Managing Parking Congestion at the H. Dana Bowers Safety Roadside Rest Area

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Executive Summary

Background

The H. Dana Bowers Safety Roadside Rest Area (Bowers SRRA), located on the northern end of the Golden Gate Bridge in Marin County, originated as a vista point offering iconic and photogenic views of San Francisco and the Golden Gate Bridge. Now an SRRA, the facility serves vehicles, pedestrians and bicyclists. With limited parking and high visitor volume during extended peak periods, congestion results in vehicle backup from the Bowers SRRA on-ramp onto mainline U.S. 101/Golden Gate Bridge. The backups, which are particularly challenging on weekends during the summer months and on holidays, can create safety issues as cars traveling at higher speeds on the mainline approach slower-moving vehicles waiting to exit the freeway.

To mitigate the negative impacts of high visitor volume and better manage Bowers SRRA access, circulation and parking, Caltrans is seeking information about possible solutions in four topic areas:

- *Intelligent transportation system (ITS) solutions*. ITS technologies to inform drivers of parking availability at the rest area may include dynamic message signs (DMS), smartphone applications, Highway Advisory Radio (HAR) and parking space sensors.
- *Active parking management*. The parking-related policies or practices considered in this topic area include maximum parking limits, dynamically priced parking, dynamic parking capacity and enforcement.
- *Bus-only access during peak times*. This alternative to addressing parking congestion requires the use of ITS technology to notify the public of the parking restriction during peak times.
- *Design changes*. Design changes that alter ingress and egress points can improve traffic circulation in a parking area.

To gather information in these areas of interest, CTC & Associates examined research and other relevant publications related to parking areas in state-supported SRRAs, national and state parks, and other public and private sites that provide parking and accommodate high visitor volume.

Summary of Findings

While we found no published research related to alleviating passenger vehicle congestion in SRRAs, we found a relative wealth of information about such practices either implemented or recommended for national parks and other public sites. Many of these feasibility studies, operations plans and planning studies provide information about the implementation, including costs, of a range of parking congestion solutions.

Below is a summary of the key resources we identified that may offer potential solutions for Caltrans. Refer to the **Detailed Findings** section of this report for additional citations.

Parking Congestion Management Practices

The most wide-ranging publication we found in our research, a 2014 National Park Service publication billed as a “toolkit,” provides information about dozens of practices to address parking congestion. Fact sheets for each solution or tool provide the pros and cons of

implementation, costs, examples of where a solution has been used and expected outcomes based on previous applications (see page 5).

Intelligent Transportation System Solutions

This section of the report includes background information and details of specific applications of ITS that have been proposed or implemented for public lands and other sites. A 2011 report prepared by Volpe National Transportation Systems takes a broad view of the use of ITS, providing recommendations for operating ITS technologies and implementing ITS projects in national parks and other federal public lands (see page 7).

Resources describing specific applications of ITS solutions are highlighted below.

Highway Advisory Radio and Dynamic Message Signs (see page 10)

HAR and DMS are part of a pilot parking management system for the Cape Cod National Seashore that keeps track of the rate at which vehicles are entering and exiting the parking lot, and displays a clock showing the time the lot is expected to reach capacity. Other applications of HAR and DMS used in tandem are described in a project hoping to “peak spread” the arrival of people and vehicles into Rocky Mountain National Park, and as part of a traveler information program implemented in conjunction with a shuttle bus program in Grand Canyon National Park.

Reservation Systems (see page 13)

A reservation system proposed for Muir Woods National Monument provides another example of an ITS solution to alleviate parking congestion. A similar parking reservation system proposed for the Weir Farm National Historic Site would employ parking space occupancy sensors able to detect the presence of a vehicle in a particular space in the parking lot. In lieu of sensors, park staff could check if every vehicle has a reservation and issue fines, as needed. An automated system, with sensors, could alert park staff in the event of a violation, reducing the need for random checks by park staff.

Smart Parking for Commercial Vehicles (see page 14)

While not specific to passenger vehicles, the SmartPark technology demonstration project sponsored by the Federal Motor Carrier Safety Administration may be of interest to Caltrans. The project tested a range of scanners and Doppler radar implemented at the ingress and egress points of truck parking areas to identify truck parking space availability in real time. A SmartParking USA project in Tennessee is providing information about the availability of truck parking along Interstate 75 (I-75) using smartphones and dynamic roadway signage.

