

A BIOCLIMATIC APPROACH TO THE INTEGRATED DESIGN OF TRAIN STATIONS AND THEIR SETTINGS

**M.I.T. - U.P.R. TREN URBANO RESEARCH PROGRAM
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OUTLINE

- Objective
- Motivation
- Methodology
- Bioclimatic Design
 - What? Why? How?
- Application/variations
- Next Steps

OBJECTIVE

- Identify bioclimatic design guidelines for San Juan
- Explore potential application to elevated train station integration
- Illustrate method for identifying guidelines
- Illustrate benefits/costs of application of bioclimatic design guidelines
- Recommend design guidelines for TU

MOTIVATION

- Integration (in all aspects) key to TU's success
- Energy mostly imported: Design practices ➡ not climate responsive. Energy for building maintenance not for train operation.
- Car use: little pedestrian activity/use of outdoor space ➡ lack of identity

METHODOLOGY

- Bioclimatic design literature review
- Application of process(es) to identify guidelines
- Illustrate application using one station (Hato Rey Nuevo Centro) as testing ground
- Identify possible site and microclimatic variations at other stations
- Recommend guidelines for Tren Urbano

BIOCLIMATIC DESIGN

What?

- Approach to design focus on effects of climate on buildings and outdoor spaces
- 'Scientific' ➡ not style prescriptive
- Applicable to urban and building scale
- Focus on study of wind, sun and materials
- Approximate ➡ not exact but an idealized symmetry with respect to noon and summer/winter

BIOCLIMATIC DESIGN

Why?

- Energy consumption/sustainability
- Economy/efficiency
- Comfort level
- Identity/responsiveness to place/climate

BIOCLIMATIC DESIGN

How? Steps

- Climate analysis
- Activity analysis
- Match conditions to activities and requirements
- Identify needs ➡ bioclimatic design strategies
- Translate strategies into design guidelines
- Inform decisions at all levels of the design process

BIOCLIMATIC DESIGN PROCESS

Climate analysis

- Data requirements (on a monthly basis):
 - Temperature (mean, maximum, minimum)
 - Relative humidity (mean)
 - Precipitation (mean)
 - Winds (direction and speed)

BIOCLIMATIC DESIGN PROCESS

- Analysis of activities at site:
- Which activities?
 - Present
 - 2001 - TU begins operations
- At what time of day? Which season?
- Comfort requirements for each
- Where? Station and immediate surroundings
 - Shelters, booths, signs, access/outdoor space, stands

BIOCLIMATIC DESIGN PROCESS

- Match requirements to conditions → identify strategies
 - Which months do not meet requirements?
 - How far from comfort?
 - Sun path and bioclimatic chart
- Strategies to adopt
 - Primary
 - Complementary

BIOCLIMATIC DESIGN PROCESS

- Translate strategies into guidelines
- Influence upon:
 - orientation
 - form
 - open space/vegetation
 - use of topography
 - relationship between buildings
 - openings: ventilation/illumination
 - materials

APPLICATION

- Illustrate use of guidelines
- Evaluate (hard to do numerically; will try)
 - Energy consumption - cooling degree days
 - Economy - cost of maintenance
 - Increases in pedestrian activity - changes in commercial activity (?)
- Study effects of each incremental use of guidelines.
Create scenarios

VARIATIONS

- Differences in site and/or microclimatic conditions
- Microclimatic conditions:
 - Vegetation, proximity to sea, winds, precipitation
- Site conditions:
 - Orientation:
 - Hato Rey: N-S
 - Bayamon - Rio Piedras: E-W
 - Elevated/at grade/underground
- Built environment/surroundings

NEXT STEPS

- Complete drawing guidelines
- Establish evaluation parameters and how to measure them
- Illustrate application at different levels of design decision process
- Define possible site/microclimatic variations
- Recommendations for different conditions

INTEGRATION OF ELEVATED TRANSIT STRUCTURES
AND DEVELOPMENT IN THE VICINITY OF STATIONS

RESEARCH PROGRESS REPORT- TREN URBANO RESEARCH PROGRAM

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JULY, 1997

M.I.T. - U.P.R. Tren Urbano Research Program
Research Progress Report, Francisco Ortiz
Master in City Planning Candidate

Introduction

This is the first report on the progress of my research on the integration of elevated transit structures into urban areas. I have been involved in the project for nearly 4 months of which the last month and a half was spent in San Juan working as an intern in the Urban Design Department of the Tren Urbano office. This experience proved crucial to a better understanding of the political environment and physical condition of San Juan.

