Transportation Technology Transfer in the Caribbean Community

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Highway infrastructure in Caribbean countries is poorly documented. Its vital links provide avenues for commerce and the foundation for development. However, as the countries address national priorities, highway design and maintenance are deferred because of lack of capital and local technical expertise. In response to the need for a comprehensive data base on highway infrastructure and for an assessment of options for technology transfer, the Federal Highway Administration in cooperation with the Pan American Institute of Highways sponsored a study of eight Caribbean countries: The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, and Trinidad and Tobago. This paper presents the results of that study and provides an initial data base on which to build more comprehensive understanding of needs and strategies for transportation technology transfer in the Caribbean Community.

In an effort to help Latin America and the Caribbean Community improve their transportation infrastructures, the Pan American Institute of Highways (PIH), a nonprofit organization, was established by the Pan American Highway Congress of the Organization of American States (OAS) in 1986. Its objective is to facilitate the exchange of technical information and training in highway-related technology throughout the Western Hemisphere (*1*).

PIH is patterned after the Local Technical Assistance Program (LTAP) and the National Highway Institute (NHI). LTAP is a network of technology transfer centers that acts as a conduit for the dissemination of information and training in design, construction, and maintenance of roads and highways. A major function of LTAP is the sharing of information related to the implementation of newly acquired technologies.

NHI develops training programs and courses and provides expert instructors from many areas of highway design, construction, maintenance, operations, and safety. As mandated by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), NHI makes available many of its training courses and information for international technology transfer, including the PIH network. Modifications of technologies and, in many cases, language translations are provided by NHI to expedite implementation of training objectives.

Though still in its formative years, PIH has become a paradigm for international technology transfer. The key to its success is the interest, active participation, and resource commitment of the Spanish-speaking community in Latin America. The only English-speaking centers outside the PIH headquarters at the Turner-Fairbank Highway Research Center in McLean, Virginia, are located at the University of the West Indies in Trinidad and the Ministry of Construction in Jamaica.

Regardless of the services offered by PIH, there has been limited participation by the Caribbean Commu-

nity. This limited participation is believed to result from local shortages of personnel and money to operate centers and the low priority developing countries have traditionally placed on road infrastructure. Another contributing factor may be a general lack of understanding about availability of and benefits derived from technology transfer operations.

Therefore, the objectives of this research are to

1. Create an awareness of PIH,
2. Develop a data base on highway infrastructure in the Caribbean Community and document major technical needs, and
3. Identify appropriate methods of technology transfer for the Caribbean Community.

PIH Technology Transfer

Some of the more popular PIH technology transfer and instructional activities are

- Loaned-staff program;
- Training seminars, workshops, and conferences; and
- Newsletters.

In addition, PIH supplies a catalog of materials and courses to each of its centers as well as computer software, design and maintenance manuals, and VCR instructional tapes. Teleconferencing and distance-learning activities are planned for future training and instructional programs.

PIH has instituted a certification process for its member centers. In order to be certified, a center must

- Maintain a program of activities,
- Publish a newsletter,
- Maintain a resource list or catalog,
- Actively participate in the PIH network, and
- Conduct an annual self-evaluation.

While only one-half of the PIH centers are certified, PIH encourages certification as a means of ensuring success.

Resources necessary for operation of a technology transfer center include dedicated office or library space, or both; at least one staff member; and access to such minimal communication and training equipment as

- Telephone,
- Facsimile machine,
- Photocopier,
- Computer and printer,
- Television and VCR, and
- Slide and/or overhead projector.

Other useful electronic equipment includes satellite downlink, modem, video reproduction equipment, and a teleconferencing facility. Few PIH technology transfer centers possess all of the recommended equipment.

Measuring Success

The success of a technology transfer center or network of centers can be measured by cost/benefit analysis and by accomplishments versus goals. The PIH network is still in its infancy, and a cost/benefit analysis that requires historical data is not appropriate. According to NHI officials, investments in training are not expected to show a reasonable return for at least three years, though some centers claim to have realized positive returns within the first year.

