Final Report

March 30, 2002

RECONSTRUCTION PROJECT

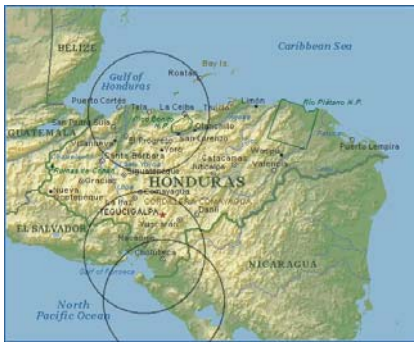
for

MARITIME NAVIGATION SYSTEMS

in

CENTRAL AMERICA

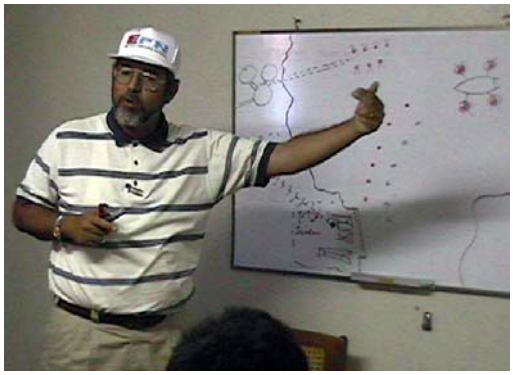
Conducted by the Volpe National Transportation Systems Center for the United States Agency for International Development (USAID) under project plan agreement with the Research and Special Programs Administration (RSPA) of the United States Department of Transportation (USDOT)

(L) Corinto, Nicaragua DGPS transmitter. (C) site location map. (R) T-antenna at Corinto

PURPOSE OF THIS REPORT

This is the final report on the project to restore navigation systems at maritime ports in Central America. The project was initiated after the devastation caused by Hurricane Mitch in 1998. The report includes a review of the project from its inception through to its recent completion with the activation of the third and final DGPS transmitter at Tela, Honduras. All major program objectives were successfully achieved during the 3+ year project lifecycle and already evidence of the significant benefits provided by the systems has been demonstrated.



EPN Engineer Jose Genet briefing officials at Port Sandino, Nicaragua.

Demonstrating the electronics during the San Lorenzo, Honduras site inauguration.

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PROJECT BACKGROUND

For several years, the Volpe Center of the U.S. Department of Transportation has been involved in the development and application of Differential Global Positioning System (DGPS) technology for various maritime venues. The accuracy of the technology is ideal for vessel tracking and navigation in harbors and waterways. Although the accuracy of GPS has improved considerably since the elimination of Selective Availability in May 2000, DGPS still is required to safely navigate narrow inland waterways. A consortium of maritime authorities in Central American countries requested assistance from the Volpe Center following the terrible damage to their marine facilities as a result of Hurricane Mitch. After an initial assessment of the situation, it was determined that DGPS-based systems not only would be effective in restoring navigation in ports, but additionally would upgrade the pre-hurricane navigation capabilities in the ports of Cortez and San Lorenzo in Honduras and Corinto and Sandino in Nicaragua.