A 2013 conference paper describes another detection technology—video—used to detect vehicles in outdoor parking areas. Magnetic truck detection has been explored in Maryland, and the Florida Department of Transportation used wireless ground sensors in a 2012 pilot smart parking management system for commercial motor vehicles. A recent Australian project to implement a truck parking management system provides an international perspective.

Active Parking Management

Some of the publications cited in other sections of this Preliminary Investigation briefly address the use of active parking management strategies such as maximum parking limits, dynamically priced parking, dynamic parking capacity and enforcement. Among the publications addressing active parking management strategies more directly are a corridor management plan for Glacier National Park’s Going-to-the-Sun Road that considers metered entry/reservations, maximum

stay limits and variable parking prices to limit the impact of the corridor's finite parking capacity (see page 17). A feasibility study for Mill Creek Canyon in Utah explored paid parking and reservation systems to address overcrowding of key parking areas (see page 18).

Shuttle Bus Services

The shuttle bus services developed or proposed for Zion, Arches, Grand Canyon and Rocky Mountain national parks are described in reports that highlight benefits, costs and comparisons of this solution with other congestion management strategies (see page 19). These services are not developed as a peak-time alternative to passenger vehicle parking.

Gaps in Findings

This research uncovered limited or no guidance in two topic areas: the implications of bus-only access during peak times, and design changes that have been made to improve traffic circulation in a parking area. However, we did identify publications that describe the plans for and implementation of shuttle bus services that may inform Caltrans' use of such a service for the Bowers SRRA. A more expansive research effort than that permitted under this Preliminary Investigation might identify more information about possible design changes to address the type of parking congestion experienced in the Bowers SRRA.

Some of the ITS applications or other parking congestion management practices highlighted in this Preliminary Investigation are associated with pilot projects, and more time may be needed to fully assess the impact of these projects on reducing parking congestion and the public response. In other cases, a solution to resolve parking congestion is in the proposal stage and not yet implemented.

Next Steps

Moving forward, Caltrans could consider:

- Examining in detail the National Park Service's Congestion Management Toolkit to learn more about practices relevant to the parking-related congestion experienced in the Bowers SRRA.
- Learning more about reservation systems proposed for or under consideration at Weir Farm National Historic Site and Muir Woods National Monument.
- Exploring the parking space sensors proposed for Weir Farm National Historic Site and other vehicle detection technologies that could be used to detect vehicles in outdoor parking areas.
- Contacting sites such as Cape Cod National Seashore, and Rocky Mountain and Grand Canyon national parks, which have used or considered the use of HAR and DMS to address parking congestion issues.
- Investigating the use of shuttle bus services and how such a service might be used in conjunction with HAR and DMS to limit parking congestion during peak times.

Detailed Findings

Parking Congestion Management Practices

Congestion Management Toolkit, National Park Service, U.S. Department of the Interior, March 2014.
https://www.nps.gov/transportation/pdfs/NPS-CMS_Toolkit.pdf
This toolkit, developed to address specific congestion issues in national park settings, includes implementation considerations, costs, examples of where these tools have been used, and expected outcomes based on previous applications. Solutions or tools are offered in five categories of congestion management. Those most relevant to this investigation include (from the toolkit):

> **Electronic systems.** These solutions are often referred to as "intelligent" system[s] (or intelligent transportation system "ITS"). These solutions include systems that can both collect information (such as how many parking spots may be available in a parking lot), and present information to travelers, through dynamic message signs or other visitor notification methods.
>
> **Traffic operational improvements.** These solutions may include static signage that improves "wayfinding" so that visitors find their destinations more quickly, adding a turn lane to reduce traffic conflicts, or other improvements, such as reducing or increasing speed limits on roadways.
>
> **Visitor demand management.** These solutions influence the choices that visitors make about how, when, where, whether, and which way they travel to their destinations. As used within this Toolkit, which focuses on vehicular congestion, the VDM solutions are "traffic" or "transportation" focused. These solutions include tools such as reservation systems to try and influence when people may enter a park, or may include Electronic Systems (ES) that may provide information to travelers that a certain location/feature may be crowded.