While a PIH cost/benefit analysis may be premature, a recent study of LTAP centers by Patsy Anderson indicates that annual dollar benefits far exceed service costs. Anderson's study indicates an annual cost/benefit ratio of 0.284 for services rendered. With 41 of 50 centers responding to her survey, a total annual cost of $15.5 million for all services resulted in a savings of $54.5 million.

The LTAP experience cannot be extrapolated to predict the success of the PIH centers. Though the PIH network is modeled after LTAP, many differences exist between the two groups. Among these are differences in levels of technology, overall infrastructure development, and budgets available for training and technology transfer. In addition, LTAP is a U.S. network, whereas PIH is a multinational organization. While future cost/benefit analyses will be beneficial to PIH for justification of its network and for promotion of its goals and objectives, such a quantitative approach is premature.

Accomplishments are also good indicators of success. PIH has achieved a sound level of success in its formative years by overcoming language and cultural differences through expansion into 18 countries. Fourteen centers are in Spanish-speaking countries, three centers are in English-speaking countries, and one center is located in the United States territory of Puerto Rico.

The success of PIH is mostly attributable to the increasingly active participation of Latin American countries. Countries that have established centers are Argentina, Brazil, Bolivia, Chile, Colombia, Costa Rica, Ecuador, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay, and Venezuela. The U.S. center in Puerto Rico is funded by FHWA, and since it is bilingual, it helps provide a coordinating function with the Latin American countries.

Only two English-speaking countries in the Caribbean Community are members of PIH. The technology transfer center at the University of the West Indies in

St. Augustine, Trinidad, is a charter member. Recently, the Jamaican Ministry of Construction established a center in Kingston, Jamaica. With the exception of these two countries, PIH activity in the Caribbean Community has been tenuous.

PIH and NHI officials believe that the lack of interest in technology transfer within the Caribbean Community is primarily due to a lack of awareness of available technology transfer options. In order to investigate these options, it is requisite to catalog highway infrastructure, prioritize technical needs, and establish amicable relations with Caribbean officials responsible for development and maintenance of highway infrastructure.

Site Visits

In order to assemble a broad spectrum of reliable information on highway infrastructure, site visits occurred in the following English-speaking countries of the Caribbean Community and Common Market: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Lucia, St. Kitts and Nevis, St. Vincent, and Trinidad and Tobago. Most of these are former British colonies that, though sovereign countries, remain members of the British Commonwealth and continue to use British engineering design standards.

Eight countries were selected for visits based upon total miles of roadway, miles of paved roadway, and invitations to participate. The countries visited were The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, and Trinidad and Tobago.

The agenda for each visit included a PIH presentation to ministry and industry engineers and technicians, an interview with ministry personnel relative to infrastructure and technical problems and needs, and tours of highway construction and maintenance projects. Because of time and budgetary constraints, visits were limited to approximately two days per country. The visits yielded information on the extent of highway infrastructure, engineering needs, technology transfer assets, and opportunities for increased participation in PIH.

In order to match the countries studied with appropriate technology transfer activities, the authors screened technology needs based on training and instructional methods currently in use. The results of screening needs versus available assets define those activities that are most appropriate for successful technology transfer.

Technology Transfer Needs

Visits to each of the eight countries were made during the autumn months of 1993. Presentations on PIH were delivered to over 130 persons representing 10 Caribbean Community countries. Those who attended the presentations included engineers, technicians, ministry chief technical officers, permanent secretaries, parliamentary ministers, and infrastructure officials from the Caribbean Development Bank and the Inter-American Development Bank.

Responses to the PIH mission were positive but cautious. Some of the apparent barriers to establishing technology transfer centers are

- Budgetary constraints;
- Lack of personnel;
- Resistance to change;
- Lack of understanding of technology transfer and its implications;
- Loyalty to the British Commonwealth and British design standards;
- Suspicion of U.S. involvement; and
- Low visibility of U.S. consultants and contractors in the Caribbean region.

In addition to creating awareness of PIH as a technology transfer option, the authors began the task of developing a highway infrastructure data base. Ministry engineers, technicians, and chief technical officers provided information. On-site inspection of roads and construction and maintenance operations yielded additional data. Table 1 summarizes pertinent data for each country and its highway infrastructure.

