware of Lasso operating silently in the background to
    generate dynamic content. Interface with the system is through
    standard HTML pages.

3. Lasso easily handles programming logic and string calculations,
    allowing for complex queries of the databases and more useful
    results for the user.

4. Maintenance of the site is minimal compared with that of static
    HTML pages insofar as keeping the information fresh and up-to-
    date. The LDML programming language allows for a dynamic
    and changing environment based on what data currently reside
    in the databases on the server.

7.2 FileMaker Database

The Lasso Web Data Engine works in conjunction with web-enabled, ODBC-compliant FileMaker Pro databases on the server to deliver spatial information over the web. Open Database Connectivity (ODBC) is an open standard application programming interface (API) for accessing and communicating with databases. ODBC makes it possible for Lasso to access a FileMaker Pro database on a server by inserting a middle layer (called a database driver) between itself and the database. This layer translates Lasso's queries, which are written in LDML and passed through a browser to the server, into commands the FileMaker Pro DBMS can understand.

FileMaker Pro software allows for relatively easy design and mainte-nance of a database system using a graphical user interface (GUI) as opposed to a more complex database query language. The GUI envi-ronment offers many advantages to a non-technical user, such as an intuitive interface that will be familiar to most office employees, the ability to perform fast and easy searches of all records in the database, the ability to frequently add and update records to the database by one or many users, and the ability to analyze information directly on the screen and to print formatted reports directly from the screen. FileMaker Pro makes it possible for people with little or no training in database management or spatial analysis techniques to become highly skilled in managing vast stores of spatial information and familiar with analyzing this information in meaningful ways by rec-

ognizing visual features and trends amongst the spatial data. But because the spatial data used for these types of analysis are fixed – maps, images, etc. – rather than existing in 'digital form' as a coordinate system and linked to attribute tables (containing data such as parcel numbers, addresses, block numbers), what is traditionally thought of as spatial analysis is not feasible.
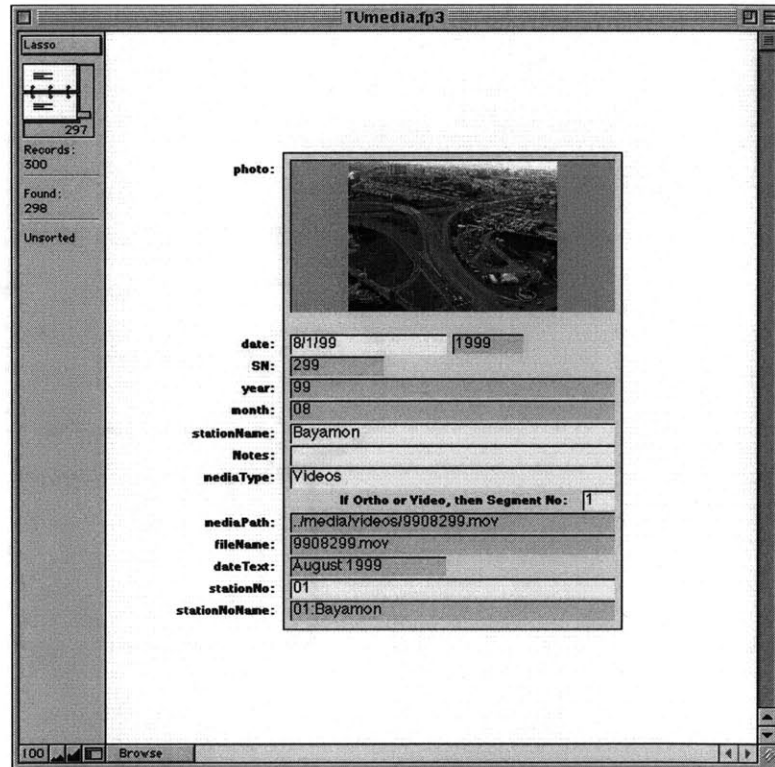

Figure 7-2 FileMaker Pro Graphical User Interface (GUI)

7.2.1 Components of a FileMaker Database

7.2.1.1 Types

A FileMaker Pro database consists of fields, records, and views (layouts) all of which are presented in a GUI environment. To create a new database file, one begins by defining the database fields and assigning them names, types, and options that will determine how the field interprets, enters, calculates, and displays information in the database. Fields may be added, renamed, or deleted from the database file at any time, and options can be removed or modified as well.

