U.S. Department
of Transportation

**Research and
Special Programs
Administration**

Gateway National Recreation Area – Sandy Hook Unit

Parking Management Study

Prepared for:

U.S. Department of the Interior
National Park Service, Northeast Region
Gateway National Recreation Area – Sandy Hook Unit

Ft. Hancock, New Jersey

Prepared by:

U.S. Department of Transportation
Research and Special Programs Administration
John A. Volpe National Transportation Systems Center

Cambridge, Massachusetts

December 2003

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*: 12/2003

2. REPORT TYPE: Planning Study

3. DATES COVERED *(From - To)*: NA

4. TITLE AND SUBTITLE

Gateway National Recreation Area - Sandy Hook Unit: Parking Management

5a. CONTRACT NUMBER: NA

5b. GRANT NUMBER: NA

5c. PROGRAM ELEMENT NUMBER: NA

5d. PROJECT NUMBER: PMIS No. 62552/part 3

5e. TASK NUMBER: NPS TIC No. D-385

5f. WORK UNIT NUMBER: NA

6. AUTHOR(S)

Gary T. Ritter, Michelle Crowder (Cambridge Systematics), William R. Baron, and Emily D. Sterzin

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Department of Transportation
Research and Special Programs Administration
John A. Volpe National Transportation Systems Center

8. PERFORMING ORGANIZATION REPORT NUMBER: NA

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Park Service
Alternative Transportation Program
1201 Eye St. NW
Washington, DC 20005

10. SPONSOR/MONITOR'S ACRONYM(S): WASO/ATP

11. SPONSOR/MONITOR'S REPORT NUMBER(S): (see 5d. and 5e. above)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Public distribution/availability.

13. SUPPLEMENTARY NOTES

This report addresses alternative transportation decision factors as indicated below (Y/N/NA):
(N) Non-construction options; (Y) park carrying capacity; (Y) life-cycle/ops. & maintenance costs; (Y) cost-effectiveness.

14. ABSTRACT

This report describes the Parking Management System (PMS) concept for the Sandy Hook Traveler Information System (TIS). The PMS is an important component of the TIS because it ultimately will be used to determine the open / closed status of the park. Inside the park, the PMS will supplement the park's current parking management strategy, which uses rangers to monitor parking areas and direct traffic. Using automated data collected and disseminated by the PMS, park rangers will be able to make early decisions on park closures while maintaining visitor safety and mitigating resource damage within the park.

15. SUBJECT TERMS

Traffic Congestion, Parking Management System, Traveler Information Systems, National Park, Alternative Transportation Systems

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
None	None	None	NA	20	Gary T. Ritter

19b. TELEPHONE NUMBER *(Include area code)*: 617-494-2716, ritter@volpe.dot.gov

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Gateway National Recreation Area – Sandy Hook Unit
Parking Management Study

Michelle Crowder
Gary T. Ritter
William R. Baron
Emily D. Sterzin

December 2003

Prepared by

U.S. Department of Transportation
Research and Special Programs Administration
John A. Volpe National Transportation Systems Center

Prepared for

U.S. Department of the Interior
National Park Service, Northeast Region
Gateway National Recreation Area – Sandy Hook Unit

Acknowledgements

The authors wish to thank the numerous organizations and individuals who graciously provided their time, knowledge and guidance in the development of this report. Those of particular note are listed below.

National Park Service Staff

Bob Holzheimer (Northeast Region)
Russ Wilson (Superintendent, Gateway National Recreation Area – Sandy Hook Unit)
Richard Wells (Assistant Superintendent, Gateway National Recreation Area – Sandy Hook Unit)
Tadgh McNamee (Gateway National Recreation Area – Sandy Hook Unit)
Tom Lobkowicz (Gateway National Recreation Area – Sandy Hook Unit)

Others

Maria Dumanis (U.S. DOT Research and Special Programs Administration, Volpe Center)
Scott Peterson (EG&G Technical Services)
Randy Clarke (EG&G Technical Services)

TABLE OF CONTENTS

1.0 Overview **1**
2.0 Background **2**
2.1 Sandy Hook Attractions 2
2.2 Park Access 2
2.3 Visitation 3
2.4 Parking 5
2.5 Parking Management Problems 7
2.6 Parking Management Goals 7
3.0 PMS Options **9**
3.1 Pneumatic Tube PMS 10
3.2 Loop Detector PMS 10
3.3 Closed Circuit TV Video Camera PMS 11
3.4 Acoustic Sensor PMS 11
4.0 Recommended PMS **12**
4.1 Initial System Concept 12
4.2 Revised PMS Concept 14
4.3 Basic PMS Operation 16
4.4 Integration with TIS 16
4.5 Signage 16
4.6 Video Technology 17
4.7 Cost Comparison of Initial and Revised PMS Concept 17
4.8 Future Enhancements 18
4.9 Upcoming Considerations 19
5.0 Conclusion **19**

LIST OF TABLES

Table 1. Sandy Hook Parking Areas 5
Table 2. Sandy Hook Parking Characteristics 6
Table 3: Parking Management System Technologies 9
Table 4. Loop Placement and Corresponding Data 12
Table 5. Estimated Costs for Initial and Revised PMS Concepts 17

LIST OF FIGURES

Figure 1: Sandy Hook Region 2
Figure 2: Hartshorne Drive 3
Figure 3. Sandy Hook Attractions and Parking Areas 4
Figure 4. Inductive Loop Traffic Detector Locations 13
Figure 5. Proposed Pneumatic Tube PMS Status Maps 15

1.0 Overview

The Sandy Hook unit of Gateway National Recreation Area is a highly visited park in New Jersey during the summer season, which runs from Memorial Day through Labor Day. The current parking supply is not sufficient to serve all recreational visitors destined for Sandy Hook's beaches on peak summer weekends. The parking shortage requires park staff to manually manage beach parking and make determinations (based on judgment calls) on park closures.

As visitation to Sandy Hook continues to increase, the parking supply will continue to be problematic for Sandy Hook visitors. While most visitors understand that the parking supply dictates the open / closed status of the park, they need to be able to plan their visit to Sandy Hook accordingly. If visitors were aware of the status of the park in advance, they could make better trip-making decisions by adjusting their departure time to make it to the park before it fills, talking an alternative means of transportation to the park, an departing the park and surrounding areas promptly when the park fills, or deciding not to travel to a destination other than the park. By coordinating an automated form of parking management with Sandy Hook's current manual system, the park will be better suited to provide parking and traffic information as well as open / closed park status to visitors.

