

## **Session 20**

### **Jose Garcia**

FDOT D1 Structures & Facilities Engineer

### ***The Skyway Bridge - Yesterday, Today & Tomorrow***

#### **Topic Description**

The Skyway Bridge - Yesterday, Today & Tomorrow

#### **Speaker Biography**

Mr. Garcia is a graduate of the University of South Florida with BSE and MSE degrees and is a Florida registered professional engineer. Mr. Garcia's areas of technical interest and experience include structures, materials, geotechnical, fluids and construction support. He worked in private industry in engineering and business, and joined the FDOT's District 7 staff in 1991. Mr. Garcia started his FDOT career in roadway maintenance, transferred to the district structures design office first and to the district structures and facilities office in 1991. As construction Resident Engineer for bridge repairs and rehabilitation and District 1 & 7 Structures and Facilities Engineer, Mr. Garcia is in responsible charge of the Department's structures inspection and maintenance work effort for two districts, which include 28% of all qualifying bridges in the State of Florida and the Bob Graham Sunshine Skyway Bridge, the flag bridge of the State. He has co-published several papers on the evaluation and repairs of post-tensioned systems in the Skyway Bridge.



# Sunshine Skyway Bridge

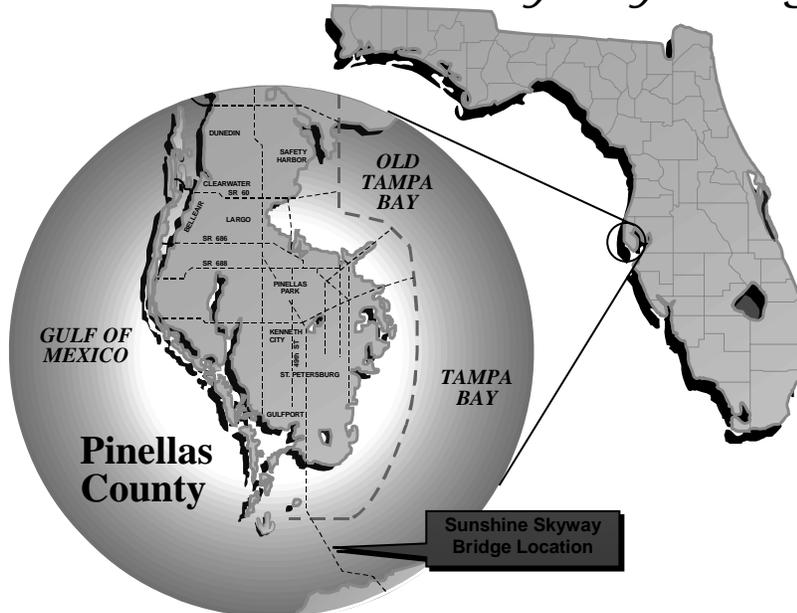
*Yesterday, Today and Tomorrow*



Presented by:  
**Pepe Garcia, P.E.**  
**Teddy Theryo, P.E.**

*FDOT Design Conference: August 2006*  
*Orlando, Florida*

# Sunshine Skyway Bridge



## *Sunshine Skyway Bridge*

### History

- SEPT. 6, 1954: The \$22 million, 4-mile Sunshine Skyway bridge opens with two lanes between Manatee and Pinellas counties
- MAY 19, 1971: A second two-lane Skyway span is added at a cost of \$25 million. Built west of the original span, it carried southbound traffic
- MAY 9, 1980: A phosphate freighter strikes a Skyway pier during a severe storm. A huge section of the span built in 1971 crumbles into the Bay killing 35 people
- MAY 11, 1980: The undamaged northbound span of the bridge reopens for two-way traffic