The following screenshot is from a FileMaker Pro database file called TUMedia.fp3 used to store images and multimedia for the Tren Urbano Spatial Database. It shows the 'Define Fields' window that was used to create the fields in the database.
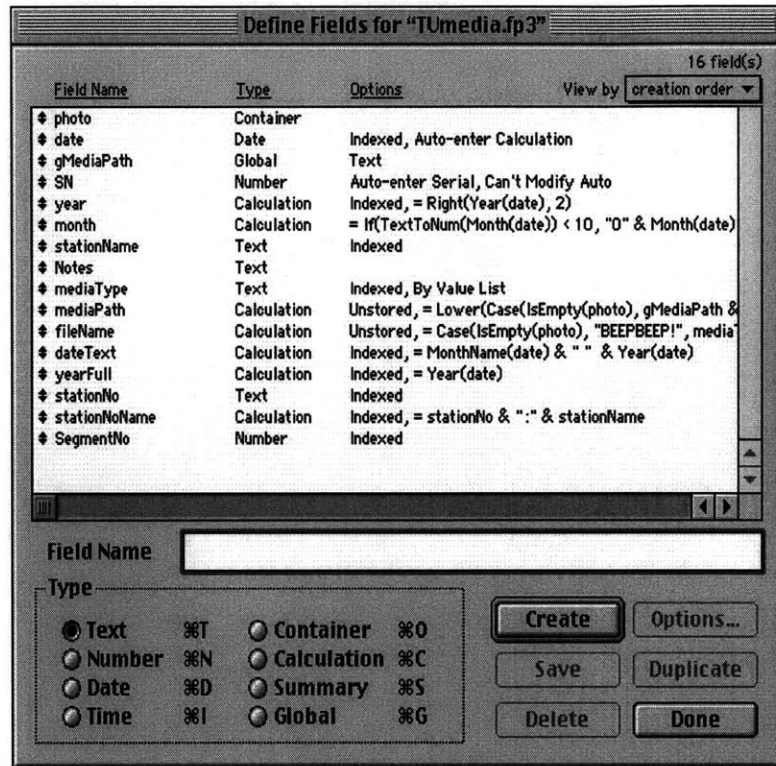
Figure 7-3 Defining Fields

Each field in the database was created first by entering a unique name for it in the 'Field Name' text-entry window, then by selecting a 'Type' and clicking on the 'Create' button. The 'Type' option is used by FileMaker Pro to interpret the data when sorting and performing calculations. It is also representative of the kinds of data that can be stored in fields. The various 'Types' of fields and their performances

are summarized below. While each field must be created manually by the user, certain fields once created can be set up to enter data automatically based on validation requirements or by selecting an 'Auto Enter' option. For instance, it is possible to create a Date Type field that automatically enters today's date in the database for each new record. This is what is referred to as an 'Auto Enter' field. A field that is assigned validation requirements will check the data entered by a user against requirements specified for that field. For instance, to prevent users from entering invalid data in a specified field, the option called "Strict: Do not allow user to override validation" will be selected. For more information about options when creating fields in a database, refer to Creating Options.

Text Type: used to sort records based on text entered into the field by the user or entered by default based on validation requirements or 'Auto Enter'. Also used in formulas for calculation and summary fields. Text fields are sorted alphabetically unless otherwise specified.

Number Type: used to sort records based on a number entered into the field by the user or entered by default based on validation requirements or 'Auto Enter'. Also used in formulas for calculation and summary fields. Number fields are sorted numerically (lowest to highest) unless specified otherwise.

Date Type: used to sort records based on a date entered into the field by the user or entered by default based on validation requirements or 'Auto Enter'. Also used in formulas for calculation and summary fields. Date fields are sorted chronologically (from earliest to latest) unless otherwise specified.

Time Type: used to sort records based on hours, minutes, or seconds entered into the field by the user or entered by default based on validation requirements or 'Auto Enter'.

Container Type: used to store graphics, sounds, or QuickTime movies such as navigation videos or panoramas. Also used in formulas for calculation and summary fields

Calculation Type: used to store the results of calculations specified by the user using field values from related records. The results of a calculation can be text, a number, time, or a container.

Summary Type: used to create a value by summarizing the values of other fields in the database.

Global Type: used to create a value to be used in all records of the database. This is a non-searchable field containing text, number, time, date, or container.

What is meant by "also used in formulas for calculation and sum-
mery fields," is that these fields can be included as parameters in cal-
culations used by other fields. For more explanation on this subject,
refer to Options below.