To communicate parking, traffic, and park closure information to visitors, Sandy Hook seeks to implement a Traveler Information System (TIS) as highlighted in the *Sandy Hook – Route 36 Corridor Summer Traffic Management and Agency Coordination Plan.* The TIS will include a Parking Management System (PMS), a Highway Advisory Radio (HAR) system, and Variable Message Signs (VMS)[1]. The three subsystems (HAR, VMS, and PMS) will be compatible with each other as well as TRANSCOM^{SM} (Transportation Operations Coordinating Committee - a coalition of eighteen transportation system operators and public safety agencies in New York, New Jersey, and Connecticut) and will help manage regional traffic as well as traffic inside the park.

Based on an evaluation of beach traffic and parking conditions, this report describes the Parking Management System concept recommended for the Sandy Hook TIS. The PMS is an important component of the TIS because it ultimately will be used to determine the open / closed status of the park. Inside the park, the PMS will supplement the park's current parking management strategy, which uses park rangers to monitor parking areas and direct traffic. Using automated data collected and disseminated by the PMS, park rangers will be able to make advanced decisions on park closures while maintaining visitor safety and mitigating resource damage within the park.

[1] Variable Message Signs (VMS) are also referred to as Dynamic Message Signs (DMS) or Changeable Message Signs (CMS).

2.0 Background

The Sandy Hook unit of Gateway National Recreation Area is located on Sandy Hook Peninsula between the Lower New York Bay and Atlantic Ocean in northern New Jersey. Notably, the tip of Sandy Hook is only about 16 miles from the New York City Borough of Manhattan by water. The park is a very popular summer destination but open to recreational visitors year round during daylight hours.

2.1 Sandy Hook Attractions

Sandy Hook's most prominent attraction is its beaches. Highly visited beaches in the park include Gunnison, North, and South Beaches. Other popular public attractions include the Sandy Hook Lighthouse, Visitor Center, and historic Fort Hancock. Fort Hancock, while a recreational attraction, also has a marine science center, community college, and research laboratory. The Coast Guard Base (located at the tip of the Sandy Hook peninsula) also attracts work commuters, but is closed to the general public.

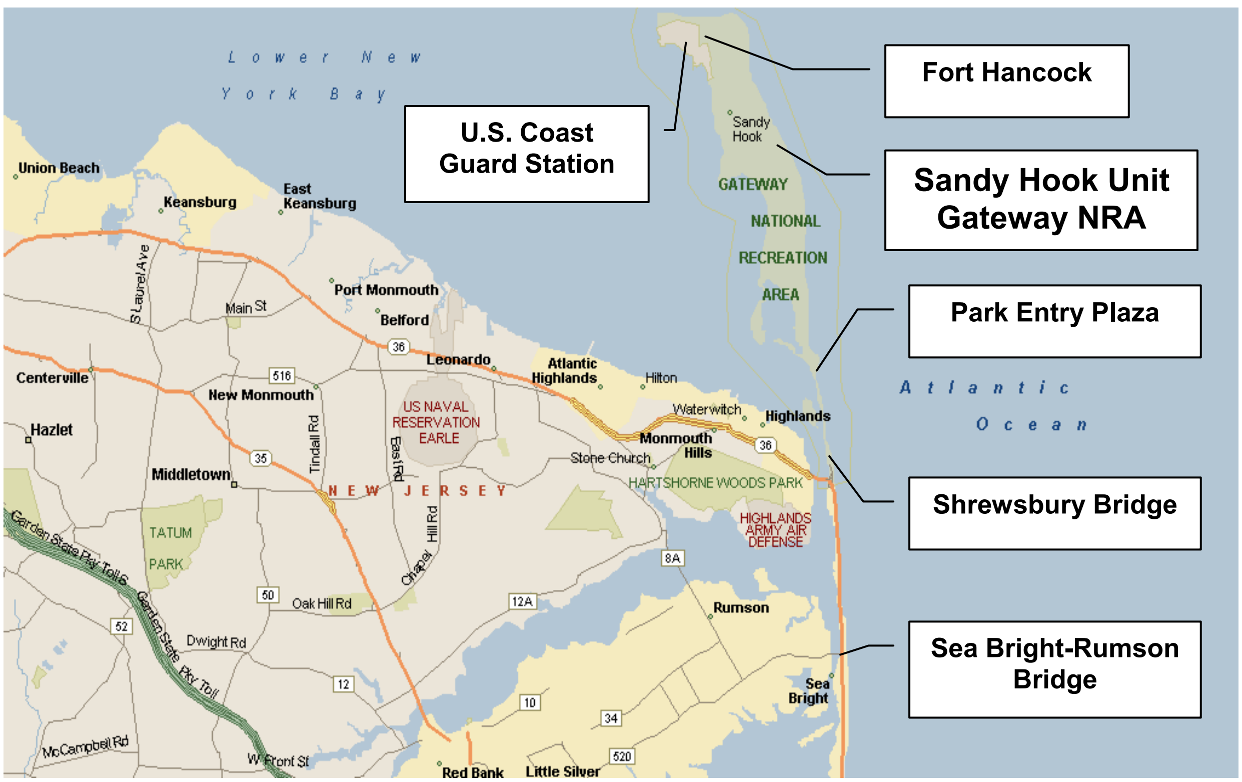

Figure 1: Sandy Hook Region

2.2 Park Access

Sandy Hook Park can be accessed via State Route 36 as well as via a ferry that runs from New York. The park entrance is located just off Route 36. All vehicular traffic entering the park must pass through this entrance, as it is the only vehicular entrance to the peninsula. There are two primary ways of approaching the park access road:

1) Route 36 over the Shrewsbury River Bridge in the Borough of Highlands and

2) County Route 520 over the Sea Bright-Rumson Bridge in the Borough of Sea Bright. Both of these roads act as connectors for traffic using the Garden State Parkway, which is about 10 miles away from the park entrance (see Figure 1).

On peak summer weekends, vehicles approaching Sandy Hook back up past the Shrewsbury Bridge into the Boroughs of Highlands and Sea Bright congesting local streets, blocking residential driveways, and increasing safety and air and noise pollution concerns. Regional traffic congestion becomes an even bigger problem when the park reaches capacity. Vehicles on Route 36 must turn around and leave the Sandy Hook area when parking areas fill and the park closes its gates.

Visitors arriving early and making it into the park are channeled through the entrance gates onto Hartshorne Drive in search of available parking. Hartshorne Drive traverses the peninsula from the park entrance to the northern destinations of Fort Hancock and the Coast Guard area. Hartshorne Drive also provides direct access to Sandy Hook's South Beaches and intersects with Atlantic Avenue to provide access to the Gunnison and North Beaches. Figure 2 shows Hartshorne Drive near the intersection of Atlantic Avenue. Figure 3 (see page 4) shows Sandy Hooks layout and popular destinations.