Table 2 shows additional comparative data. Most of the column headings follow those used by World Bank to measure relative development levels of various countries and regions in need of infrastructure investment (2). Table 3 summarizes highway engineering problems regularly encountered in each Caribbean country included in this study. The five most prevalent technical needs are

- Hydraulics, drainage, and hydrology (eight countries);
- Slope stability and erosion control (seven countries);
- Pavement design and maintenance (six countries);
- Geometric design (four countries); and
- Load limits and enforcement (four countries).

All of the Caribbean countries have tropical rainy seasons that create severe drainage problems. Heavy seasonal rainfalls are particularly troublesome in the mountainous countries where runoff contributes to landslides, unstable slopes, and severe erosion.

Paving methods vary from country to country and are a reflection of highway budgets. The Bahamas, Barbados, Jamaica, and Trinidad and Tobago pave most of

TABLE 1 General and Highway Infrastructure Data

Country	Population (1000's)	Land Area (km^2)	Gross Domestic Product ($M US)	Total Roadway (km)	Paved Roadway (km)	Bridges	Vehicles (1000's)	Annual Highway Budget ($1000US)
Bahamas	255	10,069	9,900	1,812	1,548	6	65	5,000
Barbados	257	430	6,500	1,680	1,571	78	50	18,000
Belize	190	22,800	1,635	2,549	447	149	N.A.	3,804
Dominica	70	754	2,000	1,007	513	N.A.	10	2,600
Grenada	100	339	1,806	966	644	N.A.	8	9,500
Guyana	740	196,850	325	1,046	515	N.A.	N.A.	N.A.
Jamaica	2,800	10,825	3,900	18,185	12,553	780	400	50,000
Trinidad & Tobago	1,253	5,128	4,500	2,688	2,436	1,059	212	70,000

N.A., data not available

their roads with hot-mix asphalt. In other countries, chip-seal and cold-mix pavements are prevalent, though some hot-mix pavements were observed. New rigid pavement construction was observed only in Grenada where feeder roads were being constructed to improve access to mountain agricultural areas.

Geometric design problems result primarily from topographical constraints, especially in mountainous areas, which dictate the vertical and horizontal alignments of roadways. Because of budgetary constraints, safety considerations play a minimal role in geometric design.

Many heavy trucks travel the roadways of the Caribbean. Truck overloading is a common practice. Regulations restricting loads are nonexistent but are proving to be of increasing concern to road designers throughout the region.

The Bahamas

The highways and roadways are built and maintained by the Ministry of Public Works, which employs four engineers in its roadway division. Funds for road construction and repair are appropriated by the parliament from the general fund. International lending agencies also provide funding for major road projects.

Engineers from the Ministry of Public Works indicated that hydraulics and drainage, shortage of technical literature, shortage of technical equipment, and a shortage of engineers are particular problems. The Bahamas, especially the island of New Providence, are highly developed relative to the rest of the Caribbean Community. Road construction and maintenance technologies approach those of the United States.

Because the islands are built upon coral reefs, subgrade stability problems are virtually nonexistent. Pavement base and subbase material used is primarily marl. Most pavement surfaces are of hot-mix asphalt concrete. The Ministry of Works employs its own maintenance crews but contracts major road projects with the private sector.

Barbados

The Ministry of Labour, Public Works, Community Development, and Sports employs 11 engineers in the roadway division. Funds for road construction and re-

TABLE 2 Comparative Country Data

Country	Population Density (population per km²)	Gross Domestic Product per Capita ($US)	Percent of Roads Paved (%)	Area Density of Paved Roads (km per km²)	Paved Road Density per $Million of GDP (km per km² per $M US)	Paved Road Length per 1000 Population (km per 1000 pop)	Vehicles per kilometer of Roadway
Bahamas	25.3	9,900	85.4	0.16	0.0001	6.07	35.9
Barbados	598	6,500	93.5	3.65	0.0035	6.11	29.8
Belize	8.34	1,635	17.6	0.02	0.0001	2.35	N.A.
Dominica	93.1	2,000	51.0	0.68	0.0079	7.33	9.90
Grenada	295	1,806	66.7	1.90	0.0169	6.44	8.28
Guyana	3.76	440	49.2	0.0026	0.000008	0.696	N.A.
Jamaica	259	1,400	69.0	1.16	0.0005	4.48	22.0
Trinidad & Tobago	244	3,946	90.7	0.48	0.0002	1.94	78.9

N.A., data not available

pair in Barbados are appropriated by the parliament from the general fund. International lending institutions also provide funding for major road projects.