7.2.1.2 Options

'Options' are commands based on Boolean logic and mathematical
operators that are used to customize how fields in a FileMaker Pro
database interpret, enter, calculate, and display information. The use
of Options will determine the level of complexity of a database, as
measured by the number of calculations it is asked to perform. The
more calculations it is asked to perform, however, the less compli-
cated the database will be for the user as more of the information
required to create new records is calculated automatically.
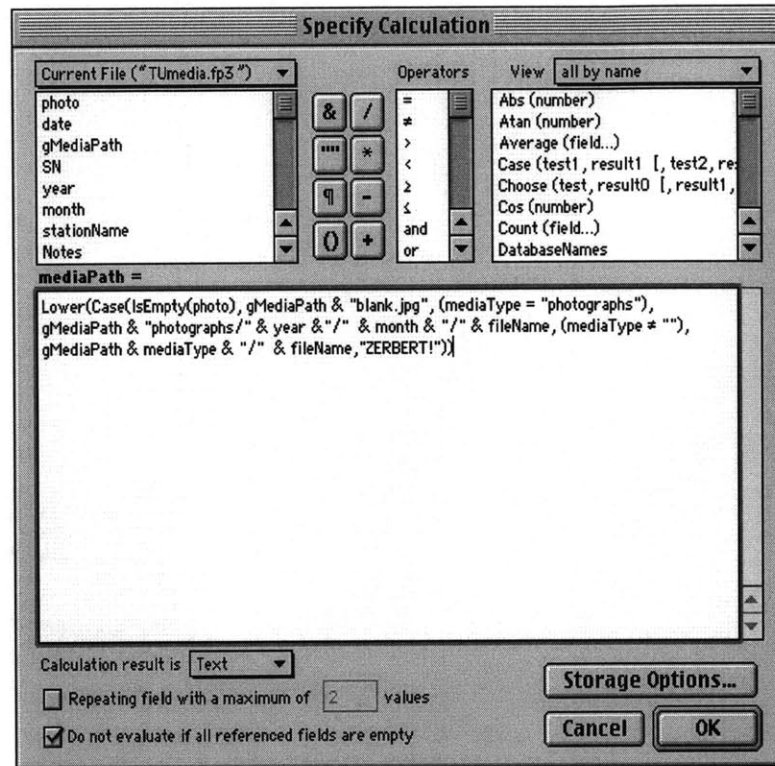
Figure 7-4 Defining Options

For this reason it is important to consider using Options as a way to both minimize demands on the user and to create meaningful relationships among otherwise isolated collections of data.

Appendix B introduces guidelines for updating and maintaining the Spatial Database.

8.1 Accounting for Phase 1A

Phase 1A is a 1.2 mile extension of the alignment northwest from Sagrado Corazon to Minillas in Santurce. It proposes two additional station stops to the current alignment: one in San Mateo and one in Minillas. Engineering studies and preliminary engineering are complete for Phase 1A and it is only a matter of time before construction begins.
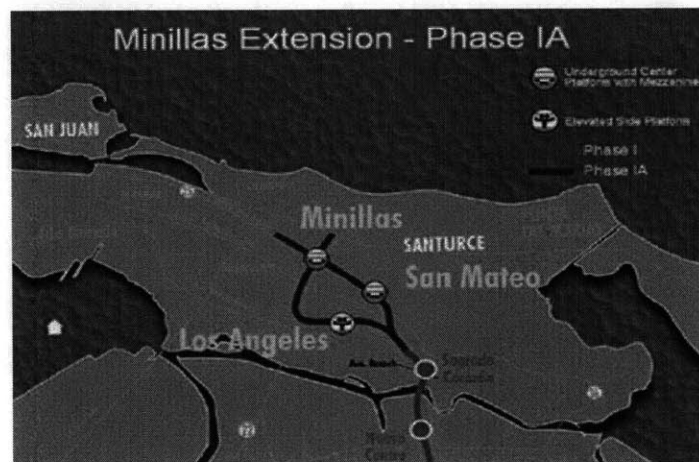
Figure 8-1 Phase 1A of the Tren Urbano Alignment

This chapter outlines the steps required to incorporate multimedia of Phase 1A into the Spatial Database.

8.2 Adding New Media to the Database

8.2.1 Quick Steps

The following is a list of quick steps for adding new media files to the FileMaker Pro database. You may choose to use this list as a refresher when updating the database. If you are unfamiliar with updating the database, refer to "Creating a new record in the database" below.

1. Open Tumedia.fp3
2. Select **Mode > Browse** from the dropdown menu
3. Select **Mode > New Record** from the dropdown menu
4. Select **File > Import/Export > Import Picture...** or **File > Import/ Export > Import Movie...** from the dropdown menu
5. Fill in the "date" field (optional, recommended)
6. Fill in the "stationName" field
7. Fill in the "Notes" field (optional)
8. Fill in the "mediaType" field
9. Fill in the "Segment No." field (for orthos and videos only)
10. Fill in the "stationNo" field

8.2.2 Creating a New Record

Open the FileMaker Pro database called TUmedia.fp3. If the database is not set to Browse Mode by default, choose **Mode > Browse** from the dropdown menu. Browse mode allows the user to enter and edit

data in the fields. (In addition to Browse Mode, use Layout mode to design how your information is displayed; use Find Mode to find records that match your search criteria; and use Preview Mode to display how your records will print.)

