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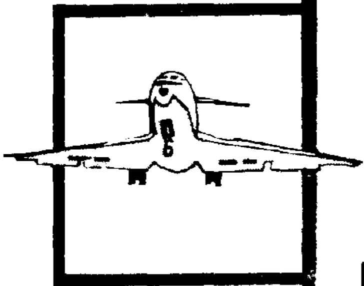

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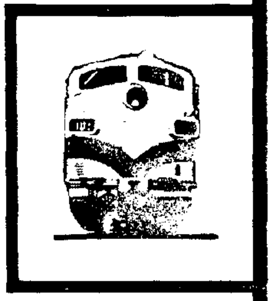
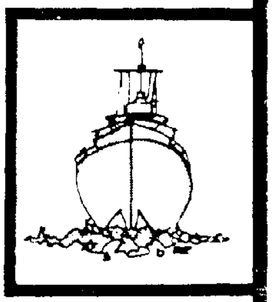
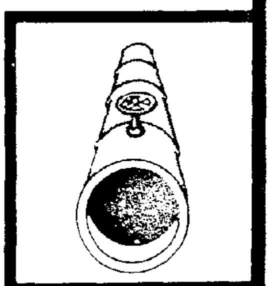


WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT



RAMMING OF THE SUNSHINE SKYWAY BRIDGE
BY THE LIBERIAN BULK CARRIER SUMMIT VENTURE
TAMPA BAY, FLORIDA
MAY 9, 1980



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16. Abstract
About 0734 e.d.t. on May 9, 1980, the Liberian bulk carrier M/V SUMMIT VENTURE rammed a support pier of the western span of the Sunshine Skyway Bridge in Tampa Bay, Florida. As a result of the ramming, the support pier was destroyed and about 1,297 feet of bridge deck and superstructure fell from a height of about 150 feet into the bay. A Greyhound bus, a small pickup truck, and six automobiles fell into the bay and 35 persons died. Repair costs were estimated at about $30 million for the bridge and about $1 million for the SUMMIT VENTURE.

The National Transportation Safety Board determines that the probable cause of this accident was the SUMMIT VENTURE's unexpected encounter with severe weather involving high winds and heavy rain associated with a line of intense thunderstorms which overtook the vessel as it approached the Sunshine Skyway Bridge, the failure of the National Weather Service to issue a severe weather warning for mariners, and the failure of the pilot to abandon the transit when visual and radar navigational references for the channel and the bridge were lost in the heavy rain. Contributing to the loss of life and to the extensive damage was the lack of a structural pier protection system which could have absorbed some of the impact force or redirected the vessel. Contributing to the loss of life was the lack of a motorist warning system which could have warned the highway vehicle drivers of the danger ahead.

17. Key Words
bulk carrier, Sunshine Skyway Bridge, thunderstorm, weather forecasts, visibility, radar, Vessel Traffic Service, bridge protection, pilotage, navigation.

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CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

Adopted: April 10, 1981

RAMMING OF THE SUNSHINE SKYWAY BRIDGE BY THE LIBERIAN BULK CARRIER SUMMIT VENTURE TAMPA BAY, FLORIDA, MAY 9, 1980

INTRODUCTION

This accident was investigated jointly by the National Transportation Safety Board and the U.S. Coast Guard. A U.S. Coast Guard Marine Board of Investigation was convened in Tampa, Florida, on May 13, 1980. Twenty-eight persons testified during the 10-day public hearing, and 93 exhibits were accepted into the record.

This report is based on the factual information developed by that investigation and on additional analyses made by the Safety Board. The Safety Board has considered all those facts in the investigative record that are pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the accident and to make recommendations.

The Safety Board's analyses and recommendations are made independently of the Coast Guard. To inform the public of all Safety Board recommendations and the responses to those recommendations, all such recommendations and responses are published in the Federal Register.

SYNOPSIS

About 0734 e.d.t. on May 9, 1980, the Liberian bulk carrier M/V SUMMIT VENTURE rammed a support pier of the western span of the Sunshine Skyway Bridge in Tampa Bay, Florida. As a result of the ramming, the support pier was destroyed and about 1,297 feet of bridge deck and superstructure fell about 150 feet into the bay. A Greyhound bus, a small pickup truck, and six automobiles fell into the bay and 35 persons died. Repair costs were estimated at about $30 million for the bridge and about $1 million for the SUMMIT VENTURE.

The National Transportation Safety Board determines that the probable cause of this accident was the SUMMIT VENTURE's unexpected encounter with severe weather involving high winds and heavy rain associated with a line of intense thunderstorms which overtook the vessel as it approached the Sunshine Skyway Bridge, the failure of the National Weather Service to issue a severe weather warning for mariners, and the failure of the pilot to abandon the transit when visual and radar navigational references for the channel and the bridge were lost in the heavy rain. Contributing to the loss of life and to the extensive damage was the lack of a structural pier protection system which could have absorbed some of the impact force or redirected the vessel. Contributing to the loss of life was the lack of a motorist warning system which could have warned the highway vehicle drivers of the danger ahead.

INVESTIGATION

The Accident

About 1634 1/ on May 6, 1980, the Liberian bulk carrier M/V SUMMIT VENTURE arrived at an offshore anchorage near the entrance to Tampa Bay, Florida, after proceeding in ballast from Houston, Texas. The master waited for loading instructions for 3 days. During the early morning on Friday, May 9, 1980, preparations were made to proceed to Rockport Terminal in Tampa Bay. No deficiencies were found when the navigational gear was tested.

About 0430, the pilot assigned to the SUMMIT VENTURE arrived at the Tampa Bay Pilot Station on Egmont Key. Although there was a slight mist, he could see Mullet Key, about 2 miles distant. The pilot determined the SUMMIT VENTURE's size and vessel type from Lloyd's Register of Ships. 2/ Using the VHF radio at the pilot station, he checked the traffic that was expected to transit the bay that morning. He contacted the SUMMIT VENTURE and received from the master a visibility report that was "something negative." The pilot told the master to keep the SUMMIT VENTURE at anchor and to stand by on the radio. About 0500, the pilot contacted the master of the inbound tug DIXIE PROGRESS in Egmont Channel and received a report that the visibility was 3 to 4 miles. Shortly afterward, the pilot received a report from the master of the SUMMIT VENTURE that the visibility was about 3 miles. Based on these reports, the pilot decided that the visibility was satisfactory to begin moving the SUMMIT VENTURE inbound. He advised the master of the SUMMIT VENTURE to keep to the north side of Egmont Channel because of outbound traffic, and informed him of the time and place he would board the vessel.

At 0543, the SUMMIT VENTURE's anchor was raised and the vessel proceeded toward the entrance to Tampa Bay. The sky was overcast, it was dark, and there was some light fog. The bridge watch on the SUMMIT VENTURE consisted of the master at the conn, the chief officer at the engine order telegraph and keeping the log, and the quartermaster at the helm. The pilot and a pilot-trainee boarded the pilot boat about 0545 for the 45-minute ride to the SUMMIT VENTURE. They arrived alongside the vessel about 0620 and boarded the SUMMIT VENTURE from the portside. The vessel was on an easterly heading with the wind from the southwest at about 10 to 15 knots. The second mate met them on deck and escorted them to the bridge. The pilot introduced himself to the master and requested information about the vessel's speed. Using a flashlight, the mate pointed out the posted maneuvering speeds used aboard the vessel. The master replied that maneuvering full speed ahead was 11.3 knots. The pilot questioned the master if the gyrocompass had any error, and the master said that there was none. After discussing the operation of the vessel's radar with the master, the pilot assumed the conn and ordered half ahead maneuvering on the engine about 0630.

The vessel at that time was north of Egmont Channel and west of channel buoy 1. (See figure 1.) After an outbound vessel had passed clear, the pilot-trainee assumed the conn and maneuvered the SUMMIT VENTURE into Egmont Channel between buoys 1 and 2. The Egmont Channel inbound course is 083°. 3/ The SUMMIT VENTURE was steadied on a heading of about 084° to allow about a 1° leeway for the effects of wind and current. The chief officer, who was also the watch officer, noted the times of passing channel buoys on the navigational chart of the area as the vessel proceeded inbound. The record of engine orders was kept by an automatic bell-logger in the wheelhouse. As the

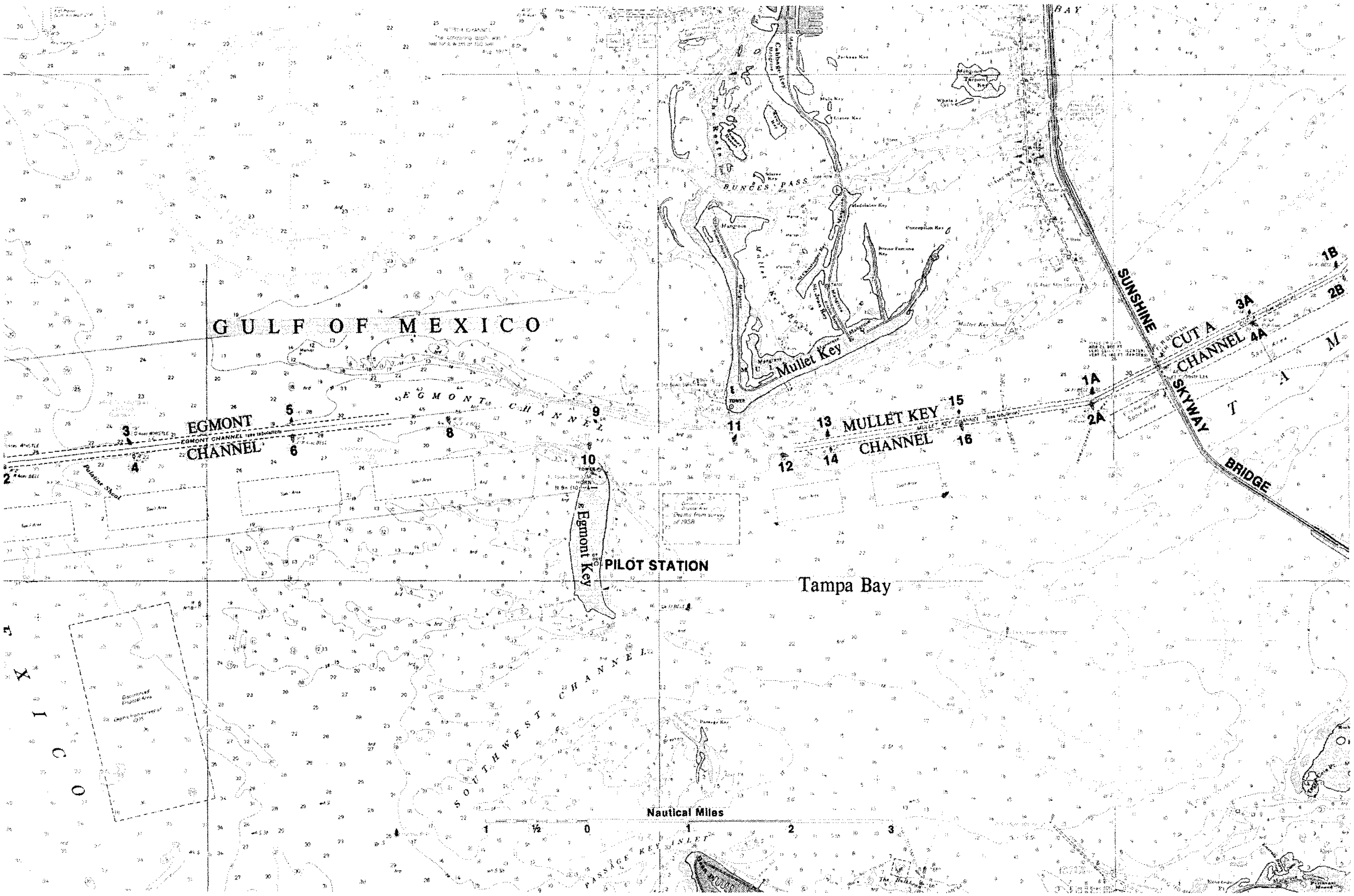


Figure 1.--Lower Tampa Bay, Florida.

vessel continued inbound in Egmont Channel, the pilot established radio communication with the master of the tug DIXIE PROGRESS, which was inbound with a barge in tow and in a rain squall near buoy 8. Because the tug's radar was not operating properly, the pilot directed the tug toward buoy 8 with information obtained from the SUMMIT VENTURE's radar until the tug's master visually sighted the buoy. An overtaking agreement was made, and the pilot-trainee ordered full ahead maneuvering on the SUMMIT VENTURE's engine about 0650 in order to overtake the tug before meeting the outbound M/V GOOD SAILOR. By the time the SUMMIT VENTURE neared buoy 8, the rain squall had dissipated, and the visibility was about 3 to 4 miles. After overtaking the DIXIE PROGRESS, meeting information was exchanged with the pilot of the GOOD SAILOR, which was about 3 nmi away and visually in sight. The SUMMIT VENTURE passed abeam the Egmont Key lighthouse about 0706, and shortly thereafter passed the GOOD SAILOR port to port.

As the SUMMIT VENTURE came abeam buoy 11, a light rainshower was encountered, and the pilot requested the master to post a lookout and an anchor watch at the bow in anticipation of reduced visibility. Buoy 13 was still in sight visually. By 0723, the boatswain, who had been assigned as the lookout, and the carpenter, who had been assigned the anchor watch, were at their stations at the bow.

As the vessel passed between buoys 13 and 14, buoy 13 was seen visually and verified by the pilot. The pilot testified that the rain had increased from a "slight drizzle around buoy 11" to "just rain, but not heavy rain." Buoy 16 was in sight visually, and buoys 15, 16, 1A, and 2A, along with the Sunshine Skyway Bridge, were displayed clearly on the radar on the 6-nmi range. The pilot also identified the outbound S/S PURE OIL, which was near buoy 1B northeast of the bridge, and contacted that vessel's pilot by VHF radio. The pilots exchanged routine positional information about their vessels, but a meeting agreement was not established because the vessels were more than 5 nmi apart.

Because the rain had increased and because the SUMMIT VENTURE was approaching the Sunshine Skyway Bridge, the pilot assumed the conn from the pilot-trainee and ordered the vessel's speed reduced to half ahead maneuvering about 0721. To allow about a 2° leeway for the effects of the current and the southwest wind, the pilot ordered a course of 083° to be steered to make good the Mullet Key Channel inbound course of 081°.

After the SUMMIT VENTURE had passed between buoys 15 and 16, buoys 1A and 2A were not in sight visually, but they remained clearly visible on radar. The rain suddenly increased in intensity when the vessel's radar range was 0.2 nmi from buoy 2A. Buoys 1A and 2A then were obliterated on the radar screen by rain returns. The pilot later testified, "I started reviewing my options immediately. . . . the rains came, but the wind has to be 30 to 10, 20, 30 seconds later. I don't know how long." The pilot-trainee switched the radar to the 3-nmi range in an attempt to minimize the effects of the heavy rain on the radar presentation. The pilot told the master to "make the anchors ready for dropping" and to have the lookout "watch carefully for a buoy on his starboard side." The pilot looked at the radar screen and saw that it was completely filled with rain return. He unsuccessfully attempted to sight buoy 2A using binoculars. The pilot-trainee manipulated the radar in an attempt to reduce the rain return. About 30 seconds after the radar screen had become filled with rain return, the pilot trainee saw buoys 1A and 2A for one or two sweeps of the radar on the 3/4-nmi range. The pilot-trainee advised the pilot that he had seen the buoys again momentarily and the vessel was in the channel. The pilot-trainee continued to manipulate the radar, but no further navigational information was obtained.

Almost immediately after the pilot-trainee reported that he had seen the buoys again, the lookout reported to the bridge, "buoy starboard bow." The pilot asked, "Where Captain, where on the starboard bow? I have to know." Because the visibility was severely reduced, the pilot believed that the buoy could not have been more than 50 feet away from the bow, and before a reply was received, he ordered the pilot-trainee to "change to the next course." The pilot-trainee ordered 10° left rudder; the pilot heard the order and concurred. The lookout reported to the master that the buoy already had passed by. The pilot checked the radar and attempted to sight buoy 2A visually, but he did not see it. When the SUMMIT VENTURE's heading reached about 067°, the pilot-trainee ordered the helm "midships, steer 063." After verifying that the rudder was midships, he returned to the radar. About 0731, the pilot ordered the vessel's speed reduced to slow ahead maneuvering. The pilot-trainee saw that the radar screen was still filled with rain return. Upon checking the gyrocompass, he noticed that the SUMMIT VENTURE's heading was 060°, and he told the helmsman, "You are on 060, steer 063." No further helm commands were given by the pilot-trainee. The pilot was looking forward to sight the Sunshine Skyway Bridge.

When the pilot saw the part of the bridge structure above pier 2S about one ship-length ahead of the vessel, he recognized that the SUMMIT VENTURE was not in the channel. He immediately rang emergency full astern on the engine order telegraph and ordered "hard to port-let go both anchors."

The helmsman complied with the helm order. The carpenter released the port anchor, and began applying the brake when about one shot 4/ of chain was in the water. Realizing that the SUMMIT VENTURE was about to hit the bridge, the carpenter jumped over the forecastle deck railing to the main deck and the boatswain ducked and hid near the port mooring bitts.