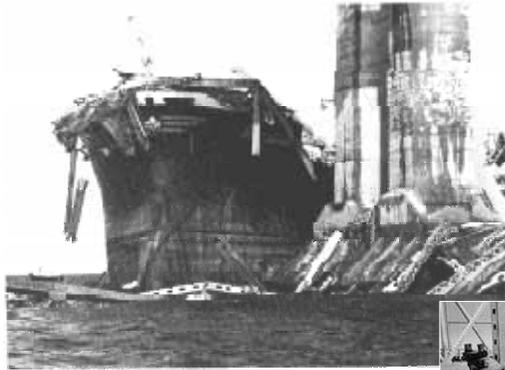
## *Sunshine Skyway Bridge*

### Yesterday...



## *Sunshine Skyway Bridge*

*Summit Venture  
Bridge Impact 1980*



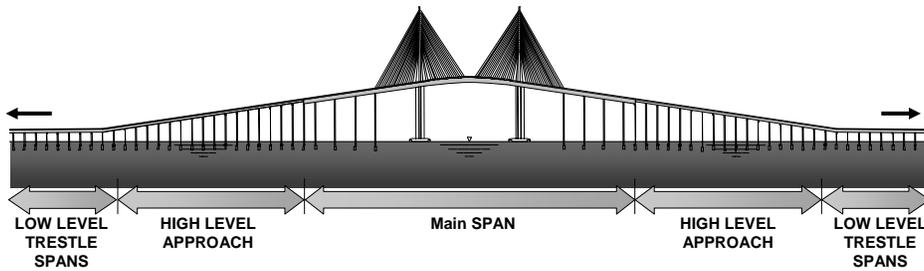
## *Sunshine Skyway Bridge*

### History

- A signature replacement bridge was envisioned by then Governor Bob Graham
- APRIL 30, 1987: A new, \$244 million Sunshine Skyway opens. It is touted as safer than the old bridge. The shipping channel is widened about 50 percent
- The bridge is considered the “flag bridge” of the State
- The bridge receives significant local and national media attention
- SEPT. 29, 1999: Establishment of Skyway Bridge Maintenance Committee,
- The bridge rates Travel Channel’s No. 3 of “Top 10 Bridges”
- NOV. 21, 2005: Bridge named The Bob Graham Sunshine Skyway Bridge

# Sunshine Skyway Bridge

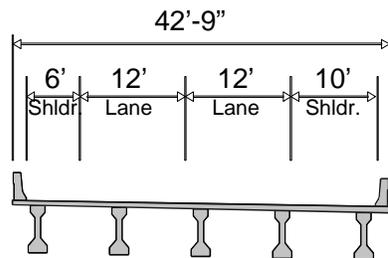
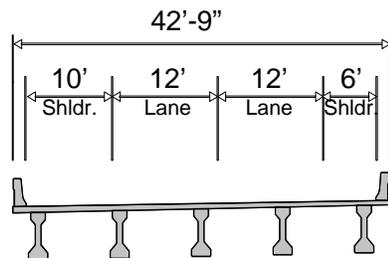
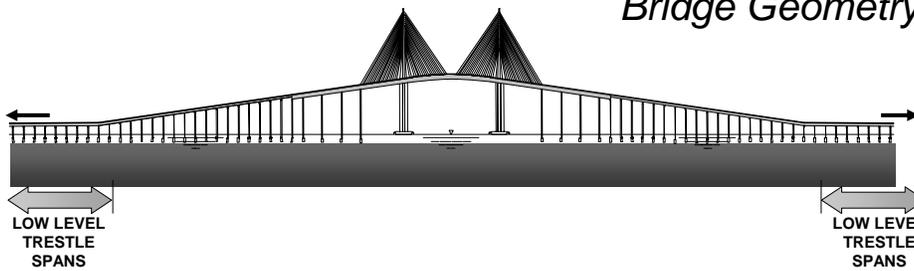
## Bridge Geometry



