National Park Service
U.S. Department of the Interior

Cape Cod National Seashore
Cape Cod, Massachusetts

Cape Cod National Seashore
Intelligent Transportation Systems Implementation Plan
Final Report

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John A. Volpe National Transportation Systems Center

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Contents

Report Notes

This report was prepared by the U.S. Department of Transportation John A. Volpe National Transportation Systems Center (Volpe Center), in Cambridge, Massachusetts. The project team was led by Kenneth Miller of the Systems Operations and Assessment Center of Innovation, and included Joshua Hassol and Ingrid Bartinique of MacroSys Research & Technology.

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Cape Cod National Seashore
Cape Cod Commission
Towns of Brewster, Harwich, Chatham, Orleans, Eastham, Wellfleet, Truro and Provincetown
Cape Cod Regional Transit Authority
Cape Cod Chamber of Commerce
Barnstable County Regional Emergency Planning Committee
Massachusetts State Police
Massachusetts Emergency Management Agency
Barnstable County Sheriff
MassDOT Highway Division
MassDOT Division of Planning and Programming
OpenCape

Executive Summary

The Volpe National Transportation Systems Center (Volpe Center) is providing technical support to the Cape Cod National Seashore in the planning of an Intelligent Transportation System (ITS). In collaboration with the Cape Cod Commission, National Seashore staff believe that ITS can improve the quality of visitor experience and help to ease congestion related to visitor traffic at the Seashore's six beaches. Such systems can also improve management of unplanned incidents and emergency events.

Several major studies and plans have highlighted the potential benefits to the National Seashore of ITS for parking management, traveler information, and emergency communication. With this knowledge base and related planning in place, the National Seashore and the Volpe Center began a more focused exploration of investment in ITS.

The National Seashore is following the recommended systems engineering model for ITS. In keeping with regulatory requirements, it has participated in the updating of the Regional ITS Architecture for Southeastern Massachusetts. Existing conditions have been identified and researched. A productive first round of discussions between National Seashore staff and stakeholders has yielded a concept of what the system should look like and do; two linked system components, Parking Management and Traveler Information, have been identified, along with details of how they should operate. Several meetings have occurred between the research team and key emergency-response agencies at the county and state levels to discuss strategies for using whatever ITS elements the National Seashore ultimately deploys to disseminate essential traveler information in the event of a hurricane or other emergency. In addition, technology assessments have been performed on key system elements (i.e., vehicle counting systems, and traveler information systems, and recommendations have been formulated for ITS deployment in the National Seashore, in terms of both the technologies to use, and the implementation steps to follow.

During the initial phases of this project, when the desired functionality of the ITS deployment was being considered, the project team invited and received participation from a broad array of stakeholders, including local towns, state and county emergency response agencies, business organizations, and the regional public transportation Authority. As part of the preliminary analyses, the team produced an *Existing Conditions* report, the main findings from which are summarized in Chapter 3.

The high-level planning steps in the ITS implementation process are now complete. This report summarizes those steps, reports on the resulting conclusions, and provides guidance on the next steps in the implementation process: system design, procurement, and deployment.

Initial Concept of Operations and System Functional Requirements

The National Seashore and partners envision an ideal parking management system, enabling the National Seashore to:

In the near term:

- Collect real-time information on parking availability at National Seashore beaches
- Process parking data to calculate availability, and transmit messages about parking availability to traveler information systems
- Use parking data for real-time operational decisions
- Retain the parking data for future analysis and financial reconciliation, and
- Report accurate and reliable visitor data to the NPS as required

In the future:

- Collect parking fee payments made by credit card and potentially other electronic payment formats.

The initial concept of operations for traveler information envisioned the use of a variety of equipment and communications media for disseminating parking status information to travelers in the National Seashore. The team pictured traveler information potentially going out over a wide variety of media, to include the National Seashore website; highway advisory radio (HAR); and Dynamic message signs (DMS). The National Seashore and partners were always cognizant of local sensitivities with regard to the appearance of signage, in particular DMS. Consequently, the group assumed for planning purposes that any DMS would be temporary (i.e., portable units), rather than permanent installations. Portable units could also be used in emergencies as part of a coordinated traffic management and traveler information plan.

The initial concept of operations also envisioned temporary control of the traveler information infrastructure by state-level emergency management agencies, in the event of an impending hurricane or other major emergency, to broadcast evacuation orders, shelter locations, road closures, and other critical information.

ITS Technology Assessment

This report includes an assessment of ITS technologies for parking management and traveler information. Based on this assessment, the report recommends that the National Seashore deploy magnetometer-based vehicle counting systems at its beaches. In addition, the report recommends deployment of HAR to disseminate beach parking status information to travelers. HAR provides advantages over DMS, including the ability to convey more detailed messages, the ability to provide ubiquitous coverage within the National Seashore, and minimal aesthetic impacts as compared with DMS. At the same time, the report suggests that the National Seashore may wish to deploy a small, context-appropriate DMS unit near the entrance to each beach parking area, to provide parking status (and, if implemented, estimated wait time).

Implementation Plan

An incremental implementation model is recommended, as well as a design-build contract vehicle. Although the National Seashore has a strong interest in ITS, and although supporting access to natural areas is part of its core mission, provision of transportation services and systems is not. The procurement model must therefore provide the National Seashore with as close to a "turnkey" project as possible, while acknowledging that the National Seashore will still need to be heavily involved in the project in many ways. Deployment of the following ITS elements is recommended:

1) Parking management information systems at the six federally-managed beaches within the National Seashore. These systems would include ITS technology to record vehicles entering and exiting each parking area, thereby generating the data needed to calculate the available parking space in each lot.
2) A traveler information system to disseminate parking status information, utilizing HAR, and potentially small, context-appropriate DMS at the entrances to the beach parking areas. The traveler information system also would be available to disseminate urgent information during emergencies such as hurricanes.
3) Purchase of a minimum of five portable DMS units, for use in emergencies as part of coordinated traffic management (e.g., hurricane evacuation), as well as during special events that create significant traffic congestion within the National Seashore.
4) Competitively-bid procurement of ITS capital equipment and specialized engineering services, as well as project management, via a comprehensive design-build contract.
5) Incremental implementation of the ITS components – first parking management, then traveler information.

6) Deferment of electronic payment systems (e.g., credit card) at the beaches until the ITS elements are fully deployed, tested, and operating satisfactorily. Then, provision of electronic payment, if desired and cost-effective, via stand-alone point-of-sale terminals.
7) Coordination with local, county and state emergency-response agencies to establish the protocols and agreements that will be needed to allow the National Seashore's traveler information system to be used during regional emergencies.

Full system design, procurement, installation, and testing are envisioned to take approximately 24 months, and cost approximately $1.3 million (initial, high-level estimates).

1. Introduction

This report gives the National Seashore the information, guidance, and stepwise pathway it needs to pursue a detailed engineering plan and the execution, testing, and launch of an intelligent transportation system (ITS).

Over the past 15 years, several major studies and plans (discussed in Chapter 2 herein) have highlighted the potential benefits to the National Seashore of ITS for parking management, traveler information, and emergency communication. With this knowledge base and related planning in place, the National Seashore and the Volpe Center began a more focused exploration of investment in ITS.

The National Seashore is following the recommended systems engineering model for ITS deployment (see Chapter 4 for a detailed discussion of the model). In keeping with regulatory requirements, it has participated in the updating of the Regional ITS Architecture for Southeastern Massachusetts. Existing conditions have been identified and researched. A productive first round of discussions between National Seashore staff and stakeholders has yielded a concept of what the system should look like and do; two linked system components, Parking Management and Traveler Information, have been identified, along with details of how they should operate. Several meetings have occurred between the research team and key emergency-response agencies at the county and state levels to discuss strategies for using whatever ITS elements the National Seashore ultimately deploys to disseminate essential traveler information in the event of a hurricane or other emergency. In addition, technology assessments have been performed on key system elements (i.e., vehicle counting systems, and traveler information systems, and recommendations have been formulated for ITS deployment in the National Seashore, in terms of both the technologies to use, and the implementation steps to follow.

The high-level planning steps in the National Seashore's ITS implementation process are now complete. This report summarizes those steps, reports on the resulting conclusions, and provides guidance on the next steps in the implementation process: procurement, and deployment.

This report describes candidate technologies and cost provides cost figures help the National Seashore assess the feasibility of the options before it. The scope of this report does not include developing technical specifications or detailed engineering requirements, however. The cost figures provided are approximate and are intended to serve only as order-of-magnitude indicators to help the National Seashore assess project feasibility.

2. Project Background and History

Cape Cod in general and the National Seashore in particular experience transportation problems related to seasonal traffic congestion, parking availability and utilization, and low transit use. Over the past 15 years, the National Park Service, the National Seashore, and the Commonwealth of Massachusetts have recognized that ITS can help address region's mobility challenges and improve transportation conditions for visitors on the way to, at, and leaving the National Seashore. Several transportation plans have included ITS in their recommendations.

2.1 ITS Applications for the National Seashore

ITS applications encompass a broad range of communications-based information and electronics technologies. These technologies can help relieve congestion, improve safety, and make public transportation more efficient and attractive. ITS applications are interrelated, and work together to deliver transportation services. The major ITS applications as they apply to the National Seashore are the following:

2.1.1 **Parking Management**

Parking management is a component of traffic management and can comprise a number of subsystems in various combinations. The vehicle counting subsystem uses sensors to monitor the availability of parking in real time. Parking data are captured and stored electronically in back-end databases for future analysis for planning and management purposes. When vehicle counting is integrated with a traveler information subsystem, drivers receive advance parking information that reduces traveler frustration and congestion associated with searching for parking. Parking systems may include automated entry and electronic fee payment subsystems. The most advanced systems also include electronic fee payment and Internet-based advanced parking space reservation.

2.1.2 **Electronic Fee Payment and Automated Entry**

Electronic parking fee payment systems can provide benefits to parking facility operators, simplify payment for customers, and reduce congestion at entrances and exits to parking facilities. These payment systems can be enabled by any of a variety of technologies including magnetic stripe cards, smart cards, in-vehicle transponders, or vehicle-mounted bar-codes.

2.1.3 **Traveler Information**

Traveler information applications use a variety of technologies, including Internet websites, web-enabled smartphones, automotive GPS units (e.g., Garmin, Tom-Tom), telephone hotlines, television, AM/FM radio, and emerging in-vehicle systems such as XM radio to inform users of current and predicted conditions, enabling them to make informed decisions regarding trip departures, routes, and mode of travel. These same systems are activated to provide essential information in an emergency or major traffic tie-up.

Traveler information applications for transit users, such as web-based trip planning tools and real-time bus locator and arrival systems, can make transit services much more user friendly and effective. This is particularly so in rural settings like Cape Cod, because of the typically longer wait between buses.

2.1.4 **Data Archiving**

Data archiving is the collection, storage and distribution of ITS data for transportation planning, management, operation, and analyses. Data archiving systems make use of a variety of software, database, and electronic data storage technologies.

2.1.5 **Emergency Management**

In a large-scale emergency, evacuation operations and other emergency responses (e.g., re-routing traffic) typically require a coordinated response involving multiple agencies, various emergency centers, and numerous response plans. Through ITS, vital emergency traveler information (e.g., evacuation routes, shelter locations, and road closures) can be disseminated in real time. In particular, highway advisory radio (HAR) and Dynamic message signs (DMS) can provide information on weather and travel conditions. DMS can also be positioned as needed on short notice to direct traffic through detours, to staging areas, to shelters, and to locations offering medical aid during evacuations, and to guide travelers through sometimes difficult conditions when they return (e.g., road closures due to flooding).

2.2 Previous ITS Planning for the Lower and Outer Cape

Several major studies and plans have recommended investment in ITS on Cape Cod. These documents include the following:

- *The Application of Intelligent Transportation Systems for Recreational Travel*, Farradyne Systems, Inc., prepared in cooperation with MHD and Cape Cod Commission, 1995
- The 1998 Cape Cod National Seashore General Management Plan
- The 2002 Five-Year Plan for Public Transportation on Cape Cod, by the Cape Cod Transit Task Force
- The Cape Cod National Seashore Alternative Transportation Systems Long Range Planning Study, prepared by the Volpe Center in 2003
- The 2003 and 2007 Cape Cod Regional Transportation Plans, prepared by the Cape Cod Commission.
- The 2010 Parking and Transit Study, prepared by the Volpe Center.

With this knowledge base and related planning in place, the National Seashore and the Volpe Center began a more focused exploration of investment in ITS.

2.2.1 **Southeastern Massachusetts ITS Architecture**

In 2005, the Massachusetts Executive Office of Transportation's Office of Transportation Planning completed and obtained Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) approval of the Regional Intelligent Transportation System (ITS) Architecture for Southeastern Massachusetts. This activity was a response to federal requirements that such architectures be completed by April of that year, and was one of four such regional architectures, which collectively encompassed the state. Among the documents provided to the architecture team for review was the 2003 ATS Study. The completed regional architecture did not capture all of the Study's recommended deployments by the National Seashore. This is in part because the regional architecture sought to represent system elements requiring an interface between agencies, and some of the National Seashore deployments as conceptualized at the time (e.g., Parking Management) did not involve such interfaces.

2.3 Initial Stakeholder Engagement in This Project

During the initial phases of this project, when the desired functionality of the ITS deployment was being considered, the project team invited and received participation from a broad array of stakeholders. Representatives of the agencies and organizations providing guidance are shown in Table 2-1.

Table 2-1
Stakeholders Engaged Early in this Project

Stakeholder	Providing Guidance On
Cape Cod National Seashore	Strategic goals and objectives for ITS within the National Seashore Coordination between National Seashore and SE Mass region
Cape Cod Commission	Cape-wide goals for ITS Transportation, demographic, and other data Coordination on regional transportation planning
Towns of Brewster, Harwich, Chatham, Orleans, Eastham, Wellfleet, Truro and Provincetown	Economic development and tourism Parking and traffic Data sharing Emergency management Aesthetic sensitivities
Cape Cod Regional Transit Authority	Traveler information applications to support transit Information on existing and planned transit services
Cape Cod Chamber of Commerce	Regional and local economic development and tourism issues
Barnstable County Regional Emergency Planning Committee	Emergency planning Inter-agency coordination
Massachusetts State Police	Traffic management (regular conditions and during emergencies)
Massachusetts Emergency Management Agency	Emergency management Inter-agency coordination
Barnstable County Sheriff	Emergency management Inter-agency coordination
MassDOT Highway Division (HQ and District 5)	ITS Planning and Deployment Emergency Management Regional RCTO Regional ITS architecture ROW issues
MassDOT Division of Planning and Programming	Regional RCTO Regional ITS architecture ROW and permitting issues
OpenCape	Fiber-optic and microwave broadband

The following chapter summarizes the physical and institutional conditions that create the need for ITS in the National Seashore.

3. Existing Conditions

As a starting point for continuing with ITS planning, this section recaps and updates the Existing Conditions Report prepared by the Volpe Center and completed in March 2010.

3.1 Contextual Conditions

3.1.1 Demographics

In recent years, much of the population growth on Cape Cod has been attributable to retirees, and commuters to Boston and the South Shore. The combined population growth of Barnstable County and the adjacent islands of Martha's Vineyard and Nantucket between 1990 and 2000 was approximately 21%, representing the greatest increase in any part of Massachusetts. Since 2000, this growth trend appears to have abated, and year-round population has leveled off.

The percentage of Barnstable County residents aged 65 years or older is nearly double the percentage of the state and the nation. As a result, the median age is 46 years, which is significantly higher than that of both the state and the nation. As of 2006, 26% of the Barnstable County population was made up of "baby boomers"—the 19-year cohort born between 1946 and 1964. When "boomers" aged 46 to 60 are added to the number of the County's seniors, together they comprise 55% of the county's total population. A concentrated aging population creates challenges around mobility, access to commercial centers and other services, and safety.

3.1.2 Population, Traffic and Congestion

Cape Cod's population swells every summer. The towns within the National Seashore typically experience four-fold to fifteen-fold seasonal population increases. Although exact summer population counts do not exist, one indicator of seasonal population variations is housing vacancy. United States Census counts of housing units, taken in April (i.e., off season), indicate the percentage of units that are vacant, and thus provide a rough gauge of the potential for summer population growth in each town.

Table 3-1
Percentage of Housing Vacant During Off-Season in Towns within the National Seashore
Source: 2000 United States Census

Town	Percentage of Off-Season Housing Stock Vacant
Chatham	53.1%
Orleans	39.1%
Eastham	56.7%
Wellfleet	67.5%
Truro	64.4%
Provincetown	52.8%

As a consequence of the surge in summer visitors and residents, over the past three decades, summer traffic volumes on the Cape have increased by 50%. This dramatic growth largely explains the increasing congestion on Cape roadways. Major traffic volume growth occurred between 1983 and 1991. From 1991 to 2002, the traffic growth rate tapered off, and from 2002 to 2008 traffic volumes decreased somewhat.

A single, mostly limited-access highway (Route 6) serves the entire Cape. Moreover, certain sections of Route 6, such as between Exit 9 and the Orleans traffic circle, further restrict capacity. High summertime traffic volumes often lead to congestion in the National Seashore. Because protecting the Cape's unique and fragile ecosystems is of paramount importance, additional highway construction is neither feasible nor desirable. Instead, traffic management, traveler information, and transit service must be improved.

3.1.3 Parking

Beach parking within the National Seashore is limited.[1] Because most visitors arrive by car, parking demand frequently outpaces supply at certain beaches during summer months. At the same time, other beaches may have parking available. The National Seashore presently has no way of systematically monitoring parking availability and communicating that information to visitors in real time, so that they can adjust their plans accordingly.

3.1.4 Transit

The Cape Cod Regional Transit Authority (CCRTA) is the Commonwealth's public transportation provider for the Lower and Outer Cape. In addition to a number of systems serving the more densely populated towns of the Mid- and Upper Cape, CCRTA has three lines that operate within the eight Lower and Outer Cape towns, as well as a fleet of paratransit vehicles. In 2006, CCRTA began operating the Flex system on the Lower and Outer Cape. The Flex bus follows a defined route and schedule, but will deviate from the established route by 3/4 of a mile by rider request.

Despite innovative services like the Flex bus, transit use on the Cape and within the Cape Cod National Seashore is low. Transit currently accounts for less than 1% of trips within the Cape Cod National Seashore. Numerous new ITS transit deployments and enhancements have been funded through the American Recovery and Reinvestment Act of 2009; these will improve the attractiveness and efficiency of transit services on the Cape, and may help increase ridership.