In my research proposal I stated that my objective was to study strategies to integrate, from a design perspective, the elevated track and surrounding development resulting from the beginning of Tren Urbano's operations. I also proposed giving my research an emphasis on proposing strategies that would respond to the climate in which it was being built. I considered it necessary to choose a station that would serve as a testing ground for the concepts I would be using and decided Hato Rey Nuevo Centro suited my requirements for various reasons: high pressures for development due to its privileged location on the 'Milla de Oro', availability of large area of land where an encompassing proposal could be made without major disruption, type of activities present and potential, transit intermodalism potential (Acuaexpreso, Metrobus, AMA), relative importance of Hato Rey's successful integration to the system as a whole.

As a result my proposed methodology included three instances of analysis: characterization of San Juan's climate, inspection of Hato Rey Nuevo Centro and lastly

analysis of similar and comparable systems around the world from which I could draw success/failure lessons.

Progress

I have made progress mainly on the first two instances of analysis I mentioned: the climatic analysis and the site analysis. I consider however, that my work experience in San Juan coupled with my natural curiosity in learning about cities and their functioning (I am a Master in City Planning Candidate) proved a very valuable asset for my research. An offspring of my work experience were the ties I made with people working in the Tren Urbano which I hope will prove a valuable source of input for my research needs and information about Tren Urbano's progress.

Climatic Analysis

The climatic analysis involves analyzing the behavior of climatic factors and how they positively or negatively affect level of comfort perceived by people. This is related to my studies as an architect where I specialized in bioclimatic architecture. I have started a review of the literature on this area, which proved important to focus and refine concepts that I had in mind. Among them:

- Definition of comfort level: hard to define, very culturally and climatically biased. Also biased by age and gender. Victor Olgyay defines it as "the condition under which no feeling of discomfort occurs". Still broad and ambiguous.

- Ways/scales of measuring level of comfort: Standard Effective Temperature (SET) and other similar scales that try to predict human reaction to certain climatic conditions.

- Interaction of climatic factors and their relation to level of comfort: relative humidity, air movement, temperature.

- Other factors affecting level of comfort: type of activity, clothing, gender, age, climate of the area.

San Juan's climate is characterized as warm humid. Average yearly temperature is 79° F and average relative humidity is 80%. The sea plays an important role in providing east to northeastern winds that reduce the effects of high temperatures. Rainfall is very variable within short distances due to the mountain range that crosses Puerto Rico from west to east. Variations between a coastal monitoring station (Isla Verde International Airport, 55 inches) to an inland monitoring station (Rio Piedras, 75 inches) can be abrupt. For Hato Rey Nuevo Centro the best may be to interpolate between these two values, 65 inches. Hurricanes are a factor though recent activity has not produced major damage. It is a factor that will affect design.

Another important aspect of analysis is to look at the location of the site and its implications. San Juan is located at 18° N and 66° W. This implies proximity to the equator which in turn means low variation between the seasons. In effect San Juan has an average difference of 5° F between average summer and average winter temperature. This also implies a very vertical sun trajectory and little variation in length of day between summer and winter. Vertical sun trajectory will affect the design of buildings and their sun protection devices (*brises-soleil*, awnings, etc.). Figure 1 shows the theoretical trajectory of the sun for 12 different days of the year (one for every month, there are six lines because the seasons are assumed symmetrical) for any location at sea level and 18° N (or south since they are assumed symmetrical with respect to the equator). This chart allows me to locate the sun in three dimensions with respect to any point at any given time and day of the year.

I have made an extensive study of the representative angles of sun incidence at different times of the day in different seasons. This allowed me to plot the shade that would be cast by the elevated structure as it crosses the site and the opportunities or problems the structure creates for integration to the surrounding fabric.