Next, select **Mode > New Record** from the dropdown menu. This creates a new blank record at the end of the database file.
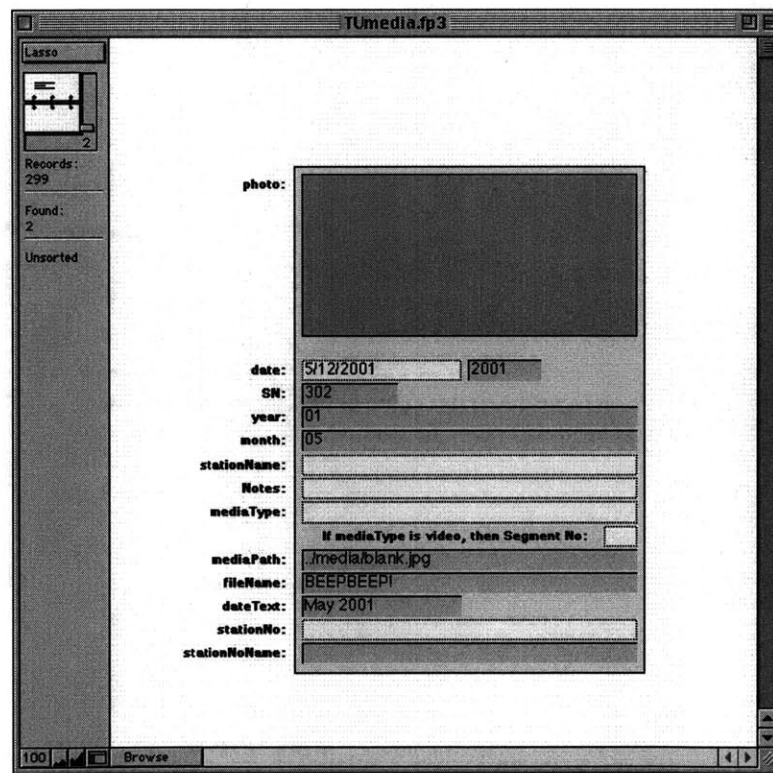

Figure 8-2 FileMaker: New Record

The blank record contains a gray photo window, as well as yellow fields and pink fields. The photo window is a "container field" used to store pictures, sounds, QuickTime movies, or OLE objects (Windows). These are called container data types. A FileMaker container field supports the following data types: Tag Image File Format (TIFF), Graphics Interchange Format (GIF) except transparent and animated GIF files, QuickTime Movies (.MOV), Joint Photographic Experts Group (JPEG), Mac OS PICT, MacPaint, and Encapsulated PostScript (EPSF). However, the Spatial Database is configured to display only JPEG and QuickTime movies. This means that your photographs should be saved first as JPEG before adding them to the database, and your QuickTime movies (including panoramas) should have the ".MOV" file extension before adding them to the database.

The yellow fields in the new record are where text can be entered, and the pink fields are where text is generated automatically. The pink fields are locked to prevent automatically generated text inside of them from being changed.

8.2.3 Import/Export

To insert new media into the blank record, click once on the photo window. This activates the window and alerts FileMaker that you will be adding new media to the database. Next, select **File > Import/ Export > Import Picture...** from the dropdown menu. This option will

not appear if you have not yet clicked on the photo window. If instead of a picture you are adding a QuickTime movie, select Import Movie...

A window will appear asking you to select a file to import. Locate the media file you wish to import and be sure to select the checkbox labeled "Store only as a reference to the file." This option will help reduce the size of the database by keeping track of the media file on your hard drive rather than actually importing the image into the database. But if you move or delete the file, FileMaker Pro won't be able to display it.

Click "Open" to complete the process.
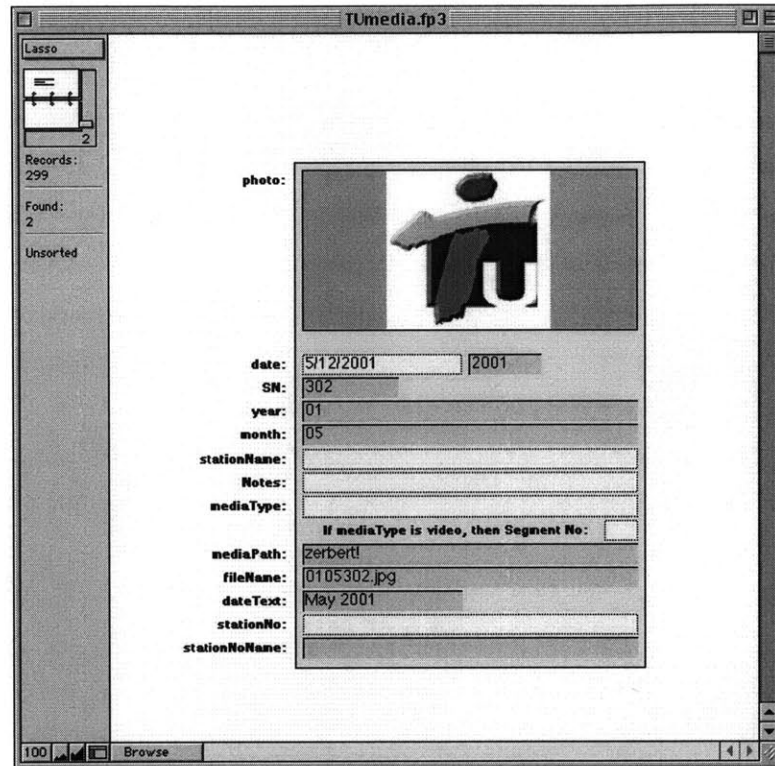
Figure 8-3 FileMaker: Importing New Media

The imported image is displayed in the photo window.