**Total Bridge length: 4.14 miles**

# Sunshine Skyway Bridge

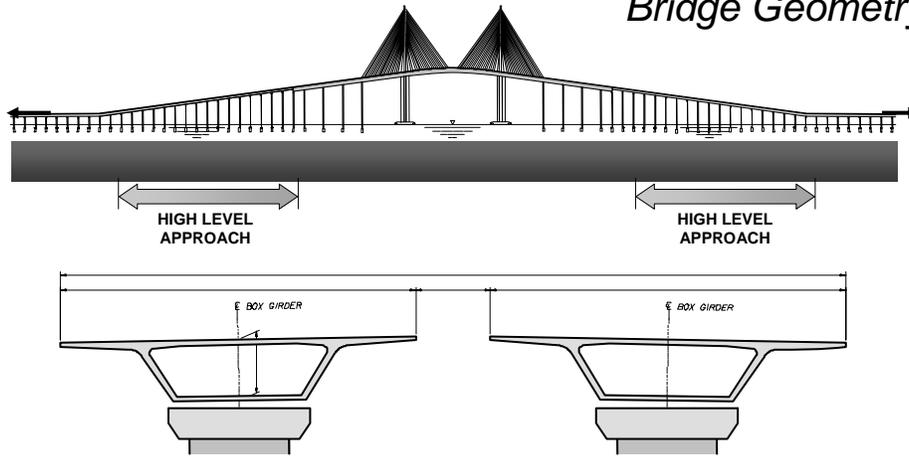
## Bridge Geometry



**Total Length: 13,000 ft**

# Sunshine Skyway Bridge

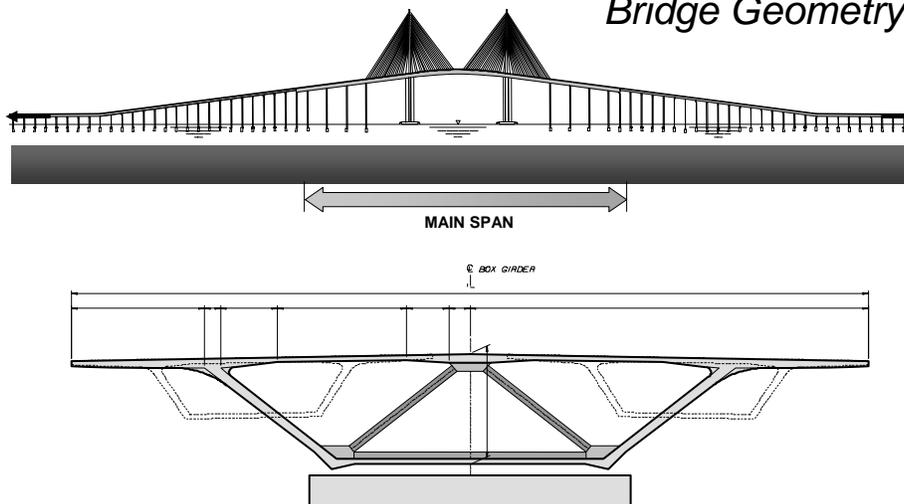
## Bridge Geometry



- Total length: 5,000 ft
- Post-Tensioned Segmental Box Girders
- Vertically Post-Tensioned Segmental Columns

# Sunshine Skyway Bridge

## Bridge Geometry

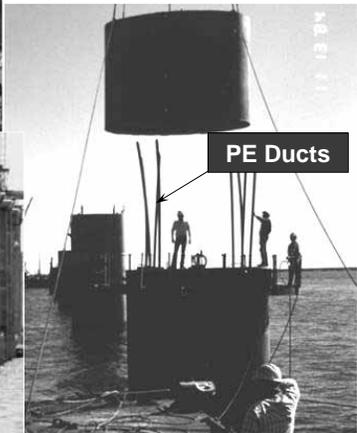


- Total length: 4,000 ft
- Post-Tensioned Precast Segmental Box
- 42 Continuous Stay Cables, 21 per Pylon

# Sunshine Skyway Bridge



High Level Approaches  
Pre-Cast Column  
PT Segments



# Sunshine Skyway Bridge

High Level Approaches  
Superstructure  
PT Segmental Construction



# Sunshine Skyway Bridge

Main Span  
Pre-Cast  
PT Segments



June 1984...