Problem areas listed by the engineers interviewed include landslides in clayey soils, longitudinal cracking in hot-mix asphalt mats, hydraulic and drainage problems, and blockage of outfall drains in the sea. Because of its level of development and a gentle topography, a relatively high percentage of roads are paved. Sixty percent of the paved road surfaces on the island are hot-mix asphalt concrete, and the remaining 40 percent are chip/seal surface treatments. Cut-back asphalts have been phased out in favor of asphalt emulsions because of environmental concerns.

Road subgrades are mainly planed coral reef; however, some pockets of expansive clay deposits create subgrade problems in the interior of the island. Base and subbase layers are compacted marl.

The ministry employs road and roadside maintenance crews for ongoing minor projects. There has been a move toward contracting of projects with private enterprise since early 1993.

Belize

Seven engineers in the Ministry of Public Works coordinate highway construction and maintenance. Funding for road construction and repair in Belize is appropriated by the parliament from the general fund. International lending agencies and other funding agencies, such as United States Agency for International Development (USAID), also provide funding for major road and bridge projects.

Ministry engineers identified the following technical needs: analytical techniques for hydrological data, computer programs for road design, methods for road and bridge design, dust control on unpaved roads in the dry season, contracting principles, and cost estimating.

The ministry is working to overcome transportation problems related to heavy rainfall that include inadequate drainage and sideslope instability. Many bridges are old and in need of repair or replacement. Most are single-lane bridges that were built to serve single-lane roadways. However, bridge replacements and roadway widening are part of a general rehabilitation project.

TABLE 3 Highway Engineering Needs

Technical Need	Bahamas	Barbados	Belize	Dominica	Grenada	Guyana	Jamaica	Trinidad
Comprehensive Transportation Plan	●					●		●
Contracting and Cost Estimation			●					
Design Methodologies			●					
Geometric Design				●	●		●	●
Hydraulics, Drainage and Hydrology	●	●	●	●	●	●	●	●
Truck Load Limits and Enforcement				●	●	●	●	●
Pavement Design and Maintenance		●		●	●	●	●	●
Quality Control and Inspection					●	●		
Slope Stability and Erosion Control		●	●	●	●	●	●	●
Traffic Congestion / Capacity Analysis	●					●	●	
Unpaved Road Maintenance			●			●		

As part of its rehabilitation program, the Ministry of Works is incorporating Geographic Information System (GIS) technology and using aerial photographs and portable Global Positioning System (GPS) receivers to accurately map road alignments.

The ministry employs road and roadside maintenance crews for ongoing minor projects. All externally funded projects are contracted with the private sector.

Dominica

Roadway construction and maintenance are under the auspices of the Ministry of Communications, Works, and Housing, which employs two engineers in its roadway section. Highway funds are appropriated by the parliament from the general fund. International lending agencies also provide funding for major road projects.

Some of the technical problems observed and discussed with the technical staff include slope instability, pavement design, construction and maintenance, hydraulic design and maintenance, river control and erosion, and geometric design.

Dominica is a very labor-intensive economy because of a lack of heavy equipment and funds for new equipment and the availability of manual labor because of high levels of unemployment. The country is moving toward privatization of road construction and maintenance operations. Division of the ministry into service units is intended to facilitate privatization.

Grenada

Roads are built and maintained by the Ministry of Communications, Works, and Public Utilities, which employs four engineers in its roadway division. Funds for road construction and repair are appropriated by the parliament from the general fund. International lending and granting agencies also provide funds for major road projects.

Technical problems include coastal erosion, slope instability pavement design, construction and mainte-

nance, hydraulic design and maintenance, quality control of materials, and geometric design on mountain roads. Grenada is labor-intensive with limited inventories of heavy equipment. A current infrastructure improvement program funded by loads from the Caribbean Development Bank includes PCC paving of feeder roads.

Maintenance and repair work on roads is conducted by ministry employees. Major construction and rehabilitation projects are contracted with local and international contractors.