Plotting the combined climatic factors in the bioclimatic chart (Fig. 2) for every month gives an idea of some of the bioclimatic strategies that can be applied to approach the comfort level. These are passive techniques which may or may not be enough to fully compensate effects of climatic factors. In future stages I will show how these strategies are translated into specific design guidelines.

Site Analysis

The site is a strategically located piece of vacant land that is under great pressure for development. This can be seen by the numerous plans that various actors have drafted for the site. It is located on the 'Milla de Oro', the financial district of San Juan, immediately in front of the underutilized Acuaexpreso ferry terminal. The area of the site is roughly 50,000 sq. mts. and includes the integration of a linear park that could be connected to a larger park and integrated to the station. Plans for the site include the location of a major stadium, a convention center, open land, a hotel, residential complexes.

The site is mainly used as a parking facility for surrounding institutions (Banco Popular). The train's right of way will divide the site into two areas. As of today the area is zoned public/future development acknowledging the pressures and value of the site. There is mention of extensive joint development. Existing uses of the area are typical of non-mixed use, 9 to 5 areas: office space, some services and retail. There is very little pedestrian activity and a large proportion of the employees get in their car to have lunch at the nearby Plaza de las Americas.

There is a clear lack of adaptation of the buildings to the climate in which they are situated. Buildings are self-contained, air conditioned prisms with little attention to street fronts and use of outdoor spaces. Vegetation is scarce (only Av. Munoz de Rivera has a pattern of trees in a boulevard style which does very little to promote walking), and the distribution of the volumes is not favorable to take advantage of the breezes.

The site's surroundings are clearly divided by Av. Ponce de Leon. To the east is a traditional grid neighborhood of modest income and mixed uses. It includes the neighborhoods of *Las Monjas* and the *Las Gladiolas* public housing project along with a school and other local services. The inhabitants rely, to some extent, on public transportation. Street life is more intensive than in the western side of Av. Ponce de Leon. The population is approximately 4400.

To the west of Av. Ponce de Leon is a growing upper-income area. A slum was cleared (barriada Tokyo) and construction of walk-up units is well under way with some units already inhabited. This is a non-mixed use area with little street life and community interaction. Most (if not all) residents own cars. The residents are mostly employed in professional and technical jobs. The population is approximately 2500. Figure 3 is a plan of the site.

Case Studies

I have made little progress in analyzing similar systems. I have given considerable thought to a critical issue for the case studies to be of any use to my research: what to look for and how to format the information so that valid comparisons can be made and conclusions drawn. I consider the use of comparative tables a useful tool to summarize data and will try to format the data so it can be presented in this way.

The information I will be looking for are the policies these systems have adopted in promoting any kind of development in the surroundings of the stations and the results

these policies have produced. As one aspect I am interested in is climatic adaptation, I will also see how apart from system-wide policies, the design decisions affect integration and therefore attractiveness leading to increased ridership.

Upon recommendation of students and faculty, I have narrowed the list of systems to Medellin, Miami and Atlanta. These I consider will be of use both for good and bad (judging from differing opinions expressed by people who have used them) due to:

- Relatively recent examples, where data may be more available
- Extensive portions of the systems are elevated
- Miami and Atlanta had similar car-oriented environments comparable to San Juan's existing condition.

This is preliminary and I hope to gain more input on this subject. I imagine it will also be guided by availability of data as I have seen occur in many research projects where access to information is very hard.

Next Steps

I plan to focus on the case studies in the immediate future. I had hoped, as was suggested, to do them simultaneously with the other instances but the visit to San Juan provided a good opportunity to center on understanding the system, the political and social environment.

I will continue with both analyses (site and climate), deepening the implications of the climatic data and their relation to design decisions. The interaction of these analyses with input from the case studies I hope will direct my research so that I can come up with an inventory of various strategies to help integrate stations and development in to their environment.

One of the most important aspects of my visit to San Juan was to realize the extent to which Tren Urbano's success will rely on non-technical or operating factors that must be taken into account in the design phase. I refer to the perception of insecurity, the degree of auto reliance and need to market very effectively. It has shaped my research in that I will place emphasis in overcoming these obstacles.

