► **COVER STORY TRANSIT** *(1/17/2000)*

Twisting and Turning through San Juan

Tren Urbano brings transportation expertise to island and relief to its congested capital

By Aileen Cho in San Juan

Waiting in the nonstop crush of traffic that marks the streets of the Puerto Rican capital of San Juan, motorists along one 17.2-kilometer stretch can see a column rising in the air alongside an office building in the city's Hato Rey section, or the shell of a future station forming in Martinez Nadal, or bridge segments rolling along a traveling truss in Bayamon. The tunnels, tracks and stations of the Tren Urbano mass transit system hold a promise of less congestion for this independent-spirited U.S. territory and also a growing local experience in transportation construction for the next generation.

Seven contracts worth a total of $1.24 billion are in full swing for the first phase of Tren Urbano, Puerto Rico's first-ever turnkey design-build project. Those contracts, the bulk of a total $1.7-billion effort, were awarded in 1997 by the commonwealth's Dept. of Transportation and Public Works' Highway and Transportation Authority (DTPW). Since then, the complicated project has faced hurricanes and a steep learning curve for local firms teaming up with outsiders on the first major transit job to come to Puerto Rico in 50 years. The challenges have forced a one-year delay in Tren Urbano's original 2001 projected completion date. But department Secretary Carlos Pesquera contends that design-build has already cut two years off the design phase and estimates it will save about $60 million during the entire first phase.

The route travels through the heart of metropolitan San Juan, from Bayamon on the west side to Sagrado Corazon in the north (see map, p. 34). It is estimated that the total 30-minute, $1 ride from end to end will generate 100,000 daily trips in the first year. According to DTPW, there are 146 vehicles per square mile in Puerto Rico and Tren Urbano is projected to

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Home

absorb 45% of all private vehicle trips by 2010.

OFFICE WEB More complex than actual construction, the organization of the Tren Urbano team is an intricate blend of contractors, DTPW officials, quality assurance and control consultants, designers and subcontractors. Los Angeles-based Daniel, Mann, Johnson, & Mendenhall and New York City-based Frederic R. Harris Inc., in a joint venture with San Juan-based engineers Eduardo Molinari and Associates and Barrett and Hale and Associates, signed a two-year, $42-million contract in 1994 with extensions for general management and architectural and engineering consultant services (GMAEC). Six of Tren Urbano's seven first-phase contracts, one a major tunneling job, are awarded to joint ventures of local and international firms. The seventh, a design-build-operate-maintain contract to build and supply the line's vehicles, systems, control center, train yard and shops and test track, is held by a Siemens Transportation Systems--led team.

"We have 150 people on GMAEC, not including the highway authority," notes Randy Altschuler, director of operations. "There are separate groups even representing the owner."

Moreover, almost every contractor has an independent quality control firm on the job, adds Chris Dixon, GMAEC's director of implementation. Two of the contract managers report to Dixon, while the other five report to the fixed facilities manager. There are also seven managers for specialized technical and professional support areas of the Tren Urbano office. "It's tough," notes Steve Roescher, manager of project administration for Siemens. "Workshops, information dissemination; there are so many issues. But it's the nature of the best of design-build. You have to make changes as you go along...there are disagreements, but there is dialogue."

HANDLING HURRICANES Dixon says most claims now under negotiation have to do with site conditions, including delays from Hurricane Georges, which raked Puerto Rico in the fall of 1998. Other weather incidents, utility relocations and problems in handling concurrent delays also generated claims. "We'll sit down and negotiate," says Dixon. "We'll reach a settlement." Roescher notes that there were no unusual archeological conditions as originally feared, but unanticipated buried utilities have been problematic. "It's an aggressive schedule, there are major issues," he concedes. "The project will be 10 to 12 months late, but I don't see any major court disputes."

Javier Mirandes, GMAEC's deputy project manager for architecture, says contractors work with an initial alignment drawing as well as one reflecting community input. "We tell the contractor, 'you need to design to 100% with this concept,'" he says. The final design is up to the contractor, but the highway authority may step in and request changes, which also adds to contract extensions. Adjusting to a different culture and to a construction community unfamiliar with big transit jobs also proved challenging. "We had to push for quality and safety" in the beginning, says Dixon. "We're trying to

promote the philosophy of prevention." He says there have been three fatalities but no abnormally high rates of injuries.

Hurricane Georges set the project timeline back. In its aftermath, "there was no availability of materials," says Siemens' Roescher. "Our trucks were used for the Federal Emergency Management Agency." The island location also limits choices of materials and equipment vendors, he adds. And with road and building construction active elsewhere on the island, "there are only so many skilled laborers," Roescher says. "You can't just to go the next state and recruit people." U.S. managers have been pulled in to help recruit and train residents to take on the work.

PROJECT POPULAR The project nevertheless enjoys strong popular support. "People here favor Tren Urbano," says Jeffrey Squires, GMAEC planning director. "They ask how late it will go and when it will come to their neighborhood." The project is also a major factor in the political future of Pesquera, who aspires to be governor of Puerto Rico. "The Secretary has the authority to set the program...as he sees fit," says Squires. DTPW is funding $962 million of Tren Urbano. Other sources are a $307-million federal grant and an additional $400 million of U.S. transportation money allotted to Puerto Rico. A direct U.S. federal loan of $300 million under the Transportation Infrastructure Finance and Innovation Act (TIFIA) last year was "a vote of confidence," notes Squires.