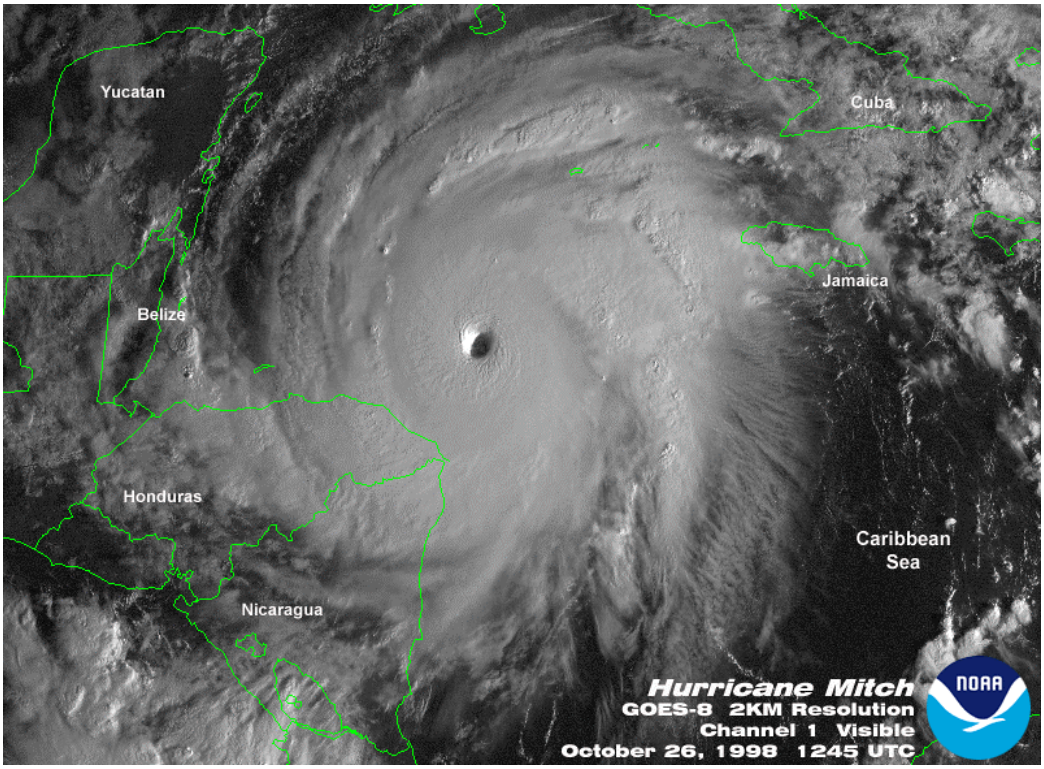


Figure 1: Hurricane Mitch

At the Western Hemisphere Transportation Ministers Conference, held in New Orleans in December of 1998, USDOT Secretary Rodney Slater made a historic announcement. He committed participation by the Department of Transportation in relief efforts to rebuild the Central American transportation infrastructure that was damaged by the hurricane. As the relief effort transitioned to recovery assistance, the port navigation systems became a top priority that was funded by the United States Agency for International Development (USAID).

FROM THE USAID HURRICANE RELIEF WEB-SITE (hurricane.info.usaid.gov):

In the aftermath of Hurricane Mitch, President Clinton asked members of his Cabinet to mobilize their agency programs and professional experience to assist the countries of Central America and the Caribbean. The supplemental bill passed by Congress included over $100 million to be used by 13 U.S. Government agencies. Through the end of September 1999, these agencies and USAID worked with Congress to develop the Inter-Agency Agreements (IAAs) and a Memorandum of Agreement (MOA) needed to allow funding and work to begin. During this period, interagency teams went to the field to develop their year-one work plans while many events were held both in Central America and the Caribbean to maintain private sector interest in "building back better."

INTER-AGENCY AGREEMENT BETWEEN USAID AND USDOT

The Department of Transportation effort was divided into three activities:

Activity 1 – provide aid to navigation systems for severely damaged harbor operations. (This is the subject of this report)
Activity 2 – establish a framework to reconstruct Central American port infrastructures and operations.
Activity 3 – develop a pilot transportation disaster response plan to strengthen transportation efforts after international disasters and to lessen the vulnerability of trade corridors to natural disasters.

Activity	Task Organization	Funding
1	USDOT/RSPA/Volpe Center	$1,562,000
2	USDOT Maritime Administration	$220,000
3	USDOT & Organization of American States	$297,450

FUNDING AND FINAL EXPENDITURE

Central America Project Expenditures by country (Activity 1)

Activity Budget: $1,562,000

Honduras	$ 812,000
Nicaragua	$ 750,000
Activity 1 - Total	$1,562,000

Remaining Balance $0

PROJECT TASKS

The Volpe Center was tasked to design, install, and make operational, Differential GPS-based port navigation and guidance systems (i.e., activity 1) to support Central American nations in their efforts to rebuild their maritime transportation infrastructure that was damaged by Hurricane Mitch in November 1998. The activity included the installation of three DGPS radio beacon transmitter stations used to broadcast GPS satellite corrections and integrity data to maritime users at four principal ports. Additionally, portable electronics navigation aids were developed for the marine pilots operating at each port. The following is a list of project tasks from the original statement of work developed prior to project initiation. Following each task definition is commentary on actual task performance and progress made toward achieving program objectives.