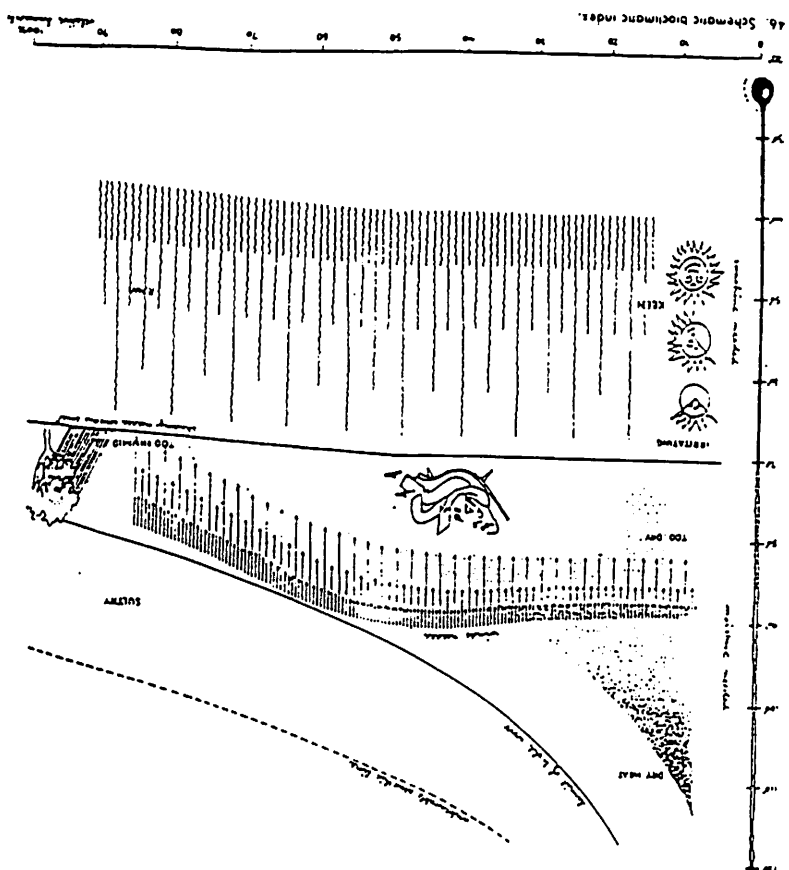


Figure 1. Solar trajectory for 18° N Latitude