About 0734, the SUMMIT VENTURE struck the Sunshine Skyway Bridge at pier 2S about 56 feet above the waterline. (See figures 2 and 3.) A 100-foot section of the bridge roadway fell across the vessel's bulwarks and forecastle deck. The bridge roadway struck the anchor windlass and prevented additional anchor chain from running out. The vessel continued to move forward, and the starboard side of the hull about amidships struck the crashwall of pier 2S with a glancing blow. The vessel stopped with the bow under the eastern bridge span on a heading of about 030°.

The pilot immediately broadcast a mayday message over VHF channel 16. He informed the Coast Guard that the bridge was down and told them to notify the Sunshine Skyway Bridge authorities to stop vehicular traffic on the bridge. Noticing that several vehicles had driven off the severed end of the bridge roadway, he instructed the master to have his crew search for survivors in the water around the vessel. One person was seen and rescued.

Meanwhile, the master of the tug DIXIE PROGRESS had heard of the accident over the VHF radio, anchored his barge off Mullet Key, and proceeded to

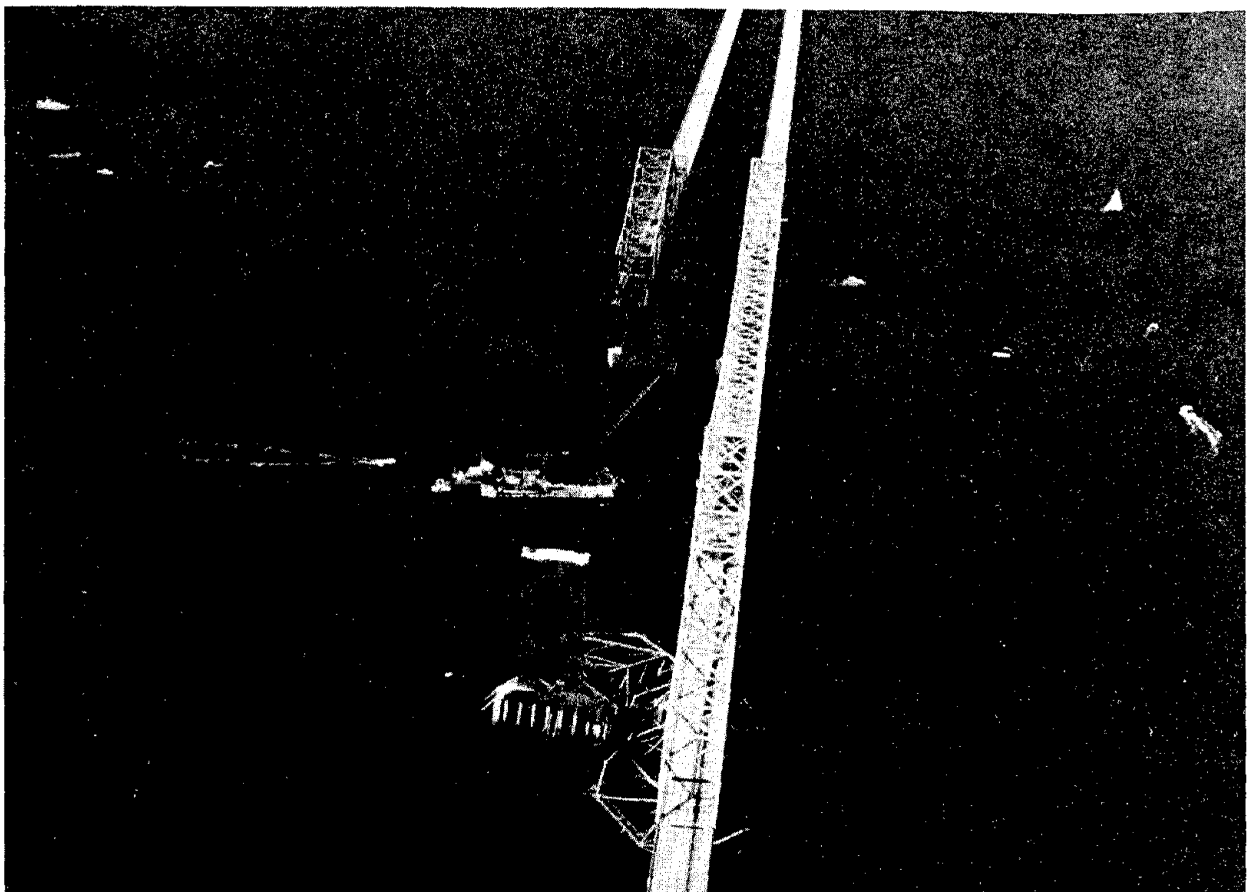


Figure 2.--Damage to the Sunshine Skyway Bridge.

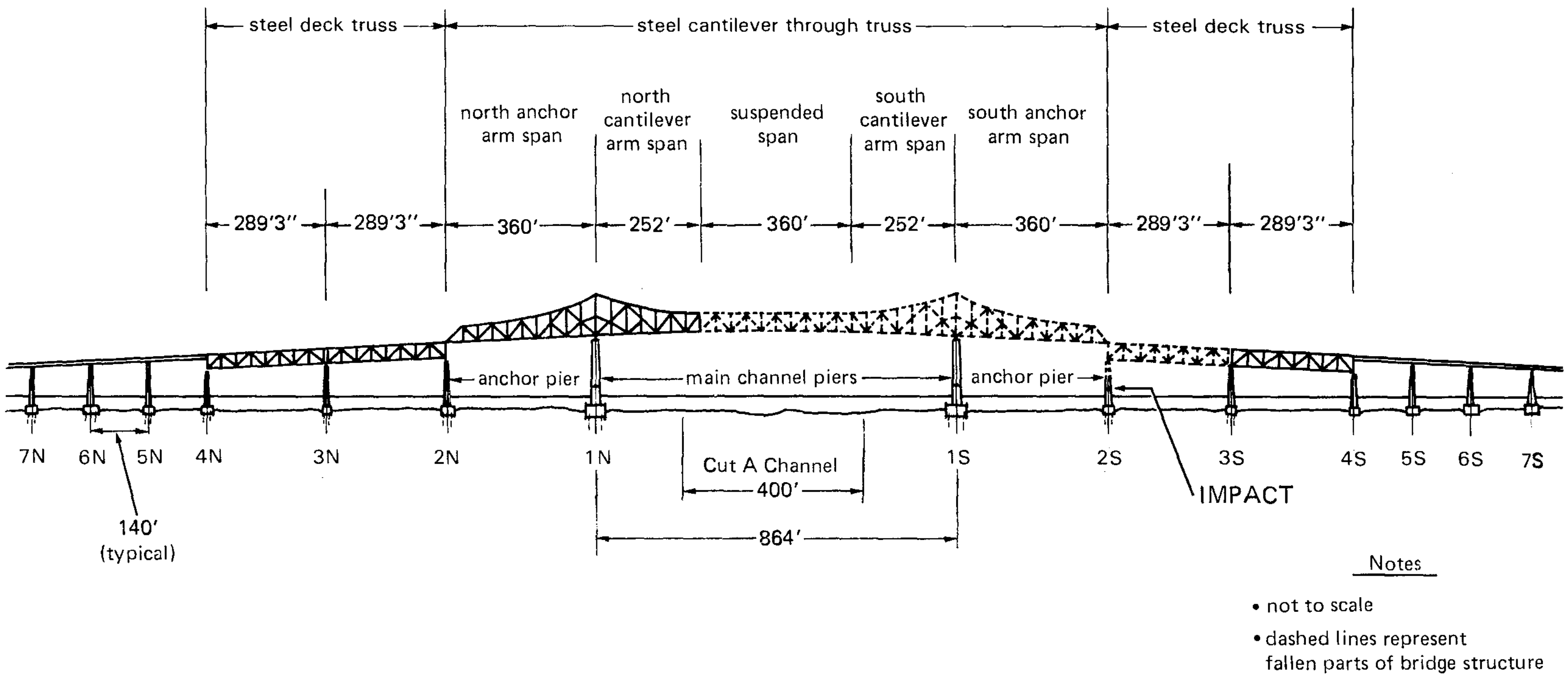


Figure 3.--Diagram of the damaged Sunshine Skyway Bridge (looking eastward).

the accident site to assist. By 0825, the tug was made fast to the SUMMIT VENTURE. Soundings were taken, and the SUMMIT VENTURE's forepeak tank was found to be taking on water. About 0919, the tug BRADENTON arrived to provide additional assistance. About 0955, another pilot arrived on board the SUMMIT VENTURE and relieved the first pilot. The vessel was pulled clear of the bridge about 1200. The port anchor was dragged along until the vessel was clear of the bridge, and was used later to moor the vessel.

Highway User's Involvement

Traffic volume on the morning of May 9, 1980, was characterized by two tollbooth operators at the north toll plaza as being ". . . lighter than usual." Witnesses observed several vehicles and a Florida State Trooper stopped at a picnic area on the west roadside immediately north of the Sunshine Skyway Bridge and said that most of the vehicles entering the bridge were traveling at 25 to 35 mph, with the slower traffic in the right traffic lane.

A witness, who may have been driving the last vehicle to safely cross the span, reported seeing the vessel and realizing that it was on a collision course with the bridge when his vehicle was a short distance south of pier 1S in the right traffic lane. He stated that he speeded up and, while in the area of pier 3S or 4S, he felt a vibration and shock which caused his vehicle to veer partially into the left lane. He moved fully into the left lane and continued accelerating until he had cleared the bridge.

Another witness, who was driving a Chevrolet, said that he was driving slowly south in the right traffic lane and that some vehicles had passed him. He could not identify or describe the vehicles. As he began the ascent onto the bridge, he could see no vehicles ahead, even though visibility was improving. He said that as he approached the bridge superstructure, "I could see the red airplane warning lights atop the bridge structure on the west side of the bridge. Suddenly those red lights fell from their original position to a point out of my view below the roadway ahead. I began stopping and, immediately after the light dropped, I saw the overhead steel superstructure ahead falling. It seemed to wave and roll as it was falling." He estimated that he stopped in the right traffic lane about one car-length north of the bridge superstructure. He then began backing northward in the right lane. He characterized the backing as ". . . not in a fast or wild manner, but much the same as one might back from a driveway." He estimated his backing speed at about 10 mph.

The Chevrolet driver continued: "I must have backed about one-half to two-thirds down the ascending portion that I had just crossed. I saw lights from the southbound traffic approaching me, so I stopped. I rolled my left window down and started waving my hands outside the window, slapping the side of my car and yelling at traffic that went around me to stop." When shown a drawing of the bridge, he estimated that he had stopped between piers 7N and 9N.

The witness further stated: "After I stopped, I remembered about three cars and then a bus passed traveling southbound." He said that other passenger cars behind the bus had passed his vehicle. About 30 seconds after the bus had passed and within 3 minutes of the bridge collapse, a small light-colored sedan stopped abreast of his vehicle in the left lane, effectively blocking the road. No other vehicles passed until a Florida State Trooper arrived a short time later.

Three sedans, the drivers of which stated that a bus had passed them as they ascended the bridge, passed the Chevrolet driver, but stopped before running off the bridge. The first driver, who was in a Buick, stopped within 2 feet of the end of a 13° downward-sloped section of bridge. (See figure 4.) The Buick driver recalled being passed by two automobiles and a bus. He could not identify the bus, but recalled that it had red, white, and blue stripes.

The second driver remembered being passed by ". . .a Greyhound bus." He said that ". . .a small, dark colored car passed me and the bus and the small car continued ahead of me in the left lane." He believed that about two additional cars had passed him during his approach to the bridge ascent. The third driver, who was in a Pontiac, also said that he was passed by a bus just before entering the causeway. He stated that he changed lanes and followed the bus, but soon lost sight of its taillights.

The Buick and Pontiac drivers saw the Chevrolet driver waving his arms, but misintepreted his actions. The Pontiac driver estimated that the stopped Chevrolet was between piers 5N and 4N. After the Buick had stopped, its four occupants exited the vehicle and ran northward along the bridge. They alerted the other two drivers who safely stopped their vehicles. All three vehicles stopped south of pier 1N and, apparently, were the last three vehicles to have passed the Chevrolet.

A pickup truckdriver, who was the only survivor of the bridge collapse, stated that he was traveling southbound on the steel grid portion of the bridge deck. He said, ". . . the pickup started to bob up and down, and I -- at that time, I thought it was just like the wind blowing up through the bridge or something like that, made it blow around. But then I, like, started to drop over a high part, and at this point I looked and there I seen the ship. I was looking down at the ship. And I knew, you know, what had happened. But I hit my brakes, but I guess the truck wasn't even on the bridge anymore. It was in the air, probably."

The pickup struck and ricocheted off the port bow of the ship and fell into the water. The driver escaped from the submerged pickup, surfaced, and swam to a section of bridge superstructure which projected above the water surface. He was seen by the ship's crewmembers who threw him a rope ladder. He could not climb the ladder, so he entwined his legs in the ladder and was hauled aboard the SUMMIT VENTURE. He was taken to a hospital later in the day.

Injuries to Persons

Injuries	Highway Vehicles		SUMMIT VENTURE	Total
	Drivers	Passengers		
Fatal	7	28	0	35
Nonfatal	1	0	0	1
None	0	0	37	37

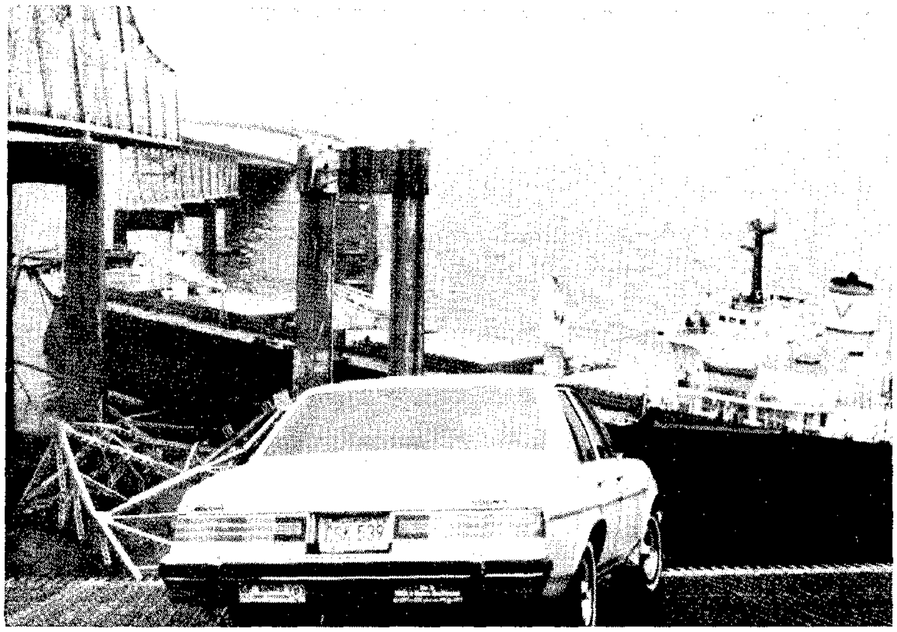


Figure 4.--M/V SUMMIT VENTURE and the damaged Sunshine Skyway Bridge.

Damage to Vessel

Safety Board investigators examined the damage to the SUMMIT VENTURE and determined that the vessel had struck pier 2S of the western span of the Sunshine Skyway Bridge about 10 feet starboard of the vessel's centerline on a heading of about 054°. (See figure 5.) The flare of the starboard bow hit the pier about 56 feet above the waterline. The vessel's stem plating, deck plating, and internal stiffeners were torn and folded in about 16 feet. (See figure 6.) A horizontal seam below the waterline in the forepeak tank shell plating was ripped from frame 212 to frame 223. The starboard shell plating was scraped heavily from frame 100 to frame 113. On the portside, there were heavy chain marks leading downward and aft from the anchor hawsepipe. The bilge keel was dished in from frame 180 to frame 188 and from frame 161 to frame 165.

A 100-foot section of the highway bridge deck and roadway landed across the forecastle deck of the SUMMIT VENTURE and damaged the forward superstructure and deck equipment. Approximately 140 feet of the port anchor chain had run out before the anchor windlass was disabled; the starboard anchor remained in the stowed position.

The vessel was towed to the Tampa Shipyard drydock where temporary repairs were made before it departed for Japan. The estimated damage to the SUMMIT VENTURE was $1 million.