3.1.5 Emergency Management

Emergency situations—such as hurricanes, Nor'easters, wildfires, or large hazmat events—may urgently require moving residents and visitors out of harm's way, often under severe time constraints, and returning them under conditions in which the normal transportation modes and routes may not be available. The last hurricane to cause real damage on the Cape was Bob, in 1991. That storm brought wind gusts reaching 200 MPH, and spawned four tornados.

The Cape Cod Emergency Traffic Plan, published in 2008, is an excellent first step toward a comprehensive emergency transportation management regime for the Cape. The plan has a tight focus: getting travelers over the Sagamore and Bourne Bridges before winds reach 70 mph and the bridges must be closed. The plan describes the logistics, command structure, and assignments for managing traffic from Exit 2 on Route 6 to the bridges. Traffic off the Cape will be channeled over the bridges but away from the canal roads. When wind speeds require bridge closure, the access points to the roads leading to the bridges will be closed, and evacuees will be directed to shelter at the Massachusetts Military Reservation.

At present the Cape lacks the ITS infrastructure to provide widespread emergency information to travelers, or to monitor roadway conditions and direct coordinated emergency responses from a

[1] The Cape Cod National Seashore does not intend to increase or reduce the existing supply of beach parking.

centralized location. This is particularly important given the large influxes of summer visitors, many of whom are unfamiliar with the Cape, and for whom emergency instructions would be especially helpful.

3.2 Changes in the ITS Planning Environment

3.2.1 The Regional ITS Architecture for Southeastern Massachusetts

In 2005, the Massachusetts Executive Office of Transportation's Office of Transportation Planning (OTP) organized the development of four regional ITS architectures for the Commonwealth. The March 2005 Regional ITS Architecture for Southeastern Massachusetts was the first ITS planning product managed by a statewide authority (in this case, the Executive Office of Transportation) that incorporated the Cape and Islands. It engaged stakeholders for ITS deployment on the Cape, and it formally set the stage for further ITS planning and deployment in the National Seashore and on the Cape as a whole. Based on review of planning documents and on stakeholder input, three major themes were identified as especially important to the region: emergency management and response, traffic congestion and traveler information, and use of ITS data. These themes were considered throughout the remainder of the architecture development process and in the framing of the Implementation Plan. Updating of this regional architecture under the leadership of the MassDOT Office of Planning and Programming is underway at this time, with a target completion window of Spring/Summer 2010.

3.2.2 The Reorganization of Massachusetts Transportation Agencies

The bulk of ITS expenditures by the Commonwealth up to the present have been for deployments in greater Metro Boston, along the Massachusetts Turnpike (I-90), and on major transportation corridors (I-95/Route 128, I-93, and I-91). As far back as 1994, the state had prepared an "Intelligent Vehicle Highway System" Strategic Deployment Plan, but its scope was limited to Metropolitan Boston, which at the time was defined as the primary roadways within I-495[2], thus stopping at Bourne. Through the middle of this decade, ITS planning for the National Seashore and the Cape was performed by the entities locally responsible for those areas; involvement of state transportation agencies was largely peripheral.

However, policy developments at the federal and state levels have since engaged state government agencies in a leadership role in relation to ITS, and have expanded thinking about ITS to a multiregional and statewide level. In Massachusetts, these state-led efforts are establishing the framework, opportunities, and policy environment for planning ITS implementation for the National Seashore, the Cape, and the eastern Commonwealth.

In July 2007, Gov. Deval Patrick signed an executive order establishing the Massachusetts Mobility Compact. The Compact was created to improve the Commonwealth's transportation bureaucracy in three areas: Mobility, Efficiency, and Best Practices,[3] by fostering coordination, communication, and resource sharing among the State's many transportation agencies and quasi-independent transportation authorities.

As a direct outgrowth of the Mobility Compact, the Governor signed a transportation reform bill in June 2009 creating a new Massachusetts Department of Transportation (MassDOT), streamlining and consolidating the multiple institutions that up to that point had overseen various sectors of the transportation bureaucracy in the state. MassDOT comprises four divisions: Highway, Mass Transit, Aeronautics and Registry of Motor Vehicles,[4] and an Office of Planning and Programming charged with

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[2] Commonwealth of Massachusetts. *Intelligent Vehicle Highway Systems Strategic Deployment Plan for Metropolitan Boston: Final Report*. 1994. p. 2-1.

[3] Commonwealth of Massachusetts Executive Department. Executive Order No. 488 Establishing the Massachusetts Mobility Compact. July 17, 2007.

[4] http://www.mass.gov/?pageID=gov3pressrelease&L=1&L0=Home&sid=Agov3&b=pressrelease&f=090626_transportation_reform_bill&csid=Agov3. Accessed 9/30/2009.

policy development and planning for the state's network of roads, bridges, tunnels and airports.[5] The new agency launched on November 1, 2009. MassDOT is administered by a Secretary of Transportation, and is overseen by a Board of Directors appointed by the Governor with expertise in transportation, finance and engineering.

3.3 Statewide ITS Planning Initiatives

In recent years, the approach to strategically planning and implementing transportation systems in general, and ITS in particular, has been shifting toward optimizing the use of existing infrastructure across modes and jurisdictional boundaries through the application of transportation systems management and operations (TSM&O) strategies.[6] In 2008, MassHighway (now , MassDOT Highway Division) received a grant from FHWA's Office of Operations to create a Regional Concept of Transportation Operations (RCTO) for Metropolitan Boston, which is defined to include Cape Cod.[7]

Phase 2 of the Metropolitan Boston RCTO development is to develop an ITS Strategic Plan that is also to include Cape Cod. This is to be a 5-year vision that will set priorities for deployment and contain high-level cost estimates.

On the Cape, a number of the past recommendations for ITS deployment are being addressed, particularly in the areas of transit management and related traveler information technologies. A wide array of transit ITS projects, funded through the American Recovery and Reinvestment Act and slated by the Cape Cod Regional Transit Authority for imminent deployment, will implement many of the long-standing recommendations in the Cape's transit sector. A tally of the ITS applications recommended in past studies and the current state of completed and imminent ITS deployments (as of the original Existing Conditions Report) is presented in Table 3-1.

3.4 Statewide Planning for Emergency Management

The devastation wrought on the Gulf Coast by Hurricane Katrina vastly increased public and governmental attention to the need for effective advance planning for managing hurricane emergencies. This additional concern became a further focus for Homeland Security planning in vulnerable states. In January 2008, as an outgrowth of the Massachusetts Mobility Compact, an EOT Director of Security Planning and Emergency Preparedness was named. His role is to spearhead an interagency initiative to include coordination of training programs and exercises, the continued development of uniform response plans, incident management protocols and procedures, interagency agreements, the completion of plans related to vulnerabilities and mitigation, continuity of operations, emergency operations, and disaster recovery.[8]

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[5] http://www.allbusiness.com/government/government-bodies-offices-heads-state/12957462-1.html. Accessed 9/30/2009. And http://www.massdot.state.ma.us/main/MassDOTAboutUS.aspx. Accessed 11/3/2009.

[6] FHWA. *Regional Concept for Transportation Operations—The Blueprint for Action: A Primer*, 2007, p. 1-1. At http://www.ops.fhwa.dot.gov/publications/rctoprimer/rcto_primer.pdf .

[7] Russ Bond, MA Highway Office of Operations, personal communication to Ingrid Bartinique and Charlotte Burger, September 22, 2009.

[8] Commonwealth of Massachusetts Executive Office of Transportation. *Massachusetts Mobility Compact Six-Month Report*. March, 2008. At http://www.eot.state.ma.us/downloads/mobility/6_Mth_Report.pdf

Table 3-2
Comparison of Recommended ITS Deployments with Existing and Imminent Deployments as of March 2010

Category	System	2002 Five-Year Plan	2003 ATS Long-Range Study Short-Term	2003 ATS Long-Range Study Long-Term	2003 Regional Plan	2007 Regional Plan	Deployed/ Imminent
Transit Management	Electronic fare system (EFS)/smart cards	X			X		X
	Integrated radio system connecting transit providers	X					
	Central dispatching system for paratransit	X					
	Replacement of CCRTA's operations center	X					
	On-board mobile data terminals						X
	Wireless communications with operations center						X
	CASD software						X
	Mobility Management Transportation Call Center						X
	Bus Locator (Internet)						X
Traveler Information	Automated trip planning	X				X	
	CMS on major roads	X	X	X	X	X	X*, ***
	Centralized collection/dissemination at Hyannis Transportation Center		X				
	Internet-based information kiosks		X				
	511		X				X**
	Highway advisory radio (HAR)		X			X	X***
	Bus Locator (Internet)						X
	Web 2.0 integrated intermodal traveler information.						X
Traffic Management	Traffic cameras			X			
	Highway probe surveillance						
Centralized Traffic Operations	Permanent regional operations center (TOC) co-located with new CCRTA operations center			X			
Parking Management	Pneumatic tube counters		X				
	Loop counters			X			
Emergency Management	Emergency control center function for TOC			X			
	VMS (i.e., to convey emergency info)			X			
	Regionwide emergency management coordination			X	X	X	
Data Archiving	National Seashore only: parking data archive		X	X			

[yellow highlight] Indicates project funded through CCRTA's ARRA monies
* One NPS sign and one Town of Orleans sign; not integrated.
** Limited; no surveillance cameras on Cape routes; 511 service area terminates at Orleans rotary.
*** The Steamship Authority uses DMS and HAR to direct travelers to available parking

3.5 ARRA Funds for CCRTA Transit ITS Implementation

CCRTA received $6.4 million through the American Recovery and Reinvestment Act of 2009 (ARRA) to support implementation of a wide array of transit ITS applications. All project components must be completed by 2012 under the terms of the grant.

3.6 Technological Advances

In the years since the issuance of the 2003 ATS Study, advances in ITS-relevant hardware and software have changed the connectivity and power-source requirements associated with deployment. Over this same period, wireless telecommunications technologies have become more sophisticated. As a result, old recommendations and timelines can and should be reconsidered to take advantage of these possibilities.

3.6.1 Cellular Wireless

Cellular wireless carriers now offer many geographic high speed data transmission. ITS technologies once dependent on telephonic wireline or fiber optic connectivity now may have wireless as an alternative. This availability is contingent upon carrier's provision of service, which sometimes is limited in many rural areas.

3.6.2 The OpenCape Initiative

The newly funded OpenCape Initiative fundamentally improves the physical environment for long-term ITS deployment at the National Seashore, throughout Cape Cod, and in the regions beyond it. The OpenCape Network will consist of a core fiber optic backbone on Cape Cod with extensions to two major regional network connection centers in Providence and Brockton, numerous fiber optic laterals extending off of the backbone, a high-capacity optical transport system, a microwave radio overlay, and a regional co-location center. The plan received funding the American Recovery and Reinvestment Act of 2009 (ARRA); as a "shovel-ready" project, the plan must be implemented within the next two calendar years. This fiber-optic capability opens new possibilities for deployment of robust, sophisticated ITS systems in the region.

3.7 Status of ITS and Related Infrastructure on the Lower and Outer Cape

3.7.1 Telecommunications

3.7.1.1 Internet

The Cape has Internet connectivity in most area, but it is largely via cable, and slow upload times make even credit card transactions difficult or impossible in some areas. While cellular wireless providers now offer broadband, the transmission of complex signals sent by highway surveillance cameras, as just one example, are best carried by fiber optic infrastructure. The Cape currently lacks fiber optic lines, but it will be gaining them soon due to the Open Cape initiative, described in Section 3.7.7.

3.7.1.2 Wireless Networks

Major wireless telephone providers (Verizon Wireless and AT&T Wireless) provide coverage on Cape Cod. Network gaps do exist, particularly along the outer beaches that constitute the majority of the National Seashore territory.[9,10]

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[9] http://www.verizonwireless.com/b2c/CoverageLocatorController?requesttype=NEWREQUEST&lid=//global//plans//coverage+maps , accessed 10/08/2009.

[10] http://www.wireless.att.com/cell-phone-service/welcome/index.jsp, accessed 10/08/2009.

3.7.1.3 Microwave

Currently, MassDOT Highway Division has no microwave towers anywhere on Cape Cod. , MassDOT Highway Division operates two digital microwave towers, one in Fall River and one in Plymouth. The , MassDOT Highway Division District 5 office in Taunton communicates with Boston headquarters using radio that is carried over this microwave system. In addition, the microwave equipment can transmit video, voice and data.

3.7.1.4 800 MHz Radio

Two 800 MHz radio towers exist within the study area. The Massachusetts State Police, local fire and police departments, and the Barnstable County Sheriff all communicate via the 800 MHz towers, which also house commercial wireless carrier equipment.

3.7.2 **ITS Deployments**

3.7.2.1 Parking Management

Since 2002, the National Seashore has owned and operated one DMS unit, which is usually positioned at the Salt Pond Visitor Center during summer months.. Employees conduct manual counts of vehicles entering the six National Seashore beach parking lots and radio the National Seashore dispatcher when each lot is starting to fill up, and again when it becomes full. The conditions at three south district beaches—Nauset Light, Coast Guard, and Marconi—are displayed on the DMS. The DMS message is controlled by the dispatcher using a wireless Internet connection with a program that allows for multiple message options. Between 9 a.m. and approximately 5 p.m. each day, the sign rotates through three message sequences.[11] Logging of messages is manual; there is no automated database.

The Town of Orleans has also deployed one DMS on Rte. 6 between Brewster and Orleans that displays parking availability at Nauset Beach.[12]

3.7.2.2 Non-Transit Traveler Information

The ITS application currently in place is 511 service that provides real-time traveler information via phone. As of May 1, 2010, the 511 system is operated under contract by Sendza, Incorporated. The company relies on advertising revenue rather than state funding for its operations. It obtains information on traffic conditions from two sources: driver call-ins, and data provided by the INRIX corporation, based on probe vehicle information. The 511 system includes Route 6 all the way to Provincetown[13], but it is unclear at this writing whether traffic data for the Outer Cape are sufficient to provide accurate, timely incident reports and estimated travel times.

3.7.2.3 Transit Management and Transit Traveler Information

Existing transit management ITS applications include mobile data terminals on all CCRTA buses, and the use of advanced scheduling and dispatching software for the Flex bus system. Projects in development, funded by the American Recovery and Reinvestment Act (ARRA) of 2009, include the development of a mobility management transportation call center to coordinate transportation on all travel modes, extension of mobile data terminals to the paratransit fleet, extension of scheduling and dispatching software to the fixed-route buses, and deployment on fixed-route buses of an electronic fare system that is interoperable with the Massachusetts Bay Transportation Authority's CharlieCard system.

[11] Bob Grant (Chief Ranger, Cape Cod National Seashore), personal communication, 8/17/2009.

[12] George Meservey and Paul Fulcher (Town of Orleans, MA). Personal communication to Lindsey Morse, December 3, 2008.

[13] See http://www.massdot.state.ma.us/highway/Traffic/Mass511.aspx for the 511 coverage map.

The CCRTA operates a web-based bus locator system that displays the locations of all fixed-route CCRTA buses on a map of Cape roads. The CCRTA website also provides a link to Google Transit, which travelers can use as a trip planner.

The National Seashore website provides a link for visitors seeking transit information.

New traveler information ITS deployments in development, funded by ARRA, include an integrated intermodal traveler information system that will take data from mobile data terminals on local, regional, and intercity passenger transportation vehicles, as well as data stored on fixed-route computer-assisted dispatching databases, and use them to provide customer information on the web, including bus estimated time of arrival, real-time automated vehicle location (AVL) mapping, and real-time AVL location for visually-imparied customers.

3.7.2.4 Emergency Management

The Barnstable County Regional Emergency Planning Committee primarily relies on the telephone to communicate with individual towns on the Cape.

All towns on the Cape have Reverse-911 capability extending to both conventional wireline and wireless phones. At the discretion of the Barnstable County Regional Emergency Planning Committee, the emergency management coordinators from each town, who are members of the Planning Committee, can send out a standardized message at the agreed-upon time.[14]

3.7.3 Availability of Traveler Information: MassDOT DMS & HAR

MassDOT has deployed portable DMS units (two year-round and one additional in the summer) to report bridge conditions to westbound travelers on Route 6; these are located in the vicinity of Exits 6 (Barnstable) and 2(Sandwich). No other DMS unites are deployed or warehoused on the Cape.

At present, MassDOT does not use highway advisory radio (HAR) systems, except in certain tunnels.

3.7.4 Additional Stakeholder Engagement

Volpe Center team members met in June 2010 with Lorenzo Parra, MassDOT Director of Emergency Preparation, and Frank Spada, Director of ITS, to discuss the status of MassDOT's emergency preparedness planning. MassDOT serves in an official Emergency Support Function to the Massachusetts Emergency Management Agency (MEMA) under the Commonwealth's Comprehensive Emergency Management Plan (MA CEMP). With the recent consolidation of transportation agencies under MassDOT, agencies are working to align emergency response practices with the definitions and preparedness levels described in the CEMP; these, in turn, directly reflect federal emergency management requirements. In addition, an all-hazards emergency evacuation plan for the greater Boston area is under development.

A review of the MA CEMP revealed that it does not comment on or prepare for emergency evacuation of the seasonal influx of tourists to Cape Cod.

Subsequently, Volpe Center staff met informally with representatives from the Barnstable County Emergency Management Planning Committee, the Massachusetts State Police, and MEMA, to show them the findings of the Existing Conditions Report in relation to emergency preparedness for the Cape.

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[14] Sean O'Brien (Barnstable County Regional Emergency Planning Committee), personal communication to Ingrid Bartinique, October 14, 2009.

3.7.5 **Progress in Regional Uses of ITS for Transit**

The Massachusetts Association of Regional Transit Authorities is proceeding with the implementation of a project to make the MBTA's electronic-payment CharlieCard[15] interoperable throughout the region, ultimately to include ferry service. In addition, a smartcard-reading parking management system designed to integrate with the Cape Cod Transit Authority's on-board fare payment system has been procured.

3.7.6 **Project Relationship to Regional ITS Architecture**

The National Seashore and its partner agencies participated in the Massachusetts Department of Transportation's (MassDOT's) updating of the Regional ITS Architecture.