Figure 2: Hartshorne Drive

2.3 Visitation

Sandy Hook attracts over 2 million visitors annually, with the bulk of the visitation in the summer season, Memorial Day through Labor Day. Summer weekends attract the largest number of visitors and, consequently, visitation to the park is directly dependent on summer weekend weather. Weather aside, visitation to U.S. National Parks continues to grow steadily, and is expected to increase significantly as people search for recreational destinations closer to home.

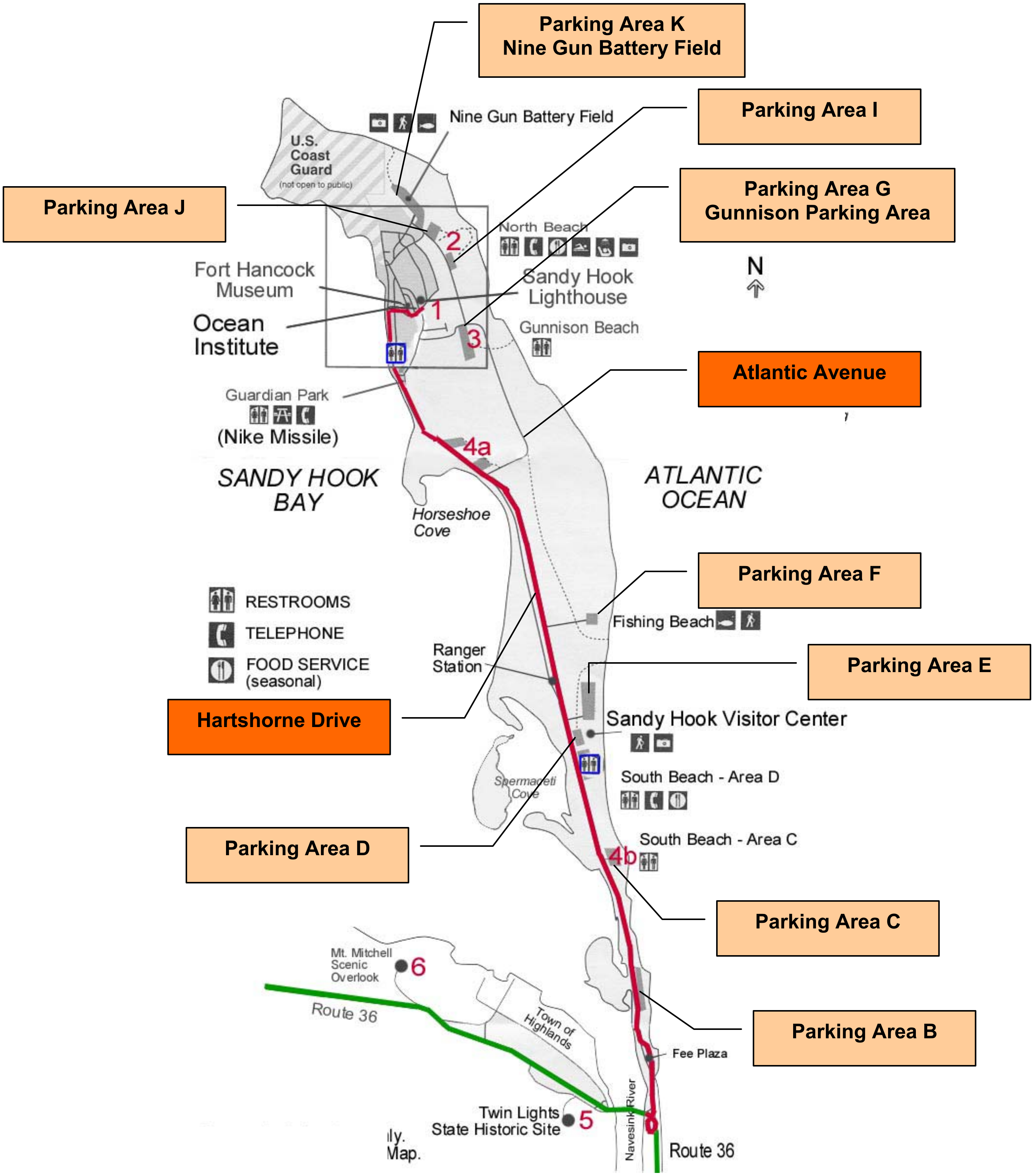

Figure 3. Sandy Hook Attractions and Parking Areas

2.4 Parking

Sandy Hook parking areas are scattered along the length of the peninsula. There are about 3,200 parking spaces available at Sandy Hook's highly visited beaches and nearby beach concessions, about 900 spaces elsewhere in the park and approximately 4,100 visitor parking spaces in total within the park. Table 1 shows the distribution of parking at Sandy Hook's main attractions. Figure 3 (see page 4) shows the location of Sandy Hook Parking areas.

Table 1. Sandy Hook Parking Areas

Parking Area	Number of Spaces	Location
B	337	South Beach
C	297	South Beach
D	703	Main Concession Area and Visitor Center
E	744	North of Visitor Center
G	787	Gunnison Beach
I	341	Gunnison and North Beaches
Beaches	**3,209**	
F	25	Fishing
J	885	Fort Hancock
K		Fort Hancock
Total	**4119**	

Beach parking areas include South Beach (Parking Areas B and C), Concession area (Parking Areas D and E), Gunnison Beach (Parking Area G), and North Beach (Parking Area I). Other parking areas include Fort Hancock area parking, Parking Area F parking, and maintenance parking areas. Fort Hancock parking provides a separate parking area for visitors and commuters destined for the venues in the Fort Hancock and Coast Guard areas. This parking is not suitable for beach goers due to its distance from beaches, but is currently adequate for Fort Hancock visitors. Park maintenance areas provide parking for employees and park vehicles and are not open to the public. While Parking Area F is a public parking area, it generally fills by sunrise, serving nearby fishing areas. Because of the restrictions on Parking Areas F, J, K and maintenance parking areas, Sandy Hook beach and concession parking areas are the most important from a parking management perspective. The parking supplies in these areas must be properly allocated to serve recreational visitation needs.

While the beach and concession parking areas are important from a parking management perspective, the availability of parking in these areas also is important from an operational perspective. When the Sandy Hook beach parking areas fill to capacity, the park must turn away incoming beach goers. Because traffic backs up along the peninsula as such visitors search for available parking, the park must also understand the primary uses of each of its main parking areas to make proper judgments of the open / closed status of the park.

Park staff currently manages the parking and open / closed status of the park beach areas based on observed travel patterns of visitors. Specific parking areas on the Sandy Hook peninsula serve specific purposes, allowing park rangers and staff to predict peak day parking behaviors and supplies. Table 2 shows the use and general supply characteristics of Sandy Hook's most "predictable" parking areas. Using these parking characteristics, park staff manually directs vehicles (via cellular phone, walkie-talkie, and face-to-face communications) to available parking spaces, and manages traffic on the peninsula.