Task I – Prepare Local Support Requirements

An advance team from the Volpe Center will travel to each port area to evaluate the suitability of several candidate transmitter sites proposed by local authorities using criteria to be furnished by the Volpe Center. Final transmitter site selection will be made by the Volpe Center in cooperation with local authorities. Local authorities (port, municipal, national, or other authorities) at each port will provide the following support, at no cost to the Volpe Center:

- Identify at least two appropriately located candidate sites of adequate size necessary for the installation and operation of a DGPS-based transmitter;
- take all measures necessary to ensure that each site is legally available for the installation and operation of a DGPS-based transmitter;
- obtain any public or private licenses that Volpe Center personnel may require to install, test, and operate a DGPS-based system; and
- prepare each site selected by the Volpe Center for installation and operation of a DGPS-based system.

Site preparation includes: providing road access; grading; adequate continuing electric power; security systems including fences; construction (foundations, footings, erection of towers, etc.); and other support that the Volpe Center may require to accomplish the successful installation and operation of each system.

Result. Trips to Honduras and Nicaragua were conducted in December 1999 and March 2000 for the purposes defined in task I. Suitable candidate sites for transmitter stations were identified near each port during the trips. Only the site at San Lorenzo, Honduras, however, was acquired without delay. Accordingly, San Lorenzo became the first port to receive a transmitter facility. Land acquisition by the governments of both Honduras and Nicaragua to house the other two transmitter stations became a major issue and ultimately adversely impacted the project schedule and cost. Return trips to both countries were required in order to survey and evaluate additional properties in Tela, Honduras

(to service port operations in Cortes) and Corinto, Nicaragua (to provide DGPS signals to the ports of Corinto and Sandino).

The site selection process delayed the start of construction by over a year, but nevertheless, resulted in excellent locations for the remaining two transmitters. The transmitter servicing Puerto Cortes ultimately was established in Tela, about 35 miles to the east. The Tela site has the added benefit of providing signal coverage not only to the approaches to Cortes, but to other ports along the northern coast of Honduras and the bay islands of Roatan and Utila.

Task II - Develop Installation Plans for DGPS Sites

The Volpe Center will establish integrated system designs that include the following components:

- Antenna assembly
- Transmitter equipment
- GPS reference station
- Transmitter equipment shelter *
- Power system
- Signal monitoring system
- User equipment (Navigation and AtN Positioning Displays)

* See attachment 1 for a list of components included in the equipment shelter for each transmitter site.

Task III - Acquire Equipment and Assemble Systems

The Volpe Center will procure hardware and develop software necessary for the DGPS-based navigation systems.

The Volpe Center will inspect, assemble, and test system components and related software before the shipment of systems to Central America.

All computer software applications to be embodied in each DGPS-based system will be customized for use in the selected ports.

Result. Electronic navigation units were designed for ease of use and customized to meet the specific requirements of this project. Electronic chart information was obtained, converted, and verified.

Task IV - Transport Equipment to Central America

The Volpe Center will arrange for the shipment of DGPS-based systems to designated locations in Central America. The Volpe Center will send a team to each identified port area:

- to inspect shipments upon their arrival;
- to work with local authorities who will be responsible for customs agencies formalities and will arrange for the transportation of equipment to transmitter sites; and,
- to verify the readiness of the transmitter sites for the installation of
- DGPS-based systems.

Result. All equipment was transported successfully to the appropriate locations in Central America. Upon inspection of the equipment, two GPS reference station units were found to be inoperable. Both units were shipped back to the manufacturer for warrantee repair and promptly returned.

Task V - Install Transmitter Facilities

In cooperation with local officials, the Volpe Center team will oversee the installation of DGPS-based transmitters at selected sites. After installations are completed, Volpe Center personnel will make any necessary adjustments to bring each DGPS-based transmitter to full operational status.

Task VI - Test Systems and Confirm Operational Readiness

The Volpe project team will validate the operational readiness of each DGPS-based system. When the system is declared operational, the Volpe Center will transfer all equipment to the local authority at each port.

Task VII - Train Local Personnel in System Operations

The Volpe Center will provide training in the operation of the DGPS-based system to local personnel. The Volpe Center will train local personnel in the operation of both land-based and shipboard equipment. Training in the performance of routine maintenance also will be provided.

Results Tasks V through Task VII. A total of 12 trips to Central America were taken by Volpe Center team members to ensure the successful installation of the transmitter facilities, to test and tune the systems, and to make sure maintenance personnel and pilots were thoroughly trained.