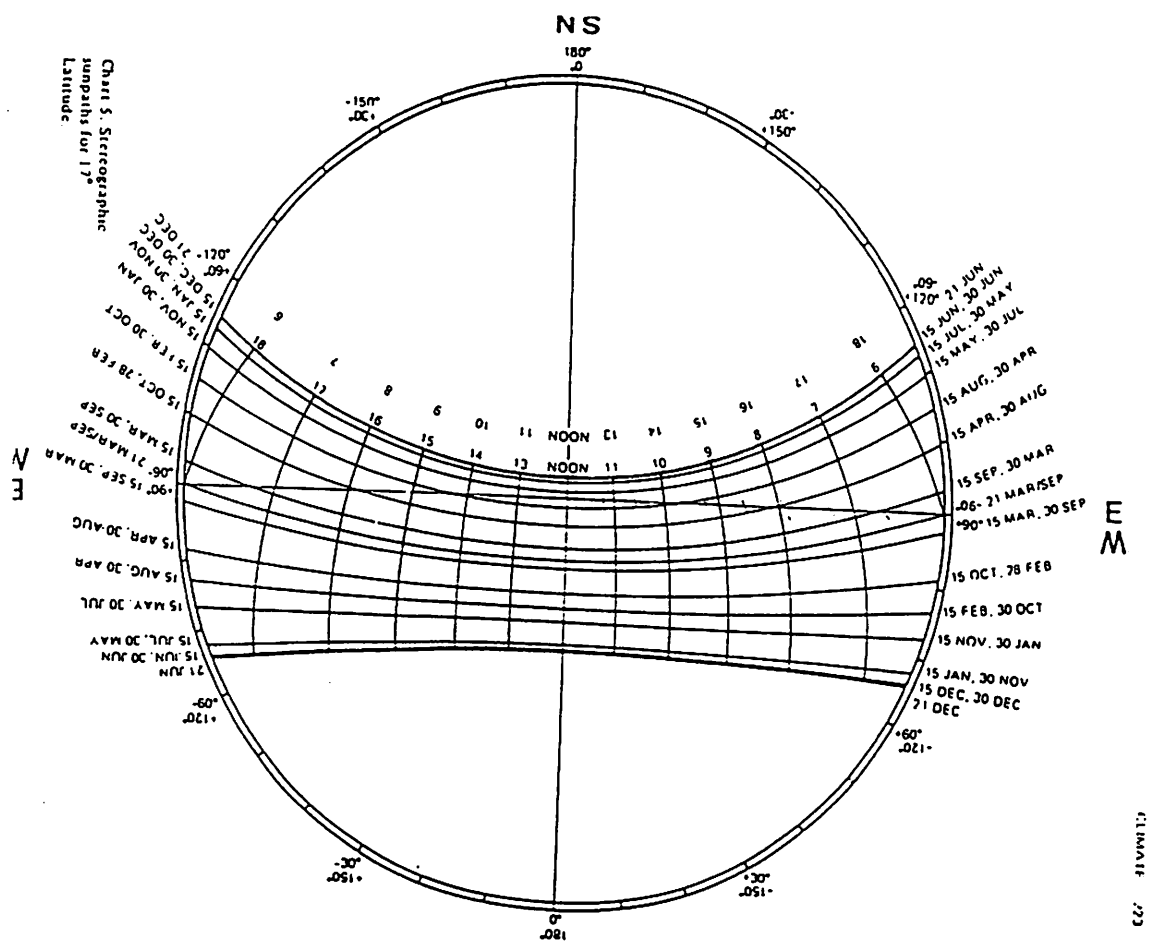
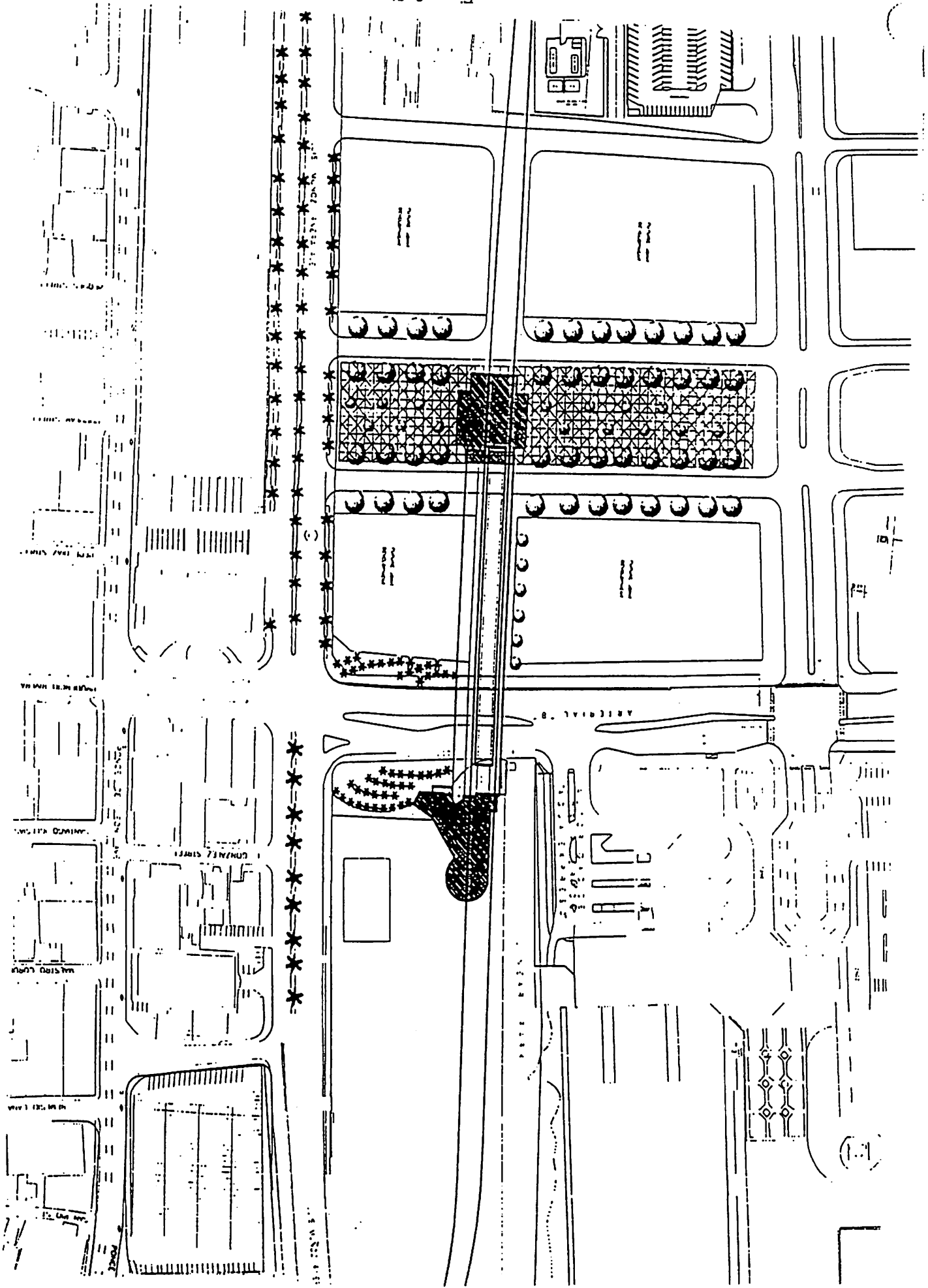