Table 2. Sandy Hook Parking Characteristics

Parking Area	Use	Parking Area Characteristics
F	Fishing	Fills early in the morning before beachgoers arrive; remains relatively full all day.
G and I	Beach parking (Gunnison and North Beach)	High-demand beaches; fill early between 8AM and 11AM; remain full all day.
E	Beach/multi-use parking	Fills last due to relatively hidden location; remains full all day.
D	Beach/concession parking	High turnover parking for concessions; site of congestion and traffic incidents.
J and K	Fort Hancock	Supply adequate for Fort Hancock area; overflow parking not desirable for beach goers because of distance from beaches.

2.5 Parking Management Problems

Parking at Sandy Hook is not adequate to serve all potential visitors on a peak summer day. The park understands that parking availability dictates the open / closed status of the park. Although park rangers are adept at predicting the travel patterns of visitors, parking and traffic management on the peninsula become difficult and manually intensive on peak weekends. When rangers are dedicated to parking management, they have less time to focus on the other aspects of their job. However, using park rangers to manage traffic does benefit the park and its visitors. Rangers provide safety and security for visitors and their automobiles and can help mitigate vehicle resource damage.

While rangers are useful inside the park, vehicles waiting in queues outside of Sandy Hook's limits currently have no way of determining the open / closed status of the park. Waiting to get into the park, these vehicles back up on Route 36 past the Shrewsbury Bridge into the Boroughs of Highlands and Sea Bright congesting local streets, blocking residential driveways, and causing safety and air and noise pollution concerns.

The TIS (including HAR and roadside VMS) will allow the park to disseminate park information to travelers destined for Sandy Hook. This information will potentially help visitors adjust their travel plans reducing regional congestion and safety hazards. In order for the TIS to be valuable, the park will need to make better decisions on what is happening inside its limits, including advanced predictions of the open / closed status of the park. This determination is based on the availability of beach parking. Travelers need to be warned of park closures before Sandy Hook parking areas fill to capacity so that they have time to adjust their travel plans and select alternate modes of transportation (such as the proposed expansion of Sandy Hook – Bayshore Bus Shuttle service with linkages to ferry and rail service) accordingly.

2.6 Parking Management Goals

The goals identified for deployment of a PMS on the Sandy Hook peninsula include:

- Integrating some form of "real-time" technology into Sandy Hook's current manual parking management system (which uses staff to manage parking supply);
- Providing park staff with traffic count information inside the park;
- Providing park staff with information on vehicles destined for Fort Hancock area;
- Allowing park staff to monitor areas where potential problems exist (specifically queues and incidents at Parking Area D); and
- Giving park staff the option of disseminating situational information via HAR, VMS or TRANSCOM when problems (including park closures and accidents) are identified.

While properly allocating the Sandy Hook parking supply is important to the park, the park feels that managing traffic will help them better manage available parking. The park would like to have a more accurate count of total vehicles in the park so that park staff can better determine when to close the park to incoming visitors. Counts of vehicles in the North and South Beach areas would also be useful to help manually direct visitors to available parking that suits their recreational activity.

The park would also like to better manage the impacts of high turnover rates at Parking Area D. Area D is located at the parks main concession area. While some visitors park at Area D for the day, others stop at Area D for concessions as they exit the park. As vehicles exit Area D and head for the park's exit on Route 36, they must cross Hartshorne Drive, which is divided at the Area D entrance. Hartshorne becomes congested in the evenings as other beachgoers from northern beaches are also exiting the park. Due to the congestion and intersection arrangement, the Area D – Hartshorne Drive intersection has the highest number of traffic incidents in the park. These incidents require immediate attention by park rangers. Park rangers are also required to direct traffic at Area D – Hartshorne Drive when queue lengths (both in Area D and on Hartshorne Drive) become untenable for visitors.

A PMS could help the park streamline portions of its current parking management strategy while helping to solve parking and traffic problems. By integrating manual management tactics (ranger communications via cellular phone and walkie-talkie and ranger traffic direction) with advanced technology, Sandy Hook could better manage its beach parking supply and make advanced decisions on park closures, which could be relayed to visitors via the TIS.

3.0 PMS Options

Several technologies have been considered to automate portions of Sandy Hook's current parking management strategy including pneumatic tubes, loop detectors, video cameras, and acoustic sensors. Each of these technologies can be used to count vehicles on the Sandy Hook peninsula. Budget constraints restricted technologies considered as initially only $36,000 was budgeted for the PMS, including sensors, power, communication and associated design and implementation costs. These cost restrictions limit the scope of the PMS at this point in time, preventing a fully automated system as other elements of the Traffic Management System have higher priority needs. Table 3 presents basic background information, costs, and benefits / disadvantages of various traffic sensor technologies in parking management applications.

Table 3: Parking Management System Technologies

Sensor	Background	Benefits	Disadvantages	Approximate Costs
Pneumatic Tubes	Vehicles are detected based on a change in air pressure in hollow rubber tubes stretched across the roadway.	Cost effective; traditional method - can be installed quickly.	Tubes are visible to visitors and easily damaged or vandalized; traffic data limited to wheel / axle count.	About $12,000 for 9 areas, each with a tube, transmitter, and battery, and one base station with a receiver and computer.
Loop Counters	Metal loop embedded in pavement that detects vehicles using the electro-magnetic field that the vehicle generates.	Cost effective & hidden from view; traditional technology - can be installed quickly.	Require roadside power; traffic data limited to vehicle count / size, with option for speed data.	About $23,000 for 3 pairs of loops, controller unit wireless links, cabinet, and software.
CCTV Video Cameras	Software interprets images from cameras and translates the info into vehicle numbers, speeds, and lengths.	Allows for security surveillance; one camera can handle multiple lanes of traffic; provides rich array of traffic data.	Highly noticeable, require roadside power, and more maintenance than loops; affected by weather (fog); large vehicles can obscure smaller vehicles.	$45,000+ for 3 pole mounted cameras, wireless links, computer, and software.
Acoustic Devices	Acoustic sensors detect sound from tires moving on the roadway.	Small; can cover multiple lanes; low power consumption.	Require roadside power. Ambient noise can affect accuracy, as do temperature and air turbulence.	$40,000+ for 3 pairs of sensors, controller unit, wireless links, software, and computer.