DGPS STATION #1 – SAN LORENZO, HONDURAS

San Lorenzo Transmitter Site Information

CORS ID *(see p.12):*	SLOR
Latitude:	13 25 26.10574 N
Longitude:	087 26 11.40269 W
Ellipsoid height:	11.995 meters
Broadcast Site ID:	905
Transmission Frequency:	306 KHZ
Transmission Rate:	200 BPS

DGPS Transmitter facility shelter

Construction of each transmitter site included:

- Clearing the land and installing a ground plane consisting of 18 copper wire radials, 500 feet in length and 8 foot ground rods.
- Pouring concrete footings for towers, antenna tuning unit (ATU) and shelter.
- Raising twin 90 foot towers.
- Installing perimeter and ATU fences.
- Building guard and generator structures.

Installing the antenna ground plane

The transmitter facility at San Lorenzo, Honduras was the first to become operational on December 6, 2000. The site has operated continuously for over a year and has enabled vessel transits at night for the first time.

Each transmitter station and port includes multiple means for operational monitoring to ensure system availability and integrity.

Official site inauguration ceremony

The approach to San Lorenzo is 16 miles long and winds through the Gulf of Fonseca. Pilots and Masters regard the approach as very difficult both because of its length, and the frequency with which floating aids to navigation are misplaced and vandalized. The DGPS transmitter broadcasts signals with vastly improved accuracy over conventional navigation aids. Vessels equipped with DGPS receivers now are able to proceed with a position accuracy of 3 meters or better any time of day and in all weather conditions.

Pilot Navigation Display

DGPS STATION #2 – CORINTO, NICARAGUA

Corinto Transmitter Site Information

CORS ID *(see p.12):*	CORN
Latitude:	12 32 45.28461 N
Longitude:	087 10 47.71760 W
Ellipsoid height:	23.812 meters
Broadcast Site ID:	909
Transmission Frequency:	283.5 KHZ
Transmission Rate:	200 BPS

The twin 90 foot towers support a T-type antenna assembly. A transmission line runs along an underground channel from the shelter to the automatic antenna tuning unit (ATU) enclosed by the wooden fence.

Twin 90' towers

The Corinto transmitter provides DGPS signals to the ports of Corinto and Sandino in Nicaragua. Four portable pilot navigation units were supplied for use by pilots at each of the two ports. The ports of Corinto and San Lorenzo (approx. 100 km apart) have the advantage of overlapping signal coverage from the transmitters installed at each port. If an outage occurs at one of the sites, the portable DGPS receivers will automatically switch to the other beacon site.

Installing the reference antenna

An inauguration ceremony was held for the Corinto DGPS site in December 2001. Several dignitaries, including Nicaraguan President Arnoldo Aleman Lacayo, were present to address the audience of about 200. The Nicaraguan government contributed $160,000 to the construction of the transmitter site. Similar investments were made by Honduras for the purchase of land in Tela and for the construction of the transmitter sites.

Dave and Henry with Pres. Aleman

DGPS STATION #3 – TELA, HONDURAS

Tela Transmitter Site Information

CORS ID *(see p.12):*	TELH
Latitude:	15 45 02.09842 N
Longitude:	087 28 56.37084 W
Ellipsoid height:	15.6639 meters
Broadcast Site ID:	908
Transmission Frequency:	310 KHZ
Transmission Rate:	200 BPS