Figure 3. Site Plan Hato Rey Nuevo Centro with Tren Urbano alignment



**RESEARCH PROPOSAL - TREN URBANO RESEARCH PROGRAM
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RESEARCH OBJECTIVE

The objective of this research is to investigate strategies to promote the physical integration of elevated transit structures and stations into their immediate surroundings. These strategies will include both land use implications as well as design considerations. Integration covers a broad spectrum of issues (information, fare, mode, schedules, physical, etc.) and my research will center on strategies to intensify the use of areas around the stations and maximize Tren Urbano's potential ridership and economic benefits. Though my goal is to produce guidelines and recommendations applicable to any type of urban fabric¹ I will center on the Hato Rey Nuevo Centro station surroundings as a testing ground. It is also my goal to merge my knowledge of climate responsive design into these guidelines.

MOTIVATION

Tren Urbano provides an excellent opportunity to transform the travel and growth patterns of the inhabitants of San Juan. At present this city of approximately 1.4 million inhabitants relies mostly on private automobiles. Public transportation is very deficient relying mostly on an extensive market driven informal jitney system, an underutilized ferry system and an inefficient bus system. This has brought about heavy congestion, decreased quality of air and promoted the creation of auto-oriented environments.

The need to create environments that will minimize the use of automobiles is essential for the patronage of transit. The reliance of Tren Urbano on non-service design considerations has been the subject of much research and integration in its various forms has been amongst the most studied. Physical integration has received some attention and I will draw on theses prepared by previous students involved in the program².

Mechanisms to obtain these desired environments and have been tested elsewhere, such as density bonuses, joint development, air-right leases, zoning changes, parking restrictions/pricing will be central in my research. The degree to which design can be specified, enforced or used as a development tool are also key issues in my research. Improving pedestrian access and intermodal integration will also be goals in my research.

Recent literature³ suggests proximity to transit-oriented developments, where mixed uses, higher densities and pedestrian friendly environments coexist, increases value of adjacent

¹Using the station area development classification that Jeffrey Sriver identified in his 1995 C. Eng. Thesis

²Among them: Jeffrey Sriver, C. Eng. 1995, Susannah Kerr, MCP 1996.

³Robert Cervero and Michael Bernick, *Transit Villages in the 21st. Century*, 1997.

property and have become increasingly in demand as the conditions in San Juan, to some degree, are common in many major American cities.