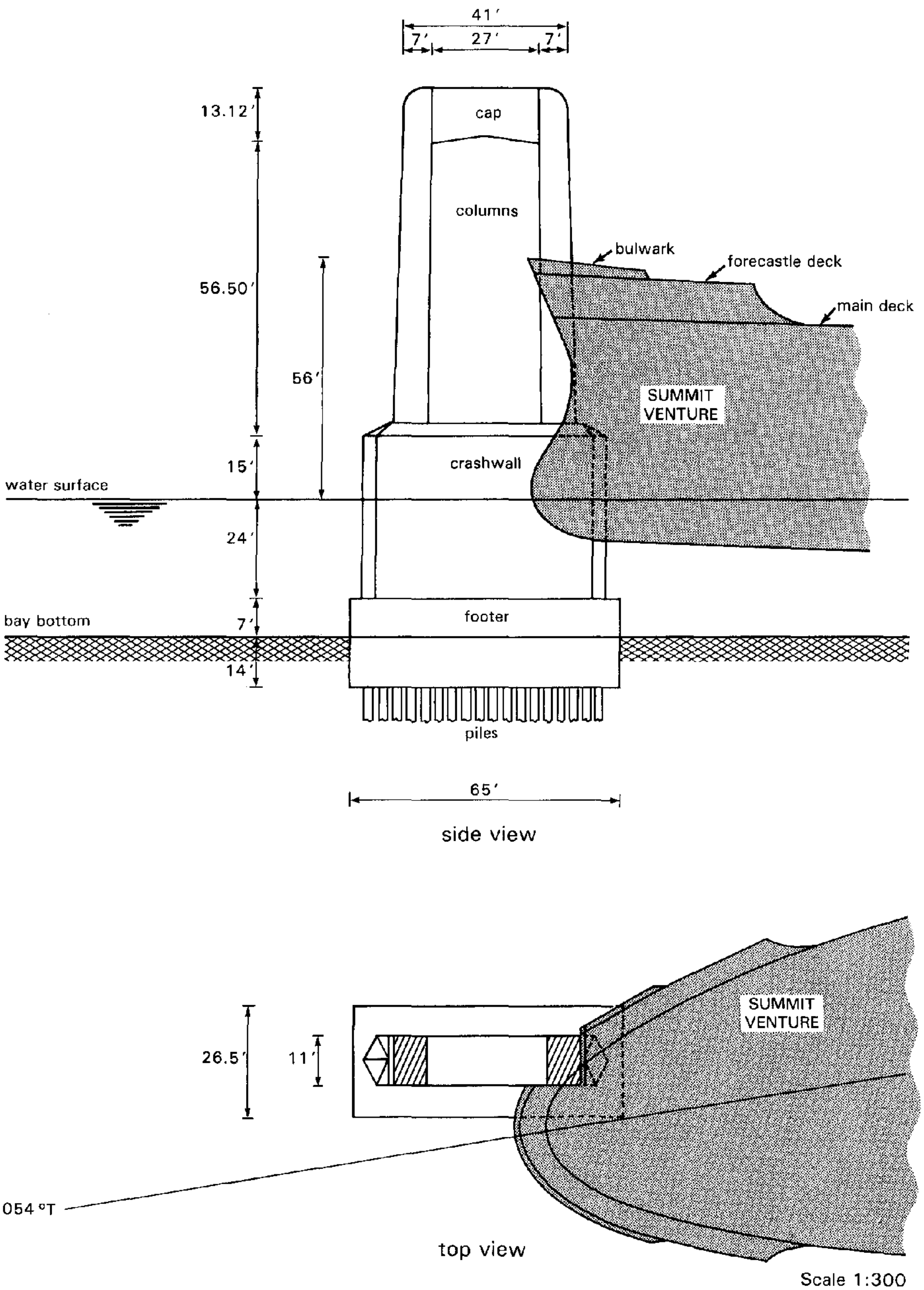


Figure 5.--Impact of the M/V SUMMIT VENTURE with pier 2S.

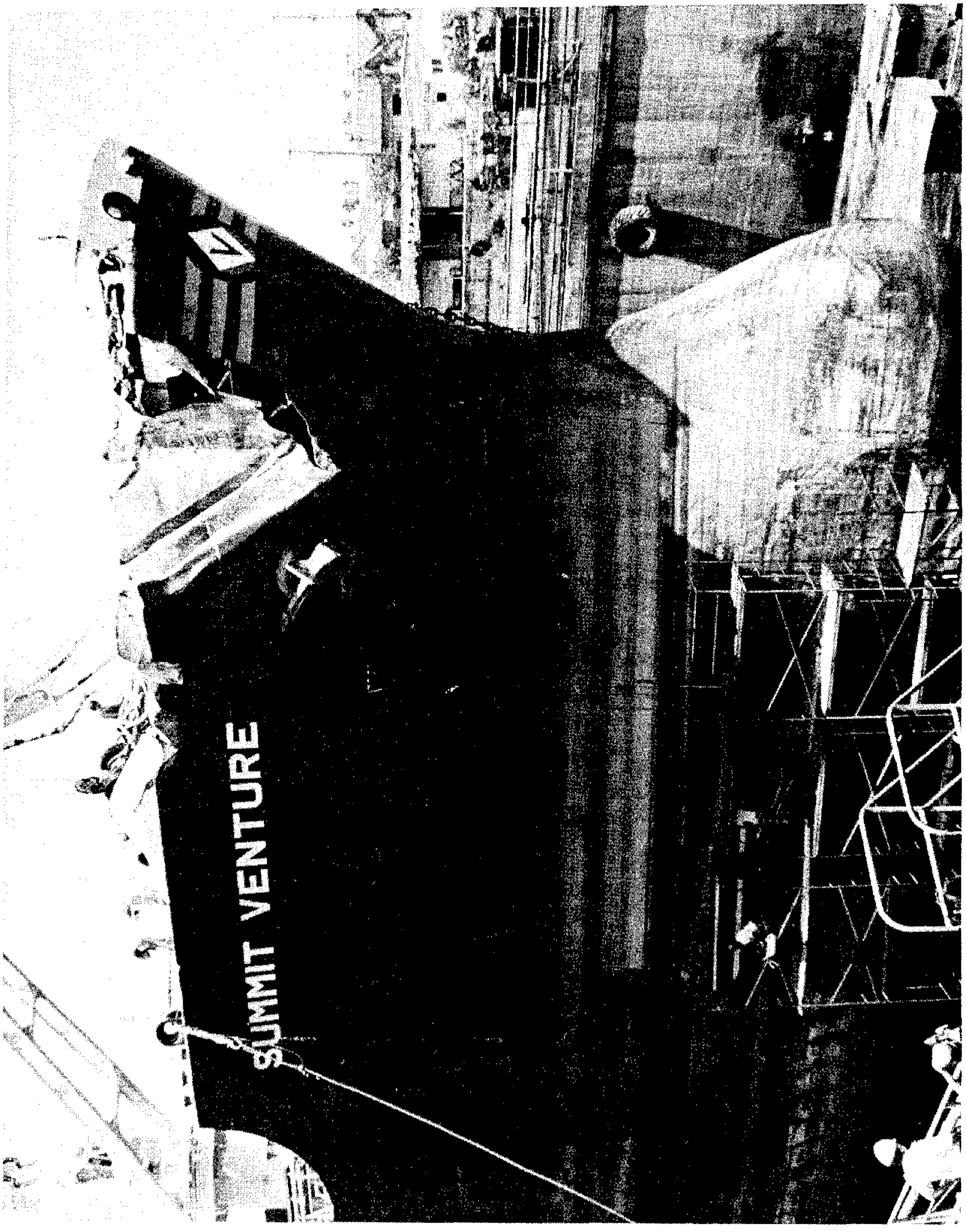


Figure 6.--Damaged forecastle of the M/V SUMMIT VENTURE.

Damage to Bridge

The ramming caused the loss of 1,297 feet of bridge deck and superstructure, and the two columns and cap of pier 2S were also destroyed.

Pier 1S showed extensive cracking throughout, particularly in the east column, with spalling at the top of the cap. The east bearing assembly was missing, but the bottom half of the west bearing assembly was intact. Both columns of pier 2S were sheared off approximately 6 feet above the crashwall. Spalling was found on the pier footer and on the northwest corner of the crashwall. Large paint transfers were found on the northwest corner of the crashwall.

The deck truss span between piers 2S and 3S landed in the water on its western side. The concrete deck pavement had separated from the truss. Approximately 100 feet of the south anchor arm span landed on the SUMMIT VENTURE; the remainder landed in the water on its east side.

The south cantilever arm span and the suspended arm span landed in the water on their east sides. A 36-foot section of the north cantilever arm span was angled 13° downward toward the channel. There was stress damage to sway frames and gusset plates in the deck truss span between piers 3S and 4S. Both bearing assemblies of pier 3S were damaged, and there was spalling on the pier cap and on the crashwall.

The eastern bridge suffered spalling on the northeast corner of pier 2S and the west column and crashwall of pier 1S.

The Federal Highway Administration (FHWA) estimated that the salvage of the damaged bridge, maintenance of traffic on the eastern bridge, and preliminary engineering for reconstruction of the western bridge would cost about $3 million. The cost of reconstruction in kind, including pier replacement and minor upgrading of bridge rails, was estimated at $27 million. The estimated reconstruction cost does not include an allowance for pier protection.

Damage to Highway Vehicles

Eight vehicles fell into Tampa Bay and were destroyed. The vehicles were a 1975 MC-B Crusader bus, a 1980 Chevrolet Citation, a 1975 Ford LTD, a 1980 Ford Fairmont, a 1979 Chevrolet Nova, a 1976 Chevrolet El Camino, a 1979 Volkswagen Scirocco, and a 1974 Ford Courier pickup truck. (See appendix A.)

The roof was torn from the bus which impacted the water in an inverted, nosedown attitude. The Citation was also inverted when it impacted the water. The LTD, Nova, and El Camino impacted the water in a wheels down attitude; the Scirocco was in a left side down and nosedown attitude at impact.

The Courier was the southernmost of the eight involved highway vehicles and the only vehicle south of pier 1S. The El Camino was about 110 feet north of pier 1S and the Scirocco was about 340 feet north of pier 1S.

The other five vehicles were clustered within 130 feet south of the downward-sloped bridge end. The southernmost of these was the LTD. The Citation was about 35 feet further north. The Fairmont and the Nova were north of the Citation, inverted, and partially under the bus. (See figure 7.)

The Courier pickup truck, the Fairmont, and the El Camino exhibited impact damage associated with steel members from the bridge superstructure. The Nova and Scirocco exhibited solid object impact damage to their roofs which could not be associated with bridge structure components and which might have been from another vehicle or the channel bed. The Citation, the LTD, and the bus showed severe water impact damage, but no solid object impact damage was evident.

Crew Information

The vessel was manned by a Chinese crew. The master and chief officer of the SUMMIT VENTURE were properly licensed under Liberian law. The master spoke English fluently. The chief officer spoke English adequately to communicate engine and steering orders and other typical navigation terms. The helmsman understood steering and engine orders given in English.

The pilot and the pilot-trainee were licensed by the Coast Guard as first class pilots for Tampa Bay. The pilot was certificated by the State of Florida as a Tampa Bay deputy pilot, and he was operating under the authority of the State certificate at the time of the accident. The pilot-trainee was completing his last day of a 30-day observing period before beginning work as a Tampa Bay deputy pilot. The pilot-trainee was a qualified radar observer. (See appendix B.)

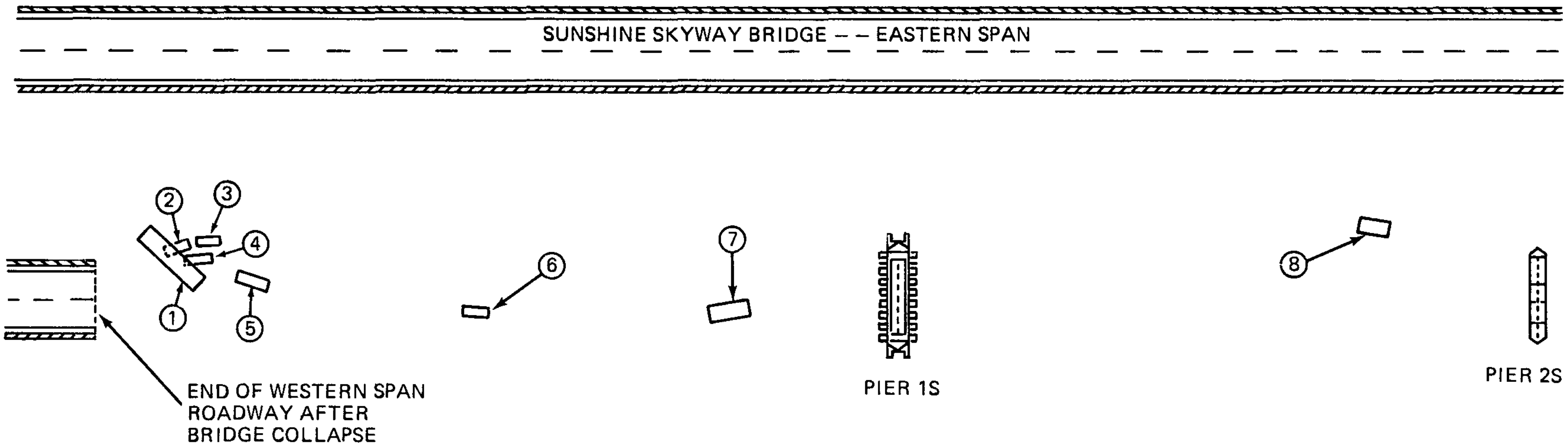
Driver Information

All drivers involved in the accident were properly licensed. The driver of the Greyhound Lines, Inc., bus was properly certified as required by the Federal Motor Carrier Safety Regulations. (See appendix C.)

Vessel Information

The SUMMIT VENTURE was a bulk carrier of Liberian registry, built in 1976 by Oshima Shipbuilding Co., Ltd., of Nagasaki, Japan. It was owned and operated by Hercules Carriers, Inc., of Monrovia, Liberia. The vessel was classed by the American Bureau of Shipping and had all of the required international safety certificates. Its principal characteristics were:

Length	609 feet
Depth	51 feet
Breadth	85 feet
Deadweight	33,912 tons
Gross Tons	19,735
Net Tons	13,948



VEHICLES

1. 1975 MC-B CRUSADER BUS
2. 1980 FORD FAIRMONT
3. 1980 CHEVROLET CITATION
4. 1979 CHEVROLET NOVA
5. 1975 FORD LTD
6. 1979 VOLKSWAGEN SCIROCCO
7. 1976 CHEVROLET EL CAMINO
8. 1974 FORD COURIER PICKUP TRUCK

NOT TO SCALE

Figure 7.--Locations of vehicles in Tampa Bay.

The deckhouse of the SUMMIT VENTURE was aft and above the engineroom. Five bulk dry-cargo holds were forward of the deckhouse. The navigation bridge was about 472 feet aft of the bow. Before leaving the anchorage, the crew had begun deballasting the forepeak tank and the No. 3 double bottom tank in normal preparation for loading cargo when the vessel arrived at the terminal; this resulted in a forward draft of about 9.4 feet, a midship draft of about 15.5 feet, an aft draft of about 21.5 feet, and a stern trim of about 12 feet. The freeboard amidships was about 35 feet, and the top of the bulwark at the bow was about 56 feet above the waterline. At the time of the accident, the vessel was in a light ballast condition with a displacement of about 17,000 tons.

The single screw, single rudder SUMMIT VENTURE was propelled by a 7R ND68 Sumitomo Sulzer 11,550-hp diesel engine that was controlled from the engineroom. Engine orders were transmitted from the bridge to the engineroom by the engine order telegraph, which operated satisfactorily when it was tested before leaving the anchorage. No engine order telegraph malfunctions occurred during the voyage.

The SUMMIT VENTURE's steering gear was an electrohydraulic Rapson slide, type RW250, manufactured by Kawasaki Heavy Industries, Ltd., of Kobe, Japan. The steering system operated satisfactorily when it was tested before departing the anchorage; no steering system problems occurred during the voyage. After the collision, Coast Guard investigators also tested the engine order telegraph and the steering system. With both steering pumps in operation, 32 seconds were required for the rudder to swing 70° from full port to full starboard. The midships to full port (35°) swing time was 14 seconds, and the full starboard (35°) to midships swing time was 12 seconds.

The maneuvering data posted on the SUMMIT VENTURE's bridge indicated that in a normal ballast condition (23-foot midship draft; 25,000-ton displacement) with the engine at half ahead maneuvering, the vessel's headreach 5/ in a crash stop would be 2,519 feet in 5.2 minutes, including 30 to 60 seconds for the propeller thrust to change from half ahead to full astern. In executing a port turn at half ahead maneuvering, the vessel would advance about 2,000 feet forward from the start of rudder deflection before swinging 90° left of its initial heading, and would transfer about 1,000 feet to the left of its initial track. Those distances would be reduced very slightly when executing a starboard turn. The maneuvering data indicated that in a normal ballast condition, the SUMMIT VENTURE's speed through the water for dead slow, slow, half, and full ahead maneuvering would be 5.1, 6.2, 9.5, and 11.7 knots, respectively. The SUMMIT VENTURE's maneuvering characteristics were derived for calm wind and wave conditions, a water depth of at least twice the vessel's draft, and normal draft and trim conditions. Changes in any of these conditions would alter the vessel's maneuvering characteristics.

The SUMMIT VENTURE's navigation equipment included a VHF radiotelephone, a gyrocompass and repeaters, a wind speed and direction indicator, a fathometer, and two Japan Radio Corporation (JRC) radar sets, all of which were operable at the time of the collision. A JRC type JMA-158FB radar with a 12-inch display was to the right of the helm, and a type JMA-153G7A-AC radar with a 10-inch display was to the left of the helm. Throughout the transit, the

12-inch radar was operating in the relative bearing mode; the 10-inch radar and the fathometer were not in use. The gyrocompass was determined to have zero error.