3.7.7 **Power and Connectivity**

Intelligent transportation system elements require electrical power, and a telecommunications connection for data transfer and system control. Connectivity, particularly when supporting public safety uses and financial transactions, must be high-speed, reliable, and secure; fiber optic broadband meets these requirements, but in wireless, communications, 3G or higher is necessary. A fundamental consideration for the National Seashore is therefore whether these exist or can otherwise be provided in the required locations.[16] The following summarizes present conditions and pending change to them.

Power. All beach lot entry booths have 110v power.

Conventional Wireline Connectivity. The National Seashore Headquarters, the Salt Pond Visitor Center, and the Province Lands Visitor Center have conventional wireline service; credit card transactions are completed via modem. None of the parking lot entry booths has conventional wireline, but the Provincetown Municipal Airport, which is contiguous to Race Point Beach, has conventional service.

GSM (2G) Wireless Connectivity. AT&T Wireless provides the region north of Provincetown, which includes Race Point Beach, with 2G service. See Appendix A for coverage maps.

3G Wireless Broadband Connectivity. Four major 3G Broadband wireless carriers serve the Outer Cape to varying degrees. In all cases, the region to the north of Provincetown, which includes Race Point Beach, lacks 3G service. See Appendix A for coverage maps.

Current Fiber Optic Broadband. None.

Imminent Deployment of Fiber Optic Broadband. The OpenCape Corporation is about to construct the core fiber optic backbone on Cape Cod with extensions to two major regional network connection centers in Providence and Brockton, a microwave radio overlay that includes Martha's Vineyard, and a regional collocation center in Barnstable Village. (Figure 3-1).[17]

Open Cape issued an RFP in October 2010 for the construction of the fiber optic backbone. The design includes a 48-strand lateral for the National Seashore. Its location is described as "beginning at the intersection of MA Route 6 and Truro Center Road in Truro, to North Pamet Road, to South Pamet road, to the end of South Pamet Road."[18] This will be a middle-mile installation; final-mile connections to National Seashore facilities would be the responsibility of the Seashore and NPS.

It is anticipated that the winning OpenCape vendor will build in several areas simultaneously, but when each segment will be completed and linked to the rest of the network has yet to be determined. All work

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[15] http://www.mbta.com/fares_and_passes/charlie/

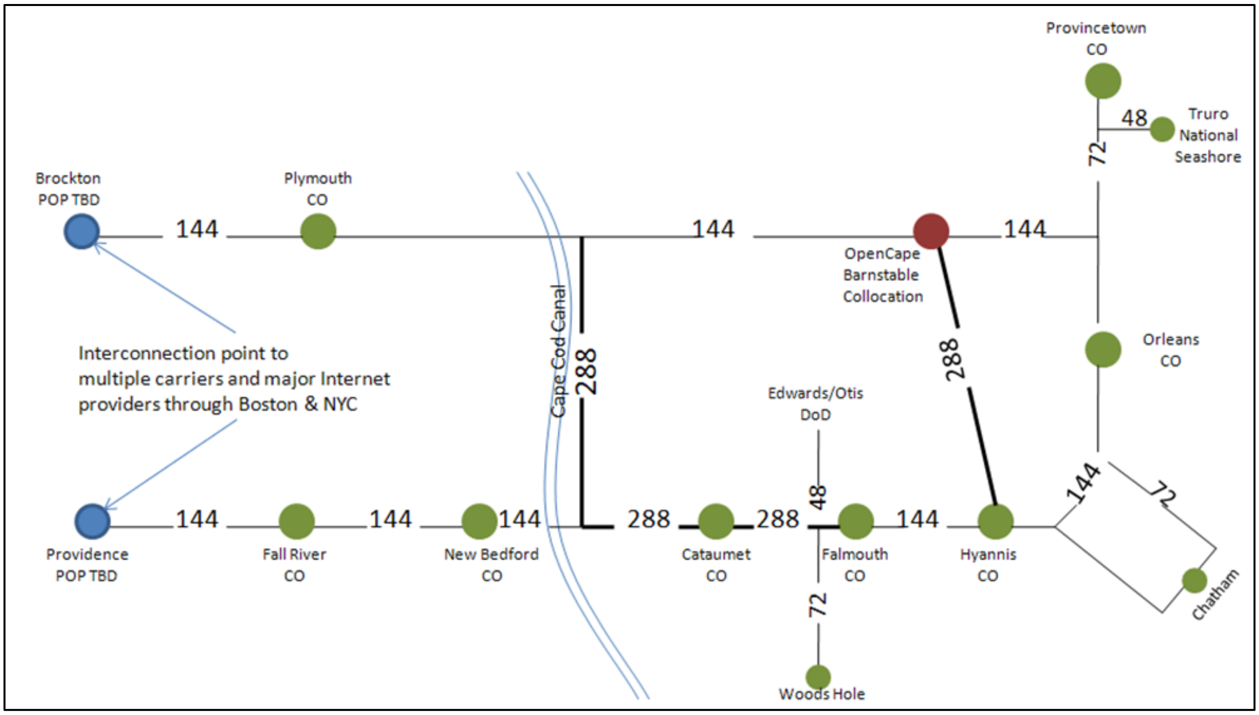
[16] The National Seashore is prohibited from engaging in any projects that could compromise the NPS ITS system. Any integration of outside communication devices or processes must be done in such a way to ensure the NPS firewall is not breached. Electronic communication is likely to have to be done via a parallel system.

[17] http://www.opencape.com/the-project

[18] OpenCape RFP No. 2010-10-001, p. A-3.

must be complete by January 31, 2013, under the terms of the Broadband Technology Opportunities Program (BTOP) of the American Recovery and Reinvestment Act of 2009, which has provided $32 million for the project.[19]

Figure 3-1
The OpenCape Fiber Backbone
Source: OpenCape RFP No. 2010-1-001, p. C-2, Fig. 2.



3.8 Challenges Addressed Through ITS

The study team has identified a number of interrelated factors that underlie the challenges the National Seashore hopes to address through ITS.

3.8.1 Parking Management

The National Seashore is a prime attractor of visitors to the already popular Outer Cape.

The vast majority of visitors to the National Seashore beaches largely arrive by car. Summer congestion and back-ups are the norm along Route 6, particularly in August.

Numerous town-managed beaches exist within the footprint of the National Seashore. Some towns have expressed interest in monitoring parking availability at their largest lots, and providing parking availability information via whatever system the National Seashore implements.

The National Seashore collects traffic count data to estimate visitation as required by the National Park Service. It has had unsatisfactory experience with the loop detectors that were installed some time ago at parking lot entrances to collect such data. The loop detectors are primitive by today's standards: they are

[19] Daniel Gallagher to Ingrid Bartinique, Personal E-Mail Communication, August 18, 2010.

not connected to computers, and instead generate a paper printout that is read once a month. No real-time data are available. The detectors have no self-diagnostic capability, so undetected breakdowns result in the loss of a full month's data.

3.8.2 **Electronic Payment/Automated Entry**

A number of other national parks and recreation areas are using or considering ITS for automated entry and/or electronic payment; all have a limited number of entry points. In contrast, each National Seashore beach has its own entrance.

The National Seashore values direct visitor contact and customer service by administrative and service staff as well by park rangers. This is particularly true in relation to the beach lot parking staff, who are the "face of the National Seashore" for many, perhaps most, visitors.

Although the gift shops in the Salt Pond and Province Lands Visitor Centers accept all major credit cards, the booths at the beach entrances accept only cash. Cash envelopes are distributed to and collected from the booths each day by supervisory staff. Each parking area begins charging parking fees only when its cash envelope arrives each morning, which may result in some loss of fee income from beach visitors who park before the booth is open.

National Seashore staff members at entrance booths to the beach parking areas collect parking fees. The parking areas are open from 6 a.m. to midnight. The booths operate from late June through early September when lifeguards are on duty, and on weekends/holidays from Memorial Day to the end of September. The booths open between 8:30 and 9:00 a.m. and close between 4:30 and 5:30. To make payment, vehicles roll up to each booth in a single lane.

The National Seashore charges the following entrance fees to its beaches:

- Vehicle: $15 (covers all occupants)
- Motorcycle: $5
- Bicycles: $3
- Pedestrians: $3

In addition to cash payment, the National Seashore also accepts Federal Lands Interagency visitor passes and national seashore annual passes. Senior citizens with a Golden Age pass may park for free (See Appendix B.) Although the Interagency passes are equipped with a magnetic stripe for electronic reading, the Interagency Standard Operating Procedures for the pass program require visual confirmation of ownership against a picture ID.[20] Therefore, automated entry with Interagency passes is not possible even at parks that are equipped for automatic, electronic payment at entry.

3.8.3 **Aesthetics**

The towns of the Outer Cape are supportive of the National Seashore's desire to reduce congestion. However, the towns and other local stakeholders are concerned about the appearance of DMS units along Route 6.

3.8.4 **Emergency Management**

There is no comprehensive emergency evacuation plan for the entire Cape at this time, or an ITS system to communicate emergency traffic information. The Outer Cape towns, as well as the Barnstable County Regional Emergency Management Committee and State Police, are acutely aware of this.

MassDOT has expressed interest in arranging with the National Seashore to gain control over any park DMS units during major regional emergencies such as hurricanes.

[20] *America the Beautiful –The National Parks and Federal Recreational Lands Pass Program. Interagency Standard Operating Procedures*, p. 7.

4. National Seashore ITS Planning Achieved to Date

This chapter describes the project's progress to date in defining the desired ITS system.

4.1 The Systems Engineering "V" Planning Model

The National Seashore is following the systems engineering "V" process for the present effort. Unlike conventional transportation engineering projects, ITS projects have less technical certainty at their inception, and therefore require a period of iterative work to map the project to user needs and develop system requirements.

Systems engineering reduces the risk of schedule and cost overruns and increases the likelihood that the implementation will meet the user's needs. Other benefits include:

- Improved stakeholder participation
- More adaptable, resilient systems
- Verified functionality and fewer defects
- Higher level of reuse from one project to the next
- Better documentation.[21]

Any project that seeks funding from the Highway Trust Fund is required to use this method;[22] this requirement extends to many transit projects, including those funded under TRIP.

The Systems Engineering V diagram, shown in Figure 4-1, has been developed by the systems engineering profession and refined by the ITS Joint Program Office to define the relationship among the phases of the intelligent transportation system life cycle. As shown in the V, the systems engineering approach defines project requirements before technology choices are made and the system is implemented. On the left side of the V, the system definition progresses from a general user view of the system to a detailed specification of the system design. The system is decomposed into subsystems, and the subsystems are decomposed into components; a large system may be broken into smaller and smaller pieces through many layers of decomposition. As the system is decomposed, the requirements are also decomposed into more specific requirements that are allocated to the system components.

As development progresses, a series of documented baselines are established that support the steps that follow. For example, a consensus Concept of Operations supports system requirements development. A baseline set of system requirements then supports system design. The hardware and software are implemented at the bottom of the V, and the components of the system are then integrated and verified in iterative fashion on the right. Ultimately, the completed system is validated to measure how well it meets the users' needs.[23]

The systems engineering process begins with the early planning activities during which the system's relationship with regional needs and other regional systems is defined, On the upper left wing of the V, this model takes the ITS planning and implementation process from the broad regional level (the Regional ITS Architecture down development steps that will be followed to develop the system; this same process applies to any subsystems within it, as well. A system concept that has been demonstrated to be feasible is then formally articulated in a Concept of Operations, which then forms the basis for a formal statement of system requirements. The National Seashore's implementation process has been spanning these steps, as indicated by the red circle.

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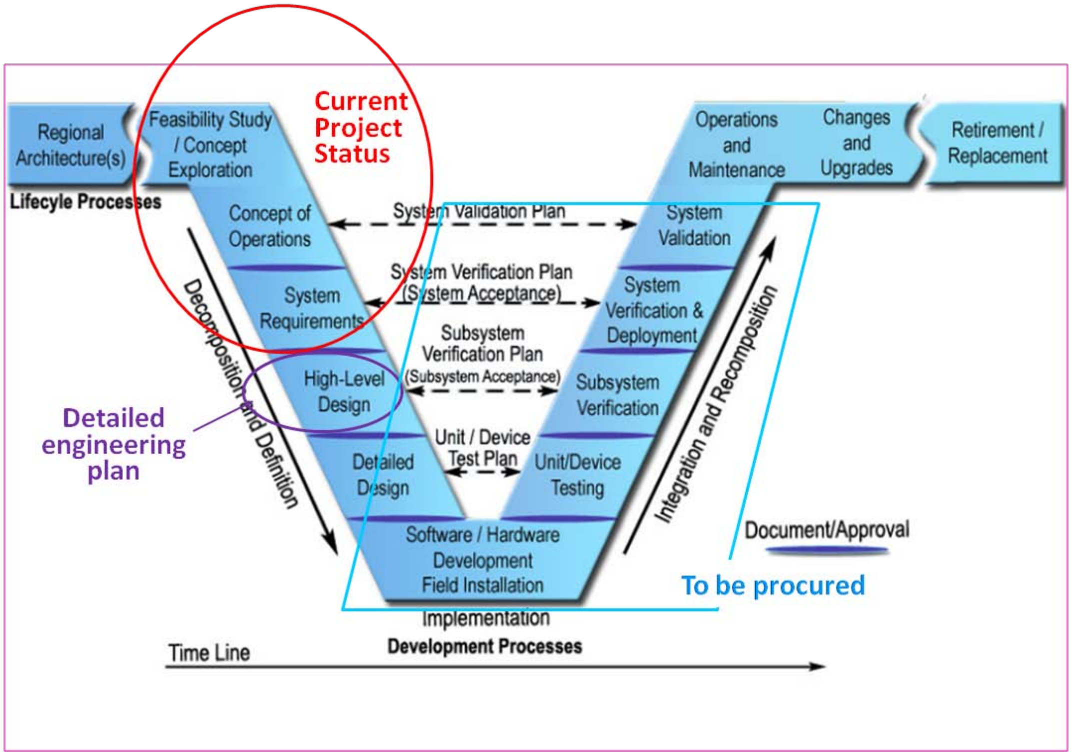
[21] FHWA, *Systems Engineering for Intelligent Transportation Systems*, p. 3.

[22] § 23 CFR 940.11.

[23] [23] FHWA, *Systems Engineering for Intelligent Transportation Systems*, p. 10.

The Concept of Operations and requirements will then inform a detailed engineering plan (indicated by the purple oval) that will provide the design for the system and subsystems. This plan then is the basis for project execution.

Figure 4-1
Project Status and the Systems Engineering V Diagram for Intelligent Transportation Systems
Source: Adapted from FHWA, Systems Engineering for Intelligent Transportation Systems, 2007, Figure 7, p. 11.



Working closely, the National Seashore and the Volpe Center have produced several important planning outputs that define the desired ITS system. During the initial feasibility and concept exploration phase, system goals were defined, and underlying factors were identified. In turn, the goals and factors informed the development of concepts of operation for the ITS subsystems (Parking Management and Traveler Information), and the concepts of operation led to system requirements. The next step will be to translate the system requirements into a detailed engineering plan.

The National Seashore wants its near-term investment in an ITS system to meet two overarching goals:

- Optimizing use of the limited parking at National Seashore beaches by monitoring parking availability, alerting visitors of the situation while they are still en route, and directing them to beaches that have open parking capacity. This will improve the National Seashore visitor experience by reducing frustrating queuing and wait times at beach parking areas; lessen air pollution by minimizing engine idling and visitors driving from beach to beach looking for parking; and help prevent ecosystem damage that occurs when beach parking areas are full and visitors park on roadsides.

- Helping to guide Cape visitors and residents to designated safe locations and to manage traffic flow in emergency situations.

In the future, the National Seashore may want to accept credit card payments at the beach lots as part of the ITS system. The ability to accept payment via visitors' CharlieCards (smart cards) was also described as a possible goal.

The National Seashore and its partners envisioned the eventual ITS deployment to involve two related ITS subsystems, one termed Parking Management and the other Traveler Information. These are described below.

4.2 Parking Management

4.2.1 Preliminary Concept of Operations

Broadly, the National Seashore and partners envisioned a management system that would enable the National Seashore to:

In the near term:

- Collect real-time information on parking availability at National Seashore beaches
- Process parking data to calculate availability, and transmit messages about parking availability to traveler information systems
- Use parking data for real-time operational decisions
- Retain the parking data for future analysis and financial reconciliation, and
- Report accurate and reliable visitor data to the NPS as required[24]

In the future:

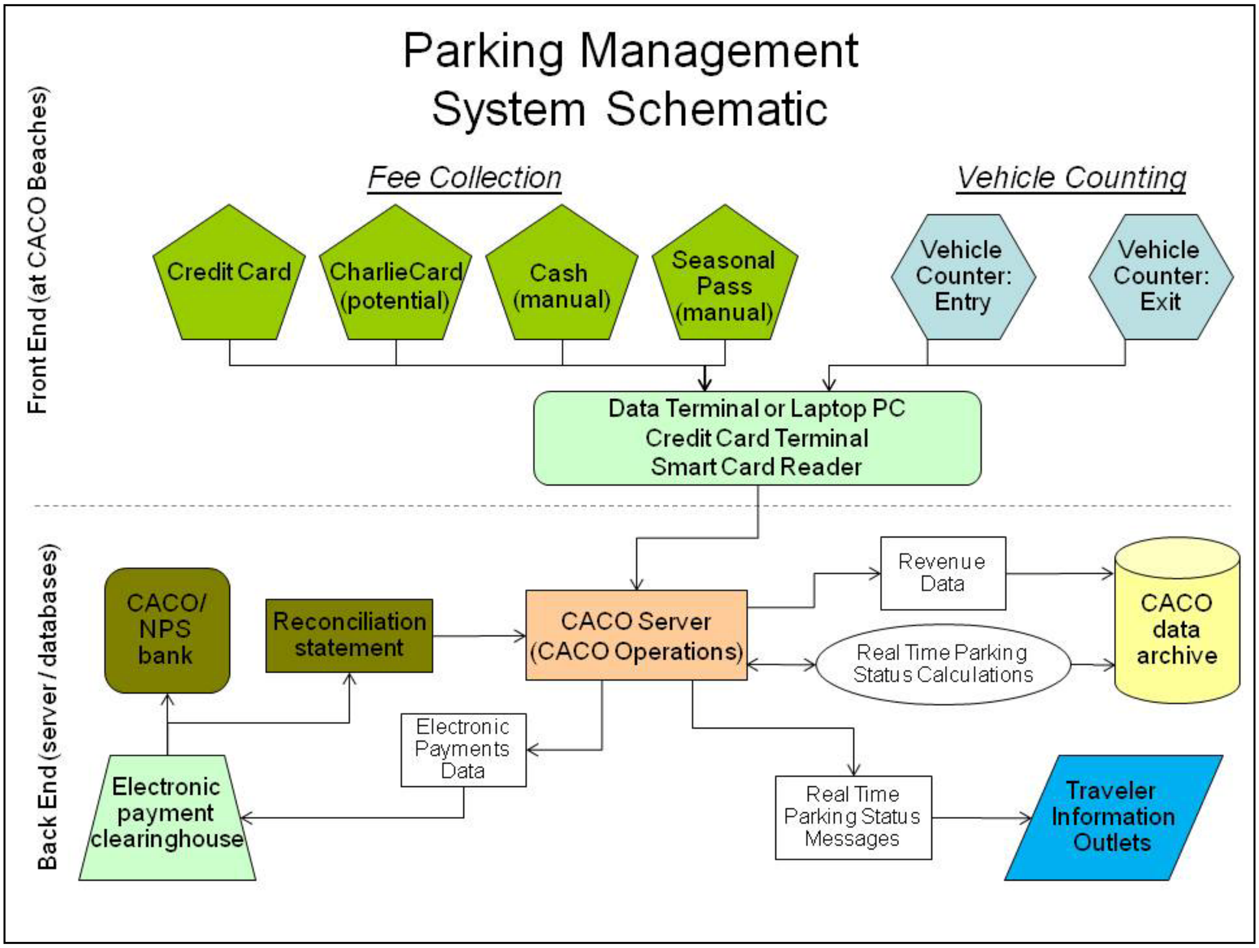
- Collect parking fee payments made by credit card and potentially other electronic payment formats.