Today's date is entered automatically in the "Date" field. You may change this date by clearing the field and entering a new date. The correct date format is "mm/dd/yyyy." New media that is added to the database should reflect the correct month and year that it was cre-

ated, if that information is known. The Spatial Database relies on these "Month" and "Year" fields to sort and deliver user-requested information on-line. If you are unsure of the correct month and year of the media you are adding to the database, then leave today's date unchanged.

The date is also used to assign a filename to the media you are adding to the database. This is another reason why it is important to enter the correct date if known.

"SN" (Serial Number) is a unique identifier for each record in the database and cannot be modified. If the SN and Record number do not match, it is because records have been deleted from the database. This is not cause for alarm. Once a serial number is assigned to a record, it cannot be assigned again (hence, the unique identifier). SN and Record number do not need to match.

Once a date has been properly assigned in the "Date" field, the pink fields for "Year" and "Month" will be updated automatically.

8.2.4 StationName

A station name is used to identify where the media you are adding will appear on the Spatial Database. For instance, if you are adding media for Bayamón, then anyone who queries the Spatial Database on-line for information about Bayamón Station will be able to view it. The Lasso Web Data Engine makes good use of this field in perform-

ing calculations, so it is very important that a station name be properly identified. For instance, if you type a brand new station name into this field, it will be displayed automatically in the left frame of the Spatial Database.

Station names for Phase 1 of the alignment are as follows: Bayamón, Deportivo, Jardines, Torrimar, Martinez Nadal, Las Lomas, San Francisco, Centro Medico, Cupey, Rio Piedras, Universidad, Pinero, Domenech, Roosevelt, Hato Rey, Sagrado Corazon. They should be entered into the stationName field exactly as shown, without accents or punctuation (but with capitalization of the first word).

If you are adding a new station name, you should be consistent in your usage of that name. For instance, if you are adding spatial information for San Mateo Station (the first station of Phase 1A) to the database, you should use always use the same spelling.

After adding a station name to the record, part of the field called "stationNoName" (stationNo:stationName) will be updated automatically. The remainder of this field updates once the "stationNo" field is assigned. "stationNoName" is a read-only calculation field. Lasso uses this field to build the navigation logic for the Spatial Database.

8.2.5 Notes

The "Notes" field is to be used by the database facilitator(s) to add descriptive information about the media file, if it is needed. Descriptive information may include, but is not limited to, the name of the author of the media file, additional information about a location or time of day, or a note to one's self to add more media files of this type. The Spatial Database does not make use of the "Notes" field. Adding information to the "Notes" field is at the discretion of the database facilitator(s).

8.2.6 MediaType

The "mediaType" field is used to assign a descriptive 'type' to the media file you are adding to the database. Type, in this sense, refers either to the format of the media file (videos, panoramas) or the content of media file (models, photographs, renderings, perspectives, site plans, or orthos).

For instance, photographs of models would be assigned the 'Models' type based on content, while QuickTime movies would be assigned the 'Videos' type based on format. As a rule of thumb, it may help to consider all construction photographs as the 'Photographs' type, and all other photographs, those not showing construction, to be one of the other media types. Movies will always be the 'Videos' type.