# Sunshine Skyway Bridge

PT Cable Stays



*Sunshine Skyway Bridge  
Main Span*



*Stay Cable Dampners*



*Sunshine Skyway Bridge*

*Yesterday and Today...*



*Sunshine Skyway Bridge*  
*Yesterday's Gone...*



*Sunshine Skyway Bridge*

*Today...*

**Skyway Run January 11, 1987  
Over 15,000 people**



**Open to Traffic  
April 30, 1987**

## *Sunshine Skyway Bridge*

*Today...*



## *Sunshine Skyway Bridge*

- **New Design Features**

- Ship Impact Protection
- Precast Segmental Construction
- Roadway/Navigational Realignment
- Increased Horizontal and Vertical Clearances
- 1980s Functional Features
- Improved Material Specifications
- Video Camera Surveillance System
- Lightning Protection System
- PT Multiple Corrosion Barrier System



## *Sunshine Skyway Bridge*

### **Maintenance Challenges**

- Chloride Attack
- Cracking in Approach Columns
- Teflon Bearings 1993
- Modular Joints
- Armored Angle Joints
- Stay Cable Painting
- Barrier Wall Coating
- PT Failures
- PT System Monitoring
- Electrical System
- Elevators
- Lightning Protection
- Tower Railings
- Access Improvements
- AASHTO Beam Shear Cracking
- Video Surveillance System

## *Sunshine Skyway Bridge*

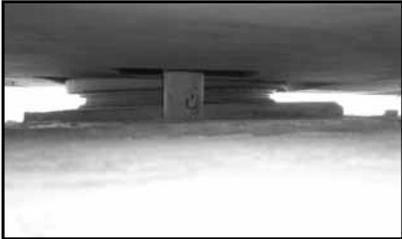
### *Armored Joint*



*Sunshine Skyway Bridge*



**Teflon Bearings**



Replacement 1993

*Sunshine Skyway Bridge*

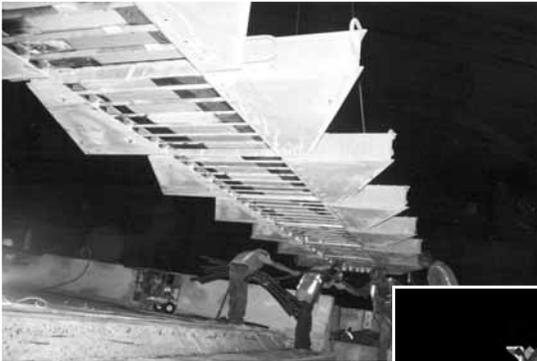


*Spot Paint Project 1997*



# Sunshine Skyway Bridge

Modular Joint Replacement  
2001



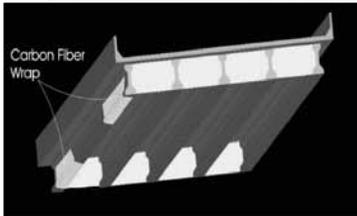
# Sunshine Skyway Bridge

Access Stairs  
Segmental Transition  
2003



# Sunshine Skyway Bridge

## Lower Trestle Spans



Beam Shear Cracking



Cap Cracking

# Sunshine Skyway Bridge



## *Sunshine Skyway Bridge*

### ***Investigation Methods***

- **Vibration Test**
- **Water Ponding Test**
- **Half-cell Potential**
- **Electrical Continuity Check**
- **Bore Scope**
- **Concrete Coring and Excavation**
- **Material Testing**