Guyana

Roads in Guyana are built and maintained by the Ministry of Public Works, Communications, and Regional Development. Funds for road construction and repair are appropriated by the parliament from the general fund. International lending agencies also provide funding for major road projects.

Problems include the need for updated innovations in pavement design, construction and maintenance, hydraulic design and maintenance, foundation and slope instability in clay soils, quality control of materials, and a general transportation plan. Guyana's capital, Georgetown, is plagued by serious traffic congestion, pavement distress and deterioration, and drainage problems.

All of the paved roads are near the coast, which is the most developed and heavily populated section of the country. The interior is traversed by earthen paths and unimproved roads that are often impassable, even on foot, during the rainy season. Guyana is extremely labor-intensive with a limited inventory of heavy equipment for major road projects.

Jamaica

The highways and roadways of Jamaica are built and maintained by the Ministry of Construction, which employs eight engineers in its roadway division. Funds for road construction and repair are appropriated by the parliament from the general fund. The Ministry of Construction is proposing a highway trust fund similar to that in the United States, which will be funded by a gasoline tax equivalent to about $0.14 (U.S.) per gallon. International lending institutions also provide funding for major road projects.

Infrastructure problems in Jamaica include slope instability, pavement design, construction and repair, hydraulic design and maintenance, river control and erosion, geometric design on mountain roads, highway capacity and traffic congestion, shortage of staff engineers, weight-limit guidelines for trucks, and lack of GIS technology. As in other mountainous Caribbean countries, mountain roads tend to be narrow with limited sight distances and are plagued by slope instability. In the southern cities of Spanish Town and Kingston, serious congestion problems exist where vehicular and pedestrian traffic greatly exceed capacity.

Because of increasing accident rates, Jamaica has embarked upon a national road safety program with technical and financial assistance from the Swedish government. As a result, a traffic enforcement and violator ticketing system was implemented in 1993.

Another area in which Jamaica is taking the lead among Caribbean countries is in establishing a maintenance management program to upgrade and restore Jamaica's road infrastructure to a condition of maintainability. The ministry employs general maintenance crews but contracts major rehabilitation and resurfacing projects with local contractors.

Trinidad and Tobago

The Ministry of Works and Transport is charged with highway construction and maintenance in the Republic of Trinidad and Tobago. The roadway division employs 35 engineers. Funds for road construction and repair are appropriated by the parliament and are generated from fuel taxes, vehicle licensing fees, vehicle taxes, and customs taxes on vehicles and accessories. International lending agencies also provide funding for major road projects.

Technical problems include slope instability, hydraulic design and maintenance, geometric design on mountain roads, shortage of senior level engineers, lack of a strategic transportation plan, lack of state-of-art equipment and computer systems, and lack of transportation research. Problems aside, Trinidad has developed multilane divided highways in the coastal areas around Port-of-Spain. There are also over 200 signalized intersections in Trinidad, and Port-of-Spain boasts the world's largest traffic roundabout, which has a perimeter exceeding 4 km.

The ministry employs maintenance crews for general and ongoing projects. Larger construction and rehabilitation projects are contracted with private firms.

Technology Transfer Assets

Table 4 provides an inventory of assets available to each ministry for technology transfer operations. In addition to the physical assets listed, most of the countries employ training staff.

TABLE 4 Available Technology Transfer Assets

Available Instructional Assets	Bahamas	Barbados	Belize	Dominica	Grenada	Guyana	Jamaica	Trinidad
Classroom or Conference Facilities	●	●		●	●		●	●
Computer(s) and Printer(s)		●	●	●	●	●	●	●
FAX	●	●	●	●	●	●	●	●
Office and / or Library Space	●	●	●	●	●	●	●	●
Photocopier(s)	●	●	●	●	●	●	●	●
INTELSAT Satellite Downlink(s)	●	●	●			●	●	●
Telephone(s)	●	●	●	●	●	●	●	●
Television(s) and VCR(s)		●	●	●	●	●	●	●
UWIDITE Teleconferencing Facilities		●		●	●		●	●

Many of the Caribbean countries have successfully participated in distance learning through the University of the West Indies Distance Teaching Experiment (UWIDITE). Raymond Charles, Director of the University of the West Indies (UWI) Technology Transfer Center in Trinidad, has conducted interactive training sessions utilizing commercially available communication links.