Diversity, density and design are essential ingredients I will be using throughout my research. Alone none of these three can accomplish the task of creating environments that will induce use of the system. Often comprehensive planning fails for lack of attention to the physical appearance of the built environment⁴. However these three are not enough if, as suggested in these studies, other market distortions (low car/fuel taxes and prices, bank lending /developers' resistance, Federal Housing tax regulation, generalized free parking, etc.) are not addressed. I will not center on these issues but will mention their importance within the overall commitment to reverting transportation and housing patterns in San Juan. Changes in future design and relative location of buildings, land uses and density in an intensively used area like Nuevo Centro could produce substantial economic and environmental benefits apart from increasing ridership of Tren Urbano.

BACKGROUND

Site and climatic conditions - Hato Rey Nuevo Centro

Hato Rey Nuevo Centro is the result of a major planning effort in the 1960 and 1970's. As a result the Nuevo Centro Plan, an ambitious plan to transform the area in to the major mixed-use and financial center of San Juan, was created. The area has undergone considerable changes since the beginning of the century and the removal of a squatter settlement (*barriada* Tokio) and the rehabilitation of the Martin Peña Canal has permitted the area to become the core financial and business district in San Juan. However, much of what the plan called for has yet to become reality.

The area included in the plan is roughly 7.000.000 sq. ft., comprising a 1800 ft. perimeter around the proposed transit station. The area is divided from north to south by two major avenues. Between these two avenues is what is known as the Golden Mile where most of the commercial development has occurred. To the east of the Golden Mile is a pre-modern densely populated grid of small lots. To the west there are numerous vacant parcels, some institutional buildings and some recently built mid-to-upper income residential buildings. These two distinct areas have a combined population of 7.584 inhabitants (1994).

Regulations

Zoning. The zoning of the area is a controversial issue. The Plan called for mixed uses, with a concentration of commercial areas along The Golden Mile with different levels of density. At present this has been implemented and is where most of the development has occurred. Other uses include residential (north of Arteria B), commercial (between Arteria B and a planned open space), recreation/open space and institutional/commercial

⁴ Philip Herr, 1994

(south of the planned open space and west of Av. Muñoz Rivera). The major vacant parcel now used as a parking lot is zoned future use/public and is where the train station will be located. This has been the subject of various plans calling for very different uses.

Land uses. The predominant use is the road network (31% of land)⁵. Other major uses are parking space (17%), residential (18%), institutional (13%), commercial (10%) and vacant (10%). The percentage of area devoted to parking excludes areas within buildings.

Ownership. The major vacant area is owned by Banco Popular and used as a parking lot. Other owners include the Puerto Rico Lottery offices, School of Music, Acuaexpreso (Port Authority), private banks (Popular, Chase Manhattan) and some private residential developments. Beyond the parking lot owned by Banco Popular there are large portions of government-owned land set aside for the Nuevo Centro plan.

Climate

There is a clear lack of consideration of the climate in the design of the buildings. Buildings are self-contained, air conditioned prisms with little attention to street fronts and use of outdoor spaces. Vegetation is scarce (only Av. Muñoz de Rivera has a pattern of trees in a boulevard style which does very little to promote walking), and the distribution of the volumes is not favorable to take advantage of the east/south-east breezes that can be used to mitigate high temperatures. The road network, which is the major land use, along with cement parking lots also contribute to worsen climatic conditions in the area. On street commercial and retail activity is minimal which, coupled with little shading, makes an unfriendly pedestrian environment.

Among the favorable features of the area are (other than the future station):

- the linear park beginning immediately adjacent to the ferry terminal and connected one of San Juan's major park.
- a relatively good bus service since it is in the main corridor between Old San Juan and Rio Piedras, where the main bus line operated by Metrobus runs.
- existence of vacant land that makes development possible without major demolition costs. This could also be viewed as an obstacle due to dependence of the area on this facility.
- some efforts have been undertaken to provide vegetation and shading. Could serve as examples.
- concentration of mixed and intensive though non-integrated uses.

⁵Tren Urbano Hato Rey Nuevo Centro Station Manual, Tren Urbano Office, 1994.

RESEARCH METHODOLOGY

My research methodology consists of four steps.

1. Site and climate analysis of Nuevo Centro and surroundings: To get a clear understanding of existing forces affecting the site. Issues of land use, zoning, ownership, social and economic characteristics of the population. The climatic conditions of the site will be analyzed using methods previously learned to evaluate the level of responsiveness of existing structures and create guidelines for future structures.