Clicking inside the "mediaType" field will launch a pop-up menu containing a list of choices. It is only possible to choose one media type per media file added to the database.
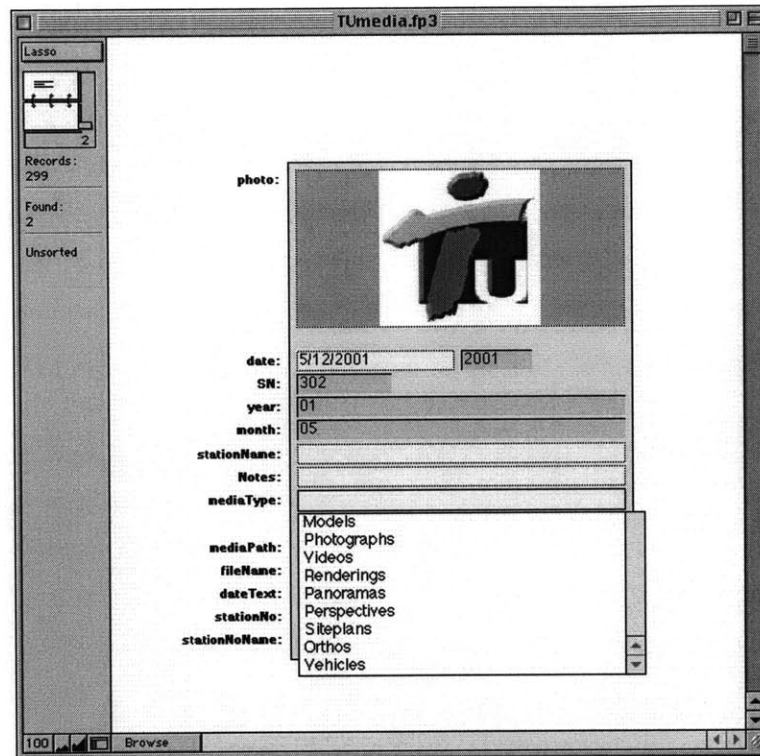
Figure 8-4 FileMaker: Various Media Types

Lasso uses the "Type" field to sort and display multimedia on the Spatial Database on-line. Requesting information about a station or station segment will query the database for the different types of media available.

8.2.7 If Ortho or Video, Then Segment No.

If you have added an ortho or video media type to the database, you will need to assign a Segment Number in the appropriate field. Segment Numbers for Phase 1 of the alignment are as follows:

Bayamón::Deportivo =1

Deportivo::Jardines = 2

Jardines::Torrimar = 3

Torrimar::Martinez Nadal = 4

Martinez Nadal::Las Lomas = 5

Las Lomas::San Francisco = 6

San Francisco::Centro Medico = 7

Centro Medico::Cupey = 8

Cupey::Rio Piedras = 9

Rio Piedras::Universidad = 10

Universidad::Pinero = 11

Pinero::Domenech = 12

Domenech::Roosevelt = 13

Roosevelt::Hato Rey = 14

Hato Rey::Sagrado Corazon = 15

Sagrado Corazon::San Mateo = 16 (does not yet exist)

If you are adding segment numbers for Phase 1A of the alignment, continue the numbering scheme as follows:

San Mateo::Minillas = 17 (does not yet exist)

Minillas:: = 18 (does not yet exist)

Segment numbers follow the alignment from left to right, beginning with "Bayamón::Deportivo" and ending with "Hato Rey::Sagrado Corazon." If the video you are adding shows movement from Bayamón Station to Deportivo Station, that is Segment No. 1. In other words, it is the first station segment of the alignment. Segments numbers are always assigned according to the station of origin. If, for instance, you are adding an ortho-photograph showing Rio Piedras below and Universidad above, the station of origin is Rio Piedras (Segment No. 10) because Rio Piedras comes before Universidad. Remember, this is based on linear, left-to-right travel along the alignment.

Lasso uses segment numbers to build the navigation logic for the Spatial Database. For more information about how Lasso uses segment numbers, refer to Chapter 4: Design and Implementation of a Simple Database Management Solution for Tren Urbano.

8.2.8 MediaPath

"MediaPath" is a calculation field that determines the directory structure in which new files are stored on the hard drive. It works by appending a global field to a calculated directory structure (based on "Type," "Year," and "Month" fields) and a file name ("fileName").

The global field contains values that are used to calculate all media paths in the database. The global field for Tumedia.fp3 is called "gMediaPath."

Example of calculated "mediaPath": ../media/photographs/01/04/0104303.jpg

In the above example, "../media/" is the value from "gMediaPath", "01" is the value from "Year", "04" is the value from "Month", and "0104303.jpg" is the calculated value from "fileName."

"mediaPath" operates by concatenating the fields and adding a directory slash '/' between them. This creates a genuine path to where the media should be stored on the hard drive. Once a new record has been added to the database, the associated media files should be renamed and inserted into the calculated directory structure on the hard drive.

8.2.9 FileName

"fileName" is a read-only calculation field. It calculates a file name automatically for new media files based on the "Year," "Month," and "SN." It is a unique identifier.

8.2.10 DateText

"dateText" is a read-only calculation field. It calculates the written date based on the "Date" field. Lasso uses the "Date" field to determine the order in which to display multimedia files on the Spatial Database.

8.2.11 StationNo

Station numbers follow the alignment from left to right, beginning with "Bayamón" and ending with "Sagrado Corazon."

Bayamón =1

Deportivo = 2

Jardines = 3

Torrimar = 4

Martinez Nadal = 5

Las Lomas = 6

San Francisco = 7

Centro Medico = 8

Cupey = 9

Rio Piedras = 10

Universidad = 11

Pinero = 12

Domenech = 13

Roosevelt = 14

Hato Rey = 15

Sagrado Corazon = 16 (does not yet exist)

If you are adding station numbers for Phase 1A of the alignment, continue the numbering scheme as follows:

San Mateo = 17 (does not yet exist)
Minillas = 18 (does not yet exist)

Lasso uses station numbers to build the navigation logic for the Spatial Database.