3.1 Pneumatic Tube PMS

Pneumatic tubes are hollow rubber tubes stretched across the portion of the roadway where vehicle counts are needed. One end of the tube is attached to a pressure sensor / transmitter and the other end of the tube is plugged to prevent air leakage as a vehicle crosses. When a vehicle crosses the tube, the weight of the car squeezes the tube and increases the air pressure inside. The pressure increase closes an electrical switch that triggers a transmitter that sends a message to a computer, which processes the pressure changes as vehicle counts. Given that each vehicle axle produces a pressure pulse, the computer recognizes two pulses as one vehicle (as vehicles towing a trailer will result in three or more pulses, the computer recognizes the vehicle combination will take more than one space). This technology does not have the ability to classify vehicle lengths, and therefore the ability to identify RVs or buses, which have two axles, but require more than a single parking space. However, such vehicles represent a small proportion of the vehicles that park at Sandy Hook.

The pneumatic tubes are typically 1.3mm (0.5 inch) in diameter, so are visible, but not obtrusive. Tubes are easily damaged or vandalized, but inexpensive to replace. Although pneumatic tubes require a paved surface to work properly, this is a viable option for Sandy Hook as the only parking area that is not paved is one of the Fort Hancock areas, for which an alternative solution (such as placing the tubes on the road on either side of the parking area entrance and determining the parking volume by the difference between the two counters) can be implemented.

Pneumatic tubes are relatively accurate for light traffic flows depending on lane division and approach angles. The transmitters can be battery powered and transmit to a single receiver, which eliminates the cost of running power lines to the counter location and communication costs between the counters and base station.

3.2 Loop Detector PMS

Loop detectors use an inductive loop of wire wound in a circular or rectangular shape that is typically placed into a precut groove in a lane of the roadway. The loops work by sending an electric current through the wire “loop” to creating an electromagnetic field with a measurable inductance. When vehicles pass over the loop, the field is disturbed and inductance decreases. A control module detects the change in inductance then outputs a signal to a computer-processing module (via cellular communication or cable) that registers the inductance changes as vehicle counts.

Loop counters have been used extensively over many years, allowing installers to have access to a wide variety of information on loop uses and maintenance requirements. Loop detectors are also fairly accurate. A good loop detector is able to count vehicles to within a 5% margin of error. An integrated system (which includes communications, a processing unit, and a central computer) can count vehicles and some also can estimate vehicle speeds. Loop detectors are also relatively inexpensive to purchase and maintain when compared to similar technologies, making these a viable option for Sandy Hook.

Loop detectors require regular maintenance to make sure that the loops remain operational and accurate. The loop wires need to be tested regularly for accuracy, as weather and direct vehicle contact can affect accuracy. This maintenance is relatively simple compared to the maintenance and operational requirements of other technologies.

3.3 Closed Circuit TV Video Camera PMS

Closed Circuit TV (CCTV) video cameras used in association with video image processors are able to count vehicles and calculate approximate vehicle speeds. A personal computer receives the digital images from the camera. The images then are digitized and passed through a series of computer algorithms that identify changes in the image background on a pixel-by-pixel basis. Information on vehicle presence, direction, speed, length, and lane change movement can be derived from the data. Emerging camera technologies use one camera image to analyze multiple lanes of traffic. This technology provides more extensive data than other counting technologies and can also be used for incident detection.

While the type of data provided by these high-end cameras is diverse, the data is not necessarily useful for a parking application in a small venue like Sandy Hook, where vehicles are traveling in a single directional lane of traffic at relatively low speeds. The cameras also require a higher degree of maintenance and are not as effective in rain or fog. Camera technology is more costly than loop detectors, several of which can be installed for the price of one camera installation.

3.4 Acoustic Sensor PMS

Acoustic sensors track the acoustic energy generated within passing vehicles from the interaction of vehicle tires with the roadway. Microphones are used to detect changes in noise levels. When a vehicle enters this detection zone, a computer processor detects the increased sound level and a vehicle presence signal is generated. When the vehicle leaves the zone, the vehicle presence signal is terminated. This signal is sent to a computer that can tabulate the counts by lane and location.

While acoustic sensors are only marginally more expensive than loop counters, traffic count information from sensors would be less accurate in the Sandy Hook setting where weather, ocean waves, and other noises can create background noises that may be mistaken as vehicle noise. Acoustic sensors are also temperature sensitive and can be disrupted by changes in air pressure.

4.0 Recommended PMS

Due to the complexities and costs associated with video camera and sensor technologies, loop detectors and pneumatic tubes were selected as the most promising and cost-effective options for monitoring the Sandy Hook parking supply. An initial system concept, utilizing loop detectors, was devised for the park. However, after a pre-installation site visit, a pneumatic tube system was determined to be a more cost effective and efficient option given budgetary considerations. Therefore, the pneumatic tube system as described below is recommended for implementation in Sandy Hook.

The following sections describe the initial loop detector-based system concept, followed by the recommended pneumatic tube PMS.

4.1 Initial System Concept

The initial loop detector PMS concept consisted of several strategically placed loop detectors on park roadways. The loop detector placements divide the park into "zones," where traffic counts would be collected and/or calculated. Table 4 shows the location of loop placement and corresponding traffic "zones." Figure 4 shows the location of these loop detectors.

Table 4. Loop Placement and Corresponding Data

Loop Detector Location	Vehicles Counted	Map Location	"Zone" Data Provided
Hartshorne Drive, North of fee plaza (possibly existing counters at plaza)	Counts vehicles entering and exiting the peninsula.	1	Provides "total park" entry traffic count.
Atlantic Drive, near intersection with Hartshorne Drive	Counts inbound vehicles exiting Hartshorne Drive to Atlantic Drive.	2	Provides partial count of vehicles at Gunnison and North Beach parking areas.
Hartshorne Drive, North of the intersection with Atlantic Avenue	Counts vehicles traveling North on Hartshorne to Fort Hancock and Coast Guard areas.	3	Provides partial count of vehicles at Gunnison and North Beach parking areas (vehicles entering through Fort Hancock.)

Based on loop detector locations and corresponding traffic counts, the total number of vehicles in Sandy Hook Park searching for available parking (at Sandy Hook's busiest parking areas) at any time will equal those vehicles entering the park (counted at Loop Location 1). This traffic data would help park staff determine total vehicles inside the park at given time intervals and allow them to close the park when the number of vehicles inside the park equals the park's total vehicle capacity. However, it would not provide parking status information at individual parking areas.