Figure 4-2 illustrates the preliminary, full-functionality parking management system as originally envisioned. Front-end functions, deployed at the CACO beach parking areas, include entrance and exit vehicle counters, the data from which would be used to calculate remaining parking capacity, and variety of payment options (including cash, credit card, and MBTA CharlieCard). Data from the vehicle counters would flow to a data terminal or notebook PC, while credit card purchases would require a credit card terminal, and CharlieCard payments would require a compatible smart-card reader.

Back end systems would include a central server to receive data from the six field locations, software to calculate parking availability and to generate parking status messages, and electronic payment processing software. In addition, the back end would include a data archive.

[24] NPS. *Cape Cod National Seashore Public Use Counting and Reporting Instructions*.

Figure 4-2
Initial Conception of Parking Management System for National Seashore Beaches



4.2.2 Preliminary Requirements

The preliminary listing of the functional and technical requirements for the envisioned parking management concept is shown in Table 4-1. The front end (field equipment) and back end (hardware and software for system control and data management) of the system are treated separately. For the front end, functional requirements are divided in the table to show those that are a primary priority in the first column, and those for future consideration in the second. The technical requirements apply to the system in both timeframes.

Table 4-1
Preliminary Requirements for the Parking Management Subsystem

	Functional Requirements	Potential Functional Requirements	Technical Requirements
Front End (at each National Seashore Beach Parking Area)	Automatically count vehicles entering and exiting parking area	Permit manual entry of number of vehicle occupants	• High level of reliability. • All hardware weather-resistant and suitable for corrosive coastal environment. • Hardware secure from vandalism/theft when unattended. • Secure wireless data transfer • Ability to operate without AC power (e.g., batteries plus supplemental solar PV during the day, overnight AC recharge).
	Capture vehicle counts from monitoring device	Process credit card payments	
	Support manual processing of cash transactions	Process CharlieCard payments	
	Transmit vehicle count data and cash transaction data to back end server/database	Transmit CharlieCard and credit card payment data to back end server/database	
Back End (Server/ Database)	Receive vehicle count data (entering and exiting parking areas) from parking areas in real time.	Register credit card transaction in Accounts Receivable pending transfer of payment from clearinghouse; register payment.	• Secure data transfer (XML feed and messages to Internet traffic reporting entities) • Connection to bank reconciliation that credits NPS for electronic payments.
	Process vehicle count data for real-time analysis.	Store financial transaction (cash and credit card) information for National Seashore management use.	
	Store vehicle count data for later analysis (e.g., beach visitation trends).	Transmit CharlieCard transactions to CCRTA or MBTA server (TBD) for reconciliation and receipt of payment transfer	
	Use vehicle entrance and exit counts to calculate when each parking area is full or has open spaces, based on pre-defined criteria.	Register CharlieCard transaction in Accounts Receivable pending transfer of payment from clearinghouse; register payment.	
	Transmit parking information messages for use by variable message signs*		
	Produce parking information XML feed for third-party use (e.g., Go Cape Cod website, etc.)		
	Transmit credit card sale information to clearinghouse.		

4.3 Traveler Information

4.3.1 **Preliminary Concept of Operations**

The traveler information system will enable the National Seashore to inform visitors of the parking status at all of its beaches, in advance of the visitors' arrival or while they travel from one beach to another. The system also will be available to inform travelers when unplanned events such as traffic accidents affect travel conditions, and when emergencies such as hurricanes demand their sheltering or evacuation.

The National Seashore and partners were always cognizant of local sensitivities with regard to the appearance of signage, in particular DMS. Consequently, the group assumed for planning purposes that any DMS would be temporary (i.e., portable units), rather than permanent installations.

The National Seashore and Volpe Center brainstormed the use of a variety of equipment and communications media for disseminating parking status information to travelers in the National Seashore, including the Internet, HAR, and DMS.

4.3.2 Preliminary Requirements

The preliminary functional requirements for the traveler information system are presented in Table 4-2.

Table 4-2
Preliminary Requirements for the Traveler Information System

	Functional Requirements	Technical Requirements
Portable Dynamic Message Signs (DMS)	Display real-time (or near-real-time) parking status information messages for multiple National Seashore beaches.	Solar power with battery back-up to ensure X hours of uninterrupted use.
	Display incident and emergency information.	Secure data transfer.
	Unit appearance/position should respect local aesthetic sensitivities to extent possible.	Message control via cellular wireless broadband.
		Interoperability with MassDOT systems, including conformance with MA and ITS standards.
		Conformance of design/messages with MUTCD standards for readability.
Highway Advisory Radio (HAR)	Antennas must be positioned so that travelers on all roads on the Outer Cape can hear its messages clearly.	Antennae must have solar power and battery back-up.
	Static signage will present "tune radio to" messages.	Transmitter: 110v AC. Must have battery back-up to assure operation for at least 36 hrs.
	Tie-in to MassDOT Highway Operations Center, for broadcast of emergency messages.	Capacity to pre-record and/or generate text-to-voice messages.
		Must conform to all applicable FCC regulations under 47 CFR 90.
		Each transmitter must have sufficient range to enable traveler to hear messages of up to 1 minute at 50 MPH
Web	Disseminate National Seashore parking information via XML feed available for third-party use. Disseminate incident and emergency information.	Secure data transfer.
Transit Information via the Web	Provide access to Cape Cod Regional Transit Authority website and other transit information via National Seashore website.	Hyperlinks on National Seashore website to Cape Cod Regional Transit Authority website, and websites of other transportation providers .
Web-Enabled Transit Info. Stations	Provide Cape Cod Regional Transit Authority information to National Seashore visitors at key National Seashore sites	Secure wireless (cellular) or wireline connectivity to CCRTA

5. ITS Technology Assessment

This chapter describes the ITS technologies comprising the core applications described in the preliminary concept of operations for parking management and traveler information, and offers a tabular comparison of the technologies in each category on key selection criteria. This is a non-technical assessment, based on published research and discussions with ITS experts. Chapter 6 recommends technologies in the context of refined concepts of operations and requirements.

5.1 Description and Comparison of Candidate Vehicle Counting Technologies

To communicate parking availability to travelers in real-time, CACO needs accurate, up to date data on the number of available parking spots at each of its facilities. Tracking parking availability is not complicated, but it does require having systems in place to record every vehicle entering and exiting each parking facility.

In myriad ITS installations across the country, vehicle counting is performed not just for parking management but for a number of purposes, most significantly for traffic monitoring on highways and arterials, and for signal control at intersections. A large array of technologies has been developed for these applications.

Broadly, vehicle-counting technologies are either embedded in the roadway or not. This section provides a brief, non-technical description of each vehicle counting technology, and then summarizes the pros and cons of all. Parking management systems until recently used inductive loop technologies and magnetometers almost exclusively. Infrared and radar technologies have been more recently employed, largely in applications where it has been possible to mount sensors overhead. In all cases, data from the vehicle sensors are stored/analyzed by an onsite computer (which can be as simple as a notebook PC), or can be transmitted to an offsite server/database.

5.1.1 **In/On-Roadway Systems**

Inductive Loop Detector. Since its introduction in the early 1960s, the inductive-loop detector has become the most utilized type of vehicle-detection sensor.

Inductive loops are large loops of wire embedded in, or sometimes buried under, the roadway surface; associated electronics are housed at the roadside. The loops carry an alternating current that creates a magnetic field. Vehicles passing over or stopping within the detection area of an inductive-loop detector affect the magnetic field. The system's electronics sense this event and send a pulse to the controller/counter, signifying the passage or presence of a vehicle. The loop configuration can be altered to record motorcycles and bicycles as well as cars. Quadrupole loops, also known as "figure 8"-style loop detectors, have enhanced sensitivity for detecting motorcycles, bicycles, and smaller cars.[25]

Historically, loop detectors have had reliability problems, but newer systems frequently are equipped with self-diagnostics that alert the operator, even if at a remote location, to malfunctions.[26]

Because the loop wires are embedded and sealed into the pavement surface, installation and repairs are relatively difficult and can disrupt traffic. The roadside electronics, however, can be swapped out easily.

Magnetometers.[27]Magnetic sensors were introduced in the l960s as an alternative to the inductive-loop detector for specific applications. A magnetic sensor, imbedded in the pavement, is designed to detect the

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[25] FHWA *Traffic Monitoring Guide Supplement*, p. 4S-3.

[26] Potter,T.. *The Evolution of Inductive Loop Detector Technology*. At http://renoae.com/traffic/files/pdf/Advances%20in%20Loop%20Detector%20Technology.pdf.

[27] From FHWA *Traffic Detector Handbook*, Ch. 2. See also: Gibson, David, Milton K. Mills, and Lawrence A. Klein, A *New Look at Sensors*, 2007. FHWA Pub. No. FHWA-HRT-08-001.

presence or passage of a vehicle by measuring the perturbation in the Earth's quiescent magnetic field caused by a ferrous metal object (e.g., a vehicle) when it enters the detection zone of the sensor. Since magnetometers are passive devices, they do not transmit an energy field. Therefore, a portion of the vehicle must pass over the sensor for it to be detected.

Reportedly, magnetometers are sensitive enough to detect bicycles passing across a 4-ft (1.2-m) span when the electronics unit is connected to two sensor probes buried 6 inches (16 cm) deep and spaced 3 ft (0.9 m) apart. Vehicle motion is not required for detection by two-axis fluxgate magnetometers. Multi-sensor arrays can be deployed to enable the system to detect different vehicle types (e.g., automobile vs truck).

Although magnetometers are embedded in the pavement, their installation and subsequent replacement is much simpler than that of inductive loop detectors. Each magnetometer sensor is a “puck” that is secured with high-strength adhesive in a small hole drilled into the pavement. Modern, wireless magnetometers require no additional hard connections to the vehicle counting electronics and/or power supplies (unlike loops, which require both).

Pneumatic Tube. Pneumatic tube systems consist of one or more air hoses stretched across the roadway and connected to an electronic counting unit containing pneumatically-activated switches. Each time a vehicle’s tire crosses the hose, it compresses it, sending a pulse of air to the counting unit. A single car will generate two such pulses, one for each axle. Systems with multiple hoses can detect vehicle type (i.e., passenger car vs. multi-axle truck) and speed, but for parking-management applications, single-hose systems are sufficient. Pneumatic tube vehicle counters are low-cost, accurate, easy to set up, and have very low power requirements. On the other hand, as the National Seashore is already aware, they are not suitable for permanent or long-term installations, because the air tubes tend to develop leaks after a few months of use. Also, they need to be removed during the winter months; otherwise they can be torn up by snow plows.

Piezoelectric. Piezoelectric materials convert kinetic energy, such as pressure from a vehicle’s tire, into electrical energy. Because their electrical output varies with the amount of pressure exerted on them, Piezoelectric systems can provide vehicle axle-weight data as well as vehicle counts; for this reason piezo systems are used almost exclusively in applications where vehicle classifications are needed (i.e., truck vs. car) and for weigh-in-motion applications (commercial vehicles). For permanent installations piezo sensors are embedded just below the surface of the roadway. With each wheel crossing, the detector sends an electrical pulse to the controller/counter (like pneumatic tube systems piezoelectric systems count axles). Piezoelectric systems have the advantage of needing no external power to operate, but they are expensive.

Fiber-Optic. Fiber-optic installations are analogous to pneumatic tube and piezoelectric in that they use a detector stretched across the roadway, but they work differently. A beam of laser light is sent down the fiber-optic cable, and the reflected light coming back is analyzed by a detector. When a vehicle drives over the cable, it bends it slightly, which changes the characteristics of the reflected light; the detector registers the change, and records the vehicle. Fiber-optic systems have medium power consumption needs, and are relatively expensive to install and replace.

5.1.2 **Off-Roadway Systems**

The various off-roadways vehicle counting systems all share the advantage of not using detectors that must be are stretched across the roadway or imbedded in the pavement. Consequently, off-roadway systems can be (but are not necessarily) faster and easier to install, and less expensive to maintain, than in-roadway systems. On the other hand, all off-roadway systems require their sensor components to be mounted on a tower, roadside pole, overhead gantry, or other structure, any of which could raise aesthetic concerns at National Seashore facilities.

Infrared. Two types of vehicle detectors use infra-red (IR) light. Active IR systems send a beam of IR light across the roadway, and read a reflected signal (from a reflector placed on the other side of the road).

When a vehicle breaks the beam, the system counts it.[28] Active IR systems can give false readings due to reflections from nearby shiny surfaces, as well as reflected headlights beams and sunlight.

Passive IR systems detect the heat differences between the background conditions (ambient) and passing vehicles. These systems work on the same principle as the motion detectors commonly used in security alarms. Passive IR systems have low power requirements, but can give false readings due to competing heat sources.

Microwave (Radar). Radar (Radio Detection and Ranging) technology was invented in World War II for tracking aircraft. Radar-based vehicle detection systems transmit microwave energy at the roadway, and detect signals reflected back by passing vehicles. Radar systems are often used in multi-lane highway applications, because a single unit has the ability to monitor multiple lanes. Radar-based have relatively high power needs.

Acoustic Detectors. Two types of acoustic vehicle detectors exist: active (ultrasonic) and passive. Active systems transmit sound waves in the 20 to 300 KHz range toward the detection zone, and sense waves reflected by vehicles. Some systems emit a continuous wave of radar energy, while others transmit pulses. Passive systems are, in essence, microphone-based "listening" systems that can detect vehicles by the acoustic energy the produce. Both active and passive acoustic systems are susceptible to error from interfering noise sources.

Video. Video Image Processing (VIP) systems were developed in the 1970s and 1980s in Europe and Japan, and are now a robust technology. VIP systems detect passing vehicles by analyzing variations in video images on a pixel-by-pixel basis. Image processing software can exclude variations due to non-vehicle sources, like shadows. VIP systems typically consist of one or more video cameras, electronics for processing the video signal, and computers and software for analyzing the data and registering vehicle counts. VIP systems are expensive, but can provide great flexibility in complex, multi-lane highway settings.

5.1.3 Queue-Counting Systems

Queue-counting functionality was not originally envisioned in the concept of operations for the National Seashore's ITS deployment. Nevertheless, it would be technically possible to collect such data, and use them to calculate wait-time estimates for each beach (once the parking area is full and a queue is forming). Data on queue length are essential for providing useful wait time estimates, because as the queue grows, the wait time for each successive vehicle at the end of the line (the "nth" vehicle) increases. VIP systems are used in queue-counting applications; in such installations the video camera must be overhead, to have a clear view of the entire queue. Queue-counting systems represent a significant "step up" from vehicle counting systems, in terms of the additional detector and back-end technology required, and processing algorithms. A careful benefit-cost assessment should be performed before deciding to provide wait-time information. As discussed in Chapter 6, this study recommends against queue-counting and wait-time information at least in the initial ITS deployment.

[28] The system measures the time for the reflected energy to return to the detector. The presence of a vehicle causes the return time to be shorter.

5.1.4 Summary of Vehicle Counting Technology Features and Costs

Criteria for evaluating alternative vehicle counting technologies typically include data accuracy, ease of installation, performance characteristics, and costs (installation, maintenance). For any system, data accuracy is largely dependent on its ability to handle unusual vehicle configurations (i.e., various tractor-trailer setups), the effects of inclement weather (e.g., snowstorms, heavy rain) and the effects of complicated traffic situations. None of these factors will be an issue at CACO beaches.[29] Therefore, for the purposes of this discussion, we have assumed that all the technologies will be accurate enough to handle CACO's simple vehicle-counting requirements. We focus on the technologies' ease of installation, performance characteristics, costs, and lifespan.[30] Tables 5.1 and 5.2 summarize these evaluation criteria for in-roadway technologies and off-roadway technologies, respectively.

[29] Inclement weather such as heavy rain certainly occurs at CACO beaches, but at those times there are few if any beach visitors, so monitoring parking availability is unnecessary.

Table 5-1
Comparison of In-Roadway / On-Road Vehicle Counting Technologies
Sources: Detector Technology Evaluation, Utah Department of Transportation - Research and Develop Division, 2003. Report No. UT - 03.30; http://www.fhwa.dot.gov/policyinformation/pubs/vdstits2007/04pt2.cfm
Costs estimated; cost data adjusted for inflation to 2010. Cost estimates do not reflect additional system engineering costs.