According to the operating manual, the 12-inch radar operated on the X-band of 9,330 to 9,420 mHz (3.2 cm wavelength), and the scanner rotated at 22 rpm. The bearing presentation could be operated in the north-up stabilized mode (true bearing), or the ship's head-up unstabilized mode (relative bearing). There were seven range scales with corresponding range rings from 3/4 to 96 nmi, and a variable range marker with a digital readout. The selected range automatically determined the distance between the range rings and the corresponding pulse length. By using the conventional radar controls to minimize the effects of sea or rain clutter, targets of interest could be displayed distinctively in most weather conditions. However, even with the controls at the optimal setting, excessive rain clutter could still obscure the echos from a target inside a severe squall or storm. The radars were tested after the accident by Safety Board investigators and were found to be operating satisfactorily. Because the 10-inch radar had a 3-cm wavelength, it would not have performed better than the 12-inch radar in the weather conditions encountered. The master maintained that operating the two radars simultaneously created an interference on the radar screens.

The SUMMIT VENTURE was equipped with a Sperry Mark IV course recorder. The recorder has an internal clock mechanism which drives a roll of graph paper with graduated time and heading increments under two marking pens. The pens are driven by a gyrocompass repeater motor which is electrically connected to the ship's master gyrocompass. As the graph paper travels under the moving pens, a permanent record of the ship's heading versus time is produced.

The master testified that the SUMMIT VENTURE's course recorder was started at 0400 on the day of the accident and was synchronized to local time by the second officer. No notations were made on the course recorder graph paper to indicate the SUMMIT VENTURE's position at various times as the vessel transited Tampa Bay.

Bridge Information

The Sunshine Skyway is a 15-mile, 4-lane, limited-access toll facility which is part of Interstate 275. It extends from Maximo Point at the south end of Pinellas County, across Lower Tampa Bay to Manatee County about 3 miles north of Palmetto, Florida. There are five "twin" overwater structures and about 10 miles of hydraulic fill causeway and land highway. In 1979, the Sunshine Skyway had an average daily traffic count of 11,121 northbound vehicles and 12,501 southbound vehicles.

The twin bridge structures which cross Tampa Bay are 22,373 feet long. The eastern structure consists of 16,752 feet of posttensioned concrete girder trestles; 2,880 feet of steel girder spans; 1,157 feet of steel deck truss; and 1,584 feet of steel cantilever through truss span. The newer, western bridge is slightly longer because of horizontal alignment with the eastern bridge, and the trestles are constructed of prestressed concrete girders on prestressed concrete piles. The two-lane eastern structure was one of the first bridges in the United States to use prestressed concrete, and extensive testing of the strength of the concrete was required during construction. The bridge was opened to highway traffic in September 1954.

The two-lane western structure was built similar to the older structure by the same contractor. The opening of the bridge was delayed for about 2 years because of cracks in pier 1S. After the pier had been strengthened by counterforts 6/ and additional piling, the western bridge was opened to traffic in 1971.

The western span of the Sunshine Skyway Bridge was designed according to the "Standard and Interim Specifications for Highway Bridges, 1961" of the American Association of State Highway Officials. Additionally, the structure was designed to resist a horizontal wind force of 50 pounds per square foot and was investigated for stability and overturning under a wind force of 75 pounds per square foot. Pier 2S was concrete reinforced with steel bars of 3/4- to 1 1/2-inch diameter.

The U.S. Army Corps of Engineers issued a construction permit for the western structure on December 12, 1966. No requirements for structural pier protection were made, but the plans did show three wooden pile dolphins on each side of Cut A Channel near the main channel piers. The two dolphins near pier 1S of the eastern structure had rotted away before the western structure had been completed and were not replaced. The dolphin west of pier 1N of the western structure was destroyed when it was struck by a 750-foot bulk carrier on February 16, 1980.

Griener Engineering Services, Inc., of Tampa conducts triannual inspections of the Sunshine Skyway Bridge under contract with the toll authority. The State of Florida Department of Transportation (FDOT) conducts additional inspections to meet the requirements of the FHWA Bridge Inspection Program. An FHWA bridge engineer testified that the "Florida bridge inspection program and staffing organization is more than adequate to meet the requirements of the Federal standards."

The last State of Florida inspection of the Sunshine Skyway Bridge was conducted in August 1979. No serious defects were found, but preventative maintenance was recommended. The recommended maintenance included sandblasting, painting, installing pile jackets, replacing missing rivets and bolts, and repairing some structural steel members. Because there was a high cost overrun on the eastern bridge maintenance, the contract for the western bridge maintenance was canceled because of a lack of funds.

FDOT records indicate that the eastern structure had experienced seven minor waterborne vessel accidents since 1969. None of those accidents involved the main span structure. The western structure had experienced three waterborne vessel collisions since 1977. On June 7, 1977, two piers north of the main span were hit by two large sections of dredging pipe aboard floats. On February 6, 1980, the west side of the main span was struck by a boom of the 502-foot Greek general cargo vessel M/V THALASSINI MANA. The repairs cost about $19,000. On February 16, 1980, when a temporary channel between piers 1N and 2N was in use for one-way shipping traffic because of salvage operations in Cut A Channel for the U. S. Coast Guard Cutter BLACKTHORN, the 750-foot Liberian bulk carrier M/V JONNA DAN struck pier 2N and ruined the wooden dolphin west of pier 1N. Superficial damage to the west column and the west side of the crashwall of pier 2N was estimated at about $5,000.

Waterway Information

The centerline of Mullet Key Channel lies on a heading of 081° inbound; the charted depth is 34 feet at mean low water and the charted width is 600 feet. Mullet Key Channel, Cut A Channel, and the Intracoastal Waterway intersect at buoys 1A and 2A. Cut A Channel lies on a heading of 063° inbound; it has a charted depth of 34 feet and a charted width of 400 feet. The inbound mariner must negotiate a left turn of 18° at this intersection, after which he must shape up on a course to pass under the navigable span of the Sunshine Skyway Bridge. The 18° bend is about 0.7 nmi from the navigable span. The outbound mariner must negotiate a right turn of 24° at the intersection of Cut A Channel and Cut B Channel, but he will travel through 2.0 nmi of straight channel and pass between a pair of gated buoys before reaching the navigable span.

The main shipping channel into Tampa Bay is marked by pairs of buoys at the channel extremities and by terrestrial ranges which delineate the channel centerline. The channel buoys are numbered, and some are lighted, to facilitate vessel positioning along the channel. Only the Egmont Channel entrance buoy has a radar reflector. Radar reflectors can improve long range radar detection, but the buoy's metal structure normally provides an ample radar target at close range. The turning buoys at Mullet Key Channel and Cut A Channel are lighted to mark the turn in the channel; buoy 1A has a quick flashing white light and buoy 2A has a flashing red light.

The terrestrial range markers are installed on fixed structures on a line corresponding to the respective channel centerline. The ranges have daymarks for daytime use and quick flashing white lights for nighttime use. There were no reported problems with aids to navigation before the accident. The floating aids to navigation were checked following the accident and were found to be on station and operational.

The navigable span of the Sunshine Skyway Bridge over Cut A Channel has a vertical center clearance of 149 feet above mean high water and a horizontal clearance of 800 feet. The center of the navigable span is marked by a green light, while the piers on the extremities of the channel are marked by red lights.

Tampa Bay has more vessel traffic than any other port in Florida, and was nationally ranked 14th in order of vessel traffic movements in 1973. Members of the Tampa Bay Pilots Association served on 4,374 vessel movements in 1977, 4,410 in 1978, and 4,974 in 1979. There was a corresponding increase in tonnage during this 3-year period. Those movements do not include vessel traffic not subject to pilotage requirements. As one of the busiest ports in the United States in 1980, Tampa Bay ranked seventh in total tonnage handled and third in tonnage of foreign export.

Pilotage Information

Pilot service is compulsory in Tampa Bay for all foreign vessels and for U.S. vessels engaged in foreign trade; the service is provided by the Tampa Bay Pilots Association. Title 46, USC 364 requires that a Coast Guard-licensed pilot serve on any U.S. vessel in coastwise service, while Florida Statute 310.141 requires that a State-licensed pilot serve on any vessel drawing 7 feet of water or more when entering or leaving the ports of Florida, except those exempted by Federal law. A Tampa Bay pilot may hold both a Coast Guard license and a State license. A pilot serves under the authority of his Federal license when piloting a U.S. vessel enrolled in coastwise trade; when piloting foreign vessels or U.S. vessels engaged in foreign trade, the pilot serves under the authority of his State license. The Coast Guard cannot act against a pilot's Federal license for wrongful acts committed as a State pilot, and the State might not act against a pilot's State license for wrongful acts committed as a Federal pilot.

The Florida Board of Pilot Commissioners sets the requirements for licensed State pilots and for certificated deputy pilots, and has the authority to discipline State pilots for wrongful acts committed while piloting under the authority of their State license. In its 5-year history before this accident, the State Board had not disciplined a pilot for a wrongful act. Licensing requirements for Tampa Bay pilots include documenting sufficient maritime education and experience, passing a comprehensive written examination pertaining to the management and operation of vessels, and demonstrating a specific knowledge of channels, ports, and harbors where the pilot will serve. The qualification criteria for licensed State pilots and certificated deputy pilots differ with respect to the level of expertise and the prerequisite maritime experience. The criterion for a certificated deputy pilot requires at least 2 years of recent service as an active first-class pilot in U.S. pilotage waters. The criterion for a licensed State pilot requires an additional 3 years of service as a certificated deputy pilot.

Current Information

The 1980 Tidal Current Tables published by the U.S. Department of Commerce predicted the following currents for May 9, 1980:

Location	Current Speed	Current Direction	Time
Mullet Key Channel Entrance	1.1 kns	055°	0743
Sunshine Skyway Bridge -- Cut A	0.8 kns	060°	0742

Vessel Traffic Service Information

The Tampa Bay Vessel Traffic Service (VTS) is a bridge-to-bridge vessel movement reporting system which was established following the recommendations of a 1973 Coast Guard study. 7/ The VTS operates on a level of L_0, the lowest level of VTS under the Coast Guard's established VTS activity levels. The other levels are designated to perform additional functions, such as active traffic control, traffic regulation, and traffic monitoring, and range from imposing Traffic Separation Schemes (L_1), to the operation of Automated Advanced Surveillance Systems (L_5).

In a study of ship bridge collisions, 8/ it was reported that, in the United States and other countries, navigational restrictions which impose traffic separation for bridges in VTS controlled waterways have had the greatest impact to date in reducing the number of bridge collisions and improving the efficiency of traffic lanes. Also, the closing of bridges to marine traffic whenever extreme wind, wave, current, or low visibility conditions exist has been effective in some overseas ports. This degree of traffic management is significantly higher than the present level of the Tampa Bay VTS.

Previous studies of the Tampa Bay vessel traffic pattern have recommended upgrading the existing low level of VTS. In a 1978 study of VTS, 9/ Commander William J. Ecker, USCG, assessed the accident history of Tampa Bay from 1973 to 1978, and recommended the implementation of one-way traffic schemes and tug assistance regulations. In August 1980, the Safety Board recommended that the level of Tampa Bay VTS be reevaluated to determine if a higher level was needed. 10/ Although the Coast Guard has not announced plans to upgrade the level of the Tampa Bay VTS, the Coast Guard expects to complete a study of Tampa Bay's vessel traffic management needs by the end of 1981.

Bridge Protection Information

There are several methods of structurally protecting bridge piers from ramming by vessels. They include fender systems, ranging from simple wooden fenders to elaborate reinforced concrete structures; reinforced piers; dolphins, ranging from groups of typical wooden piles to large stone or concrete-filled circular caissons; fender-net "ship catchers," consisting of buoys, anchor lines, and anchor piles; and artificial protective islands and cofferdams built around the piers.

Several bridges with pier protection systems have survived collisions similar to the ramming of the Sunshine Skyway Bridge without major damage to piers or superstructure. Other bridges without pier protection systems have not survived such collisions. In 1964, the Maracaibo Bridge at the entrance to Lake Maracaibo, Venezuela, was struck broadside, and two piers and three spans collapsed. 11/ The struck piers were lightweight, unprotected, and several spans away from the navigation channel. About 0130 (local time) on January 18, 1980, the 557-foot Liberian bulk carrier STAR CLIPPER struck the Almo Bridge in Gothenburg, Sweden, west of the main ship channel at about 7 to 8 knots. About 800 feet of the bridge's center span collapsed, and some time later seven vehicles were driven off the remaining spans and fell into the water. Eight persons died. The east approach to the bridge was closed in about 15 minutes, but the west approach remained open for more than 30 minutes. 12/

One study 13/ of major collisions of ships with bridges, quays, and oil piers which occurred worldwide from 1965 to 1979 concluded that the causes of highest frequency were human error, mechanical failure, and bad weather; the collisions often occurred a long way from the navigation channel at locations where the bridges were unprotected; and the structures were often lightweight.

On December 8, 1980, the FHWA Bridge Division issued a policy memorandum about bridge span failure detection and warning systems. That memorandum states, in part:

> Several bridge failures involving the collapse of a bridge span have occurred in the recent past as a result of the collision of a ship with the bridge. In the immediate aftermath of such an accident, the potential exists for drivers to be unaware of the danger and to drive off the damaged bridge before warning devices and barricades can be installed....
> While this type of catastrophic failure is not too common, enough accidents do occur to warrant consideration of the need for motorist warning systems on bridges subject to ship collisions. At this time, the most practical warning device is considered to be some type of electrical conductor attached to or a part of the bridge which will activate warning systems and/or gates when the continuity is disrupted (span collapse).... The design and location of warning mechanisms becomes more complex for bridges susceptible to collision over a considerable number of spans. Thus, the warning system must be designed to fit the type of structure, the approaches, and other specific conditions existing at each bridge site.... Federal funds may be used to construct warning systems on existing bridges and on new construction...The warrants for such systems should be based on an assessment of the risks and consequences of a ship-bridge collision, taking into consideration (1) the type and frequency of shipping on the waterway; (2) the location and arrangement of the bridge piers in relation to the navigable channel and the resulting vulnerability of the piers to ship collisions; (3) other factors (fog, channel geometrics, wind, river currents, etc.) which may create navigational problems in the vicinity of the bridge; and (4) volume of highway traffic using the bridge.

Although Federal funds may be used to construct such systems, there are no standards for the design, performance, and installation of the systems.

As a result of the February 24, 1977, collision of the S.S. MARINE FLORIDIAN with the Benjamin Harrison Memorial Bridge near Hopewell, Virginia, 14/ the Safety Board issued the following recommendation to the FHWA on February 14, 1978:

> Work with the U.S. Coast Guard to develop specifications for the design of dolphins, fenders, and other energy absorption and/or vessel redirection devices for the protection of both bridge and vessel during an accidental impact. Issue these design specifications along with guidelines and requirements for the placement of dolphins, fenders, and energy absorption and redirection devices. (H-78-2)

In partial fulfillment of that recommendation, the U. S. Coast Guard initiated a research project for bridge protection systems. In the first phase of the research project, a study was conducted on the advantages, disadvantages, design parameters, materials of construction, and design procedures for seven different fendering systems. The study concluded that "present-day bridge protection systems and devices are inadequate.... tankers, containerships, and barge tows have increased in substantial size without a proportional change in design criteria or innovative ideas in the bridge protection area.... Future research should center on the design, analysis, and laboratory modeling of new and innovative ideas in fendering, protective cells, and shear fences." 15/

In the second phase of the research project, which is currently underway, computer modeling will be used to analyze existing fendering systems. The performance of each system under various loading conditions will be determined, and design standards will be proposed. However, there has been no attempt to consider the effects of an impact from a ship's bow which occurs significantly above the water surface.

The U. S. Coast Guard Bridge Administration Manual sets forth Coast Guard policy for bridge construction permits, drawbridge regulations, and the alteration of bridges which pose hazards to navigation. The Coast Guard establishes minimum vertical and horizontal navigation clearances for all bridges over the navigable waters of the United States. The FHWA reviews bridge design plans for conformance with American Association of State Highway and Transportation Officials (AASHTO) specifications. 16/ Those specifications include detailed standards for highway and bridge configuration, load-bearing capability, material specifications, and construction methods. The FHWA also makes a general review to insure that the bridge size and type are appropriate for the proposed sites. There are no standards or requirements for structural pier protection.

Meteorological Information

On the average, Tampa Bay annually has about 91 days of thundershowers which usually occur in the late afternoon between June and September. The risk of a hurricane from the Gulf of Mexico has been greatest in June and October. The highest recorded wind velocity, 75 mph from the southeast for a 5-minute period, occurred during the 1935 hurricane season. Based upon weather observations made by vessels passing through the Florida northwestern coastal area during the months of May, the percentage frequencies of observations of wind speeds of 34 knots or more, wave heights of 10 feet or more, and visibilities of less than 2 nmi are about 0.0, 1.0, and 1.1, respectively. Those data are biased toward good weather samples because masters tend to avoid bad weather when possible. 17/

On the morning of May 9, 1980, southern Florida was under the influence of a moist tropical air mass with a southwesterly surface flow from the Gulf of Mexico. An instability line developed in the southwesterly flow over the Gulf of Mexico and generated a line of intense (level 5) thunderstorms which later passed over the Tampa Bay area.