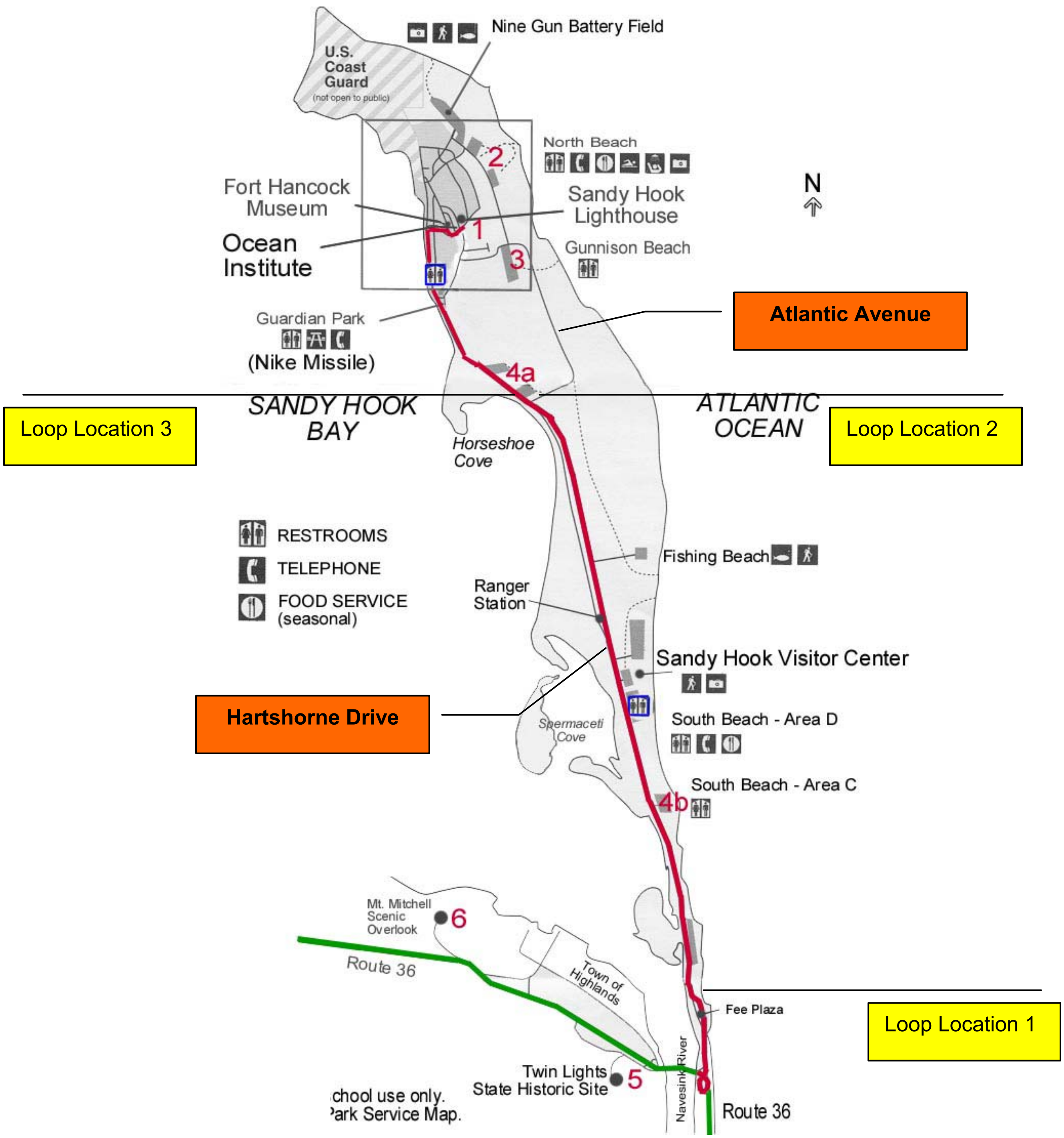

Figure 4. Inductive Loop Traffic Detector Locations

The traffic counts also allow park staff to monitor the overall parking supply in its North and South Beach areas. The northern beaches (Gunnison and North Beach) can be accessed either via Atlantic Avenue or through Fort Hancock. Traffic counts on Atlantic Avenue and just north of the Atlantic / Hartshorne intersection on Hartshorne will allow park staff to manage parking in the north beach areas, and redirect visitors when the traffic counts in those areas reach parking area capacities. The same concept applies for the South Beach area, however, the vehicles in that area will be calculated from the total number of vehicles in the park (vehicles counted at Loop Location 1 minus the number of vehicles in the Gunnison / North Beach area (the sum of vehicles counted at Loop Location 2 and Loop Location 3).

The loop detector PMS would monitor traffic within the park and allow rangers to make better decisions with respect to managing parking supplies and park closures. This system would not, however, monitor individual parking area usage. Parking area supplies would have to be determined by the park rangers and would be based on the intuitive assessment of the parking situation based on the information collected and processed by the PMS. The zonal data provided will help the rangers make better and more advanced decisions about the parking and traffic situation on the peninsula as well as help staff manage the open / closed status of the park.

The Sandy Hook park staff has a general understanding of visitor parking behavior patterns. Therefore, rangers can generally anticipate parking conditions based on their understanding of the trip destinations of visitors. By integrating the loop detector technology with the traditional manual methods of managing beach parking (and standardizing these methods), Sandy Hook could more effectively manage parking situations.

4.2 Revised PMS Concept

The implementation site review for the initial loop-based system revealed opportunities to reduce costs, improve coverage and provide more detailed parking status information for park rangers. The revised PMS concept is based on placing pneumatic tubes at the entrance and exit of each parking area in the park, thus eliminating the need to power the inductive loop detectors and the need for cellular communications, while collecting more data at points of interest. This system provides real-time data at each parking area and eliminates the need under the initial concept to predict trip destinations. In addition, it will incorporate a predictive feature to estimate the time at which the various parking areas (and consequently, the park overall) will be filled based on prevailing vehicle arrival / departure rates.

Pneumatic tubes will count passing vehicle axles (from an air pressure pulse) at each parking area and transmit these counts to a receiver and computer at a base station. The computer will run a program that reads the axle counts and processes them to vehicle counts associated with the appropriate parking area. The computer program maintains a real-time count of each parking area's capacity and graphically displays a map of the park with the volume of each parking area and displays a color-coded box (green, yellow or red) to indicate its status. Green indicates open but changes to yellow when the area is 75% full. When the parking area is 95% full, its status is changed to full, indicated by red, and the ranger sends out an order to close the area and display its closed status on message signs at the entrance and throughout the park. In addition to individual parking area counts, the program maintains an overall count of the entire park, using the green, yellow, and red color-codes. This information enables the park (by declaring green, yellow or red conditions as the threshold levels warrant) in accordance with the February 2001 *Sandy Hook - Route 36 Summer Traffic Management and Agency Coordination Plan*.