*Note: Combination of Tests Required  
No Single Definitive Reliable Test*

## *Sunshine Skyway Bridge*

### **PT Investigation**



*PT Tendon Vibration Testing*

**Academia  
Collaboration**

*NDT- Non-Destructive Testing*



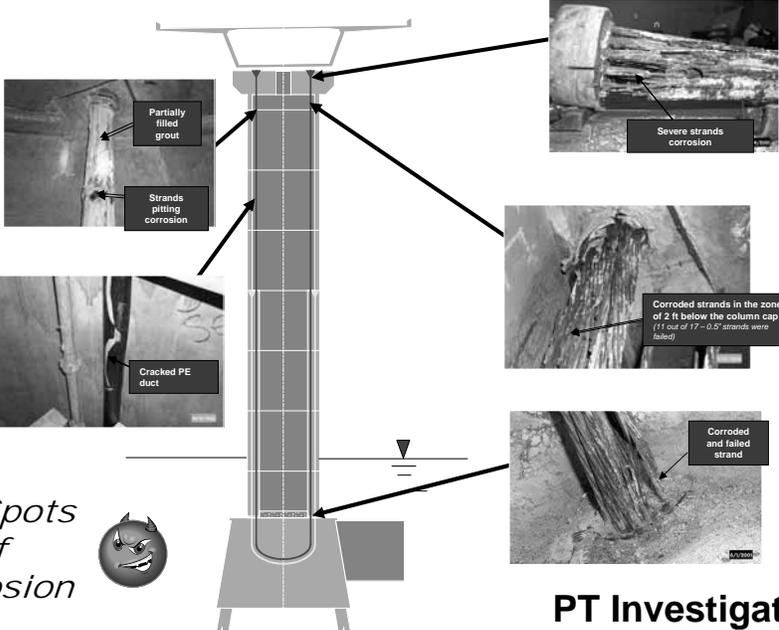
# Sunshine Skyway Bridge

## PT Investigation



Destructive Testing

# Sunshine Skyway Bridge



Hot Spots of Corrosion



## PT Investigation

# Sunshine Skyway Bridge

## PT Investigation



High Level Approach  
Superstructure Inspection



# Sunshine Skyway Bridge

## PT Investigation



Main Span  
Superstructure  
Inspection



# Sunshine Skyway Bridge

P2

## PT Investigation



- Stay Cables
  - Vibration Testing
  - Shock Absorber Testing



# Sunshine Skyway Bridge

## PT Investigation Summary

- Tendon Corrosion
- Tendon Failures
- Split/Crack PE Duct
- Grout Voids
- Contaminated Grout
- Salt Water in Hollow Columns
- Segmental Joint Leaks
- Concrete cracks
- PE Duct Material Deficiency
- Poor PE Duct Connection Detail
- Cracked Pourbacks

**Slide 35**

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**P2** This is Preventive Maintenance- Both tests to be performed every 5 years  
PBQD, 7/6/2006

## *Sunshine Skyway Bridge*

### **PT Repair and Maintenance Strategy**

#### Structural Redundancy

#### Restoration of Corrosion Protection

- PT Duct Wrapping
- PT Void Grouting

#### New Levels of Corrosion Protection

- Surface Coatings
- Pour-backs
- Caps
- Main Span Median
- Watertight Joints
- New PT Corrosion Protection Strategies

#### Localized or Universal Repairs as Applicable

#### Monitoring Program

## *Sunshine Skyway Bridge*

### **Engineering Evaluation**

#### **Geotechnical:**

- Review of existing pile driving records
- Review of boring log
- Evaluate the existing foundation capacity (FB Pier)

#### **Structural:**

- Global time dependent analysis model
- Finite element analysis
- Vessel Collision Risk analysis
- Evaluate structural capacity of existing column and new repair options
- FDOT PT Corrosion Protection Improvement Strategies

#### **Materials:**

- Mass concrete with fly ash or slag
- PT bars (45 mm diameter)
- Approved pre-packaged grout material
- Improve PT details
- Polymer coating (polyurethane)
- Shrink Wrap