Technology	Performance Characteristics	Estimated Unit Cost	Ease of Installation or Replacement	Installation Cost ($/unit)	Annual Operation and Maintenance Cost	Installed System Lifespan
Inductive Loop	Spotty track record.	$500 - $1,000 per loop including installation.	Difficult (requires pavement cutting).	Included in unit cost estimate.	$500 - $800 (assumes four loops with controller, etc.).	5 – 15 years.
Magnetometer	Excellent accuracy. Wireless connectivity. No external power required.	$700 - $1,300 including installation.	Easy – Medium. Requires limited pavement drilling. Periodic sensor replacement is simple.	Included in unit cost estimate.	Assumed to be similar to inductive loop costs.	15 years (with periodic battery replacement in each sensor).
Pneumatic Tube	Limited useful lifespan. Not suitable for permanent systems.	$1,000	Easy	Unknown	N/A - Pneumatic tube installations are temporary.	N/A - Pneumatic tube installations are temporary.
Piezoelectric	No external power required. More accurate than inductive loops. Able to differentiate number of axles with high precision.	$2,000 -$ 4,000 per lane.	Difficult (requires pavement cutting).	Included in unit cost estimate.	Assumed to be similar to inductive loop costs.	Assumed to be similar to inductive loop lifespan.

Table 5-2
Comparison of Off-Roadway Vehicle Counting Technologies
Sources: Detector Technology Evaluation, Utah Department of Transportation - Research and Develop Division, 2003. Report No. UT - 03.30; http://www.fhwa.dot.gov/policyinformation/pubs/vdstits2007/04pt2.cfm
Costs estimated; cost data adjusted for inflation to 2010. Cost estimates do not reflect additional system engineering costs.

Technology	Performance Characteristics	Estimated Unit Cost	Ease of Installation or Replacement	Installation Cost ($/unit)	Annual Operation and Maintenance Cost	Installed System Lifespan
Active IR	Potential aesthetic concerns. Susceptible to error from nearby heat sources.	$6,000 - $8,000	Easy	$200	Assumed similar to microwave.	5 -10 years
Passive IR	Potential aesthetic concerns. Susceptible to error from nearby heat sources.	$700 - $1,400	Easy	$200	Assumed similar to microwave.	5 – 10 years
Microwave (Radar)	Potential aesthetic concerns. High power requirements.	$800 - $3,400	Easy	$200	$100	5 – 10 years
Active Acoustic	Potential aesthetic concerns. Susceptible to error from nearby noise sources.	$500	Easy	$400 - $500	$200 - $400	5 – 10 years
Passive Acoustic	Potential aesthetic concerns. Susceptible to error from nearby noise sources.	$3,600 - $6,000	Easy	$400 - $500	$200 - $400	5 – 10 years
Video	Potential aesthetic concerns	$4,100 - $16,100 per camera (plus image processing and associated electronics)	Easy	$1,000 - $1,500	$200 - $400	10

5.1.5 **Electronic Parking Fee Payment**

Some national parks have moved to electronic payment via credit card or other form of electronic payment (e.g., transponders). They have done so primarily to reduce queuing. These parkshave only a few entrances, and so are subject to congestion and long queues. Adding a separate line for automatic, electronic payment mitigates these problems. For example, Bryce Canyon, Grand Canyon, Zion, and Rocky Mountain all have just a few entrances relative to their extensive perimeters and large interiors. These parks have installed systems to increase the rate of throughput and/or to provide an alternative means for park staff and concessionaires to enter without having to wait in line (See Appendix C).

The National Seashore's geographic layout and collection of entrance fees at each of its beaches distinguishes it from many other National Parks. While the availability of parking is frequently a problem at some beaches, excessive queue lengths during periods when space is available and payments are being made at the booths may not be. This is particularly important because visitors using automated payment lanes would not experience the valued interaction with National Seashore booth attendants. Furthermore, automated-payment lanes would require gate access (to prevent vehicles from entering without payment), and, for transponder payments, overhead readers. Both of these items would impact the character and aesthetics of the Seashore beaches, perhaps in ways the Seashore would find objectionable. Finally, constructing additional entrance lanes would have environmental impacts that may be unacceptable.

Multi-use payment applications, as the name implies, enable travelers to pay for multiple transportation services using one form of payment. For example, in certain areas where regional transportation authorities are trying to encourage greater use of transit through improving the predictability of space availability at Park & Ride facilities, patrons are able to pay for parking with their transit smartcards. These systems are tied to advanced traveler information systems and often can enable space reservation in advance, and/or guide the driver after entering the lot to the available space without delay, in the interest of enabling the driver to connect with the scheduled transit service.

5.2 Description and Comparison of Candidate Traveler Information Technologies

5.2.1 **Dynamic Message Signs (DMS)**

DMS units display Dynamic messages to give motorists real-time information on local conditions. DMS may be permanent or portable; in either case the sign is remotely controlled to display a series of repeating messages.

DMS units are seriously limited in the amount of information they can convey – usually a maximum of three lines of text. Message content is governed by FHWA guidelines, and appearance by the Manual on Uniform Traffic Control Devices (MUTCD). Portable DMS can display up to three different messages in rolling succession; the timing of the rotation is only one of many factors affecting the passing motorist's ability to take in the information. The crafting of these messages therefore requires care to make them effective.

Three potential uses for DMS in the National Seashore are:

- Permanent DMS units along Route 6, displaying parking status information for the six National Seashore beaches. This would be challenging, given the limitations of DMS noted above. Stakeholder representatives from some of the local towns have voiced concerns that DMS units along Route 6 would not fit with the Cape's aesthetic.
- Small, permanent DMS units at each of the beach parking areas. These units could display simple "parking open" or "parking full" messages, and would be candidates for "context-sensitive design" treatments such as timber frames rather than metal.

- Portable DMS units for traffic management and traveler information in emergencies and during special events that can create significant congestion within the National Seashore.

Portable DMS are available with long-life batteries and solar power back-up. Permanently installed DMS units can run on AC power or battery/solar arrays.

Permanent DMS units exhibit a wide cost range, depending upon their size and complexity. Documented permanent DMS unit costs range from $41,000 to $110,000, with annual operation and maintenance costs ranging from $2,000 to $5,000. Portable DMS units range in cost from $16,000 to $21,000, with annual operation and maintenance costs of $500 to $1,600.[31]

DMS units typically are self-contained, with pre-programmable message capacity, and are controllable over TCP-IP-compliant wireless or wireline communications channels. Appendix D provides examples of DMS units, some of which have multiple panels and could potentially display parking status information for all six National Seashore beaches.

5.2.2 Highway Advisory Radio

Higway advisory radio (HAR) consists of low-power roadside transmitters that provide motorists with up-to-the-minute travel information via their AM/FM radios. HAR systems can provide warnings, advisories, directions, parking information, or other non-commercial material. HAR messages may be pre-recorded, or generated automatically as needed via text-to-speech software The physical setup for HAR is uncomplicated: a transmitter and one or more antennae.

10-watt HAR AM systems are the most common. According to the Federal Highway Administration,

> *When properly maintained and installed, 10-watt transmitters have a broadcast radius of approximately 3–5 miles depending on topography, atmospheric conditions, and the time of day. Frequencies used are generally located at the extreme ends of the AM band using specific frequencies based upon the availability of "holes" in the spectrum left by government and commercial stations. New FCC rules permit HAR to be broadcast on any frequency between 530 kHz and 1710 kHz provided an FCC license is obtained*.[32]

Message length is a factor of the speed at which the listener is traveling through the carrying range; the message length is adjusted to permit the driver to receive the message at least twice while passing through one station's coverage zone.

HAR Antenna citing must account for terrain, nearby buildings, power lines, and other factors. A consulting engineer is typically engaged to specify optimal HAR locations for a given ITS deployment.

HAR systems are required also to display static signs, the shape, color, and wording of which are controlled under the MUTCD. These signs have flashing lights that are activated when urgent traveler information is being broadcast over HAR.

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[31] United States Department of Transportation, Research and Innovative Technology Administration: http://www.itslessons.its.dot.gov/its/benecost.nsf/CostComponents?OpenForm. These cost data are from 2005, adjusted for inflation to 2009 dollars.

[32] http://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/chapter13_02.htm

Figure 5-1
Highway Advisory Radio Static Sign

Typically, the physical arrangement at the back-end comprises a configurable, stand-alone PC workstation, preprogrammed software with user-interface tools, and power back-up. For the National Seashore's envisioned HAR deployment, integration with back-end systems that calculate parking status from vehicle-count data would be required. Back-end IT systems and software could generate parking status for each beach (i.e., "open" or "full"), and produce text messages. In turn, those status messages could be broadcast via HAR systems through text-to-speech software.

HAR costs for permanent installations (as opposed to trailer-mounted portable HAR units) range from $15,000 to $36,000, with associated annual operations and maintenance costs of $600 to $1,000. Costs for static HAR signage (with flashing beacons) range from $4,000 to 8,000, with estimated annual operation and maintenance costs of $200. [33]

5.2.2.1 HAR Planning Considerations.

A number of vendors offer both fixed and portable HAR equipment, software, and broadcast hardware. The products themselves are commercially available off the shelf. However, the citing, licensing and installation are not trivial. The National Seashore should consider contractor support in HAR deployment.

The Federal Communications Commission (FCC) licenses state and local agencies and government-affiliated agencies, such as airport authorities, to use HAR. The licensures of these stations, and the permissibility of message content, are strictly regulated under 49 CFR 90. The agency seeking licensure is required to investigate a number of environmental factors, in addition to identifying a band in the spectrum that does not interfere with other radio traffic at any time over the full 24-hour day. The licensure process requires special project planning attention because of the potentially long lead time it creates before the station can go live. The FCC is currently processing hundreds of narrow-band transmitter license applications, including HAR, and it reviews each one individually. For planning purposes, it is wise to assume that FCC licensing will require a minimum of three to six months. [34] The

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[33] United States Department of Transportation, Research and Innovative Technology Administration: http://www.itslessons.its.dot.gov/its/benecost.nsf/CostComponents?OpenForm. These cost data are in 2005 dollars, adjusted for inflation to 2009 dollars.

[34] Personal communication between Josh Hassol (Volpe Center) and FCC representative.

FCC does have provisions for allowing a transmitter to begin operation before it is licensed, but that requires special approval.

The National Seashore would use the HAR system both to convey emergency information and, on a daily basis, beach parking availability. This use appears to be permissible under FCC regulation. However, the configuration and appearance of static HAR signage is regulated under the MUTCD, and the park will have to investigate with MassDOT and FHWA static sign options to support both uses.

5.2.2.2 Example of HAR in Another National Park

Grand Canyon National Park (GCNP) is trying to encourage use of a transit/shuttle service to reduce extreme parking and traffic congestion, and thereby to improve visitor access to the South Rim. Through the deployment of DMS and HAR at two sites on State Route 64/US 180, the park will inform travelers about parking availability, shuttle bus service, and general park information/fee options. The deployment includes two portable HARs, two HAR static signs, and one portable DMS unit. This is a pilot program. The operations plan and evaluation of this program will be used as guidance for future ITS deployments.

5.2.2.3 Internet Web Pages and Apps

These are ubiquitous. A useful analogue to the National Seashore's situation is that of transit agencies wishing to disseminate real-time transit information (e.g., bus locator apps, based on GPS data feeds from the buses). Rather than paying programmers to build custom applications many transit agencies have simply made the raw data publically available as XML feeds, and have found that numerous free apps get created very rapidly. For example, when the MBTA first made its bus GPS data feed available, a free bus locator website was online within one day, and within one week iPhone apps were available.[35]

With the advent of smart phones and related applications development, travelers have the ability to access Internet information resources on traditional websites as well as new social media, such as Twitter. With the nation collectively concerned about the problem of distracted driving, and Massachusetts having banned texting while driving, the National Seashore may want consider the advisability of using the Internet or Twitter to broadcast parking availability.

5.2.2.4 Transit Information

As discussed in Chapter 3, the CCRTA is moving forward with a number of innovative traveler information services for transit customers on the Cape. The National Seashore should stay abreast of these developments, with an eye toward providing real-time transit information, such as 'next bus" arrival information, at the National Seashore Visitor Centers. In the future, if transit services are extended to serve the beach parking areas, this type of traveler information will be especially useful.

[35] Personal communication between Josh Hassol (Volpe Center) and MBTA CFO Jonathan Davis.

6. System Implementation

This chapter provides the National Seashore with a recommended deployment strategy to complete system planning, procurement, and execution. The feasibility of the envisioned system and subsystems is considered on the basis of known conditions and constraints; technological alternatives are evaluated in relation to subsystem requirements and preferred alternatives are identified (pending technical confirmation from professional engineers).

The most straightforward fact about using the systems engineering approach to ITS deployment is that the details of design grow directly out of the stipulated requirements; these, in turn, grow out of the details of the Concept of Operations.

6.1 Parking Management & Vehicle Counting

6.1.1 **Finalizing System Requirements: Key Considerations**

Guided by clearly-defined system requirements for traveler information and the resulting data requirements, the National Seashore will need to finalize its system requirements for parking management & vehicle counting. The following are key considerations.

6.1.1.1 Data Quality

As discussed previously, the National Seashore lacks reliable vehicle count data at its facilities. Existing loop detectors at National Seashore parking areas are primitive by today's standards: they are not connected to computers by any means, generating a paper loop that is read once a month. There are no real-time data available. The detectors have no self-diagnostic capability, and so undetected breakdowns result in the loss of a full month's data. Hence, the foundational system requirement for parking management is that it provides a reliable steam of accurate data from all beaches in a network environment. This translates into additional system requirements. First, the system should be rugged and whether-proof. Second, it should be self-diagnostic, and able to signal when it is not operating correctly. Second, when repairs are needed, they should be easy to accomplish. This has a direct bearing on the choice of vehicle counting sensors.

6.1.1.2 Data Types

There are several types of data the National Seashore may wish to collect at its beach parking areas. Collecting each type of data will necessitate different ITS components. The most basic data are vehicle counts – simply recording each vehicle that enters or exits each parking area. Vehicle-count data will:

- Enable parking status messaging
- Help the National Seashore reconcile daily cash-box balances at the beach parking booths with actual visitor volumes
- Enable the Seashore to fulfill its mandated public use data reporting requirements
- Provide the Seashore with a better understanding of hourly, daily and weekly use patterns, which may help it manage its facilities more efficiently (e.g., scheduling trash collection for each beach area based on its patterns of use).

For a more detailed understanding of beach use, the Seashore may wish to record vehicle types as well as counts. For example, the Seashore may want to know how many motorcycles are parking at each facility. Different in-road sensor configurations are required for vehicle counting, and vehicle counting plus type identification. Finally, as discussed previously, queue-length data may be desired, in order to calculate estimated wait times for parking. This requires installation of video-based queue-counting systems.

It will also be important to fully specify the data elements the National Seashore needs the system to collect. At minimum, the system should collect date and time of day for each vehicle counted.

6.1.1.3 Connectivity.

The ability of the envisioned ITS deployment to provide useful parking status information to National Seashore visitors will be compromised unless data from all beaches (i.e., all available beach parking options) are included. As noted previously, at present there is no reliable cellular service on Race Point. Therefore, it is strongly recommended that a wireline connection to Race Point be included in this ITS deployment. Telephone lines extend as far as the Provincetown Airport (approximately 1,000 feet from the Race Point beach parking entrance) so a connection to the National Seashore should be simple.

6.1.1.4 Back-End Infrastructure

In the system design, provision needs to be made for locations to house back-end server and telecom infrastructure (primary and back up). This will include systems to acquire parking availability information from all instrumented beach parking areas and produce the appropriate traveler information messages for dissemination via HAR (and small DMS at the beaches, if deployed), as well as to archive data.

6.1.2 **Recommendations**

- ***Use Magnetometers.*** Based on the system requirements (including accuracy, weather resistance, ease of replacement, aesthetics, and the option of configuring the system to record vehicle types as well as vehicle counts), and taking into account installation and maintenance costs, magnetometers appear to be the best available technology for the National Seashore's needs. Specific system design configurations for each parking area, and system specifications will need to be developed by the consulting engineer.
- ***Estimate Costs for Robust Data Collection.*** The marginal cost difference between a magnetometer-based system that records just vehicle counts, and one the records counts plus vehicle types (e.g., car, truck, motorcycle) may be slight, particularly in comparison to the cost of engineering and design, which are likely to be essentially the same for either configuration. As part of its competitive procurement process, the National Seashore should request cost estimates for both types of systems. If the cost difference is small, the Seashore may wish to install the vehicle-type detection even if there is no immediate need for vehicle-type data, since adding that capability later, should it become desirable, would be far more costly than building it in from the start.
- ***Install and Test First.*** The study team recommends that the National Seashore install a vehicle-counting system at one beach parking area, and pilot test it over a series of days, before proceeding with installations at the remaining beaches. It is far better to uncover any fundamental system flaws when only one system has been installed, than after installing multiple systems.
- ***Defer Electronic Payments.*** The study team recommends that the National Seashore defer a decision about providing electronic payment processing until after the current ITS deployment is completed. As discussed in Chapter 5, the National Seashore may not face the same queue-length issues as parks that have installed dedicated entrance lanes for electronic payment. There may be other benefits from electronic payment that could be derived without installing separate, automated payment lanes. These include visitor convenience, and reduced cash handling (with the associated problems of loss). The Seashore should evaluate these potential benefits against the costs of equipping existing beach parking entrance lanes/booths with electronic payments systems. Should the Seashore decide to provide electronic payment processing in the future, that functionality (e.g., point-of-sale credit card terminals) can be added separate from the installed ITS components. Wireline or secure (3G or better) wireless connectivity will be required to support electronic payment data transfer.

6.2 Traveler Information

As discussed previously in this report, the ultimate goals of the ITS deployment in the National Seashore are to provide visitors and residents with reliable parking status information and emergency information. The specifics of traveler information message delivery (e.g., level of message detail, locations of messages) will drive the data requirements and technology needs.

6.2.1 **Finalizing System Requirements: Key Considerations**

Before proceeding with procurement, design, and deployment, it will be important for the National Seashore to finalize its traveler information requirements, to insure that the system ultimately deployed fully meets the National Seashore's needs. This is particularly important because of the the way traveler information system requirements drive data and technology requirements for the entire ITS deployment. The following are key considerations related to traveler information system requirements.

6.2.1.1 Layout of the National Seashore Beaches

The National Seashore beaches are spread across the Outer Cape, divided into the South and North Districts. The National Seashore has entrance facilities at each of its beach parking lots; these are not gated.