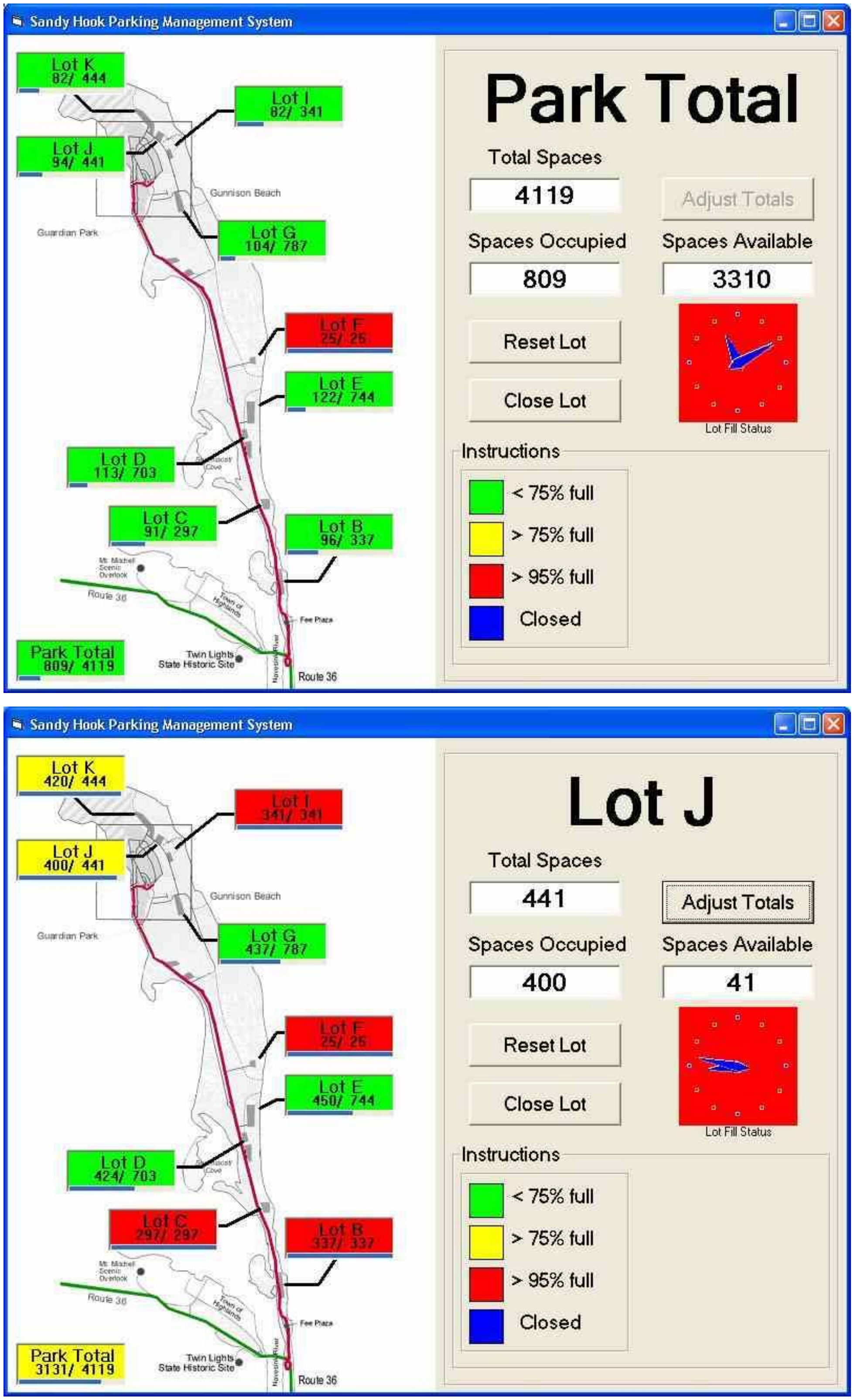

Figure 5. Proposed Pneumatic Tube PMS Status Maps

Another feature of the proposed system is a graphical battery-life indicator to inform the park rangers of the status of transmitter batteries and when these must be recharged or replaced. In addition to displaying real-time data, the program will archive the parking data for future use in assessing traffic volumes or analyzing parking trends.

4.3 Basic PMS Operation

The PMS will provide parking area traffic counts in four basic steps:

- Pneumatic tubes, located at the entrance/exit to each of the nine parking areas on the Sandy Hook peninsula, monitor air pressure changes generated by each axle of passing vehicles;
- A small microcontroller will store the number of signals from the pneumatic tube and buffer them so the transmitter will send one signal for each axle that passes over the tube;
- The transmitter will send axle counts (via radio signals) to the receiver and computer at the base station, which will calculate vehicle counts from the axle counts;
- The computer processes real-time vehicle arrivals / departures for each parking area, displaying the information graphically for park rangers;
- Rangers close full parking areas as needed and change the message displayed on variable message signs and highway advisory radio to inform visitors.

4.4 Integration with TIS

Once the TIS sub-systems (including the VMS and HAR) are operational, Sandy Hook parking and traffic information could be disseminated using these media. Cellular access to the VMS will allow for immediate communication of parking information to the signs via a phone call. HAR updates will require a recorded message.

Due to budgetary limitations, parking management capabilities were not able to be more fully automated. However, recommended software and communications links should be compatible with other TIS components to allow a more fully automated system as a future option. A fully automated system would disseminate parking information directly to the VMS, the HAR, and other traveler information systems in the region.

4.5 Signage

Inside the park, parking information can be disseminated at the park entrance via the park's manual parking area sign. Once traffic data and park staff confirms parking status (open / full), the ranger in the park entrance station can manually change the sign inform visitors that areas have reached capacity. These signs should be adjusted when areas are near capacity based on the parking patterns of visitors (see Table 2). This will prevent visitors from entering the park destined for a particular parking area when that parking area is full. (The "full" status of a parking area should be determined by both the number of vehicles inside the parking area and the number of vehicles inside the park destined for that area.)

4.6 Video Technology

While video cameras may not provide the most cost effective solution for traffic management and vehicle counts, it is an ideal addition for safety and security monitoring. A video camera is to be mounted on one of the concession areas within Parking Area D and aligned toward the Hartshorne intersection to provide park rangers the ability to monitor traffic congestion and incidents at the Parking Area D – Hartshorne Drive intersection. An initial park concept to deploy three remote controlled video cameras to monitor traffic conditions at the approaches to the park and at the fee collection station was abandoned in favor a an internal parking management system given that the status of the parking areas provides more critical insight regarding the need to take actions to restrict park entry than does traffic conditions on the approaches to the park and at the fee collection station. The desire on the part of park rangers to have information about the extent of traffic destined for the park is in part addressed by a predictive feature incorporated as part of real-time monitoring within the proposed PMS. Future enhancements to the TIS might include additional video traffic monitoring to the extent that funding permits.

4.7 Cost Comparison of Initial and Revised PMS Concept

An important aspect in determining the selection of a PMS concept for Sandy Hook was cost-effectiveness. As shown in Table 5, the revised pneumatic tube PMS concept not only provides parking data at the individual parking area level, it also is more cost-effective than the initial inductive loop system overall, in part due to avoiding the costs of loop and roadside power installation.