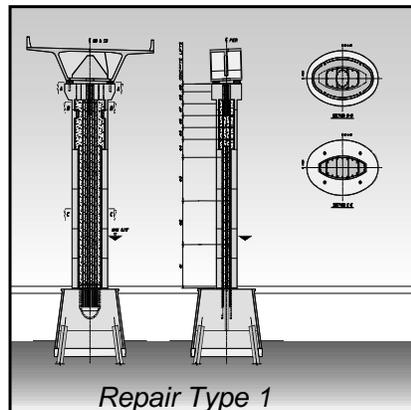
## *Sunshine Skyway Bridge*

### **FDOT PT Corrosion Protection Improvement Strategies**

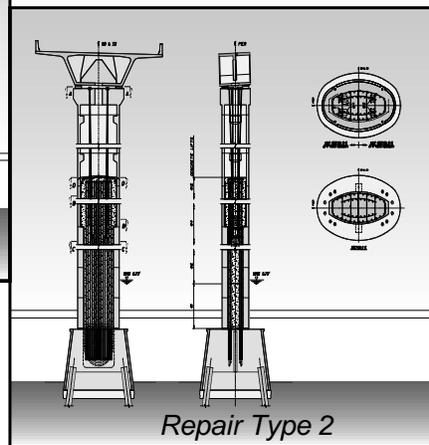
- 2001: Revised grouting specifications
- 2001: FDOT allowed only Non-Bleed approved prepackaged grout materials
- Since 2002: FDOT New Direction for Florida Post-Tensioned Bridges
- FDOT Five Strategies
  - Strategy 1: Enhanced PT Systems
  - Strategy 2: Fully Grouted Tendons
  - Strategy 3: Multi-Layered Anchor Protection
  - Strategy 4: Watertight Bridges
  - Strategy 5: Multiple Tendon Paths

## *Sunshine Skyway Bridge*

### **PT Repairs Structural Redundancy**



High Level Approaches  
Column



*Sunshine Skyway Bridge*  
**PT Repairs**



*Column Bars Through Segmental Box Girder*

*Sunshine Skyway Bridge*  
**PT Repairs**



*Sunshine Skyway Bridge*

**PT Repairs**



*Vertical Tendon Grouting  
Mock-Up Test Set-Up  
2003*



*Sunshine Skyway Bridge*

**PT Repairs**



*Additional Levels of Corrosion Protection*

# Sunshine Skyway Bridge

## PT Repairs



*Additional Levels of Corrosion Protection*

# Sunshine Skyway Bridge Today's Maintenance Plan

### Maintenance Steering Committee

- Maintenance Continuity for Service Life

### Asset Maintenance Contract

- Inspection and Monitoring Services
- Routine Maintenance MMS 800 Series Activities
- Non-Routine (Periodic)

### Non-Routine Maintenance

- Asset Maintenance
- Project Specific
- Emergency
- Fast Response

### Engineering, Planning and Construction Management Support



*Maintenance Steering Committee  
September 1999*

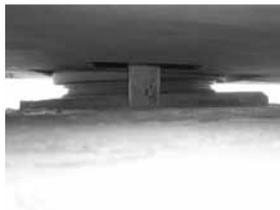
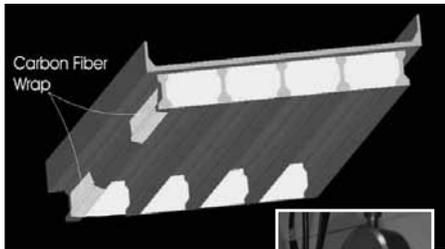
## *Sunshine Skyway Bridge*