Transmitter site at Tela

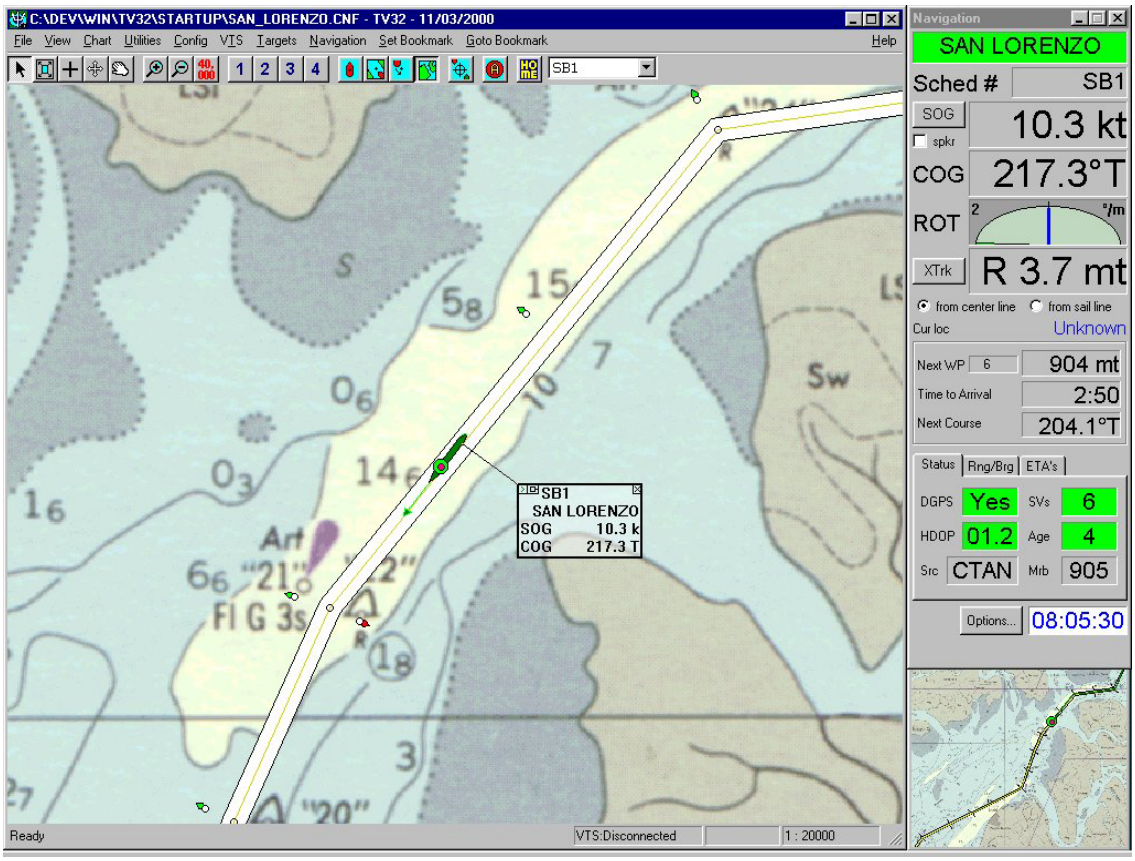
The pilot navigation display software was customized specifically for use at each of the 4 designated ports. Chart accuracy of the shipping channels and floating aids to navigation were verified using DGPS. Pilot training was conducted in the use of the portable navigation units (PNU). In addition to use as an aid to navigation by pilots, hydrographic office personnel can utilize the PNU to survey the position of floating buoys.

Pilot training and operational testing

The transmitter site located at Tela provides DGPS signal coverage to Puerto Cortes and to other maritime venues along the northern coast of Honduras. New shipping channels and terminal facilities being constructed on the Island of Roatan also may benefit from the beacon signal.

The installed systems provide DGPS services that conform to internationally adopted standards that are the norm in the United States and many other countries throughout the world. The DGPS service significantly enhances maritime safety and efficiency while lessening a dependence on visual aids to navigation. Any ship already equipped with a DGPS radio beacon receiver and electronic chart display system will be able to benefit from the system.