Radar overlays plotted from the National Weather Service (NWS) weather radar at Ruskin, Florida, showed an area of thunderstorms with intense rain showers crossing the western coastline approximately 65 nmi north of Tampa at 0430. An area of widely scattered thundershowers extended to the southwest from the intense thunderstorms activity into the Gulf of Mexico. By 0530, a line of thunderstorms with intense activity had developed approximately 115 nmi west of Tampa. The cells were moving from 260° at about 32 knots. At 0630, the line of intense thunderstorms was approximately 65 nmi west of Tampa and was still moving from 260° at about 32 knots.

Photographs of the NWS weather radar display were taken before and after the accident. At 0713, when the last photograph before the accident was taken, the weather radar showed that the leading edge of the heaviest thunderstorm activity was about 9 nmi west of the accident site. By 0743, when the first photograph after the accident was taken, the weather radar showed that the major part of the most intense activity had moved east of the accident site.

The following surface weather observations were made on the day of the accident:

Saint Petersburg -- Clearwater Airport, about 18 nmi north of the accident site:

Time--0702; type--special; ceiling--measured 400 ft broken, 2,000 ft overcast; visibility--one-half mile; weather--thunderstorm with moderate rain showers and fog; wind--270°, 20 kns; remarks--thunderstorms all quadrants moving east.

Time--0748; type--record special; ceiling--measured 400 ft broken, 2,000 ft overcast; visibility--2 miles; weather--thunderstorm with light rain showers and fog; temperature--71° F; dew point--67° F; wind--220°, 11 kns; remarks--thunderstorms overhead and all quadrants moving east.

MacDill Air Force Base, about 17 nmi north-northeast of the accident site:

Time--0655; type--record special; ceiling--measured 1,200 ft broken, 2,400 ft overcast; visibility--2 1/2 miles; weather--thunderstorm with light rain showers and fog; temperature 75° F; dew point--70° F; wind--200°, 10 kns; remarks--thunderstorm overhead moving east, occasional lightning in clouds and cloud to cloud.

Time--0730; type--special; ceiling--estimated 500 ft broken, 2,000 ft overcast; visibility--one-half mile; weather--thunderstorm with moderate rainshowers; wind--220°, 13 kns gusting to 22 kns; remarks--thunderstorm overhead moving east, occasional lightning in clouds and cloud to cloud.

Time—0735; type—special; ceiling—estimated 1,600 ft broken, 3,000 ft overcast; visibility--1 mile; weather--thunderstorm with moderate rain showers and fog; wind--240°, 12 kns; remarks--thunderstorm overhead moving east, occasional lightning in clouds and cloud to cloud.

Albert Witted Airport, about 9 nmi north of the accident site:

Time--0700; type—surface aviation; ceiling—indefinite 500 ft obscured; visibility—three-fourths mile; weather—thunderstorm with moderate rain showers and fog; wind—240°, 12 knots; remarks—lightning cloud to cloud.

Time—0733; type—special; ceiling—indefinite 200 ft obscured; visibility--one-fourth mile; weather-thunderstorm with heavy rain showers; wind--220°, variable 290°, 25 kns gusting to 35 kns; remarks--lightning cloud to cloud.

Time—0752; type—surface aviation; ceiling—measured 700 ft overcast; visibility--1 1/2 miles; weather—thunderstorm with moderate rain showers; wind—240°, 15 kns; remarks—lightning cloud to cloud.

Sarasota-Brandenton Airport, about 15 nmi south-southeast of the accident site:

Time—0648; type—surface aviation; ceiling—indefinite 700 ft obscured; visibility—1 1/2 miles; weather—thunderstorm with light rain and fog; temperature—74° F; dew point—71° F; wind—180°, 10 kns; remarks-- rain began 0647, lightning in cloud northeast.

Time—0747; type—surface aviation; ceiling—indefinite 300 ft obscured; visibility—three-fourths mile; weather—thunderstorm; temperature—69° F; dew point—65° F; wind—270°, 25 kns gusting to 35 kns.

The NWS Contract Office at Tampa International Airport, about 23 nmi north-northeast of the accident site, reported thunderstorms beginning at 0621 and continuing well past the time of the accident. The gust recorder showed a period of high wind activity from 0702 to 0745; the highest wind recorded was 23 kns at 0741. Precipitation during the hour ending at 0751 was 0.88 inch. Thunderstorms were reported at Saint Petersburg -- Clearwater Airport beginning at 0626 and ending at 0810. The highest wind reported was 20 knots from 270° at 0702. MacDill AFB first reported thunderstorms at 0638 and last reported them at 0815. The peak wind reported was 34 knots from 220° at 0742.

At 0555 on Friday, May 9, the NWS National Severe Storms Forecast Center at Kansas City, Missouri, issued a convective SIGMET 18/ for Florida and the surrounding coastal waters. The SIGMET indicated that an area of embedded thunderstorms from 30 nmi south of Crestview, Florida, to 60 nmi southeast of Jacksonville, Florida, to 80 nmi west-southwest of St. Petersburg, Florida, was moving eastward at 25 knots. The maximum height of the top of the thunderstorms was indicated as 50,000 feet above mean sea level. As the area of thunderstorms continued to move eastward and passed over Tampa Bay, the SIGMET was updated hourly.

Convective SIGMETs are issued for tornadoes, lines of thunderstorms, embedded thunderstorms of any intensity level, isolated thunderstorms of intensity level 5 and above, areas of thunderstorms containing thunderstorms of intensity level 4 and above, and hail three-fourths of an inch in diameter or greater. Although convective SIGMETs are readily available to the aviation community, they generally are not broadcast over the NWS weather radio, nor are they readily available to mariners.

At 0030 on Friday, May 9, the NWS forecast office at Miami issued the following marine forecast for the coastal waters within 50 miles offshore from Cape Sable to Tarpon Springs:

> Small craft should exercise caution. Winds southerly 15 to 20 kns this morning becoming northerly 10 to 15 kns north of Fort Myers during the day Friday and variable around 10 kns elsewhere through Friday night. Seas increasing 4 to 6 ft then diminishing Friday night. Winds and seas higher near scattered thunderstorms today.

The following marine forecast was issued for the same coastal waters at 0425, on Friday, May 9:

> Small craft should exercise caution. Winds southerly increasing to 15 to 20 kns this morning, becoming northerly 10 to 15 kns north of Fort Myers during today and variable around 10 kns elsewhere through tonight. Winds Saturday mostly northeast 10 kns. Seas increasing 4 to 6 ft today then diminishing tonight. Winds and seas higher near scattered thunderstorms today.

Those marine forecasts pertained to the SUMMIT VENTURE's route, and their contents were broadcast from the NWS weather radio station in Tampa. Testimony established that the pilot boats were equipped to receive NWS weather radio broadcasts, but the pilot did not listen to them while en route to the SUMMIT VENTURE because the radio on the pilot boat normally scanned channels 10 and 16; tuning the radio to the NWS weather channel would discontinue reception on other channels. The radio at the pilot station on Egmont Key was not equipped to receive NWS weather radio broadcasts; the NWS forecasts could be obtained by telephone. The radio at the pilot station normally scanned channel 16. The Coast Guard broadcasts severe weather warnings on channel 16 immediately upon receipt from NWS. The dispatchers at the pilot station inform the pilots of the existing weather conditions on Tampa Bay and of any weather warnings that they have received.

The pilot testified that he always obtained weather information before going out to a vessel by discussing over the pilot station's radio the current weather with pilots operating other vessels on the bay and by listening for information on channel 16 from the Coast Guard regarding severe weather warnings. The pilot said that he always checked the visibility by looking toward 2-nmi distant Mullet Key from the pilot station and by asking the master of his assigned vessel about the current weather near the sea buoy. The pilot said that he would not "start up" a vessel on a transit through Tampa Bay unless the visibility was at least 2 nmi. The pilot testified that he would anchor his vessel if the visibility fell to one-fourth nmi while he was in Tampa Bay. A representative of the Tampa Bay Pilots Association testified that the Association has no rules regarding visibility conditions or weather conditions for piloting vessels in Tampa Bay.

The pilot of the outbound M/V GOOD SAILOR testified that about 0725 when that vessel was near buoy 10 in Egmont Channel "it was blowing a gale." He said the visibility became nil and the wind shifted. He estimated the wind to be from 280°, and the course he was steering at that time, at 60 to 70 mph. He said that "the water was white it was blowing so hard" and that it was "raining horizontally practically."

The pilot of the outbound S/S PURE OIL testified that he encountered a "vicious thunder-rain squall" and that the wind change was "almost instantaneous from a light breeze to 50 to 60 mph" as the PURE OIL turned from Cut B Channel into Cut A Channel. He described the precipitation as "heavy, heavy rain which was horizontal. . . ." He said, "We were into the storm probably about 5 to 8 minutes and approaching the bridge and. . .knowing another ship was approaching the bridge inbound. The squall didn't pass over as quickly as some of the light rains we had had and wind was so strong and visibility so bad and nothing on the radar, blanked out completely, that I determined since I could easily get out of the channel and anchor, that was the thing to do." The pilot testified that he made the decision to anchor the PURE OIL at 0734, and that he was not aware until later that the SUMMIT VENTURE had rammed the Sunshine Skyway Bridge about the same time.

The pilot-trainee onboard the SUMMIT VENTURE testified that the initial picture on the radar of the rain squall "indicated that it was nothing more than an intermittent squall or an intermittent thundershower that is so common down here. . . . There was nothing that was alarming about it at all." He estimated that the winds were "in excess of 60 knots." The pilot-trainee said that he had encountered stronger winds numerous times during his seagoing experience around the world, but "never have they come on so suddenly."

The helmsman on the SUMMIT VENTURE testified that he could see the vessel's bow until the rain was very heavy. The carpenter testified that the visibility was less than 600 feet when the rain was the heaviest. The carpenter and the boatswain said that the wind and rain were from the port quarter when they were at the bow. Motorists testified that it was raining very hard and a severe west wind was blowing when they were on the western bridge span.

A Gulf Coast Weather Service "cooperative" observer reported a 60-mph wind gust about 0735 about 13 nmi south of the accident site. On the day of the accident, the sun rose at 0654.

Medical and Pathological Information

Postmortem examinations and autopsies indicated that 28 persons died from multiple blunt impact injuries. Seven persons 19/ drowned; however, each of those persons had sustained nonfatal blunt impact injuries which could have caused unconsciousness or other incapacitation. Divers indicated that only one drowning victim appeared to have attempted to escape from a vehicle to swim to the surface.

Survival Aspects

The bridge deck between piers 1N and 1S was 144 to 155 feet above mean sea level. A vehicle falling about 150 feet would impact the water at about 67 mph. The severe crushing of most of the involved vehicles was commensurate to that which would occur from impacting a semisolid object at a similar speed.

Several bus passengers were found outside the vehicle. However, it is unlikely that they were ejected before the vehicle impacted the water. Both Scirocco occupants were found outside of that vehicle; all other vehicle occupants were inside their vehicles when recovered from the bay.

Tests and Research

The SUMMIT VENTURE's course recorder graph was removed from the instrument and was forwarded to the Safety Board's laboratory in Washington, D.C. for examination and readout. The graph paper was not damaged, the course trace was clear, and there was no evidence that the course recorder had malfunctioned. The device used for the readout was an X-Y measuring machine with a moving microscope to follow the course trace and an X-Y display to show the inches of microscope movement continuously from the point where the readout was begun. The information derived from the readout of the course trace was plotted on an expanded scale. (See figure 8.)

An expert witness who testified on behalf of the pilot made a preliminary analysis of the course trace. Regarding areas on the course recorder trace which correspond to the areas lettered A, B, and C on figure 8, the expert said, "It's not impossible that any one of those three could possibly represent the collision."

Other Information

A series of five marks were found on the steel grid in the left southbound lane at the beginning and at the end of the bridge section which sloped 13° downward. The marks were 2 to 3 inches wide and about 18 inches apart. Adhering to the metal grid within these marks was a black, rubberized material. There was abrading and southward bending to the metal grid and several studs in the grid were bent southward or displaced.

Two tire scuff marks were found on the face of the west bridge curb on the downward-sloped bridge section. Skid marks on top of the steel curb trailed southward from each tire scuff to the end of the downward-sloped bridge section. In the same area on the west bridge rail, there were beige paint transfers which matched the color of the El Camino.

The master of the SUMMIT VENTURE testified that piloting a ship through a channel in a harbor area is "one man's job." He indicated that he should not interfere with the pilot unless the pilot was doing something wrong. The master said that he did not know the exact position of the ship when he assumed the navigation watch from the chief officer, but he did know the ship's approximate position.

The Inland Rules of the Road applied to the SUMMIT VENTURE as it approached the Sunshine Skyway Bridge. Article 15 states, in part: "In fog, mist, falling snow, or heavy rainstorms, whether by day or night, a steam vessel under way shall sound, at intervals of not more than one minute, a prolonged blast." The pilot of the SUMMIT VENTURE did not sound the required fog signals.

ANALYSIS

Maneuvering of the SUMMIT VENTURE

As the SUMMIT VENTURE transited Egmont Channel, the pilot became aware of a rainshower near buoy 8 through a radio conversation with the master of the inbound tug DIXIE PROGRESS. By the time the SUMMIT VENTURE neared buoy 8, the rainshower had dissipated and the visibility had improved to 3 to 4 miles. As the SUMMIT VENTURE came abeam buoy 11, a light rainshower was encountered, and the pilot requested the master to post a lookout and an anchor watch at the bow. The pilot's request indicates that he was sensitive to weather changes while underway. That request also shows that he was preparing for the possibility that the visibility would deteriorate sufficiently to require termination of the transit and anchoring of the vessel.

Although the visibility was reduced by the rain shower when the SUMMIT VENTURE was abeam buoy 11, the pilot could still see visually buoy 13, which was about 1 nmi away. The radar showed the channel buoys clearly. As the SUMMIT VENTURE passed between buoys 13 and 14, the intensity of the rain increased, but the pilot could see visually buoy 16 about 1.3 nmi away. Because the rain had increased and because the SUMMIT VENTURE was approaching the Sunshine Skyway Bridge, the pilot took the conn from the pilot-trainee, and shortly thereafter, he ordered the vessel's speed reduced to half ahead. Those actions were prudent responses to the reduction in visibility. However, there was no navigational or weather information available to the pilot at that time to indicate that the transit should be aborted.

When the SUMMIT VENTURE came abeam of buoy 16, the pilot could not see visually the 1.3-nmi distant buoy 2A, but buoys 1A and 2A were still clearly displayed on the radar. The pilot did not notice any appreciable difference in the rain, and he later explained during testimony, "That rain in Mullet Key was intermittent -- now it's a little heavy, now it's drizzle, now it's a little heavy." Because the somewhat reduced visibility did not hazard the vessel and because he expected to sight visually buoy 2A "in moments," and with the vessel at half ahead, he continued the transit. It is apparent from the pilot's testimony that he did not consider the weather to be beyond his or the vessel's capability at that time. He said that the weather "wasn't out of the ordinary until ... we lost the radar and I lost my visual on anything." Since buoy 16 was about 1.3 nmi from buoy 2A, at least 6 minutes were available before the SUMMIT VENTURE would pass buoy 2A and approach the point past which the transit could no longer be safely aborted in the then existing weather conditions. The Safety Board concludes that the pilot's decision to continue the inbound transit in the existing weather conditions at buoy 16 was not unreasonable.