2. Create a framework for evaluating and analyzing case studies: A set of criteria for evaluating the case studies I will conduct must be established. This will determine what I will look for as I conduct the case studies in order to avoid deviation from the subject of interest. My intent is to make, in a table format, cross-comparisons between different systems' actions with respect to integration and their results. The initial aspects of the systems I will look at are: zoning regulations and changes, land-use changes, densities allowed before/after construction, mechanisms used to implement changes, design specifications and degree of requirement, institutional arrangement and any additional tools that have been implemented (or not) around transit stations.

3. Conducting case studies of similar transit systems: I tried to select systems that would be of use for the case of San Juan. Given that the case of San Juan seems to contradict the norm that income level is directly proportional to car ownership⁶ I will not limit the case studies to cities with similar incomes. I have also made sure these systems have elevated structures. My preliminary list of systems is: Caracas, Mexico, Los Angeles, San Francisco, San Diego, Washington DC, Atlanta, Medellin, Miami.

I plan to narrow this list as I either realize information is not easily available or comparisons will not be of much use. Moreover, I must be very careful since the information I will search is not quantitative and the information may not be clearly accessible or stated. Some judgment will be necessary in evaluating the commitment of a system to integration. One of my prime interests is to show the do-nothing scenario to stress the importance of this issue to Tren Urbano's overall success.

4. Recommendations for San Juan's Tren Urbano using Hato Rey Nuevo Centro as a testing ground. Based on the case studies and my understanding of the site and its regulatory condition, I will draw conclusions that will be of use initially for the case of Hato Rey Nuevo Centro Station. However my intention is to also provide criteria for application in other transit stations both in San Juan and in other future transit stations.

⁶Puerto Rico has an average income below that of any state in the US but its car ownership rate is disproportionately high.

RESEARCH TIME PLAN

June 1997 - July 1997

Site and climate analysis. Literature review/background research

September 1997 - November 1997

Creation of framework for case studies. Classification of variables. Design the evaluation criteria. Continue background research/literature review. Initiate case studies: detect data availability and comparison value. Determine the cases.

November 1997 - January 1998

Draft report on case studies. Refine criteria as case studies provide additional information/exceptions.

January 1998 - March 1998

Investigate application to San Juan and Hato Rey Nuevo Centro Station. Second draft of case studies.

March 1998 - May 1998

Apply research to Tren Urbano's Hato Rey Nuevo Centro Station. Final draft on case studies and recommendations.

PRELIMINARY BIBLIOGRAPHY

- Tren Urbano Office, *Manual for Hato Rey Nuevo Centro Station*, 1994.
- Cervero Robert and Bernick Michael. *Transit Villages in the 21st. Century*. McGraw Hill, 1997.
- Fruin, John. *Pedestrian Planning and design*. Edmund J. Cantilli, 1971.
- Calthorpe, Peter. *The Next American Metropolis*. Princeton Architectural Press, 1993.
- Hoel, Lester A. *Criteria for Evaluating Alternative Transit Station Designs*. USDOT, 1976.
- Sriver, Jeffrey. *Factors Influencing Land Development Around Rail Transit Stations*. Civil Engineering Thesis, 1995.
- Kerr, Susannah. *Pedestrian Access in Puerto Rico*. MCP Thesis 1996.
- U.S. Census, 1990.
- Southworth, Michael. *Walkable Suburbs: An Evaluation of Neotraditional Communities at the Urban Edge*. Journal of the American Planning Association, Vol. 63, No. 21.
- Garreau, Joel. *Edge City: Life on the New Frontier*. New York: Doubleday, 1991.
- Kunstler, James. *The Geography of Nowhere: The Rise and Decline of America's Man-Made Landscape*. New York: Simon & Schuster, 1993.
- Olgyay, Victor. *Climate and Building*. 1964
- Working Papers # 548, 581, 606, 611, 621, 622, 624, 688, Institute of Urban and Regional Development, University of California at Berkeley.
- Climate of U.S. Cities
- Philip Herr, *New England Towns*