Table 5. Estimated Costs[2] for Initial and Revised PMS Concepts

Inductive Loop System		Pneumatic Tube System	
PMS Component	**Cost**	**PMS Component**	**Cost**
Loop Counters: 3 pairs @ $2,000 per pair	$6,000	Tube, transmitter, burial boxes, and battery: 2 sets for 9 areas @ $500 each	$9,000
Loop detector cellular communications for 3 stations @ $1,600 ea.	$7,400	Repeater	$2600
Central controller, cabinet, computer, and software	$9,500	Base station: receiver and computer	$3,000
Surveillance camera and software	$6,295	Surveillance camera and software	$6,295
Loop pair installation @ $3,500 each for 3 stations, plus roadside power @ $2,000 per site	$16,500	Installation @ $1000 per site for 9 areas	$9,000
Design & Development	$8,500	Design & Development	$7,000
Capital Cost	**$54,195**	**Capital Cost**	**$36,895**
Annual Operations & Maintenance @ 20%	$10,840	Annual Operations & Maintenance @ 20%	$7,380
Total First Year Cost	**$65,035**	**Total First Year Cost**	**$44,275**

[2] In year 2002 dollars, and not including cost of preparing government solicitations, contracting costs, and oversight.

4.8 Future Enhancements

The recommended PMS will provide comprehensive parking counts but will not fully automate parking management. A fully automated system would require communication links between the parking data system computer and other TIS components (i.e., the VMS and/or the HAR), to automatically convey appropriate messages when the PMS computer signaled that various parking areas or the park in total was full. Parking area access could also be automated; some sort of automatic gate (rather than park rangers) would be needed to prevent additional vehicles from entering full areas.

In addition to automated gates and intelligent communication to variable message signs / HAR, there are several other future enhancements that may be possible with this system:

- Install solar or roadside power to eliminate the ongoing necessity for battery recharging or replacement by park staff. Importantly, improving roadside power will allow for the use of traffic sensors other than pneumatic tubes, which require ongoing maintenance as well as being less accurate, capable, and reliable than other sensor technologies.
- Replace proposed wireless data transmitters with technology having error detection and handling capabilities to prevent data loss. This is especially a concern with respect to the more active parking areas where simultaneous triggering of transmitters using a common frequency is possible, and may result in degraded vehicle count accuracy. The additional cost of the better transmitters ($2,000 ea) was not possible within PMS budget limits, as simple transmitters costing a tenth as much can perform satisfactorily at most locations. It is recognized that those transmitters that prove unsatisfactory in service will need to be upgraded, with the expectation that the less capable equipment will serve as spares for locations which do not exhibit a problem.
- Archive parking data and use this historical data to flag unusual data. Rangers could be alerted when the current parking conditions differ from historical norms and park staff then could investigate to determine whether it is an aberration or a PMS malfunction or another reason exists for the discrepancy.
- Use real-time counts in conjunction with historical data to better estimate when the areas will fill. This would allow rangers to give visitors advance warning that the park is full and may reduce congestion.
- Connect the park's PMS with the permanent traffic counting station[3] at the park entrance station. Park staff would be able to correlate park entrance volumes with parking demand at each area.
- Connect the PMS to the Internet to provide traveler information to visitors, possibly to include posting parking area status predictions once sufficient experience is gained with the data and predictive algorithms.
- Acquire real-time data on traffic conditions on major approaches to the park, possibly via deploying video monitoring as initially conceived by the park.

[3] Part of the National Park Service Traffic Count Program administered by the WASO Field Operations Technical Support Center, Highway Operations.

4.9 Upcoming Considerations

The movable Shrewsbury River Bridge is to be replaced within 5 years with a non-movable span. This is expected to have a major impact on traffic patterns at the park entrance. These traffic patterns will not affect the ability of the PMS to count vehicles within the park; however, the new traffic patterns may change historical visitor behaviors upon which park staff makes parking management decisions. The PMS, once implemented, should be evaluated and possibly revised in conjunction with the bridge replacement, particularly with respect to the possible need for data on traffic conditions on the major approaches to the park.

The park has also noted the possibility of incorporating the E-Z Pass automated fee technology into its entry station. Data collected by automated toll collection could be compiled with data collected inside the park. The software and connections utilized for the Sandy Hook system will function as a stand alone system, but is to allow the possibility of future system interconnections within the context of the regional ITS architecture for the area, including in particular, data and information sharing through TRANSCOM.

The proposed redevelopment of Fort Hancock area as a commercial area may also require some modifications to Sandy Hook's parking management strategy. Again, after implementation, the PMS should be evaluated and reassessed if Fort Hancock development materializes. The revised PMS is structured to be able to monitor parking at Fort Hancock through the installation of PMS units at three additional locations, giving a capability for the park staff to monitor and record the number of vehicles overall in several parking areas within the vicinity of the Fort.

5.0 Conclusion

Parking and traffic management is an important part of the Sandy Hook park operations. Adding a more automated PMS to Sandy Hook's current management strategy will allow park rangers to make better decisions with respect to parking and traffic management. The proposed PMS for Sandy Hook will incorporate low-cost, pneumatic tube traffic detectors, wireless communication using battery powered transmitters, and a customized parking management system software (via a central computer) to collect and process park traffic information. The proposed PMS will meet park PMS goals by:

- Providing park staff with parking utilization data for each beach parking area on the Sandy Hook peninsula;
- Allowing park rangers to more easily and effectively monitor traffic, detect, assess and respond to potential traffic problems (like queues or accidents at Parking Area D); and
- Allowing park staff to make more informed decisions with respect to park closures and parking supply utilization.

The proposed PMS will provide vehicle counts for all beach park areas in total, as well as counts of vehicles at each beach parking area in the park. Utilizing a customized graphical software program, the park staff will have the necessary data to provide parking information to visitors entering the park, close specific parking areas (or the park) when capacities reach "full" status, and to communicate forecasts of parking availability (and eventually, corresponding alternative transportation options) to travelers destined for Sandy Hook. A video camera at Area D will allow park staff to have real-time access to incidents and queues at this parking area, which experiences the greatest number of traffic incidents. The traffic and video data will help park staff quickly attend to situations requiring intervention.

The PMS will complement the VMS and HAR sub-systems of the TIS. Park staff can post traffic / parking information or park closure messages on the portable VMS (via cellular phone), and/or record a message to disseminate information via the HAR. The information generated by the PMS and conveyed through the TIS will allow visitors to make informed decisions about their trip and in turn, reduce congestion and safety and pollution concerns on Route 36 and its adjacent communities.

#

As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our parks and historic places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-385/ July 2005