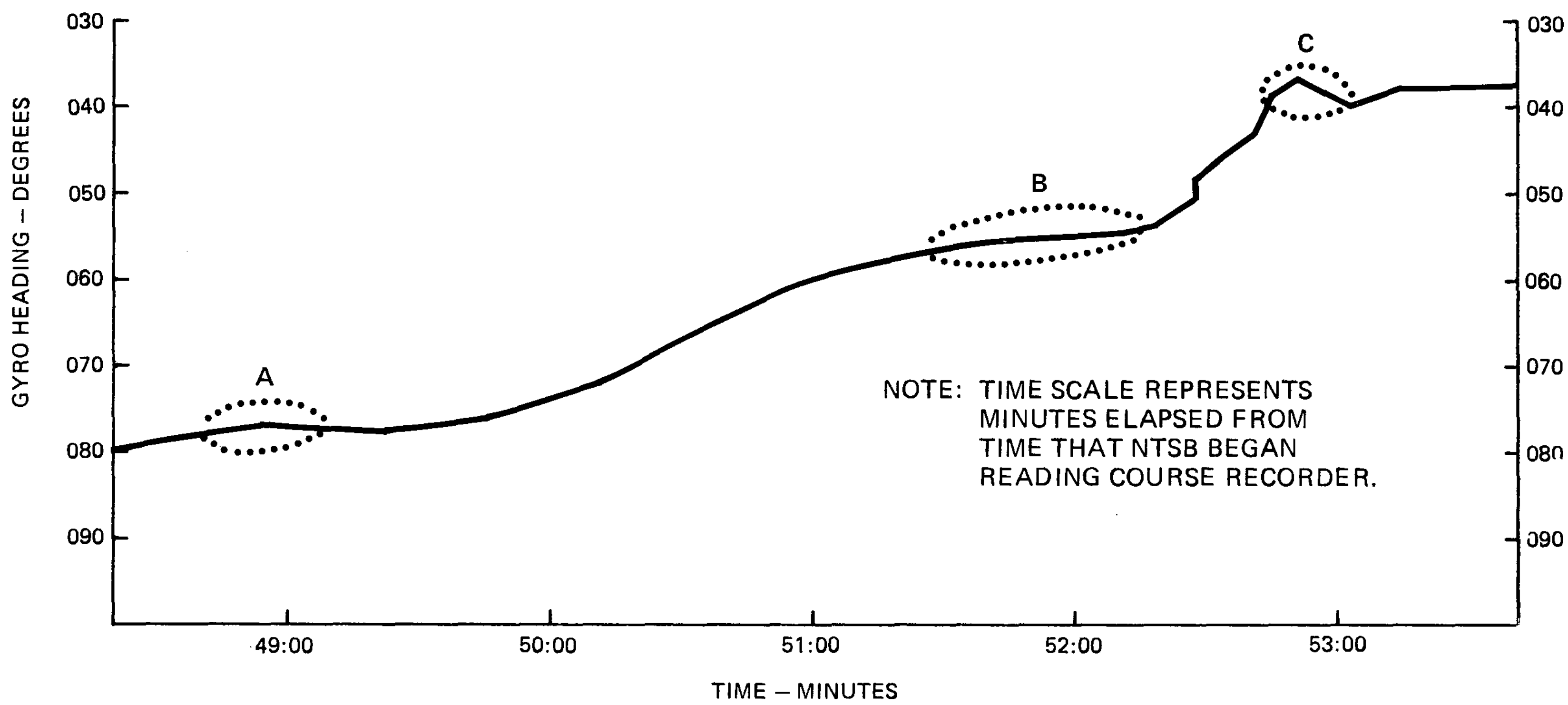


Figure 8.--Graphical representation of the SUMMIT VENTURE's course recorder trace as read by NTSB.

As the SUMMIT VENTURE continued inbound, buoys 1A and 2A remained clearly visible on the radar, but the pilot could not see them visually. The pilot alternately checked the vessel's position by radar and looked forward with binoculars to sight buoy 2A. Because the radar continued to display the channel buoys clearly, the pilot believed he could safely navigate the vessel at that time on the inbound transit, but at the same time the vessel was steadily approaching the "decision point" past which the transit could not be safely aborted. There is no evidence that the pilot had firmly established the precise geographical location of that "decision point" in his mind. In the then existing weather conditions, the SUMMIT VENTURE could have been safely turned out of the channel after it had passed buoy 2A. The pilot testified that there was adequate water to turn out of the channel on both sides because the vessel was in a light ballast condition. As the vessel approached within 0.2 nmi of buoy 2A and that buoy did not come into sight, the pilot's initial plan, according to his testimony was to turn the vessel "hard starboard" and anchor. He said that he did not intend to navigate through the bridge solely by radar and that the bridge should not be approached in reduced visibility. However, he testified that his plans "changed rapidly" when "all hell broke loose..." The Safety Board believes that the pilot's initial plan of turning hard to starboard was based upon the reduced visibility encountered after passing buoy 16, and that the initial plan should have been executed immediately upon the initial loss of the visual and radar navigational information.

When the rain and wind suddenly increased, and the radar scope filled with rain clutter, all navigational information on the radar became obliterated. Instead of turning the vessel hard to starboard, the pilot took several other actions -- he told the master to "make the anchors ready for dropping" and to have the lookout "watch carefully for a buoy on his starboard side," and he checked the radar and continued to attempt to sight buoy 2A visually. At that time, the pilot considered two turning actions -- turn the vessel hard to port or turn the vessel hard to starboard. He also considered an attempt to stop the vessel before reaching the Sunshine Skyway Bridge. Because he could not ascertain the PURE OIL's precise location at that time, the pilot of the SUMMIT VENTURE feared that a left turn might cause a collision with the PURE OIL, and he decided not to turn in that direction. The pilot believed that an attempt to crash stop would have made the vessel uncontrollable and probably would have caused the vessel to be blown into the bridge. Calculations performed by the Safety Board indicate that if the pilot had attempted to stop the vessel when the radar became ineffective, its headreach would have been about 5,300 feet, considering the influence of the current and a 60-knot wind from 280°. Since the SUMMIT VENTURE was about 5,000 feet from the bridge, the Safety Board believes that an attempt to crash stop short of the bridge without turning probably would not have succeeded.

About 30 seconds after the radar scope filled with rain clutter and the wind increased, the pilot-trainee reported that he had again picked up buoys 1A and 2A on the radar and that the SUMMIT VENTURE was in the channel. At that time, the pilot had not made a firm decision or commitment to turn the vessel to starboard and anchor. He had become concerned that the vastly increased wind velocity would blow the turning vessel toward the bridge and cause the SUMMIT VENTURE to crash broadside into the bridge piers. Regarding his consideration of a turn to starboard and the pilot-trainee's sighting of the buoys on the radar at that time, the pilot testified, "that's what I was thinking to do and he saw it right as I was thinking it." Almost immediately after that report by the pilot-trainee, the lookout on the bow reported "buoy starboard bow." The pilot apparently believed that those reports provided sufficient navigational information so that an attempt to turn to the next course and to proceed through the channel and under the bridge was less risky than turning the vessel to starboard. However, with only a momentary sighting of the buoys on the radar and a buoy sighting by the lookout on the bow, the pilot should not have expected to be able to successfully turn the vessel into Cut A Channel and to successfully navigate through the channel and under the bridge.

The Safety Board performed calculations to evaluate the SUMMIT VENTURE's turning ability in the conditions that existed after the wind had increased. The calculations accounted for the effects of a 0.8-knot current flowing at 060° and a 60-knot wind blowing from 280°. Because the wind direction and velocity could not be precisely determined, the calculations are only approximate. The calculations indicate that if the pilot had turned the vessel hard to starboard immediately upon the initial loss of the navigational information on the radar, the SUMMIT VENTURE's advance toward the bridge probably would have been about 3,000 feet while turning 90° to starboard. Thus, the vessel probably would have approached within three or four ship-lengths of the bridge. If the turn was delayed until the vessel's bow was abeam of buoy 2A, the SUMMIT VENTURE probably would have approached within two or three ship-lengths of the bridge.

When asked if he could have turned to starboard immediately upon the initial loss of buoys 1A and 2A on the radar, the pilot said, "I was thinking I have to do it, but at that time I thought that if I went hard right, I have 600 feet of ship facing a howling wind which I knew was from aft and... I figured she'd just go broadside into the bridge..." The pilot deferred the decision to turn hard to starboard for about 30 seconds, and in so doing, he allowed the vessel to proceed about 600 feet further toward the bridge. The risks presented by turning hard to starboard steadily increased until that alternative became no longer viable, and the only alternative remaining was to attempt to navigate the SUMMIT VENTURE through the channel and under the Sunshine Skyway Bridge. The Safety Board believes that there was an element of risk attendant to each navigational alternative available to the pilot as the SUMMIT VENTURE proceeded inbound, and that the least risk would have resulted from turning the vessel to starboard immediately upon the initial loss of buoys 1A and 2A on the radar.

When the pilot decided to attempt to navigate the SUMMIT VENTURE through Cut A Channel and under the Sunshine Skyway Bridge, the vessel was very close to buoy 2A. He ordered the pilot-trainee to effect the course change. The pilot-trainee ordered 10° left rudder. When questioned during the public hearing, "Did you at any time feel that was insufficient rudder amount?" the pilot replied, "Yes, I did. But I thought about it and I -- that's the normal order I'd have given under normal circumstances and I didn't want anything out of the ordinary." He also said, ". . . I wasn't sure what effect that wind would have on the ship, whether it would blow it one way or the other way . . . grab the stern, grab the light bow . . . I wanted to keep it normal and work from a normal situation . . ." Unfortunately, the pilot was not faced with a normal situation. Without the force of the wind, a turn executed in that manner at that position in Mullet Key Channel would have allowed the SUMMIT VENTURE to slide to the right of Cut A Channel about one-half the width of the channel before steadying on course. Although a turn into Cut A Channel could be made successfully with the SUMMIT VENTURE close to buoy 2A, the rudder angle would have to be significantly greater than 10° to swing the vessel around smartly to the next course. Regardless of the weather conditions, the pilot should have recognized that more than 10° left rudder angle was necessary to keep the SUMMIT VENTURE within the channel because of the vessel's position when the course change was ordered.

In this case, it would be extremely difficult to determine from the course recorder trace alone the exact time of the ramming or the heading of the ship at the ramming. The course recorder was not precisely synchronized with the bridge clock, nor were the engineroom clock and bell-logger. One area on the course recorder trace indicated by the course recorder expert as a possible point of collision was between headings of about 054° to 057°. As shown on the course recorder readout prepared by the Safety Board's laboratory, there is a distinct change of slope of the course trace at a heading of 053.6°. An abrupt change in the rate of the vessel's turning must have occurred at that point. Such an abrupt change could have been caused by the ramming. That heading of 053.6° corresponds closely with the 054° heading calculated by Safety Board investigators based upon measurements of the actual damage to the SUMMIT VENTURE. This is convincing evidence of the vessel's heading at impact, and it allows an evaluation from the course recorder trace of the vessel's headings before the impact. The course recorder trace shows that for several minutes before the impact, the SUMMIT VENTURE was steadily turning left. The 063° course ordered by the pilot-trainee was not obtained as a steady heading. Instead, the vessel turned further left through that heading, although its rate of turn decreased after passing 060°. Even with the vessel's heading steadily changing to the left, the SUMMIT VENTURE rammed the bridge to the right of the channel. The manner in which the SUMMIT VENTURE was turned from Mullet Key Channel to Cut A Channel alone could not have caused the vessel to slide sufficiently out of Cut A Channel to hit pier 2S, which is about 800 feet from the channel centerline. If the pilot had meticulously watched the vessel's gyro repeater and had attempted to order helm changes to correct the vessel's heading to 063°, the SUMMIT VENTURE would have rammed the bridge even further to the right of the channel. Since the vessel slid only slightly out of the channel during the turn from Mullet Key Channel into Cut A Channel, an external force must have acted on the vessel to force it further to the right of the channel. The force of the 0.8-knot current would have tended to push the vessel slightly to the left. The force of the wind is the only external force remaining -- and that force must have been significant.

Weather Conditions

At the time of the accident, there was a line of thunderstorms with intense rainshowers passing over the area of the Sunshine Skyway Bridge. The heaviest activity passed over the southern part of the St. Petersburg metropolitan area, the entrance to Tampa Bay, and the Sunshine Skyway Bridge. This is indicated by radar information and witnesses' statements.

The pilot of the GOOD SAILOR said he experienced 60- to 70-mph (52- to 61-knot) winds; the pilot of the PURE OIL estimated the winds at 50 to 60 mph (43 to 52 knots); the pilot-trainee onboard the SUMMIT VENTURE said the winds were in excess of 60 knots; and a "cooperative" observer reported a 60-mph (52-knot) gust. Based upon those witnesses' statements and the intensity of the thunderstorm activity as shown on the weather radar photographs, it is probable that the SUMMIT VENTURE experienced about 60-knot winds for several minutes preceding the accident.

Motorists said that the severe winds were blowing from the west. The pilot of the GOOD SAILOR reported that his vessel was heading into the wind when on a course of 280°. The pilot of the PURE OIL indicated that the winds were about west-southwest. Surface observations, although not in the immediate vicinity of the accident site, showed a variety of wind directions from 140° to 300° with the greatest number of reports between 240° and 270°. Thunderstorm generated winds are quite variable in direction. The strongest winds associated with a thunderstorm are generally in the direction of the thunderstorm's movement, although deviations from this rule are not unusual. In this case, the thunderstorms were moving from 260°, and the wind direction probably could have varied between 210° and 300°. Based upon several witnesses' statements and upon the conditions to be expected in thunderstorms of the intensity encountered in the vicinity of the accident site, the visibility was probably less than 500 feet for several minutes before the accident and probably was occasionally near zero.

The line of thunderstorms which overtook the SUMMIT VENTURE as it proceeded inbound through Tampa Bay was identified by the NWS by 0530 on radar. The line of thunderstorms was known to contain intense rain showers and to be moving east toward the Tampa Bay area. The thunderstorms were of an intensity which could cause weather conditions significantly more severe than originally forecast, and the weather conditions experienced by the SUMMIT VENTURE and other vessels on Tampa Bay were far more severe than those forecasted by the NWS. Therefore, the Safety Board concludes that the NWS weather forecasts pertinent to the time and place of the accident were substantially in error.

Since the intensity and direction of movement of the thunderstorms were known early enough to process a severe weather warning before the thunderstorms reached the Tampa Bay area, the Safety Board believes that such a severe weather warning should have been issued. Convective SIGMETs had been issued to warn the aviation community of the thunderstorms. Although he had not listened to the NWS weather radio broadcasts, the SUMMIT VENTURE's pilot had made a reasonable effort to ascertain the weather conditions that would be encountered during the inbound transit through Tampa Bay, and he had monitored channel 16 for the majority of the time from 0430 until the accident. If a severe weather warning had been issued, it is likely that the pilot would have heard it himself or would otherwise have been informed of its content. Although the actions that the pilot might have taken in face of a severe weather warning cannot be determined, he did delay the scheduled inbound voyage because of poor visibility. Because the pilot was taken completely by surprise at the intensity of the wind and the rain at a critical point in the approach to the Sunshine Skyway Bridge, he was obliged to make crucial decisions about the navigation of the SUMMIT VENTURE in a short period of time. If the pilot had been aware that severe thunderstorms were expected in the Tampa Bay area, he might have delayed the inbound voyage until the storms had passed or he might have anchored the vessel as soon as the visibility began to deteriorate. In any case, any decision made by the pilot would have been based upon more complete weather information, and it is possible that he might have taken actions which would have prevented the accident.

Vessel Traffic Service

Vessel traffic monitoring or active traffic control in congested waterways, such as Tampa Bay, is a proven method of increasing the safety of navigation and improving the efficiency of traffic lanes. The existing level of the Tampa Bay VTS involves only bridge-to-bridge radiotelephone communication and does not include traffic monitoring or navigation restrictions. The SUMMIT VENTURE's pilot testified that he avoided turning hard left at buoys 1A and 2A because he was concerned about the proximity of the outbound tanker PURE OIL. It was later determined that the PURE OIL was about 1.5 nmi distant and should not have been a cause for concern.

The Safety Board believes the establishment of one-way traffic zones in the vicinity of the Sunshine Skyway Bridge would reduce the risk of vessels meeting near the navigable span. If a no-meeting zone were specified by the Tampa Bay VTS, this would eliminate possible traffic congestion in the bridge approach. Also, during severe weather conditions, such as strong winds, swift currents, or reduced visibility, the Coast Guard in cooperation with local Port Authorities, could implement a plan to forbid or restrict vessels from transiting bridges. The development of the severe weather in Tampa Bay on May 9 might have been too rapid to implement such a plan without benefit of an appropriate weather forecast, but the integration of updated weather information with a vessel traffic system could reduce the risk of weather-related accidents.

Waterway Factors

The location of the turning buoys at the intersection of Mullet Key Channel and Cut A Channel requires that inbound vessels negotiate a left turn of 18° only 0.7 nmi before passing under the Sunshine Skyway Bridge. If a vessel operator fails to properly negotiate the turn, this can greatly reduce the probability of safe bridge passage. For example, if the helm is put over too early, if it is held over too long, or if the rudder deflection is too great for the appropriate speed, the vessel may overshoot the turn and cross the channel toward the north. With a late helm or too little helm for the appropriate speed, the vessel can slide out of the channel toward the south. Either condition could place the vessel in an untenable position because of the limited distance available to correct the vessel's course before arriving at the Sunshine Skyway Bridge. Those conditions could be further aggravated by the influence of wind or current. The Safety Board believes that channel bends should not be so close to bridges that the success of navigating under the bridge span is dependent upon the successful navigation of the channel bend, especially in a major waterway, such as Tampa Bay, where there is adequate sea room for the placement of channels.

Navigation Aids

One method of bridge protection is to provide the mariner with positive identification of the navigable channel or the space between the piers during low visibility conditions. Position fixing systems are being developed for radio-assisted pilotage by port authorities throughout the world. Among these systems are those which obtain position fixing data from the shore, active radar transponder beacons, passive radar reflectors, and precision Loran-C systems.

The shore-based system works in conjunction with an automatic portable transmitter/receiver unit which displays the vessel's positional data in digital format in relation to a fixed point, and which may be used for acquiring or maintaining the proper sailing track through a bridge or narrow channel. The device operates at a frequency of 2 MHz, has an accuracy of about 6 to 10 meters within the port area of transmitter coverage, and constantly updates the vessel's position coordinates based on the range measurements to two or more remote stations. Because this equipment operates on a line-of-sight principle, a certain amount of redundancy would be needed to guard against the loss of one remote station signal due to vessel movement. A major advantage is that the unit is lightweight, portable, and operates on an independent source. One anticipated difficulty is the need for embarking and debarking pilots to carry the portable equipment to and from each vessel.