8.2.12 StationNoName

"stationNoName" (stationNo:stationName) is a read-only calculation field. Lasso uses station numbers to build the navigation logic for the Spatial Database.

8.2.13 Completed New Record

The following is a completed new record for a construction photograph of San Mateo Station (in this case a 'sample image'), taken April 11, 2001 apparently by Sylvia. From the record we can see where the image exists on the hard drive. To find it easily a simple search could be performed using the Find application on your computer.

Figure 8-5 FileMaker: Completed Media Record

8.3 Adding Records to the Student Research Database

8.3.1 Quick Steps

The following is a list of quick steps for adding student profiles to the FileMaker Pro database. You may choose to use this list as a refresher when updating the database. If you are unfamiliar with updating the database, refer to "Creating a new record in the research database" below.

1. Open TUresearch.fp3
2. Select **Mode > Browse** from the dropdown menu
3. Select **Mode > New Record** from the dropdown menu
4. Fill in the yellow fields

The following Quick Steps are for renaming and archiving students' PDFs.

1. Rename student's PDF to match the auto-generated text in the "pdfName" field (must match exactly).
2. Save student's PDF onto the Hard Drive referring to the auto-generated directory structure in the "Research Path" field.

8.3.2 Creating a New Record

Open the FileMaker Pro database called Tumedia.fp3. If the database is not set to browse mode by default, choose **Mode > Browse** from the dropdown menu. Browse mode allows the user to enter and edit data in the fields. (In addition to Browse Mode, Use Layout Mode to design how the information is displayed; use Find Mode to find records that match your search criteria; and use Preview Mode to display how your records will print.)

Next, select **Mode > New Record** from the dropdown menu. This creates a new blank record at the end of the database file.

Figure 8-6 FileMaker: New Student Research Record

The yellow fields in the new record are where text can be entered, and the pink fields are where text is generated automatically. The pink fields are locked to prevent automatically generated text inside of them from being changed.

8.3.3 Research Title

The "Research Title" field contains the title of the student's research report. If the student has not submitted a report to the TUO, then the working title of the student's report should appear in this field. Standard punctuation marks (including most special characters) are acceptable and will appear as written on the Lasso-delivered web page.

8.3.4 Research Summary

The "Research Summary" field contain a brief synopsis of the student's research report. The synopsis should be less than 300 words, if possible; longer entries will extend the Lasso-delivered web page unnecessarily. Students are usually asked to submit an abstract of their research along with their report, which may be 'cut and pasted' into the "Research Summary" field. Standard punctuation marks (including most special characters) are acceptable and will appear as written on the Lasso-delivered web page.

8.3.5 Research Topic

Clicking inside the "Research Topic" field will launch a pop-up menu containing a list of choices. It is only possible to choose one research topic per report added to the database.
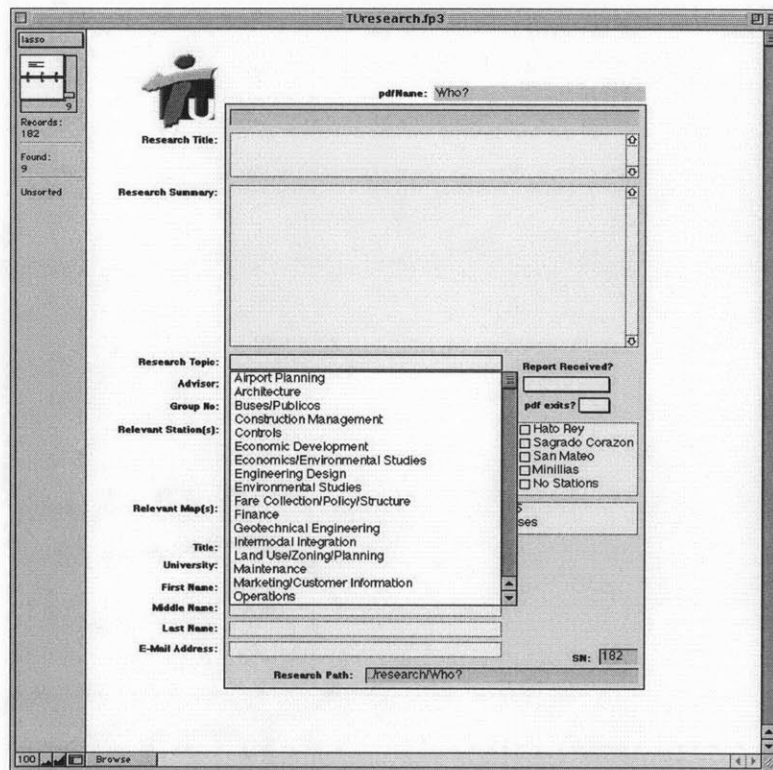
Figure 8-7 FileMaker: Various Research Topics

Lasso uses the "Research Topic" field to sort and display student research on the Spatial Database on-line. Requesting information about a topic will initiate a query of the database to display all research available about a particular topic.