"Each station is different and the corridor helps define each," says GMAEC's Mirandes. Topology, neighborhood characteristics and space all factor into the concept given to the contractor at that station to fulfill. For instance, the Jardinez station is built in a retained cut to reduce impact on surrounding suburban streets while at Lorimar, the station is "half-elevated, half at grade. There is little concession space and no desire for major growth," says Mirandes. "We could have integrated it with an adjacent shopping center, but we didn't." At stops within urban cores such as Bayamon and Hato Rey, however, stations are built with intermodal connections to parking lots, ramps, garages and pedesetrian access.

About 40% of Tren Urbano's total line is at grade. The rest is either elevated over major streets or underground, where two types of tunnels are being built under Rio Piedras. At Bayamon, Grupo Metro San Juan, a joint venture of Mexico's ICA and San Juan-based Miramar, is building a 2.7-km-long elevated guideway of precast concrete segments with single and double track spans under a $71-million contract. An overhead launching truss places the segments, which vary from 21 m to 31 m because of a 90° curve and approach ramps. The guideway, in one section elevated 17 ft above a parking lot, passes within 20 centimeters of a basketball coliseum on one side and baseball stadium on the other.

A joint venture of Redondo-Entrecanales holds four contracts encompassing nine stations and about 13 miles of track. The guideway at Bayamo travels into a corridor originally meant for a highway and ends below

grade at the Jardinez station. Siemens' systems and track contract include the next two stations at Torrimar and Martinez Nadal, where barrel vault sections make up the roof. Adjacent to a north-south route, the station will become a focal point for car and pedestrian access, says Mirandes. At Las Lomas, the elevated guideway resumes, but this time in match-cast segments of consistent depth. The station is excavated at 30 ft near a five-road intersection where the route continues through the Centro Medico complex, a major hospital.

GOING UNDERGROUND The most complex alignment contract was awarded to a joint venture of Omaha-based Kiewit Construction, Kenny Construction Co., Chicago, and San Antonio-based H.B. Zachry Co., with managing designer cma Architects & Engineers, for $225.6 million. The Rio Piedras contract provides for the construction of 1.8 km of underground track with two stations beneath a dense urban area full of historic buildings. "There have been quite a few change orders," notes Vinton Garbesi, contract manager.

In one 430-m section, twin tunnels are being driven with an earth pressure balance machine. Another 100-m tunnel section is being built using the New Austrian Tunneling Method (NATM). A cut-and-cover station is being put at the University of Puerto Rico and the Rio Piedras station is built using stacked drift construction methods. "It was difficult to get the alignment to where it had to be because of the curves," says Garbesi. The guideway dips underground at a steep grade to run about 80 ft beneath the groundwater table and then rises to a level that provides less than 5 m of cover under some historic buildings. Soft soils include silts and sands mixed with limestone karst.

The Rio Piedras Station is located in a tunnel 150 m long, 19 m wide and 16 m high. Fifteen concrete-filled drifts form a horseshoe arch. About 3 m x 3 m each, the drifts are sequentially excavated to form the station's cavern. Soils under the arch are removed and the arch reinforced with concrete. The contractor also built a grout gallery to provide access for horizontal grouting needed to compensate for settlement. Some 30,000 cu yd of concrete was poured in 12 weeks, he says.

SENSITIVITY From the Rio Piedras station to the University of Puerto Rico station, twin 6.3 m-dia tunnels are excavated with an earth pressure balance tunnel boring machine for about 430 m and lined in one pass with precast concrete segments. "It was originally a two-pass system," notes Garbesi, "but we proposed a single-pass." The one-pass segmental lining--a seven-piece, 250-mm-thick, 1.2-m-wide ring gasketed and bolted--can interact better with surrounding soil loads, designers say. Subsurface grouting also was done between the tunnels and the spread footings of a university building with sensitive scientific equipment, notes Dixon. A robotic settlement monitoring system, including mirror prisms installed on buildings, also tracks earth movement every 10 minutes in the historic downtown. The system is so sensitive that it even records heat-generated building expansion.

Flexibility and the proximity of two structures in downtown Rio Piedras dictated the NATM method for one section of four mined tunnels, each about 100 m long and 6 m in diameter, says Garbesi. Two of the tunnels are for future extensions.

From the open cut of the university station, the route heads north into the Hato Rey financial district, weaving between buildings and across arterials as a 3.5-km elevated guideway. A locally based joint venture of Necso (formerly Intercanalas) and Redondo holds the $125.8-million contract, which ends at Sagrado Corazon. Jimenez says the route was redesigned to avoid interfering with the median of a major avenue and to interface with a new coliseum being built and a transportation terminal. North of Sagrado Corazon, an environmental impact statement is being done for a proposed extension to Manillas.

The $640-million seventh contract is led by Siemens, local firm Juan Requena Associates and Boston-based Alternate Concepts, with a quality control subcontract to New York City-based Parsons Brinckerhoff and a construction subcontract to Redondo-Perini. The team must coordinate interface between adjacent alignment contracts and adjust schedules and access. The multidisciplinary system seems to work; operation and maintenance experts see things that designers and builders might miss, notes Roescher.

The jury is still out on the multicontract approach to design-build, officials say. But they all favor a $10-million technology transfer program with students at the Massachusetts Institute of Technology and the University of Puerto Rico. Students have internships on every contract, and several have joined Tren Urbano after graduating, says Lydia Mercado, program director. With future extensions planned, "we want to have enough locals so we don't have to import talent," she says. "I expect one of these students will be the Secretary of Transportation 10 years from now." --

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