A second, recently developed method of bridge channel identification is the installation of broadband passive radar reflectors on the navigable span. The reflectors mark the channel extremities on the vessel's radar display. The proper navigation track under the navigable span is identified by two distinct points along the bridge span as it is displayed on the radar scope. Although the effectiveness of the reflectors is reduced by heavy rain, recent improvements in reflector design have eliminated the directional sensitivity problems of the older metal corner reflectors. Radar reflector manufacturers in coordination with the Coast Guard are evaluating the new reflectors for applications in U.S. ports.

Also, a computerized shipboard navigation system has been developed to aid the piloting of vessels. Using Loran-C transmitting stations within range, this system provides a constantly updated visual display of the vessel position within a charted waterway. Computer graphics provide the pilot with channel alignment data, vessel speed, bearing, and the estimated closing rate to specified checkpoints. The system operates in low visibility conditions and will continue to function in the absence of other aids to navigation. The Loran-C systems have an accuracy of about 1,600 feet in 1,200 nmi, and their superior long-range capability is widely recognized. The Coast Guard is evaluating their position accuracy and applicability to navigation in restricted waters. The more promising aspects of the Loran-C piloting system are the cost-effectiveness and the possibility of using existing Loran-C transmitting stations.

Finally, radar transponder beacons may be utilized with conventional 3-cm marine radars. The X-band energy from the ship's radar, which is incident on the beacon, actively interrogates the beacon transponder and produces an encoded X-band radar response signal for collision avoidance information. The beacons may be installed on the bridge structure, and upon interrogation, will transmit collision avoidance data to the interrogating vessel. Use of radar transponder beacons would require only minimal changes to existing navigation systems.

The Coast Guard is currently studying U.S. ports to find a more objective basis for measuring the aids to navigation needs. The study uses visually perceived characteristics, such as the buoy size, color, configuration, and lighting, to judge the effectiveness of the buoy in enhancing the safety of marine traffic. One useful product of the study is the ability to quantify, based on pilot performance tests, the improvement or degradation that results from a change to particular aids to navigation system. This study is a commendable example of the Coast Guard's ability to respond to changing demands in the performance of aids to navigation in U. S. ports. However, the Coast Guard should also study the use of precision navigation systems for application in certain U.S. ports, with a view toward requiring the use of precision navigation systems in harbors where critical navigation problems are determined to exist. In the interim, in cooperation with the State of Florida, the Coast Guard should study the feasibility of using passive broad-band radar reflectors to delineate the extremities of Cut A Channel under the Sunshine Skyway Bridge.

Pilotage Authority

The existing State and Federal laws pertaining to Tampa Bay and other pilotage services allow a pilot who holds both licenses to operate under the authority of either, but not both at the same time. If the Coast Guard revokes a pilot's Federal license, this will not necessarily prevent him from piloting vessels under his State license; the converse is also true. This condition can limit the Coast Guard's jurisdiction in setting the qualifications for obtaining a pilot's license and in initiating remedial action for suspending or revoking a pilot's licenses. Cases might arise where a pilot could continue to serve under the authority of his Federal license even after he had an established history of hazarding the safety of vessels while piloting under the authority of his State license.

To alleviate this situation, the Safety Board believes that the Coast Guard should seek congressional legislation to gain statutory authority to act, when appropriate, against the Federal license of a pilot serving under the authority of his State license. This need not reduce the State's authority in the area of pilotage.

Sunshine Skyway Bridge Collapse

Theoretically, a cantilever bridge structure remains stable by a system of balanced weights. The weight of the anchor arm spans balances the weight of the cantilever arm spans and the suspended span, with the main channel piers acting as fulcrums and main supports. The anchor piers perform the dual functions of providing support for the anchor arm span and the steel deck truss span and of maintaining the stability of the structure's balance. Because of these major functions of support and balance, the anchor piers are critical elements of the structure.

Pier 2S was designed as a support for the steel deck truss span between piers 2S and 3S and for the south anchor arm span between piers 1S and 2S. Under normal conditions, the columns of pier 2S would be subjected to large vertical support loads and only minimal horizontal loads. The horizontal load exerted on the west column of pier 2S by the impact of the SUMMIT VENTURE far exceeded the maximum horizontal design load, and the column failed. Once the west column had failed, the south anchor arm span and the steel deck truss span began to twist to the west and an overstress condition was induced in the east column, and both columns and the pier cap collapsed into the bay.

After pier 2S had failed, the unsupported weight of the steel deck truss span and the south anchor arm span caused the steel deck truss span to pull away from its connection at pier 3S. The separation of those two spans caused a chain reaction of instability and twisting to the east in the south anchor arm span, the south cantilever arm span, and the suspended span. The steel deck truss span fell into the bay with the roadway facing west. The south cantilever arm span and the south anchor arm span lifted off the west bearing assembly and slid off the east bearing assembly at pier 1S, and, along with the suspended span, fell into the bay with the roadway and superstructure facing east. The weight of the north anchor arm span and the north cantilever arm span, and the support provided by pier 1N, helped to arrest the chain reaction of instability and twisting at the pin connection between the suspended span and the north cantilever arm span. That span remained stable and upright, but a 36-foot section of the span was pulled downward as the suspended span fell into the bay. Therefore, the Safety Board concludes that the collapse of the steel deck truss span, the south anchor arm span, the south cantilever arm span, and the suspended span resulted directly from the loss of support at pier 2S and the chain reaction which followed.

Pier 1S did not play an active part in the collapse, nor did any of the concrete piles. The replacement of some missing rivets and bolts and the repair of some structural steel members had been deferred, but the minor reduction of local strength attributable to those items is insignificant when compared to the extreme forces which acted on large parts of the bridge during the collapse. Therefore, the Safety Board concludes that the condition of the Sunshine Skyway Bridge with respect to maintenance and repair did not contribute to the collapse of about 1,297 feet of the bridge span.

Structural Pier Protection

The mass and design of bridge piers and pier protection systems and the configuration, weight, and speed of ships has a direct effect on the damage which may result from a collision. The bulwark and the forecastle of the SUMMIT VENTURE struck the pier column before the lower bow struck the pier crashwall. If the pier crashwall had been larger, or if a pier protection system had been installed at that location, the initial impact would have occurred near the waterline. Because the pier crashwall is anchored through the pier footer directly into the bay bottom and is larger and stronger than the columns, it is possible that sufficient energy might have been absorbed to reduce the vessel's forward motion and perhaps to redirect the vessel before the bulwark and forecastle struck the column. While the pier still could have been damaged, only the vessel's mast would have struck the bridge span if the vessel had been redirected to starboard, and the vessel could have passed under the bridge span if it had been redirected to port. Then, the damage to the bridge span might have been minimized.

Because the Coast Guard and FHWA have no requirements or standards for structural pier protection, the bridge owner must determine what, if any, protection will be provided. However, the Government of France requires that all bridges over navigable waterways be protected against ship impact. For small vessels, this is done by reinforcing the piers, while in the case of large vessels, steps are taken to ensure that the ships go aground on artificial islands and do not strike the piers. The official French view is that ship collision is so frequent an occurrence that it is absolutely essential to safeguard against it. 20/ Bridge owners should consider protecting existing vulnerable bridges and take particular care in pier placement in future bridge construction. The FHWA should examine this issue carefully in its review process for bridges built with Federal aid funds.

The Safety Board believes that the Coast Guard and the FHWA should coordinate their efforts in providing for the safety of the general public by determining the specific existing and proposed bridges which are in need of additional protection from ship collisions and issue standards for the design, performance, and location of structural bridge pier protection systems.

Highway User's Involvement

The vertical component of each vehicle's speed when it impacted the water was 67 mph. The water yielded for a few milliseconds after initial contact, but the shock would have been tantamount to impacting a solid object. Deformation of the involved vehicles illustrates the impact forces involved.

The Courier pickup truck's fall was partially broken when it struck and ricocheted off the SUMMIT VENTURE, which probably accounts for that vehicle's driver being the only survivor. Beyond the injury-reducing circumstances of having the fall broken, this accident was clearly nonsurvivable.

The Chevrolet driver who was attempting to stop traffic recalled that two or three cars, then a bus followed by up to six cars passed his vehicle before the road was blocked. At least three sedans, which were known to have been behind the bus, stopped south of pier 1N. The witness stated that after the road was blocked he directed his attention to the south and saw that a few vehicles were stopped south of his vehicle.

Final resting positions, vehicle damage patterns, and witnesses' statements indicated that the Courier pickup truck was the southernmost involved highway vehicle, and all traffic ahead of that vehicle crossed the bridge safely. The Courier pickup truck, the El Camino, and the Scirocco were definitely on the part of the bridge which collapsed at the time of collapse. The remaining five vehicles were driven off the downward-sloped bridge section and fell into the water after the bridge had collapsed. Those five vehicles carried 32 persons. The sequence in which those vehicles were driven off the bridge could not be determined. Since the bus was resting over the Fairmont and Nova, it must have followed them off the bridge. However, the Citation and LTD could have preceded or followed the bus; a speed of 25 to 30 mph when running off the bridge would have been sufficient to carry them over the bus to their final resting positions.

The Chevrolet driver, who attempted to stop other traffic, believed that he first stopped his vehicle about 20 to 30 feet north of pier 2N. He estimated that his backing speed was about 10 mph (14 feet per second) and that he stopped and began to wave between piers 7N and 9N. The Pontiac driver believed that the Chevrolet had stopped between piers 4N and 5N.

If the Chevrolet had stopped between piers 7N and 9N, it would have required about 70 to 90 seconds to back the 978 to 1,258 feet from the initial stop. The backing distance, if the Pontiac driver's estimate of the stopped vehicle position is accurate, would be about 558 to 698 feet and the time required for backing this distance at 10 mph would have been about 40 to 50 seconds.

The Chevrolet driver estimated that about 45 to 60 seconds elapsed from the time he stopped between piers 7N and 9N until the bus passed. Two witnesses estimated the bus' speed at 35 mph (51 feet per second). At that rate, it would require about 23 seconds to travel from pier 4N to the end of the downward-sloped bridge section and about 32 seconds to travel from pier 7N to the same point.

If those witnesses' statements are reasonably accurate, the bus ran off the bridge about 110 to 160 seconds after the bridge had collapsed. While the times are obviously not precise, they do show that the bus and four sedans ran off the bridge substantially after the collapse. The time available was more than sufficient to allow the drivers to stop safely, but they were not aware of the bridge condition ahead. If a bridge span failure detection and warning system had been installed and activated, it might have alerted the drivers of those vehicles of the danger ahead and many lives might have been saved.

CONCLUSIONS

Findings

1. As the SUMMIT VENTURE passed buoy 11, the pilot prepared for the possibility that the visibility would deteriorate sufficiently to require termination of the transit and anchoring of the vessel.

2. Before the initial loss of navigational information on the radar, there was no navigational or weather information available to the pilot to indicate that the transit should be aborted.

3. An attempt to stop the SUMMIT VENTURE short of the Sunshine Skyway Bridge after the initial loss of navigational information on the radar probably would not have succeeded.

4. The pilot failed to establish a meeting agreement with the pilot of the outbound S/S PURE OIL.

5. Because he did not know the precise location of the PURE OIL, the pilot's decision to not turn to port was not unreasonable.

6. The pilot's decision to attempt to navigate the SUMMIT VENTURE through the channel and under the Sunshine Skyway Bridge after visual and radar navigational references were lost 0.2 nmi west of buoy 2A was not a reasonable and prudent decision.

7. There was an element of risk attendant to each navigational alternative available to the pilot as the SUMMIT VENTURE proceeded inbound, but

the least risk would have resulted from turning the vessel hard to starboard immediately upon the initial loss of buoys 1A and 2A on the radar. The pilot should have executed his initial plan to turn hard to starboard immediately upon the initial loss of the visual and radar navigational information.

8. The SUMMIT VENTURE probably would not have struck the Sunshine Skyway Bridge if the pilot had turned the vessel hard to starboard immediately upon the initial loss of navigational information on the radar.

9. An active VTS would have greatly increased the likelihood that the SUMMIT VENTURE's pilot would have known the precise location of the PURE OIL and, therefore, would have decreased the risks inherent with passing under the Sunshine Skyway Bridge.

10. The intersection of Mullet Key Channel and Cut A Channel is too close to the Sunshine Skyway Bridge to allow safe aborting of a large vessel's inbound voyage when the turn is not properly executed.

11. An active VTS could have provided timely weather and traffic information to the pilot of the SUMMIT VENTURE.

12. Additional aids to navigation in Cut A Channel between buoys 1A and 2A and the Sunshine Skyway Bridge would allow a final check on a vessel's position and course-made-good before passing under the Sunshine Skyway Bridge.

13. The NWS weather forecasts pertinent to the time and place of the accident were substantially in error.

14. There is a need for a higher level of VTS in Tampa Bay.

15. Electronic navigation aids which are currently under development and testing may provide significantly improved navigational data to pilots in harbors.

16. Passive radar reflectors and marine radar transponders might provide a cost-effective means to enhance radar detection of bridge piers.

17. The Coast Guard cannot act against the Federal license of a pilot for wrongful acts committed while serving under the authority of a State license.

18. Anchor arm piers of cantilever bridge structures stabilize and balance the structure and are critical supports for large parts of the bridge span.

19. The collapse of about 1,297 feet of the Sunshine Skyway Bridge resulted directly from the loss of support at pier 2S and the chain reaction of instability and twisting which followed.

20. The condition of the Sunshine Skyway Bridge with respect to maintenance and repair on the date of the accident did not contribute to the collapse of about 1,297 feet of bridge span.

21. There is currently no unified Federal program to insure the safety of bridges which cross navigable waterways from ramming by off-course vessels.

22. There are currently no Federal standards or guidelines for the location and protection of critical bridge piers.

23. If the crashwall at pier 2S had been larger, or if a pier protection system had been installed at that location, the damage to the Sunshine Skyway Bridge from the ramming by the SUMMIT VENTURE might have been reduced.

24. If a bridge span failure detection and warning system had been installed and operated on the Sunshine Skyway Bridge on the date of the accident, lives might have been saved.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the SUMMIT VENTURE's unexpected encounter with severe weather involving high winds and heavy rain associated with a line of intense thunderstorms which overtook the vessel as it approached the Sunshine Skyway Bridge, the failure of the National Weather Service to issue a severe weather warning for mariners, and the failure of the pilot to abandon the transit when visual and radar navigational references for the channel and the bridge were lost in the heavy rain. Contributing to the loss of life and to the extensive damage was the lack of a structural pier protection system which could have absorbed some of the impact force or redirected the vessel. Contributing to the loss of life was the lack of a motorist warning system which could have warned the highway vehicle drivers of the danger ahead.

RECOMMENDATIONS

As a result of its investigation of this accident, the Safety Board reiterates the following recommendation which it issued to the U.S. Coast Guard as a result of the collision of two vessels in Tampa Bay, Florida, on January 22, 1980: 21/

> Reevaluate the proposed level of vessel traffic service (VTS) in Tampa Bay and determine if a higher level of VTS is needed. (Class II, Priority Action) (M-80-78)

In addition, the Safety Board made the following recommendations:

—to the U.S. Coast Guard:

> Improve navigational aids for vessels passing under the Sunshine Skyway Bridge. (Class II, Priority Action) (M-81-11)

Prohibit ships from meeting near the Sunshine Skyway Bridge. (Class II, Priority Action) (M-81-12)

In cooperation with local port and bridge authorities, determine the feasibility of installing nonstructural bridge protection devices for the Sunshine Skyway Bridge. (Class II, Priority Action) (M-81-13)

Seek legislation to allow the Coast Guard to act against a pilot's Federal license for acts committed while serving under the authority of his State license. (Class II, Priority Action) (M-81-14)

In cooperation with the Federal Highway Administration, develop standards for the design, performance, and location of structural bridge pier protection systems which consider that the impact from an off-course vessel can occur significantly above as well as below the water surface. (Class II, Priority Action) (M-81-15)

In cooperation with the Federal Highway Administration, conduct a study to determine which existing bridges over the navigable waterways of U. S. ports and harbors are not equipped with adequate structural pier protection. (Class II, Priority Action) (M-81-16)

Distribute a copy of the results of the Coast Guard's studies regarding bridge and pier protection systems to each appropriate member of the American Association of State Highway and Transportation Officials. (Class II, Priority Action) (M-81-17)

—to the Federal Highway Administration:

Develop standards for the design, performance, and installation of bridge span failure detection and warning systems. (Class II, Priority Action) (M-81-18)

Establish criteria to evaluate the need for installing bridge span failure detection and warning systems on existing and proposed bridges. (Class II, Priority Action) (M-81-19)

In cooperation with the U.S. Coast Guard, develop standards for the design, performance, and location of structural bridge pier protection systems which consider that the impact from an off-course vessel can occur significantly above as well as below the water surface. (Class II, Priority Action) (M-81-20)

In cooperation with the U. S. Coast Guard, conduct a study to determine which existing bridges over the navigable waterways of U. S. ports and harbors are not equipped with adequate structural pier protection. (Class II, Priority Action) (M-81-21)

Use the results of the study conducted under recommendation M-81-21 to advise appropriate bridge authorities of the benefits of installing additional pier protection systems. (Class II, Priority Action) (M-81-22)

—to the State of Florida:

Provide structural pier protection for the cantilever arm piers and the anchor arm piers of the Sunshine Skyway Bridge. (Class II, Priority Action) (M-81-23)

—to the National Weather Service:

Establish a program to disseminate the contents of all convective SIGMETs which pertain to coastal areas to mariners by NWS weather radio broadcasts and by other appropriate means as the severity of the weather may require. (Class II, Priority Action) (M-81-24)

—to the Tampa Bay Pilots Association:

Provide radio equipment capable of receiving NWS weather radio broadcasts at the Egmont Key pilot station. (Class II, Priority Action) (M-81-25)

Instruct member pilots regarding the importance of complying with Article 15 of the Inland Rules of the Road which states, in part: "In fog, mist, falling snow, or heavy rainstorms, whether by day or night. . . a steam vessel under way shall sound, at intervals of not more than one minute, a prolonged blast." (Class II, Priority Action) (M-81-26)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

ELWOOD T. DRIVER, Vice Chairman, and G. H. PATRICK BURSLEY, Member, did not participate.