8.3.6 Advisor

The "Advisor" field is an optional field. If a student's adviser is known, it should be entered and will appear on the Spatial Database on-line.

8.3.7 Group No.

The "Group No." field indicates the number assigned to each group of students in the UPR/MIT Professional Development Program on a yearly basis. The group number for year 2000-2001 student is 7. This means that Group 7 is the seventh group of students to participate in the Program. The "Group No." field is used to calculate the PDF name for each student's research report.

8.3.8 PDF Received? and PDF Exists?

The "Report Received?" field indicates whether the TUO has received a research report from the student. The "PDF Exists?" field indicates whether a PDF of the student's research report exists. NOTE: the "Research Path" and "pdfName" will be generated automatically even if a report for the student does not exist. Once a report for the

student is found, it should be named and saved to the Hard Drive according to the same criteria mentioned above. In which case, "Report Received?" and "PDF Exists" fields should both indicate 'Yes'.

Relevant Station(s)

The "Relevant Station(s)" field is designed to associate a student's research report with selected station names in the Spatial Database on-line. For instance, a request for spatial information on Bayamón Station queries the TUmedia.fp3 database for images and multimedia as well as the TUresearch.fp3 database for student research reports pertaining to Bayamón Station (for more information, see Relational Databases in this thesis). Both media and research appear in the left-panel of the Spatial Database. This feature is still in development at the time of writing this thesis.

If the title of a student's research report includes the name of a station, indicate that station by selecting the appropriate checkbox in the "Relevant Station(s)" field. If it is possible to discern from the research abstract that no stations are relevant to the topic, select "No Stations." If unsure, select "All Stations." Consider "All Stations" the default entry for this field.

8.3.9 Relevant Map(s)

The "Relevant Map(s)" field is reserved for subsequent phases of the
Tren Urbano alignment when it will be necessary to distinguish
between alignment phases (1-5) as indicated by maps on the Spatial
Database. As of the writing of this thesis, only Phase 1 of the align-
ment is under construction. Consider "All Phases" to be the default
entry for the "Relevant Map(s) field, unless otherwise indicated in the
student's research title or abstract.

Title and University

Clicking inside either the "Title" or "University" field will launch a
pop-up menu containing a list of choices. It is possible to choose only
one title or university affiliation per report added to the database.

8.3.10 First Name, Middle Name, Last Name

These fields contain the student's full name. The student's last name
is used in the calculation of a unique PDF name. In the case of a stu-
dent with two last names, only the second is used in the calculation.
The student's full name is calculated and displayed at the top of the
record in a locked field.

8.3.11 PdfName

"pdfName" is a calculation field that creates a unique identifier for
each student's research PDF saved on the Hard Drive. It is composed
of a Group Number, a Last Name, and a Serial Number associated

with a student's profile in the database. PDFs should be renamed to match this calculated file name. If a PDF is not renamed to match this file name, or if it is not renamed exactly as it appears in the "pdfName" field, then Lasso will be unable to retrieve the file on-line.

8.3.12 Research Path

"Research Path" is a calculation field that determines the directory structure in which research PDFs are stored on the Hard Drive. It works by appending a global field (called "gResearchPath") to a calculated PDF name.

Example of calculated "Research Path": ../research/ 7_Martinez17.pdf

In the above example, "../research/" is the value from "gResearch-Path" and "7_Martinez17.pdf" is the calculated file name from the "pdfName" field.

"Research Path" operates by concatenating the fields and adding a directory slash '/' between them. This creates a genuine path to where the PDF should be stored on the hard drive. Once a new record has been added to the database, the associated PDF should be renamed and inserted into the calculated directory structure on the Hard Drive.

8.3.13 Completed New Profile

The following is a completed new profile for a Group 7 undergraduate student from UPR.

Figure 8-8 FileMaker: Completed Student Research Record

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      dia Systems," *Environment and Planning B: Planning and
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      Moving From Stand-Alone Systems to the World Wide
      Web," *Environment and Planning B: Planning and Design*,
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      Support in City Planning Contexts," Draft, 1995.

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      Design of a Web Site: Targeting the Technology Transfer
      Audience," *Journal of Technology Transfer*, Vol. 22 (1): 19-
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      the Transfer of Technical Know-How," *Journal of Technol-
      ogy Transfer*, Vol. 23 (3): 51-57.

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      Taylor & Francis, 1995.