Map of Honduras



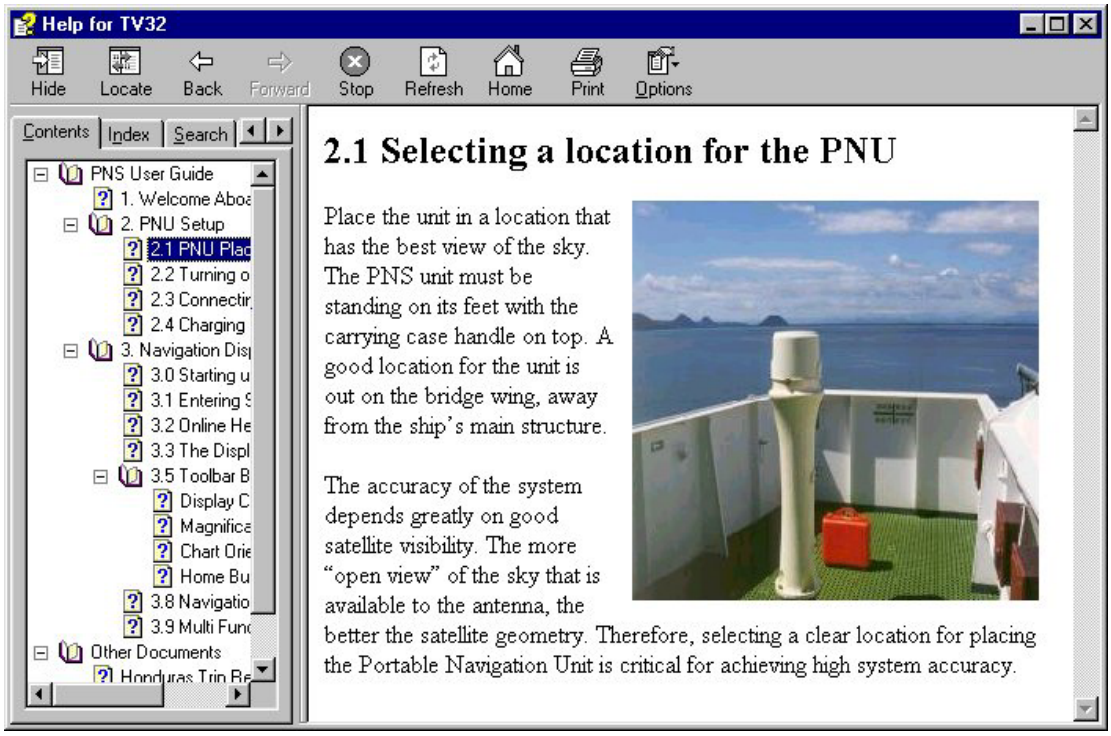
Transview Navigation display at San Lorenzo.

PILOT NAVIGATION UNITS (PNU)

The pilot navigation software, called Transview, was developed by the Center for Navigation at the Volpe Center. The displayed transit log was recorded during a visit in October 2000 to the port of San Lorenzo, Honduras. Along with precise navigation information, such as speed and distance to the next turning point, the display shows a representation of the ship and its position relative to the navigation channel.

The portable navigation units (see cover photo) were designed for durability and ease of use. The unit consists of a combined GPS and marine radio beacon receiver, switching power supply, internal batteries, and a transmitter for wireless data connection to the laptop display. The rechargeable batteries allow for at least 6 hours of continuous operation. The unit is simply switched on and placed on the bridge-wing of the ship.

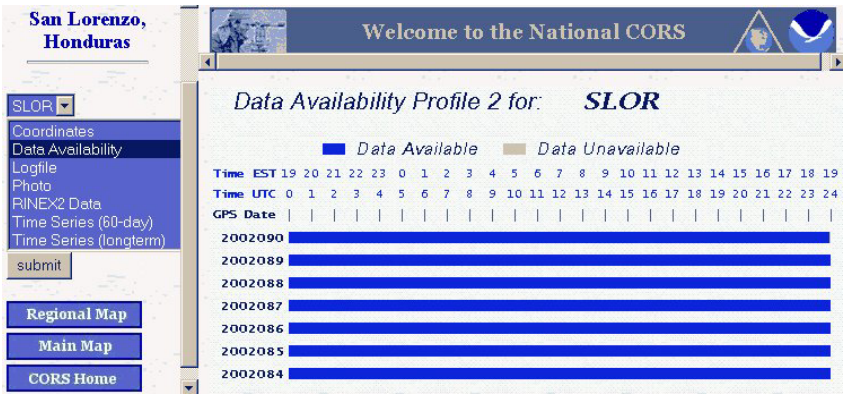
The pilot display software automatically loads when the laptop is powered on. After entering a few fields of information, such as the vessel dimensions and the location of the GPS antenna on the vessel, the display software starts plotting the course of the ship on the scrollable chart.



A page from the Pilot Navigation Unit (PNU) Online User Manual

CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

The Volpe Center team cooperated with the National Geodetic Survey (NGS) of the United States by incorporating the DGPS transmitter sites into the NGS Continuously Operating Reference Stations (CORS) network. CORS provides GPS data for positioning activities such as land surveying. The two agencies were able to leverage the investment made by the United States, Honduras and Nicaragua by co-locating the CORS equipment with the navigation system electronics. The result is a network of systems that provide vessel traffic services and geodetic services to a wide range of users employed in a variety of disciplines. An additional benefit of the cooperative effort is the enhanced system monitoring capability provided by the daily upload of GPS reference data to the CORS data network (refer to the NGS website at www.ngs.gov for information on CORS).



Data Availability Profile of San Lorenzo from CORS website.