The six National Seashore beaches have a total of eight parking areas: Herring Cove parking is divided into the North and South lots, and Coast Guard Beach, which lost its primary parking area in the Blizzard of 1978, also operates a remote parking area inland at Little Creek. With the exception of Coast Guard Beach, the parking areas are open year-round. At Coast Guard, from mid-June to Labor Day, the parking area behind the former Coast Guard station is closed to all but park staff, Eastham residents, and visitors who are disabled. Access is provided by shuttle bus from the Little Creek parking area, a 10-minute ride away. Although the parking area at Coast Guard Beach is open the remainder of the year, parking is limited.[36]

Except for Herring Cove, all beaches are located some distance down side roads off Route 6. Table 6-1 presents the driving distances involved in getting from the southernmost to northernmost National Seashore beaches, starting at the Salt Pond Visitor Center.

[36] http://www.nps.gov/caco/planyourvisit/coast-guard-beach-eastham.htm

Table 6-1
Mileage to and Between National Seashore Beaches (South to North)
Source: Google Maps

District	Beach	Between Beach Road Exits Along Rte. 6 (starting from National Seashore Salt Pond Visitor Center)	From Rte. 6 to Beach	Total from Beach to Next Beach North
South	Coast Guard	0	1.8	1.1
	Nauset Light	0*	2.7*	6**
	Marconi	2.7***	1.4	14.3
North	Head of the Meadow	11.6	1.1	9.6
	Race Point	7.1	2.3	4.1
	Herring Cove	1.8	0.2	0

*Assumes visitor travels from Rte. 6 via Nauset Road to Doane Road to Ocean View Drive.
**Assumes visitor returns to Rte. 6 via Cable Road to Nauset Road.
*** Distance from northern intersection of Nauset Road and Route 6.

When visitors in cars encounter a queue at a National Seashore beach parking area that is temporarily full, they have three options. Remaining in the cue often means keeping the engine running to drive the air conditioning, and the result is compromised air quality, as well as the loss of active recreation time by the visitor. Alternatively, the visitor may leave the queue. If he/she does so to park along the shoulder,[37] the car's tire may damage the fragile ecosystem, but the visitor then walks into the park and likely receives a ticket for illegal parking. The third option is to drive to another beach. However, the visitor has no information regarding the likelihood of finding another beach parking area open or already full, and the travel distances are not trivial.

6.2.1.2 System Coverage

Budget constraints or other issues may require the National Seashore to prioritize deployment. If that occurs, it would be logical to deploy ITS to the south district (Eastham through Wellfleet) first, since those National Seashore beaches are the most heavily used. Ideally, of course, all National Seashore beaches will be included in the ITS deployment.

6.2.1.3 Message Content and Level of Detail

With respect to parking information, the fundamental question is: what kind of message does the National Seashore wish to provide? Parking messages can range from static, general information (e.g., beach parking hours of operation, fees, and locations), to dynamic parking status information (e.g., "open" vs. "full" status of each parking area), to detailed information about each parking area (e.g., estimated wait time for parking at each beach). With each increase in message complexity, there is a corresponding increase in the complexity of the data required, and the ITS system components (hardware, software, back-end IT, and processing algorithms) needed. For example, as discussed in the concept of operations

[37] Such parking is usually illegal, but the Park does not ticket violators, so they have little incentive not to continue the practice.

(see Chapter 4), providing "open" vs. "full" status information for each parking area will require continuous counting of vehicles entering and exiting each parking area. In turn, generating vehicle count data will require sensor technology at each parking area. Providing estimated wait times at each beach will require vehicle count data also and, in addition, queue length data, which will necessitate additional system components.

6.2.1.4 Message Length

Providing traveler information involves the fundamental challenge of disseminating messages that are simultaneously complex enough to provide travelers with information they can use to make good decisions, and simple enough to be read (or listened to) "on the fly" at highway speed. DMS units have inherent limitations on the amount of information they can convey, and even highway advisory radio broadcasts must be short enough for drivers to hear, process, and act upon them in a relatively short period of time. Furthermore, more complex messages require correspondingly complex data and back-end processes to support them.

6.2.1.5 Message Locations

To be useful, traveler information needs to be provided close to travelers' destination alternatives (so that it is current), and prior to routing decision points (e.g., highway exits). If, for example, Nauset Beach parking is full, travelers need to know that before they exit Route 6 at Nauset Road. At the same time, travelers need to know what alternatives exist – for example, that Marconi Beach has parking available. In practice, this means that beach parking information will need to be widespread, if not ubiquitous, within the National Seashore. Ideally, visitors would have access to parking status information from anywhere within the National Seashore

6.2.1.6 Stakeholder Concerns

Stakeholders have raised concerns about the aesthetic impact of DMS along Route 6 (and, potentially, elsewhere) within the National Seashore. The National Seashore is deeply cognizant of these concerns, particularly since its core mission includes protecting the unique landscape and beauty of Cape Cod.

6.2.2 **Recommendations**

Based on the initial ("ideal") concept of operations described in Chapter 4, and in light of the system requirement key considerations outlined above, the following are recommendations for traveler information ITS deployment in the National Seashore:

- ***First Deploy All Parking Management/Vehicle Counting Systems.*** Traveler information systems are only as useful as the data that feed them. Without good information about all parking options available to them, travelers in the National Seashore will not be able to make informed decisions, and the value of the entire ITS system will be compromised. Therefore, the National Seashore should deploy traveler information systems only after vehicle counting systems have been deployed at all beaches and are working reliably. In practice, this will mean traveler information deployment will lag parking management deployment by at least one year.
- ***Use Highway Advisory Radio.*** Given the National Seashore's stated needs and anticipated requirements for its traveler information system, and also in light of stakeholders' important concerns about visual impact, HAR has several advantages over DMS.

  First, HAR can provide ubiquitous coverage within the National Seashore. An engineering study will be needed to determine the exact number and optimal locations for HAR units, but it is likely that no more than six will be needed to provide seamless coverage (as discussed in Chapter 5, typical 10-watt HAR systems have a broadcast radius of 3-5 miles).

  Second, whereas a DMS message must be short enough to be read quickly at highway speed, a HAR message can provide significantly more detail, because the driver is listening as he or she travels.[38] Thus, while it would be extremely challenging (and perhaps impossible) to provide comprehensive parking status information for all six National Seashore beaches on a single DMS, a single HAR broadcast could easily provide such information.

Third, HAR avoids most (but not all) of the aesthetic concerns raised in opposition to DMS. HAR transmitters can likely be installed out of view (e.g., on National Seashore land several hundred yards back from Route 6) and would therefore be "invisible" to the general public. On the other hand, numerous static signs will be needed along Route 6, advising travelers to tune their car radios to the HAR frequency for National Seashore beach parking information.[39] If the HAR system is also intended to supply emergency information, these signs would need to include flashing lights that would activate in emergencies.

As noted in Chapter 5, the HAR FCC licensing process can be lengthy. Therefore, initiation of HAR licensing will be among the first tasks in the overall ITS deployment timeline for the National Seashore.

Engineering expertise will be required to select the appropriate locations for HAR transmitter/antennas, and to develop appropriate security protocols for their use.

- ***Deploy All Messaging Simultaneously***. To be useful, beach parking status information must provide travelers with a complete picture of their beach parking options. Having only some of the National Seashore beaches in the system would render the entire system dramatically less useful. It is strongly advised that the National Seashore deploy the entire HAR system and all associated static signage simultaneously, rather than in phases.
- ***Keep the Message Simple***. Parking status messages should be clear and simple, especially during the first season of use, and potentially beyond that. For example, the HAR parking status message might say simply:

> "Current National Seashore beach parking status: Coast Guard Beach – open, Nauset Beach – full, Marconi Beach – open . . . Next update at . . ."

Back-end IT systems and software can generate parking status for each beach (i.e., "open" or "full"), and produce text messages. In turn, those status messages can be broadcast via HAR systems through text-to-speech software.

As discussed earlier, the provision of estimated waiting time at each beach would require significantly more front-end infrastructure (queue counting video systems) and back-end processing. In addition, because National Seashore beaches are separated by several miles in most cases, and, with the exception of Herring Cove, are also at least one mile from Route 6, estimated wait times are likely to change while a traveler is in transit from one beach to another. This could lead to a frustrating situation where a traveler receives the estimated wait time for a given beach over HAR, and arrives at the beach only to find that the wait is now longer.

Once full, beach parking lots typically remain that way for several hours, until the first visitors (the ones who arrived early in the morning) begin to leave. Since parking conditions do not change minute by minute throughout the day, it will not be necessary to update parking status information in real time. Updates every 10 to 15 minutes should be more than adequate to provide visitors with timely, useful information, but the update frequency can be adjusted based on experience.

[38] With HAR the limiting factor is how quickly a driver at highway speed travels out of range of a given transmitter. Subject to FCC approval, the National Seashore could deploy enough HAR transmitters to provide continuous service within the Seashore boundaries.

[39] Conservatively assuming one HAR static sign per mile in both directions along Route 6 within the National Seashore, yields an estimated 40 static HAR signs. Fewer signs might suffice, which would lower the total system cost.

- ***Incorporate Buffers***. Travelers cannot react instantly to parking status information. For example, some travelers may have exited Route 6 and be travelling to a particular beach at the moment the last parking space is taken. For this reason, the traveler information system will need to incorporate "buffers." For each beach area, the system will need to report the parking status as "full" when some small number of spaces is still available. Similarly, the system will need to delay reporting the parking area as "open" until a small number of spaces becomes available. The optimal sizes of these buffers are likely to vary from beach to beach, by day of the week, and by month, and will be determined over time through observation and analysis of vehicle count data.

  It is recommended that the parking buffer be set initially at 5 percent of the total number of spaces at each beach, and optimized from there on a beach-by-beach basis.

- ***Consider Small DMS Units For Beach Parking Areas***. Although large, permanent DMS units along Route 6 may not be optimal or desirable, the National Seashore should consider, and get cost estimates to deploy, a small, "context-appropriate" DMS unit ahead of the entrance to each beach parking area. These signs would provide the same recommended "open / full" message as the HAR system, but each one would be specific to its beach. Wherever possible, the beach-specific DMS units should be installed in advance of the actual parking areas, at points where it is safe and legal for drivers to divert to another road, or to turn around, when a beach parking area is full.

  If the National Seashore decides to provide estimated wait time information for each parking area, the, beach-specific DMS units would be the appropriate places to display it. Each DMS would provide the estimated wait time for its beach. That way, a traveler who arrives at a beach only to find the parking area full would have additional information to help him or her decide whether to wait for a parking space, or go to another beach.

  Additionally, the National Seashore may wish to research the viability of larger, permanent DMS units for use along Route 6, as a potential alternative to HAR (assuming stakeholders' concerns could be alleviated through context-appropriate design).

- ***Consider DMS for Emergency Communication.*** Even with a robust HAR system deployed, DMS will be useful, particularly in emergencies when travelers will need to be informed of shelter locations, road detours/closures, and other locally-variable information. The National Seashore should consider purchasing portable DMS units, to be used during major emergencies such as hurricane evacuations, to assist with traveler information and coordination with regional emergency operations. The DMS units could also, potentially, be used during special events that create significant traffic congestion within the National Seashore (e.g., Wellfleet Oysterfest) to direct visitors to satellite parking and shuttle buses, and to advise of road closures.

- ***Coordinate on Emergency Communication.*** Careful advance planning, including memorandums of understanding (MOUs) between the National Seashore and each participating municipality, Barnstable County emergency response agencies, and MassDOT will be needed to:
  - Develop a coordinated plan for emergency communication.
  - Codify the terms and conditions of local deployment of DMS purchased by the National Seashore.
  - Develop operational protocols and inter-agency agreements to allow MassDOT to communicate with HAR and DMS units within the Seashore's boundaries. For DMS, connectivity is likely to be as simple as, in essence, providing MassDOT with the wireless telephone numbers or IP addresses of the portable DMS units deployed within the National Seashore. Connectivity for HAR use may be more complex, because MassDOT does not currently use HAR except in certain tunnels. If direct connections from MassDOT to the National Seashore's HAR system are not possible, provision will need to be made for

MassDOT to forward messages to the National Seashore for broadcast over the HAR system.

6.3 Deployment Approaches

There are several different ways an ITS investment can be deployed using the "V" systems engineering model. Three basic development strategies can be used:

- **Once-through** – Plan, specify, and implement the complete system in one pass through the "V". This approach, also sometimes called the "waterfall" approach, works well if the vision is clear, the requirements are well understood and stable, and there is sufficient funding. The problem is that there isn't a lot of flexibility or opportunity for recovery if the agency's vision or the requirements change substantially.
- **Incremental** – Plan and specify the system and then implement it in a series of well-defined increments that each delivers a portion of the system. In this case, the agency makes one pass through the first part of the "V" and then iterates through the latter part for each phased increment.
- **Evolutionary** – Plan, specify, and implement an initial system capability. Gain experience with the initial system and define the next iteration to fix problems and extend capabilities. Refine the Concept of Operations, add and change system requirements, and revise the design as necessary. Continue with successive iterative refinements until the system is complete. This strategy provides the most flexibility, but also requires project management expertise and vigilance to make sure the development stays on track. It also requires that agency ask for patience on the part of project stakeholders, since they need to continue to support the overall program even though their desired feature may not be ready as soon as they had hoped. In any evolutionary deployment strategy, therefore, each iteration should include stakeholder involvement to ensure consensus on direction and commitment to proceed as the system is incrementally implemented.

The National Seashore's ITS system requirements are sufficiently straightforward that successive rounds of evolutionary refinement and stakeholder reappraisal are not likely to be needed. At the same time, attempting a single, all-at-once deployment would be a mistake, because some subsytems will be best deferred until others are deployed, tested, and adjusted as needed. For example, parking management/vehicle counting subsystems must be operating flawlessly prior to going live with traveler information subsystem (although the planning of both subsystems will need to proceed in parallel). Thus, an incremental deployment model makes the most sense for the National Seashore. Implementation strategies are discussed in more detail later in this chapter.

The preceding sections have discussed the originally envisioned system in terms of distinct subsystems. A detailed engineering plan should address all subsystems that the National Seashore and partners select to move forward, because the technical and operational integration and/or coordination of those subsystems at the back end is fundamental to meeting the National Seashore's goals. However, the planning and engineering implementation of each subsystem should follow its own separate systems engineering plan.

6.4 Procurement Process

This section discusses key issues related to the procurement of ITS technologies, planning, engineering and related services.

6.4.1 Key Issues and Requirements

The procurement process includes four dimensions: work distribution, method of award, contract form, and contract type. Once these key procurement decisions have been made then appropriate terms and conditions can be identified.

ITS system procurement decisions should be driven as much by how, and by whom, the project will be executed as by the intended system's purpose and functional and technical specifics. Any ITS project has a much greater chance of coming in on time and on budget if it performs thorough planning in advance of the project's administrative and technical management.

This aspect of project planning involves:

- Assignment of project management responsibility and authority to individuals experienced in ITS deployment.
- Development of a detailed project plan and a systems engineering management plan.

The sponsoring agency has to factor into its planning how experienced it is with ITS deployment, and whether it has the appropriate personnel (that is, both experienced and sufficiently available) needed to manage the project so that it is executed on time and within budget. When necessary, the project management function can be procured; in that event the contractor develops the project and systems engineering plans as early deliverables. The sponsoring agency must still dedicate resources to assure active oversight of the project at all times.

The project plan documents how the project will be managed and controlled. It identifies the detailed work plans for both administrative and technical tasks. For each project task, the PP documents what is to be done, by whom, with what funds, when, how (processes to be used), and dependencies. The systems engineering management plan defines how the engineering portion of the project will be executed and controlled. It describes how the efforts of system designers, test engineers, and other engineering and technical disciplines will be integrated, monitored, and controlled during the complete life cycle.[40]

Even when the administrative and technical planning and management of an ITS project are procured, the sponsoring agency has a significant role to play throughout project implementation. Each step in the systems engineering process has a gate at its termination that formally precludes going on to the next step until a series of documentation review and acceptance procedures are executed with the participation of agency personnel with assigned authority and responsibilities. At the completion of the project, after it has been installed and tested, the agency is responsible for the final acceptance testing. The system should not be accepted unless it passes this test. Additionally, the agency must validate the system once it is operating to confirm that the system has been built, is functioning as intended, and is having the desired impact in relation to the stakeholder needs it was originally conceptualized to address. In that way the benefits of the system are documented relative to its costs.

6.4.2 Recommendations

The vast majority of ITS deployments are made by transportation agencies, whose core missions involve providing infrastructure, services, and information to improve the efficiency and effectiveness of transportation systems. Although the National Seashore has a strong interest in ITS, provision of transportation services and systems is not part of its core mission. The procurement model must therefore provide the National Seashore with as close to a "turnkey" project as possible, while acknowledging that the National Seashore will still need to be heavily involved in the project in many ways. The following are recommendations for procuring the ITS technologies and services. Appendix E provides a detailed discussion of various procurement models.

- ***Use Design-Build Approach.*** A Design-Build contract, procured through a competitive Request for Proposals (RFP) process, will provide the National Seashore with a turnkey approach. The Seashore's winning contractor will be responsible for overall project execution, including installation and testing. The contractor's bid package will specify subcontractors to perform engineering tasks such as mapping systems specifications to functional requirements, magnetometer layout design, HAR site selection and FCC licensing, systems integration, and

[40] US DOT, *Systems Engineering for Intelligent Transportation Systems, pp. 82-83*.

computer programming. Procuring all necessary services with a single contract will be much simpler than having to procure them separately.

An additional benefit of using a design-build approach is that a single, large contract is likely to attract more bidders, and better qualified bidders, than would a series of small contracts.

As an alternative to the RFP process – which can be complex and time consuming – the National Seashore could work directly with the Volpe Center, which can provide design-build and overall project management services, and has implemented parking management ITS for another National Park.