### *Asset Maintenance Contract*



## *Sunshine Skyway Bridge*

### *Non-Routine Maintenance*

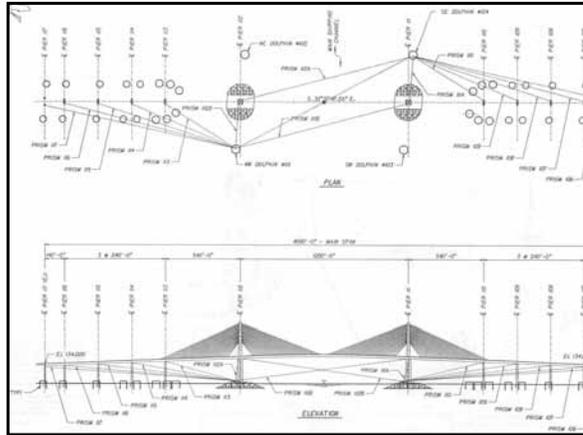


## *Sunshine Skyway Bridge Engineering, Planning and Construction*



**Running Dolphin  
Control Traverse**

*Monitoring  
GPS and ATS*

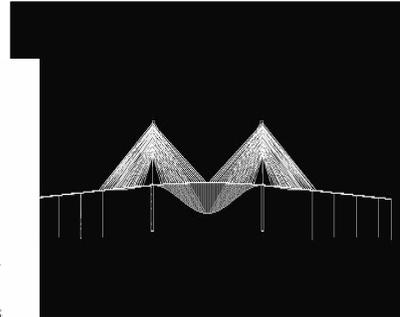
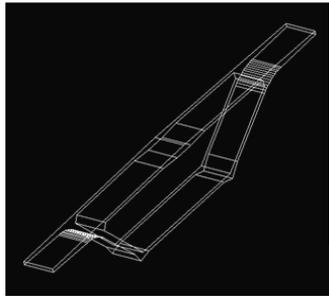
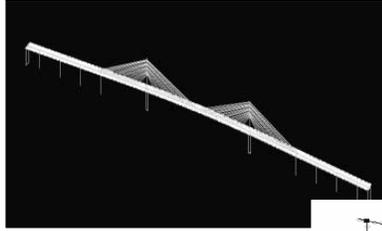


## *Sunshine Skyway Bridge Engineering, Planning and Construction*

### **Structural Modeling**

- **Time-Dependent Structural Analysis**
  - High Level Approaches
  - Main Span
- **Finite Element Modeling**
- **Soil-Pile Interaction**
  - High Level Approaches

## *Sunshine Skyway Bridge* *Engineering, Planning and* *Construction*



*Monitoring*  
*Structural Modeling*  
*Calibration*

## *Sunshine Skyway Bridge* *Tomorrow...*

### Immediate

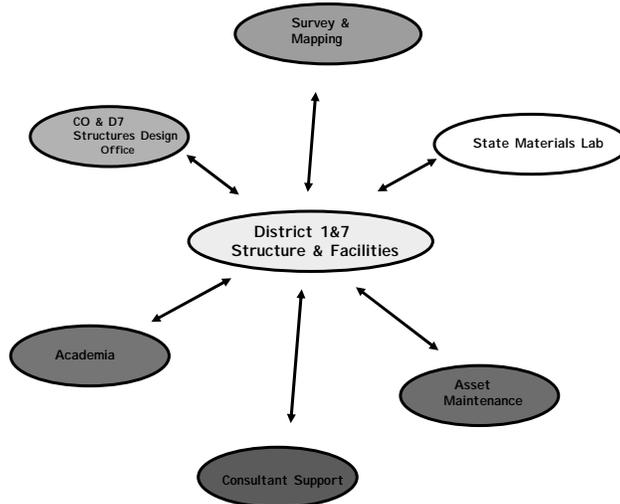
- Lightning Protection System Minor Upgrade
- Cable Stay Painting and Barrier Wall Coating
- Lighting Rehabilitation
- AASHTO Beam Repairs
- Additional Global Positioning System (GPS) and Automatic Total Stations (ATS)
- Security/Emergency Table Top Exercise

### Longer Term

- Continuing PT Monitoring
- Corrosion Monitoring
- Elevator Upgrade
- Calibration of Analysis Models
- Aesthetics

# Sunshine Skyway Bridge

## A Team Effort



# Sunshine Skyway Bridge

## Today and Tomorrow...



**Gene Figg**  
1937 - 2002



**Pepe Garcia**



### Travel Channel's Top 10 Bridges

1. Golden Gate Bridge, San Francisco, California
2. Akashi Kaiyko Bridge, Kobe, Japan
- 3. Sunshine Skyway Bridge, St. Petersburg, FL**
4. Tower Bridge, London, England
5. Firth of Forth Bridge, Queensferry, Scotland
6. Brooklyn Bridge, Brooklyn, NY
7. Chesapeake Bay Bridge-Tunnel, Virginia Beach, VA
8. Sydney Harbour Bridge, Sydney, Australia
9. Leonard P. Zakim Bridge, Boston, MA
10. London Bridge, Lake havasu, AZ



*Bob Graham Sunshine Skyway Bridge*



Questions?