In a report to the PIH Advisory Committee in 1992, Charles reported that the UWIDITE network uses audio and computer conferencing to link the UWI campuses in Jamaica, Barbados, and Trinidad with UWI teaching centers on Antigua, St. Kitts, Dominica, St. Lucia, St. Vincent, Grenada, Barbados, Tobago, and Tortola. The only teletransmission centers in the UWIDITE network are located at the UWI campuses on Jamaica and Trinidad. The two campuses are linked by statellite communications. The other islands are linked by line-of-sight microwave transmissions from Trinidad in the south to Tortola in the north, a total distance of 800 mi. The only exception is the link from St. Lucia to Barbados, which utilizes tropospheric microwave scatter because of the long transmission distance. Future plans for expansion of UWIDITE include

- Linking Montserrat by microwave scatter from St. Kitts,
- Connecting Grand Cayman by cable from Jamaica,
- Adding access to the Bahamas via satellite from Jamaica to a U.S. ground station and from the United States to New Providence Island by cable, and
- Accessing Belize with satellite links from Jamaica via the United States.

In addition, NHI has plans for future distance learning activities. INTELSAT satellite downlinks and

planned improvements to UWIDITE may some day allow access to inexpensive training modes for technology transfer throughout the Caribbean Community.

Technology Transfer Options

Special Considerations

When training programs and other technology transfer activities are assessed for the countries of the Caribbean Community, a number of important factors must be considered.

The economies are very labor-intensive. Construction and maintenance methods that displace workers will not be implemented. With high levels of unemployment throughout the area, infrastructure projects provide work for many of their citizens.

Safety is recognized as needed but is not given a high priority. Safety considerations in geometric and roadside design are given low priority in many of the areas. Construction of safe thoroughfares is always desirable; however, when there is a choice between an "unsafe" roadway and no roadway, providing access is always the first priority.

Environmental issues are becoming increasingly important but are still of low priority. Growing reliance on tourism and better-educated engineers have raised awareness of the environmental impacts of highway construction.

Funding irregularities are considerations on all projects. Because of frequent budgetary shortfalls, construction and maintenance projects are prioritized in the planning process. However, for political and practical reasons, implementation of planned activities is subject to change. Frequent natural disasters such as flooding, hurricanes, and major landslides chronically drain highway budgets, which results in long delays or even cancellation of planned activities.

There is a general lack of understanding of the correlation between highway infrastructure and economic growth by many political leaders. The economic benefits of maintaining roads are not fully understood. World Bank and Caribbean Development Bank have begun to stress the importance of road maintenance, but, in many cases, political leaders have been slow to respond.

Airport design and maintenance should be considered in the transportation technology transfer program. There are many kilometers of permanent runways and taxiways throughout the Caribbean region. Expanding instructional horizons to include other ministries, such as those responsible for airports and public transit, may make establishing a technology transfer center more viable.

It will always be necessary to consider cultural differences and economies of scale when communicating with Caribbean countries. Care should be taken to avoid making judgments based on U.S. values and policies. Assistance in the mechanics of identifying needs and prioritizing objectives would be beneficial in establishing a technology transfer foothold within the Caribbean Community.

Assessing Technology Transfer Options

Appropriate methods of technology transfer are dependent upon specific highway needs and available instruction resources. A logical method of selecting technology transfer options is to match technical needs (Table 3) with appropriate and proven methods of delivery and the resources available for such activities (Table 4). Table 5 summarizes recommendations for technology transfer activities based on technical needs and available assets.

Matching needs with assets does not include an economic analysis. Indeed, costs associated with some technology transfer activities may prove prohibitive. However, objectivity in selecting activities and methods of technology transfer is a first step in justifying those activities to government officials and international lending institutions.

For instance, Dominica, which employs only two engineers in its roadway division, cannot support the costs associated with printing and distributing a newsletter or sponsoring higher-level training courses. Alternatively, establishing an office library of maintenance and design manuals, trade journals, and VCR training tapes would be inexpensive and desirable.