PROJECT IMPACT

The primary objective of the navigation systems restoration project was to install navigation systems that would operate in all weather conditions, in Central America ports damaged by the hurricane. While traditional aids to navigation (i.e., floating buoys) are vulnerable to storms, expensive to maintain, and require clear visibility during navigation, the new DGPS systems allow navigation 24 hours a day, and will aid the transport of emergency supplies during future disasters if any should occur.

The installation of the technologically advanced Differential GPS navigation systems in Honduras and Nicaragua represents a significant advancement for maritime port operations in the region. These are the first and only DGPS radio beacon systems installed in Honduras and Nicaragua. For over a year, the transmitter station at San Lorenzo has been broadcasting differential corrections to the GPS signals used by the pilot navigation units to aid navigation at the port. Members of the port authority at San Lorenzo express confidence that the navigation systems will continue to provide a catalyst for new growth. In addition, plans are underway for the development of a new concrete manufacturing facility at San Lorenzo that will bring a significant increase in the volume of vessel traffic at the port.

Likewise, in his address made at the official inauguration ceremony for the DGPS transmitter site at the Port of Corinto, Nicaragua President Aldolfo Aleman, stated that he envisions the eventual establishment of a major commercial center in the region based on the proximity of the port and the importance of maritime trade to the economies of Central America. The importance of maritime trade to the economy is reflected in the multi-million dollar investment made by the Government of Nicaragua to modernize and improve their port facilities, including the establishment of the new navigation systems.

The transmitter installation at Tela, Honduras provides DGPS navigation services to the Port of Cortes and to many of the smaller maritime ports along the northern coast and bay islands of Honduras. These ports can expect an increase in vessel traffic directly due to the added assurance of navigation safety and efficiency that the new system provides. As anecdotal evidence, several conversations with commercial shipowners and masters were held regarding the establishment of the new navigation systems. All agreed that the new systems would provide valuable aids to navigation in the often-difficult approaches to the ports throughout the region. As the emphasis on expanding trade throughout the Western Hemisphere continues over the next few decades, vessel traffic services will become ever more important in maintaining safety while ensuring competitiveness.

LOCAL SUPPORT AND COMMITMENT

The Volpe Center project team received outstanding support from officials of the National Port Authorities and Transportation Ministries of Honduras and Nicaragua. This support is viewed as a testament to the importance of this project to each country, and as an expression of the sincere gratitude felt by both Central American governments for the assistance provided by USAID and the United States Department of Transportation, in the wake of Hurricane Mitch. Furthermore, this project, to restore and modernize navigation systems in Central America, provides an excellent example of how the application of technology, developed in the United States, can be used to strengthen the bonds of friendship between countries.

Authorities at the National Port Enterprises in both Honduras and Nicaragua have expressed a deep commitment to sustain the operation of the DGPS navigation systems. The level of investment made and the attention to detail by the partners has resulted in the establishment of DGPS radio beacon transmitter sites that are among the best in the world and should continue to provide navigation services for many, many years to come.

ACKNOWLEDGEMENTS

The Volpe Center project team would like to acknowledge the support and leadership provided by USAID staff both in Washington and the missions in Honduras and Nicaragua. The missions assisted in issuing country clearances and helping to coordinate US representation at dedication ceremonies at which ownership of the DGPS navigation systems was transferred from the United States to the host countries. The team owes a special debt of gratitude to Mr. Don Harrison who recognized the value of satellite technology in the navigation restoration program and to both Mr. Raymond Lynch and Mr. Robert Meehan for their superb leadership and vision during the multi-agency reconstruction efforts in Central America, as well as for helping ensure the successful completion of our project. We also would like to extend special thanks to Dr. Steven Van Beek and Mr. Bill Medigovich of RSPA and Dr. Richard John and Ellen Bell of the Volpe Center for their assistance and interest in this project. Many others contributed invaluably to the success of this program and we thank all of you as well.

Toncontin Airport, Tegucigalpa – December 1999*. Volpe Team with (front l to r) RSPA Administrator Kelly Coyner, DOT Secretary Rodney Slater, and COCATRAM Executive Director Liana de Cáceres.*

DGPS Transmitter and Shelter

The following is a list of the equipment that was shipped from the Volpe Center and arrived at the Soto Cano AFB in Comayagua, Honduras on December 13, 1999. The shipment included one 20' ISO container that was used to shelter the first DGPS transmitter deployed in Central America as part of the USAID Reconstruction Project for Maritime Navigation Systems. Later, similar equipment was shipped to Corinto, Nicaragua and Cortes, Honduras.