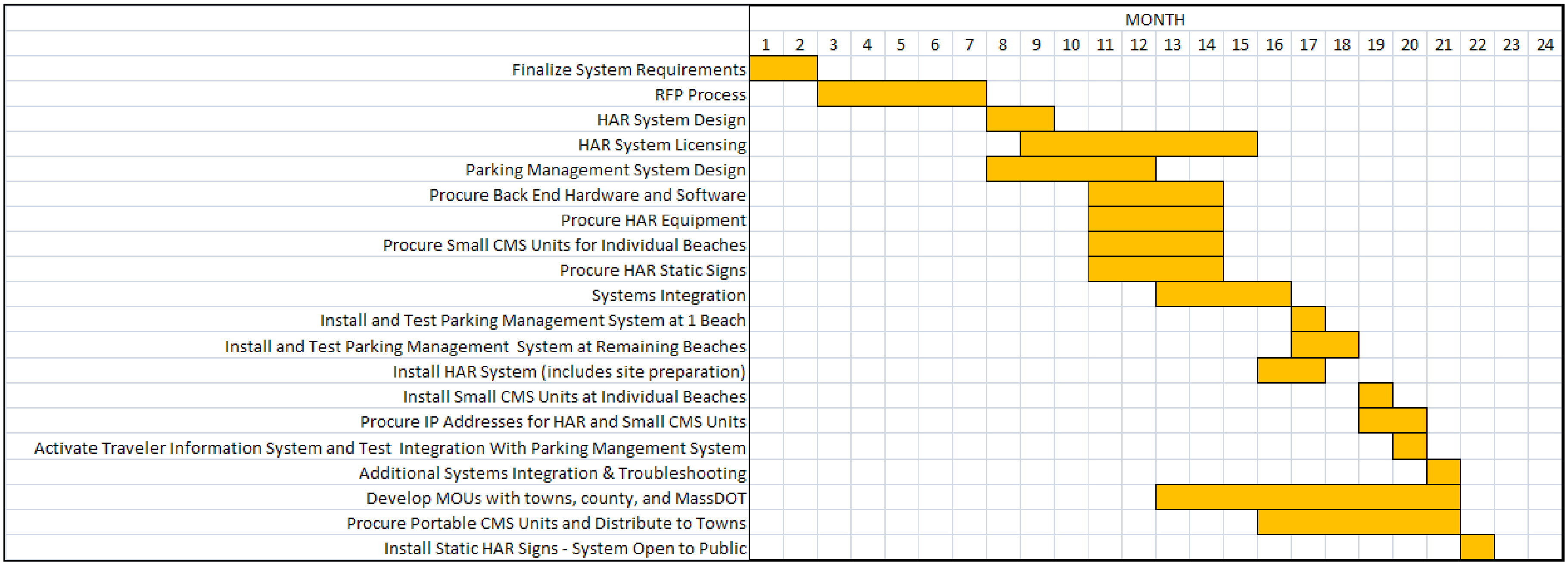
- ***Best Value Procurement***. Many goods and services are appropriately procured through lowest-cost bidding; ITS investments are not among them. ITS deployments, even relatively simple ones such as what the National Seashore is envisioning, are complex. Price is important, of course, but must be balanced against qualifications and expertise.
- ***Get a Warranty***. The National Seashore should require the winning bidder to warranty all components, engineering and workmanship against defects. The length of the warranties offered by the competing firms should be among the criteria the National Seashore uses to select a winner.

6.5 Implementation Timeline

The following timeline (Figure 6-1) provides a generalized implementation schedule for the National Seashore's envisioned ITS deployment. The timeline is intended to provide a high-level overview of the implementation process; consulting contractors, engineers and other advisors will develop detailed design and implementation schedules.

As the timeline shows, although parking management/vehicle counting is installed and tested prior to going live with traveler information services, engineering of the two subsystems proceeds in parallel.

Figure 6-1
Implementation Timeline



6.6 *Preliminary Cost Estimate.*

Table 6-1provides estimated capital and professional services costs for system installation. The cost estimates do not include operation and maintenance. These are preliminary estimates, for planning purposes only, based on the professional judgment and initial research of the study team. The initial implementation task – detailed engineering specifications – will generate precise cost estimates. The cost estimates presented in Table 6-1 use the high end of any cost range data, in order to be conservative.

Table 6-1
Preliminary System Design and Installation Cost Estimate

Item	Unit Cost	Number (Units, Days)	Total Cost
Finalize System Requirements (Consulting Services)	$3,000	20	$60,000
Parking Management System Design (Consulting Services)	$3,000	30	$90,000
Magnetometers and Associated Electronics (assumes 4 per parking area: 2 entrance, 2 exit)	$1,300	24	$31,200
Engineering for HAR System Including Licensing and Site Selection (Consulting Services)	$3,000	30	$90,000
HAR Units and Associated Site Work	$36,000	6	$216,000
Static HAR Signage (assumes one sign approximately every two miles on both sides of Route 6 within National Seashore	$8,000	20	$160,000
Systems Integration (Consulting Services)	$3,000	30	$90,000
Back-End IT Infrastructure	n/a	n/a	$150,000
Portable DMS Units	$21,000	6	$126,000
Small, Context-Appropriate, Permanent DMS at Beaches (cost assumed to be 2/3 that of portable DMS)	$14,000	6	$84,000
TOTAL			**$1,097,200**

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Appendix A: 3G Cellular Wireless Coverage as of September 2010

Wireless connectivity to support the transmission of data is shown for Verizon Wireless (Figures A1-1 and -2), AT&T Wireless, (Figures A1-3 and -4), Sprint Mobile Wireless (Figures A1-5 and -6), and Nextel National Network (Figures A1-7 and -8).

Figure A-1. Verizon Wireless Broadband Coverage: Cape Cod National Seashore North District
Source: Verizon Wireless Coverage Locator: http://www.verizonwireless.com/b2c/CoverageLocatorController?requesttype=NEWREQUEST Accessed 9/4/10

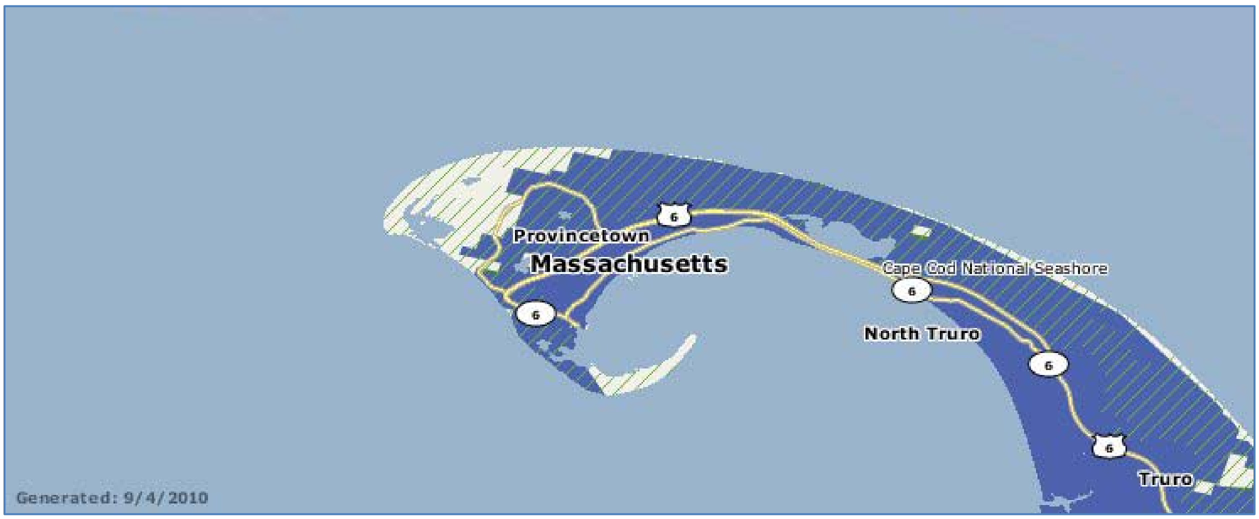
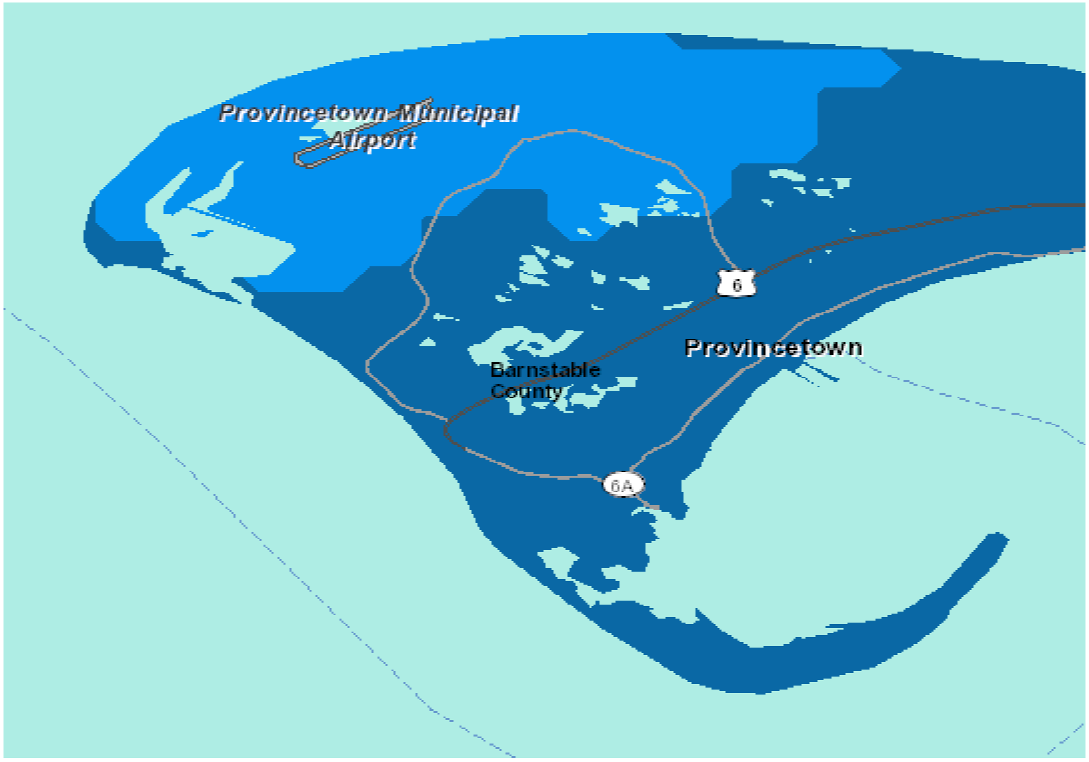


Figure A-2. Verizon Wireless Broadband Coverage: Cape Cod National Seashore South District
Source: Verizon Wireless Coverage Locator: http://www.verizonwireless.com/b2c/CoverageLocatorController?requesttype=NEWREQUEST Accessed 9/4/10

In both of the above figures, dark blue indicates broadband and VCast coverage. White indicates no coverage.

Figure A-3. AT&T 3G Broadband Wireless Coverage: Cape Cod National Seashore North District
Source www.wireless.att.com/http://www.wireless.att.com/coverageviewer/#?type=data&lat=42.05234479701735&lon=-70.2019760907421&sci=9 Accessed 9/4/10



The area in dark blue in above figure represents 3G/wireless coverage. AT&T's figure legend explains that the area shown in medium blue represents AT&T owned EDGE/GPRS, "a GSM network providing Enhanced Data rates for GSM Evolution with typical speeds of 75 to 135 kbps, advanced mobile services like video and music clips, full picture & video messaging, high-speed color Internet access, and email on the move are possible."[41]

[41] http://www.wireless.att.com/coverageviewer/popUp_legend.jsp

Figure A-4. AT&T 3G Broadband Wireless Coverage: Cape Cod National Seashore North District
Source www.wireless.att.com/http://www.wireless.att.com/coverageviewer/#?type=data&lat=42.05234479701735&lon=-70.2019760907421&sci=9 Accessed 9/4/10

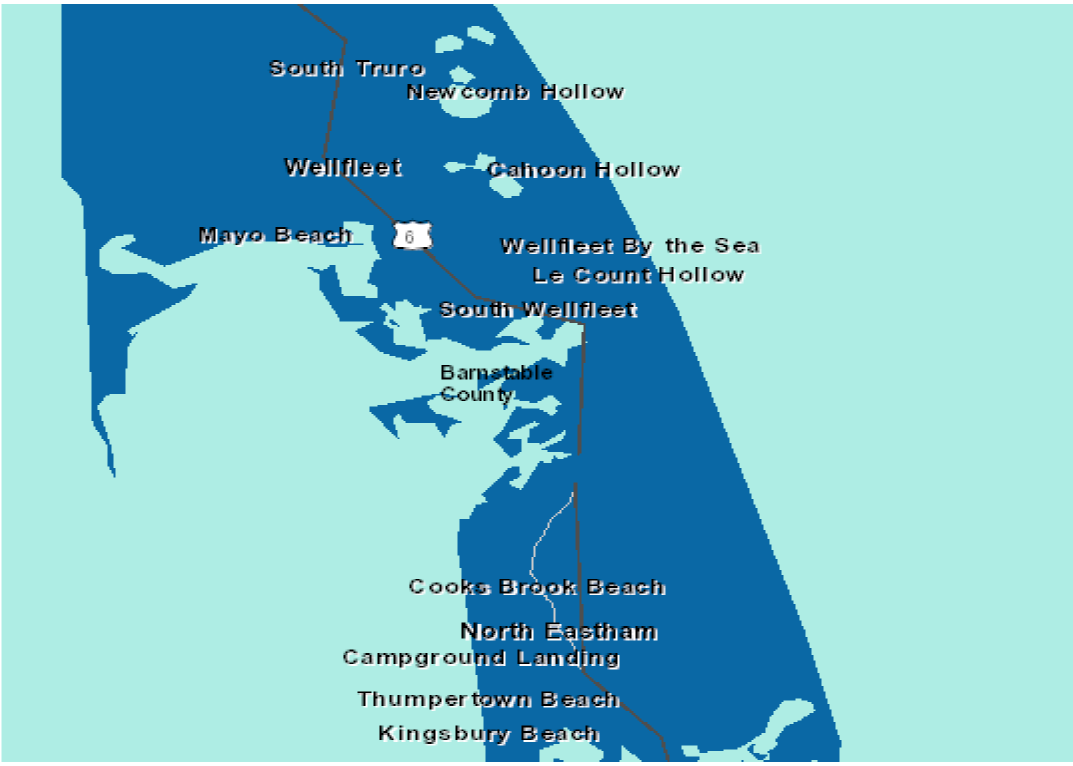


Figure A-5. Sprint Mobile Wireless 3G Broadband Coverage: Cape Cod National Seashore North District
Source: http://coverage.sprint.com/IMPACT.jsp?INTNAV=ATG:FT:Cov. Accessed 9/6/2010

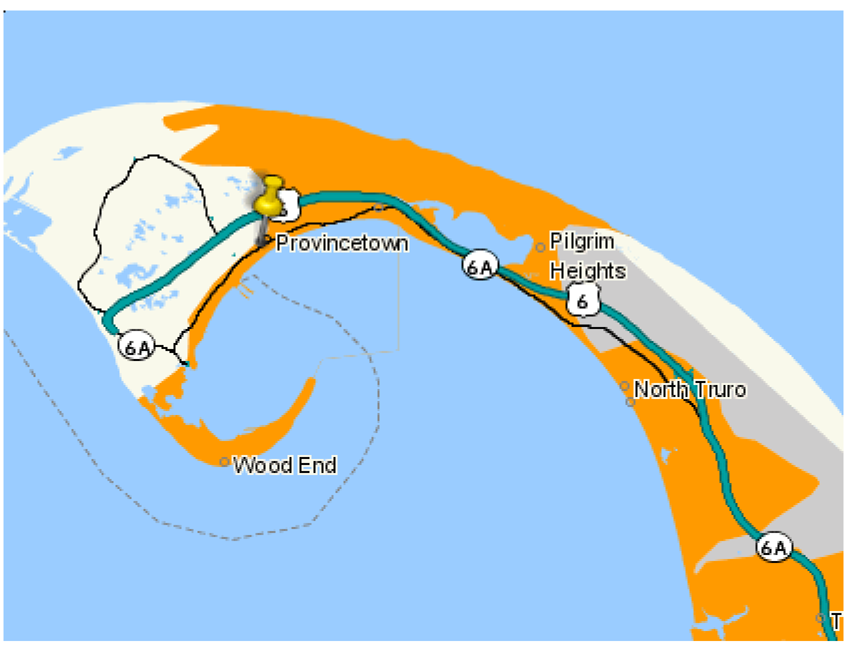
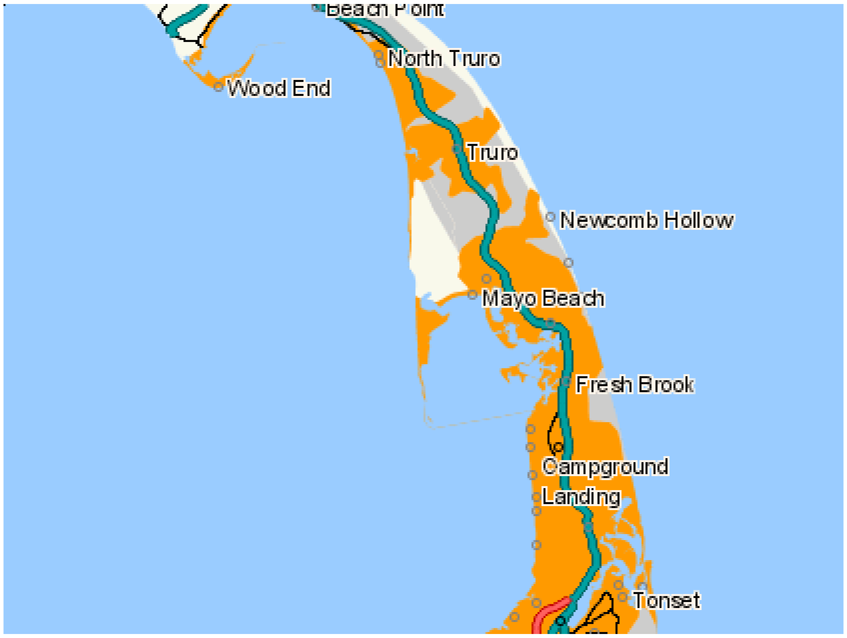


Figure A-6. Sprint Mobile Wireless 3G Broadband Coverage Cape Cod National Seashore Southern District
Source: http://coverage.sprint.com/IMPACT.jsp?INTNAV=ATG:FT:Cov. Accessed 9/6/2010



In the two figures immediately above, orange signifies 3G wireless coverage, grey indicates "3G roaming - limited access to some services", and white means no coverage.