Furthermore, the Dominicans may be able to cosponsor training courses in specific technical areas with such neighboring islands as St. Lucia and St. Vincent. The three islands experience similar problems but have small professional staffs and, by combining resources, could afford invited instruction and training.

Twinning Network for Caribbean Community

Not all of the Caribbean countries can feasibly establish independent technology transfer centers. However, a cooperative network of smaller centers around a fully operational one is feasible and might encourage participation by minimizing costs associated with technology transfer. This network is based upon the "twinning" concept for technology transfer centers. The authors recommend the following network for the Caribbean Community based on geographic proximity:

- Southern Caribbean Region
  –Certified center: Trinidad

TABLE 5 Recommended Technology Transfer Methods and Tools Based on Technical Needs and Available Assets

Technology Transfer Method / Tool	Bahamas	Barbados	Belize	Dominica	Grenada	Guyana	Jamaica	Trinidad
Catalog of Available Materials / Courses	●	●	●	●	●	●	●	●
Circuit Riders		●		●	●		●	●
Computer Software		●	●	●	●	●	●	●
Continuing Education	●	●	●	●	●	●	●	●
Distance Learning	●	●					●	●
Loaned Staff	●	●		●	●		●	●
Manuals	●	●	●	●	●	●	●	●
Newsletters		●	●	●	●	●	●	●
Networking	●	●	●	●	●	●	●	●
Seminars, Workshops and Conferences	●	●		●	●		●	●
Technical Assistance	●	●	●	●	●	●	●	●
Technical and Trade Journals	●	●	●	●	●	●	●	●
Teleconferencing		●		●	●		●	●
VCR Instructional Tapes		●	●	●	●	●	●	●

–Satellite centers: Barbados, Dominica, Grenada, Guyana, St. Lucia, St. Vincent

- Northern Caribbean Region
  - –Certified center: Jamaica
  - –Satellite centers: Antigua and Barbuda, Bahamas, Belize, St. Kitts and Nevis

Since Trinidad and Jamaica have established PIH technology transfer centers, are geographically at opposite ends of the Caribbean Community, and are the only teletransmission centers in the UWIDITE network, they will function well as conduits of information to neighboring countries. As smaller countries become involved, they can be twinned with a geographically appropriate, fully operational center for activity planning.

Under this proposed structure, each country will determine its individual needs. However, all centers should participate in the networking and activity planning processes. For instance, all centers can contribute to a newsletter and receive recognition for their contributions.

In addition, all countries should participate in the development and delivery of training courses. The site for training courses and seminars can be rotated so that all countries can economically benefit from course delivery.

The goal of PIH is to promote communication among countries of the Western Hemisphere. This proposed network allows greater participation and simultaneously limits technology transfer operating expenses.

Conclusions and Recommendations

Participation in technology transfer operations by the Caribbean Community will evolve slowly. Most or all of the highway technical solutions can be realized through training and instruction. Twinning of smaller countries with larger ones and adoption of an appropriate technology transfer model may encourage active participation by the Caribbean Community.

Specific recommendations for PIH and NHI relative to the Caribbean Community are as follows:

1. Make timely follow-up contacts with government officials;
2. Encourage twinning of smaller countries with Trinidad and Jamaica for delivery of technology transfer activities as geographically appropriate;
3. Adopt a technology transfer model for developing countries;
4. Develop a seminar or workshop on fundamentals of technology transfer for economies in transition cosponsored by World Bank, Caribbean Development Bank, and the Inter-American Development Bank. This program should include

- Economic impact of highway infrastructure and development;
- Benefits of training and implementation of new technologies;
- Appropriate technology transfer activities for economies in transition;
- Principles of economic analysis and decision making; and
- Success stories from existing technology transfer networks.

The target audience for this workshop should include ministers of public works, permanent secretaries, chief technical officers, and training officers from the various Caribbean countries.

5. Continue to seek recognition and endorsement from international lending and granting institutions.

If transportation technology transfer activities are conducted in the Caribbean Community, more highway-related information will be shared, new technologies will be introduced, users of new technologies will be supported, and new markets will be opened for those who develop and manufacture products and equipment related to new technologies. Sharing of technical information will help reduce the technology disparity between the developed and developing countries of the Americas and promote healthy relations between the United States and its Latin American and Caribbean neighbors.

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