ISO Container (white corrugated steel - 8'6"H x 8'D x 20'W)
Identification Number: 920171

1. Finished/Insulated walls
2. Square D General Duty Safety Switch, Model: 200A, 240VAC
3. Square D Breaker Panel 1 (UPS Panel/Small)
4. Square D Breaker Panel 2 (Main Panel/Large)
5. Time Delay Circuit
6. 4 High Pressure Sodium Lamps
7. Emergency Safety Door
8. Two (2) Air Conditioner Wall Openings
9. Four (4) Grounding Lugs

Nautel 1000W Transmitter System

- *Transmitter System*
  Model: NX4000BD-50-01
  S/N: 112

- *Top 500W Power Cube:*
  Type: NAP1/2
  S/N: 133

- *Bottom 500W Power Cube:*
  Type: NAP1/2
  S/N: 132

- 16 Power Amplifier Slices

P/A Slice	Type	Serial No.
1	NAA-7	1093
2	NAA-7	2851
3	NAA-7	984
4	NAA-7	2848
5	NAA-7A	B4211
6	NAA-7A	B4206
7	NAA-7B	B4224
8	NAA-7	1149
9	NAA-7	2849
10	NAA-7B	2850
11	NAA-7B	2855
12	NAA-7	872
13	NAA-7	2839
14	NAA-7	2856
15	NAA-7	2836
16	NAA-7	2167

- *Harmonic Filter/Combiner:*
  Type: NAF25
  S/N: 38

- *Exciter Drawer: Type:*
  NAD3/4
  S/N: 19

- *Exciter Boards:*
  A – Assy: 141-3060; Iss: B; S/N: 84
  B – Assy: 141-3060; Iss: B; S/N: 592

- *Monitor Board: Assy:*
  Assy: 141-3023; Iss E; S/N:36

- *Power Supply:*
  Type: NASR50/1
  S/N: 8

Two (2) Nautel 1000W Antenna Couplers/Tuners:
Model: MX400TUB
S/N: 8, 9

Nautel Interface Protection Unit for 1000W Transmitter
Model: NAX057/02
S/N: B269

PolyPhaser 200A Impulse Protector
Model: IL240-BP-200A;
S/N: 000011867

Dayton Transfer Switch: Model:
Model: 4W123A,
S/N: 3112896

Powerware Un-interruptable Power Supply:
Model: 12.5L/10
S/N: BR397W0566

Protection Circuits and Grounding Equipment:
1. PolyPhaser Gounding Panel
2. Two (2) PolyPhaser Protector for GPS antenna
3. Model: MR50LNZ+15, 1.2GHz-2.0GHz
4. PolyPhaser Protector for MSK antenna
5. Model: IS-50NB/18, DC-50MHz
6. PolyPhaser Single Pair Telephone Line Protector
7. Model: IS-SPTL
8. PolyPhaser Dual Pair Telephone Line Protector
9. Model: IS-DPTL
10. Ground strap and ground hubs
11. 4-Port Cable Entry & Ground Bar

Two (2) Friedrich 28,000 BTU Air Conditioners
Model: SL28J30A
S/N: JJGS15694
S/N: JHMS19215

72" Receiver Electronics Rack

340' Coaxial Cable *(TRANSMITTER TO ANTENNA COUPLER)*

Three (3) 20' Coaxial Cables *(RECEIVERS TO PROTECTORS)*

Coaxial Supplies:
1. Four (4) ½" Superflex Coaxial Cable Connectors (for receivers)
2. Two (2) ¼" Superflex Coaxial Cable Connectors (for receivers)
3. Four (4) ½" Foam Heliax Connectors (for transmitters)

Cable Conduit Supplies:

1. Thirty (30) 10’ 2” PVC Conduit Sections
2. Five (5) 2” PVC Elbows
3. Ten (10) 2” PVC Couplers
4. Three (3) 32oz PVC Cement

Miscellaneous Supplies

1. Four (4) Cans White Spray Paint
2. 100’ Extension Power Cable
3. U.S. Government issue steel 72” book shelf
4. U.S. Government issue steel 2’ x 3’ table
5. Two (2) 250’ SJOOW Power Cables