Figure A-7. Nextel National Network 3G Coverage: Cape Cod National Seashore North District
Source: http://coverage.sprint.com/IMPACT.jsp?INTNAV=ATG:FT:Cov. Accessed 9/6/10

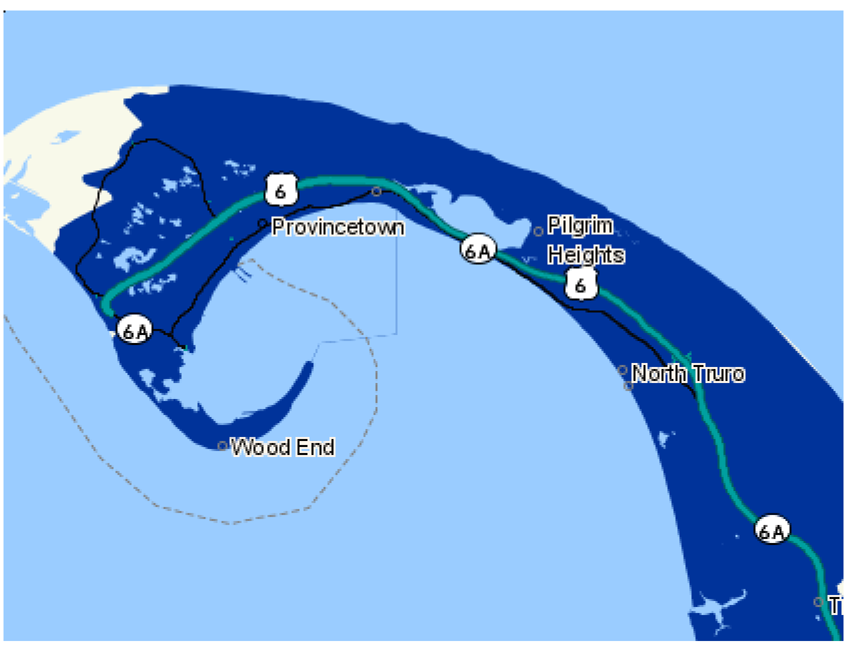
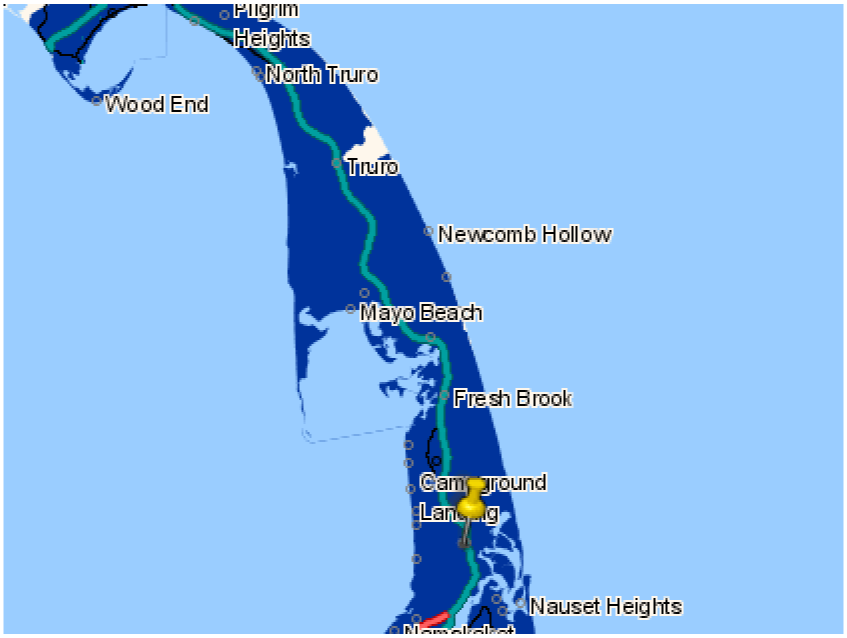


Figure A8. Nextel National Network 3G Coverage: Cape Cod National Seashore South District
Source: http://coverage.sprint.com/IMPACT.jsp?INTNAV=ATG:FT:Cov. Accessed 9/6/10



Appendix B: Federal Lands Interagency Passes

The Federal Lands Recreation Enhancement Act (REA) of 2004 (PL 108-447) established the "America the Beautiful – the National Parks and Federal Recreational Lands Pass" (Interagency Pass Program) to replace the Golden Eagle, Golden Eagle Hologram, Golden Age, and Golden Access Passports and the National Parks Pass. The Interagency Pass Program provides four pass options for the public to use at Federal recreation sites where entrance or standard amenity fees are charged. The four passes that make up the program are:

- **Interagency Annual** – Available to anyone 16 years and older at a cost of $80 and good for one year from the date of purchase
- **Interagency Senior** – Available to US residents and citizens 62 years old and older
- **Interagency Access** – Available to US residents/citizens with a permanent disability
- **Interagency Volunteer** – Available to anyone who volunteers over 500 hours at one of the participating agencies[42]

All passes consist of a four-color 3 ¼" x 2 ¼" plastic card with a title and serial number on the front, and a magnetic strip, signature line(s), and barcode on the back. The Annual and Volunteer Passes also have a place for an expiration date on the back.[43]

The overall objectives of the program included making the passes more convenient to purchase and use, and incorporating technologies to allow for improved data collection and to prevent misuse.[44] In 2006, however, the US Government Accountability Office had observed:

> While units are generally able to track the number of passes sold, it would be difficult for many units to collect accurate data about use of the pass. At most NPS and FWS sites, fees covered by the new interagency pass will generally be collected at staffed entry points, whereas at BLM and FS sites, fees covered by these new passes will generally be collected at unstaffed and often remote locations where fee compliance and enforcement will be irregular and infrequent. One way to track pass usage would be to swipe a magnetic strip on the passes at recreation site entry gates. However, even within NPS, whose sites frequently have staffed entry points, only one-third of the sites with entrance fees are currently capable of reading magnetic strips at their entry gates. [45]

With regard to swiping passes, it should be noted, however, that the Interagency Pass Program SOP requires strict verification of authenticity: "Anytime a pass holder presents an Interagency Annual or Volunteer Pass the expiration date must be checked. Since [all] passes are non-transferable, the verification of ownership is a legitimate component of the program. As stated on the back of the Pass, valid photo ID is required, and pass signatures will be compared to verify ownership."[46] The operational implication of these requirements is that either the verifying park employee then swipes the card for the visitor, or that the verification must take place before the visitor swipes the card in an electronic reader.

The National Seashore sells the Interagency Annual Pass at its two visitor centers.[47] In addition, the National Seashore offers a pass good for a calendar year fee season (it is thus not an annual pass in the same sense as the Interagency Annual Pass). The pass costs $45; the National Seashore has these passes

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[42] *America the Beautiful Interagency Pass Program SOP,* p. 4.

[43] *America the Beautiful Interagency Pass Program SOP,* p. 5.

[44] *America the Beautiful Interagency Pass Program SOP,* p. 4.

[45] GAO-06-0016, p. 19.

[46] [46] *America the Beautiful Interagency Pass Program SOP,* p. 7.

[47] http://www.nps.gov/caco/planyourvisit/feesandreservations.htm

made commercially.[48] Cape Cod National Seashore passes are usually available at visitor centers starting Memorial Day, and at fee booths when they are open.[49]

[48] Karst Hoogeboom to Ingrid Bartinique, personal e-mail communication, August 25,2010.

[49] http://www.nps.gov/caco/planyourvisit/feesandreservations.htm

Appendix C: Examples of Automated Entry Systems at Other National Parks

Examples of automated entry systems implemented at national parks are described in this appendix.[50] The technologies employed by these systems involve transponders, magnetic stripe cards, or contactless cards.

Bryce Canyon National Park

Bryce Canyon has one entrance for access to almost all park sites and amenities in its 56-square-mile interior.

The park uses windshield-mounted transponders to provide automated access for NPS employees, NPS shuttle vehicles, and some contractor vehicles (i.e., those who enter the controlled area frequently), but not for Park visitors.

The park has taken on responsibility for the card management and database functions associated with the system, and has not found these to present an unreasonable burden. The card database is updated once per season.

While data on access times were not available, park staff believe that the system has generally worked well. The sensors on the gate are set so that the gate will not open until the vehicle has slowed, which makes it good for access control. One glitch, however, was that the sensors could not always detect when a lighter vehicle (including their new shuttle buses) had passed, and in some cases this led to the gate arm coming down onto a vehicle. This situation has been fixed. Another "lesson learned" is that is important to structure the entrance plaza such that a vehicle that erroneously enters the automated lane can switch to a manual lane without having to back up or create additional tie-ups.

Cards cost about $20 apiece to issue or replace. This is considered by the park to be acceptable for a system oriented toward employees and some on-site contractors or vendors, but would likely be too expensive for use with seasonal passes.

Rocky Mountain National Park

Rocky Mountain National Park (415 sq. mi.) has three entrances.

Rocky Mountain uses two different types of automated access at its Beaver Meadows entrance. The first is a tag system similar to Bryce Canyon, and is used by staff, contractors, and park vehicles. Their experience has been similar to Bryce Canyon's in that the system generally works well, despite some initial glitches with the gates, and that the database and card management burdens are not unreasonable.

The second system is a magnetic-stripe card for Rocky Mountain pass holders and for national passholders who choose to have their card encoded for use at Beaver Meadows. The park owns a pass printer and makes their own park passes at a cost of approximately $0.70 per card. During 2006, the park printed and sold 32,000 park passes that are sold for $35 each and coded an additional 20,000 national passes. A magnetic-stripe system was chosen to be compatible with the national pass, which has a magnetic stripe.

The park has had good success in that environment with the reader; the system is modular, and a replacement reader is kept at the gate in case of failure. Since 2003 a changeout has been needed only two or three times, despite the pervasive dust and snow in the Rocky Mountain environment.

[50] More recently, in FY2010, the Volpe Center provided technical assistance to Assateague Island National Seashore in the choice of an ITS system to manage entry to its Over-Sand Vehicle area.

Most visitors using Beaver Meadows have come to understand the system and the park reports improved goodwill among frequent visitors. The park is working on improving signage to address the relatively small share of visitors who are confused about which lane to use.

Because of the satisfactory experience with this equipment at Beaver Meadows, the Park is proceeding with installing essentially the same system at the Grand Lake entrance. The cost for this equipment, installation, and testing is approximately $23,000.[51]

Zion National Park

Zion National Park covers 229 square miles and has three entrances.

Zion has issued contactless, RFID access cards to staff and some concessionaire employees. A box-controller at the entry gate reads the cards and operates the gate arm. The gate can also be opened by remote control in cases where manual intervention is needed.

Park staff are in charge of maintaining the card database and re-issuing cards, which they describe as a manageable burden. Cards cost about $30 each from the supplier, and tend to last about 5 years.

Data on processing times were not available, but park staff estimated that service time averages 2 seconds and that the total interval between arrivals is somewhere between 5 and 10 seconds. Because the system is limited to staff and other frequent users, there have been very few issues with confusion about the system.

Yellowstone National Park

Yellowstone National Park covers 3,472 square miles and has 5 entrances. In 2009 it had 3,295,187 visitors.[52]

Yellowstone has equipped the employee-only lane at its North entrance with an automated access system based on transponder cards. These cards are issued to permanent NPS staff and are generally mounted on the back of the rearview mirror. There is no need to swipe the card; when equipped vehicles arrive at to the access point, their cards are verified wirelessly and the drivers are presented with a green light at the traffic signal there. (There is no gate or other physical means of controlling access, only the traffic signal.) Although processing times are very fast, there is little to no overall time advantage in using the automated lane because of the way the lane merges back into general traffic after the access point. This highlights the need to consider not only access technology but the roadway configuration.

The park handles the card and database management functions associated with the system, which requires a significant but manageable level of effort. They do not plan to extend the program to their 3000 seasonal (as opposed to permanent) employees because this would increase the cost and administrative burden of the program. Cards cost about $25 each.

As of 2007 the park was considering options for automating one or more lanes at the West entrance using contactless RFID cards for NPS staff and possibly also a magnetic stripe reader for annual pass holders and visitors entering on a re-entry permits.

[51] John Hannon, Rocky Mountain National Park, personal communication to Ingrid Bartinique, August 20, 2010.

[52] http://www.nps.gov/yell/planyourvisit/factsheet.htm

Appendix D: Examples of Dynamic Message Signs

The following are examples of multi-display DMS units, of the type that may be viable in the National Seashore. These examples are not indicative of the context-appropriate designs that could be applied in a national park setting.

Appendix E: Choosing a Procurement Model

Planning for and conducting the management of an ITS project deployment is a significant commitment. The ability to take on this role is to a significant extent a function of an agency's previous experience with ITS, as well as the practical availability of personnel and other resources to commit to this task. Contracting out this role is an option. Therefore, deciding how the management of project execution will be dealt with is therefore a first step in choosing a procurement model.

The procurement process includes four dimensions: **work distribution**, **method of award**, **contract form**, and **contract type**. Once these key procurement decisions have been made then appropriate terms and conditions can be identified.

Work Distribution

The work distribution category represents the project responsibilities defined by the agency for the contractor by the contract statement of work. These assignments are expressed in the systems engineering terminology—concept of operations, requirement, design, implementation and testing. They also include the crosscutting activities of configuration management, risk management, validation and verification, and metrics. The types of work allocation are:

- **Low-Bid Contractor** – the selection of a contractor for system installation using the low-bid process. The low-bid contractor is responsible for furnishing a fully operational system including all hardware, software and construction services required to satisfy a detailed design defined by plans and specifications.
- **Systems Manager –** utilizes an organization known as the systems manager whose responsibilities may include all project activities associated with a system acquisition except for the provision of equipment, electrical contracting and construction contracting.
- **Systems Integrator** – similar to that of the systems manager, except that the integrator is not involved in the planning and design stages. The systems integrator provides all of the personal services associated with the systems implementation except for the provision of equipment, electrical contracting and construction.
- **Design Build (Operate and Maintain) (DB (OM))** – based on an agreement that provides for design and construction improvements by a (single) contractor or private developer. The term encompasses design-build, design-build-maintain, design-build-operate-maintain, design-build-operate, design-build-finance and other contracts that include services in addition to design and construction. The design build contractor's work is based on an initial design that may be prepared by a consultant.
- **Commodity (COTS)** – Contracting for the acquisition of commodities is applicable to ITS contacting to the extent that an agency is procuring commercial-off-the-shelf (COTS) products. These may include field equipment such as variable message signs, traffic signal controllers, radios, or computers. It may also include COTS software and systems.
- **Consultant Services** – Work provided by consultants is limited to provision of personal services. Some of the ways in which consultant contracts may be used include system design and installation support, inspection, design, and documentation and training.
- **Services** – Contracts for the other forms of services are frequently awarded during the life cycle of an ITS investment. The differentiation is made here to identify services that are outside the mainstream of system development, such as inspection, IV&V, outreach, information service providers (ISPs), and staff supplements.

Method of Award

The method of award category of contracting defines the criteria used and steps taken to select a contractor to perform the work. The form of work allocation that has been selected determines the method of award. As indicated below, there are distinct differences between the various methods of award. These differences should be taken into account when selecting a form of work allocation. The types of method are

- **Low Bid** – Low-bid contracting, commonly referred to as sealed bidding, is a contracting method that employs competitive bids, public openings of bids and contractor selection based on the lowest price offered.
- **Negotiated** – Unlike formal advertising of a contract requirement which is precise, highly structured method of procurement with one definitive set of procedures, negation allows considerable flexibility, permitting the use of a number of different procedures in making awards. The negotiated selection is typically based in the evaluation of a technical approach, qualifications and experience as represented in a technical proposal and possible subsequent presentations to the agency.
- **Sole Source** – Sole source procurement is the direct selection of a contractor without competition.
- **Best Value** – Selection is made on a weighted combination of the technical approach, qualifications, experience and price of the offeror. Best value is in effect, a combination of the low bid and negotiated methods of award.

Contract Form

The contract form defines the manner in which work is authorized. Three contract forms are:

- **Phased Contracts** – Phased contracts are the conventional form of contracting that is in use for the majority of projects including ITS acquisitions. Phased contracts divide the work into sets of predefined activities (or phases) with specified deliverables.
- **Task Order (or Indefinite Quantity) Contracts** – Indefinite-delivery contracts are used with contracts in which the required supplies and services are unknown at the time of contract execution. They provide a mechanism for the agency to place orders for these supplies and services during the life or term of an overarching “umbrella” contract.
- **Purchase Orders** – A purchase order is a form of sole-source contracting used for relatively small procurements. Purchase orders are a simply, rapidly executed form of contract that usually contains a standard set of terms and conditions (payment, insurance, cancellation clauses, etc.) and a relatively brief description of the work to be performed.
- **Firm Fixed Price** – the contractor assumes full responsibility for the performance costs and any profit or loss at a fixed price.
- **Cost Reimbursable** – the contractor is paid (reimbursed) for his actual costs of performing the work and the fee (profit) is fixed.
- **Time and Materials** – the contractor is paid for his actual costs of performing the work, and a percentage fee is added to all payments.
- **Incentives** – the contractor’s responsibility for performance costs and profit and/or fee incentives are dependent upon the uncertainties associated with the desired outcomes of the procurement. Incentives are paid over and above the three types of reimbursements described above.

For firm fixed price contracts, the contractor assumes all of the financial risk. The agency assumes all of the financial risk for time and materials contracts. Cost reimbursement contracts are a form of contracting in which the financial risks are shared.

Terms and Conditions

Terms and conditions have been defined in Step 8 of the Decision Model process.

The procurement process is defined by the federal Acquisition Regulations (FAR). Title 48 of the Code of Federal Regulations Chapter 1 codifies the FAR. The FAR presents policies for acquisition of supplies and services by executive agencies. The FAR is available on the Internet at *ww.arnet.gov/far*. But the FAT is not the only source of regulations. All State and local government agencies have their own processes that must also be followed.

The Decision Model

The preceding information can create a daunting task for agencies interested in procuring ITS. Fortunately, an excellent we-based decision model has been developed for the purpose of streamline the process of choosing an appropriate procurement model; it can be found at http://www.citeconsortium.org/Model/index.htm

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The Volpe National Transportation Systems Center (Volpe Center) is providing technical support to the Cape Cod National Seashore in the planning of an Intelligent Transportation System (ITS). In collaboration with the Cape Cod Commission, National Seashore staff believe that ITS can improve the quality of visitor experience and help to ease congestion related to visitor traffic at the Seashore's six beaches. Such systems can also improve management of unplanned incidents and emergency events.

This report includes an assessment of ITS technologies for parking management and traveler information. Based on this assessment, the report recommends that the National Seashore deploy magnetometer-based vehicle counting systems at its beaches. In addition, the report recommends deployment of Highway Advisory Radio to disseminate beach parking status information to travelers.

An incremental implementation model is recommended, as well as a design-build contract vehicle. Deployment of the following

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