April 10, 1981

JAMES B. KING, Chairman, filed the following concurring and dissenting statement:

Although I concur with the majority in the basic thrust of the probable cause, I must take exception to the finding of failure on the part of the pilot of the SUMMIT VENTURE. After a careful review of the events of the day, I don't feel we can hold the pilot responsible to the degree implied in the majority's probable cause. In retrospect, we can see that if he had taken another course of action the tragedy might have been averted. However, I feel he acted in a manner which accords with reasonable professional standards.

The pilot had to base his decisions on the facts as he knew them. He had no way of knowing the radar would remain ineffective. He had no way to calculate precisely the dynamic effects of the high winds and current on moving his ship broadside toward the bridge if he turned her hard to starboard. In those few seconds available to make crucial navigational decisions after the SUMMIT VENTURE was overtaken by the line of thunderstorms, he received critical information when buoys 1A and 2A were presented again on his radar confirming that he was in the channel and on course. Almost immediately thereafter, the lookout at the bow reported "buoy starboard bow." The pilot recognized that there was an element of risk associated with each available navigational alternative. He had passed through that point almost 800 times and felt that the least risk maneuver was to attempt to navigate through the channel and under the Sunshine Skyway Bridge. There was no bright line for decisionmaking. He acted reasonably in the situation in which he found himself.

/s/ JAMES B. KING
Chairman

April 21, 1981

APPENDIXES

APPENDIX A

HIGHWAY VEHICLE INFORMATION

1975 MC-B Crusader Bus

The 43-passenger, 1975 MC-8 Crusader bus, VIN S11552, was purchased from the manufacturer, a subsidiary of Greyhound Lines, Inc., August 11, 1975. The bus had accumulated 701,344 miles. It was equipped with a GM Model 8V-71 diesel engine, an Allison Model HP 74 D 4-speed transmission, air brakes, and an air-ride suspension system. It had a governed maximum speed of 65 mph. The previous driver, who had driven the bus 247 miles from Tallahassee to Tampa, and had arrived in Tampa at 0545 on May 9, 1980, reported that he had experienced no mechanical problems during the trip and that all pertinent subsystems were in good working order. At the time of the accident, the bus carried 25 passengers.

Damage prevented any dynamic testing of the mechanical subsystems. The postaccident inspection did not reveal any apparent mechanical malfunctions.

The roof of the bus was torn off completely and the side panels were compressed downward and buckled outward. All seats remaining within the bus were pushed rearward and down. Several seats were torn from the floor. The passenger loading door was nearly torn off and the front bumper was missing. There was transverse buckling to the floorpan forward of the drive axle and the driveline spline was pulled loose. Undercoating material had been scraped from the longitudinal metal beams under the floorpan. At the time of postaccident inspection, the speedometer indicators was frozen between 27 and 28 mph.

1980 Chevrolet Citation

The silver 1980 Chevrolet Citation 3-door hatchback, VIN 1X085A6161416, was equipped with a 4-cylinder engine, an automatic transmission, a power-assisted steering system, and power-assisted brakes. There were two occupants in the vehicle.

No mechanical defects were noted. The left front lap and shoulder belts were frayed and showed signs of stress. The right front belts did not exhibit these conditions. The headlight switch was full "on" and the air conditioner switch was on and set to "cold."

There was severe downward crush to the vehicle's roof and hood. All window glass was shattered, and there was pillar separation. There was minor longitudinal forward buckling at the vehicle's right rear corner. The instrument panel and dash were torn apart and the front seat backrests were buckled downward.

1975 Ford LTD

The black vinyl/yellow, 1975 Ford LTD 4-door sedan, VIN SU63H177281, was equipped with an 8-cylinder engine, an automatic transmission, a power-assisted steering system, power-assisted brakes, and air conditioning. There were two occupants in the vehicle.

The headlight switch was "off" and the fan switch was in the high position with the slide thermostat control near the center position. The front seatbelts did not show evidence of usage.

There was severe upward thrusting of the floorpan from the A-pillars to the rear bumper. All vehicle components forward of the front axle were buckled upward and the hood was laid over the windshield and roof. The fuel tank was flattened and burst at the forward seam. The dash and instrument panels were exploded, and there was severe vertical intrusion into the passenger compartment at the floorpan.

1980 Ford Fairmont

The blue, 1980 Ford Fairmont, 4-door sedan, VIN OF92R145007, was equipped with a 6-cylinder engine, an automatic transmission, a power-assisted steering system, power-assisted brakes, and air conditioning. There was one occupant in the vehicle, and there was no evidence of seatbelt usage.

The headlight switch was on, the wiper switch was on full, and the hazard light switch was pushed in. The air conditioning was set to "max" with the fan switch on "low."

The vehicle's left front fender was torn loose and was laying on the hood. There were bridge superstructure beam impacts to the hood and right front fender. There was a 9 1/2-inch-wide beam imprint from the rear right center deck lid to the right C-pillar with minor scraping on the right B-pillar. The rear trunk panel was buckled forward and downward.

1979 Chevrolet Nova

The light green, 1979 Chevrolet Nova, 4-door sedan, VIN 1X69D9T136983, was equipped with a 6-cylinder engine, an automatic transmission, power-assisted brakes, a power-assisted steering system, and air conditioning. There was one occupant in the vehicle, and there was no evidence of seatbelt usage.

The headlight, windshield wiper, and hazard light switches were on. The fan was on, the air conditioning was set to "normal," and the thermostat slide control was midway between hot and cold.

The vehicle's hood was missing, and there was moderately severe upward bowing of the floorpan. There was moderate impact crushing to the roof's right side with scraping extending to the Nova's right rear corner.

1976 El Camino Classic

The light tan/beige, 1976 Chevrolet El Camino Classic, 2-door sedan, VIN 1D80V6D527711, was equipped with an 8-cylinder engine, an automatic transmission, and a power-assisted steering system. One occupant was in the vehicle.

The El Camino was the most severely damaged vehicle. There was extremely severe upward bowing of the floorpan and bed, with separation from the right half of the firewall to the right front corner, thence rearward along the right side to the right rear wheelwell. There was severe lateral crushing at the left door. A 6 1/2-inch-wide bridge beam imprint ran longitudinally along the roof about 1 foot right of the left edge. A moderately severe 8-inch-wide imprint ran from the left rear wheel well to the tailgate about 21 inches left of the right rear corner and then forward diagonally to the right sideboard. Several motor compartment components were missing, including the brake master cylinder, grille, and radiator. The transmission was separated from the engine, and the bell housing was shattered. There was superficial longitudinal scraping along the side of the right front fender.

1979 Volkswagen Scirocco

The gray, 1979 Volkswagen Scirocco, 3-door hatchback, VIN 5392031, was equipped with a 4-cylinder transversely mounted engine, a 4-speed manual transmission, power-assisted brakes, and a power-assisted steering system. There were two occupants in the vehicle. Examination of restraint belts and hardware showed no evidence of belt usage.

The fan and wiper switches were on, but the headlight rocker-switch was in the "off" position.

There was severe crushing (left to right) of the Scirocco's left side; the most severe crushing was at the left door and rocker panel. The left door window frame was buckled outward. There was minor longitudinal compression (forward) at the vehicle's right rear corner and minor impact damage extending from the left C-pillar to the center of the backlight header.

1974 Ford Courier

The blue, 1974 Ford Courier pickup truck, VIN SGTAPO32452, was equipped with a 4-cylinder engine, a 4-speed manual transmission, and a manual steering system and brakes. The headlight switch was on and the fan switch was off. The occupant of the vehicle was the sole survivor among the involved highway users. Restraints were not used.

There was moderate downward crushing to both pickup bed side panels directly over the rear wheelwells. The cab had been impacted from the rear; its top was partially separated and displaced forward with severe roof buckling. The left door was sprung open and the right door was buckled. The tailgate exhibited a vertical cut centered 15 inches left from its right end. All window glass was missing. Large chunks of concrete were packed into the right front wheelwell. The seat backrest were displaced forward, and there was moderate deformation of the steering wheel rim.

APPENDIX B

CREW INFORMATION

Captain Hsiung Chu Liu

Hsiung Chu Liu, 50, had been the master of the SUMMIT VENTURE since February 12, 1980. He had graduated from the Chinese Naval Academy in 1951. He had attained the rank of Lieutenant Commander and had served as the executive officer of a minesweeper before retiring from the Chinese Navy in 1961. He had served as second officer for 1 year, as chief officer for 2 years, and as master for about 15 years on merchant vessels. His Liberian license authorized him to serve as master of oceangoing vessels of any gross tonnage.

Chief Officer Chan Chim Yee

Chan Chim Yee, 50, had served as the chief officer of the SUMMIT VENTURE for about 8 months. He had attended the Wang Hai Navigation School in Hong Kong and had been a licensed officer since November 7, 1963. His Liberian license authorized him to serve as master of oceangoing vessels of any gross tonnage.

Pilot John E. Lerro

John E. Lerro, 37, pilot of the SUMMIT VENTURE, held a United States Coast Guard license as master, steam and motor vessels of any gross tons upon oceans; first class pilot, Port Everglades sea buoy to port docks; Miami main ship channel and turning basin, sea buoy to docks; Tampa and Hillsborough Bay from the sea buoy via main ship channel to Tampa; and Old Tampa Bay to Port Tampa. His license was issued on September 9, 1977, at Tampa, Florida, and was endorsed to show his qualifications as "radar observer." He had sailed as third mate, second mate, and master from 1964 to 1976, and had served as a pilot in the Panama Canal for 11 months. Mr. Lerro was certificated by the State of Florida as a deputy pilot and was a member of the Tampa Bay Pilots Association. He had piloted vessels in Tampa Bay for 3 1/2 years and had completed 788 transits through Tampa Bay. Many of these transits were made in vessels similar to the SUMMIT VENTURE, but he had not piloted that vessel previously.

Pilot-Trainee Bruce R. Atkins

Bruce R. Atkins, 32, pilot-trainee onboard the SUMMIT VENTURE, held a United States Coast Guard license as master, steam and motor vessels of any gross tons upon oceans; operator, uninspected towing vessels upon oceans and the inland waters of the United States including the Great Lakes and western rivers; first class pilot, New York Harbor, Lower Bay, Narrows to the sea; first-class pilot, Tampa Bay from the sea buoy via main ship channel to Port Tampa, Tampa and Hillsborough Bay via main ship channel to Weedon Island, Port Manatee, Big Bend, East Tampa and East Bay including Cut D channel. His license was issued July 1, 1976, at Boston, Massachusetts, and was endorsed to show his qualifications as "radar observer." He had graduated from the United States Merchant Marine Academy in 1970 and had sailed as a deck officer for about 10 years, including 3 1/2 years as master. On the day of the accident, he was completing his last day of a 30-day observing period before beginning work as a certificated deputy pilot in Tampa Bay.

APPENDIX C

DRIVER INFORMATION

1975 MC-B Crusader Busdriver

The 43-year-old busdriver had been employed as a busdriver by Greyhound Lines, Inc., since May 10, 1968. He was properly certified as required by Federal Motor Carrier Safety Regulation No. 391.27. His most recent physical examination on December 13, 1979, indicated a need for corrective lenses, but reported no other physical disorders. He held a valid Florida chauffeur's license with no restrictions. A toll collector at the north toll plaza stated that the busdriver was not wearing glasses when the bus passed through the toll plaza.

The busdriver's employment record showed that he had been involved in seven accidents while driving a bus. Five of those accidents were classed as preventable. His Florida driving record showed one accident and one conviction for a moving traffic violation, both of which occurred on November 27, 1979.

1974 Ford Courier Driver

The 56-year-old driver of the 1974 Ford Courier pickup held a valid Florida chauffeur's license which was restricted to use with corrective lenses. He was employed as a professional truckdriver. His Florida driving record showed convictions for three moving traffic violations and failure to have a proper inspection sticker. His record also showed involvement in one traffic accident. The pickup driver had departed Gulfport, Florida, and was en route to his place of employment.

1976 El Camino Classic Driver

The 43-year-old, 1976 Chevrolet El Camino driver held a valid Florida operator's license which was restricted to use with corrective lenses. His Florida driving record showed involvement in one accident and no convictions for moving traffic violations.

1979 Chevrolet Nova Driver

The 52-year-old, 1979 Chevrolet Nova driver held a valid Florida operator's license which was restricted to use with corrective lenses. His Florida driving record showed involvement in one accident and no convictions for moving traffic violations.

1980 Ford Fairmont Driver

The 40-year-old, 1980 Ford Fairmont driver held a valid Florida chauffeur's license with no restrictions. His Florida driving record showed one conviction for unlawful speed and no accidents.

1980 Cevrolet Citation, 1975 Ford LTD, and 1979 Volkswagen Scirocco Drivers

There were two persons in each of the three remaining vehicles. In each vehicle, the two occupants were husband and wife. The drivers of these vehicles could not be positively identified. Investigating police officers believed that, in each case, the husband was driving.

The reported 47-year-old driver of the 1980 Chevrolet Citation held a valid Florida operator's license with no restrictions. His Florida driving record showed convictions for six moving traffic violations and for special hazard-failure to use due care. He had been involved in one accident.

The reported 68-year-old driver of the 1975 Ford LTD held a valid Florida operator's license with no restrictions. His Florida driving record showed convictions for two moving traffic violations. He had been involved in two accidents.

The reported 37-year-old driver of the 1979 Volkswagen Scirocco held a valid New Jersey operator's license. No further information was obtained.

NOTES

1/ All times herein are eastern daylight time based on a 24-hour clock.

2/ A publication of Lloyd's Register of Shipping giving names, dimensions, types, and general information of ships.

3/ All headings, courses, and wind directions are true unless otherwise noted.

4/ Fifteen fathoms or 90 feet.

5/ The distance traveled in coming to a stop.

6/ Braces attached perpendicularly to the crashwall and footer to provide strength and structural stability.

7/ "Vessel Traffic Systems Analysis of Port Needs," U.S. Coast Guard, August 1973.

8/ A.G. Fraudsen and H. Langso, "Investigation into the Ship Collision Problem," February 1979.

9/ Ecker, W.J., "Casualty Analysis of Selected Waterways," Third International Symposium on Marine Traffic Service, Liverpool, England, 1978.

10/ Marine Accident Report - "Collision of USCG BLACKTHORN and U.S. Tankship CAPRICORN, Tampa Bay, Florida, January 28, 1980" (NTSB-MAR-80-14).

11/ C. Osterfeld, "Ship Collisions Against Bridge Piers," International Association of Bridge and Structural Engineering, 1965.

12/ Preliminary Accident Report--Star Clipper and the Almo Bridge, Report of the Investigative Commission and the Swedish Ports Commission, February 1980.

13/ A.G. Frandsen, and H. Langso, "Ship Collision Problems," International Association of Bridge and Structural Engineering, May 1980.

14/ Marine Accident Report--"U.S. Tankship S.S. Marine Floridian Collision with Benjamin Harrison Memorial Bridge, Hopewell, Virginia, February 24, 1977" (NTSB-MAR-78-1).

15/ "The State of the Art of Bridge Protective Systems and Devices," completed under USCG contract CG-71955-A, November 1978.

16/ "Standard Specifications for Highway Bridges," AASHTO, 1977 and "Interim Specifications, Bridges," AASHTO, 1980.

17/ "United States Coast Pilot, Atlantic Coast: Gulf of Mexico, Puerto Rico, and the Virgin Islands," National Oceanic and Atmospheric Administration, 1978.

18/ A convective SIGMET is a weather advisory concerning convective weather significant to the safety of all aircraft.

19/ Two bus passengers, both occupants of the Scirroco, and the drivers of the Fairmont, Nova, and El Camino.

20/ C. Osterfeld, "Ship Collisions Against Bridge Piers," International Association of Bridge and Structural Engineering, 1965.

21/ Marine Accident Report--"Collision of USCGC BLACKTHORN and US Tankship CAPRICORN, Tampa Bay, Florida, January 28, 1980" (NTSB-MAR-80-14).

*U.S. GOVERNMENT PRINTING OFICCE : 1981 0-341-828/21