Solutions/tools that may assist in addressing congested parking areas include (from the toolkit):

- *ES-7, Highway Advisory Radio*. Highway advisory radio is a low-powered radio broadcast on AM stations. It can be obtained in both permanent and portable form and communications to update the repeated message can be either cellular or satellite. Motorists are alerted to tune to an AM station to listen to the radio broadcast via a sign with flashing beacons.
- *PT-1, Implement Transit/Shuttle Services/Operations*. Transit/shuttle services is a method to transport visitors to and around the park/unit without the use of a private automobile.
- *PT-9, Transit Technology Applications*. These can include automated vehicle location systems, which are electronic systems that focus on tracking buses through GPS; automated passenger counting (boarding) systems; systems that automatically track maintenance issues; in-vehicle electronic information such as stop annunciation and electronic display boards; and transit status signs to provide users with bus arrival times (often referred to as "next bus" signs).
- *TOI-11, Traffic Circulation Changes*. This tool involves management techniques such as one-way or reversible lanes for changing traffic flow patterns and circulation to reduce congestion.

- *TOI-12, Parking Management and Parking Area Improvements*. Parking management is a solution whereby visitors are informed either by a person/staff or by signage that a parking lot is full, and that they need to proceed to another lot. Parking area improvements may include modifying the lot to decrease traffic conflicts and limiting the number of access points (entrances and exits) to a parking area.
- *TOI-20, Turn Prohibitions/Restrictions*. Prohibiting or restricting turning movements at intersections, parking lots, and/ or visitor centers can improve traffic flow by eliminating the slower/stopped traffic attempting to turn left which improves efficiency.
- *TOI-21, Vehicle Use Restrictions*. Prohibiting or restricting certain vehicles (or certain sized vehicles) from areas in a park/unit can help improve traffic flow (reduce congestion), enhance visitor experience, and protect resources.
- *VDM-3, Congestion Pricing/Financial Incentives*. Congestion pricing adjusts the cost of transportation facilities, such as roads and parking lots. Increasing costs during congested or peak visitation periods and decreasing costs during off-peak periods can encourage visitors to visit a park during off-peak periods (hours, days, seasons) or to use alternative modes.
- *VDM-5, Media/Social Media/Mobile Device Apps.* With smart phones rising in popularity, the use of social media (e.g., Facebook, YouTube, Twitter, Flickr, Tumblr, Instagram, blogs, and other programs) and mobile device apps have also become acceptable low cost ways to provide information to an abundance of people.
- *VDM-6, Parking Fees*. Adjusting parking fees by increasing costs at congested/high-utilization times or decreasing costs during non-congested times can encourage visitors to visit the parks during off-peak periods, adjust their visitation times, or to use alternative modes.
- *VDM-9, Promote No-Car Park Access Options*. Implementing transit or ridesharing for access to/from and within a park or unit will help improve congestion issues only if visitors know about these systems and utilize them. A marketing campaign can help with getting the word out to visitors and incentives can help to encourage transit use.
- *VDM-10, Promote Tour Bus Use*. Visitation via tour buses rather than private automobiles can assist the unit in decreasing congestion related to automobiles and can also provide an opportunity to enhance the visitor experience.
- *VDM-11, Reservation Systems*. Reservations systems are a great way to manage the demand placed on a destination within a unit that has limited capacity by allowing the number of visitors entering a location to be capped/limited to a maximum number.

Visitor Access and Transportation Guide, Volpe National Transportation Systems Center, September 2011.
http://ntl.bts.gov/lib/44000/44200/44253/Visitor_Access_and_Transportation_Guide.pdf
This guide recommends ways to reduce congestion in parking lots at federal land units. Suggestions that may be applicable to this investigation include:

- Warn visitors beforehand of parking shortages (e.g., park web page, DMS).
- Restrict parking to vehicles with a minimum number of occupants.
- Promote use of off-site parking lot and shuttle visitors to site (or provide walking routes).
- Restripe parking lot for greater efficiency.
- Develop a reservation system.

Page 23 of the PDF provides a brief case study about the use of a variable message sign to inform visitors of Muir Woods National Monument when the parking lot is full and directing them to a shuttle service. See pages 13 and 21 of this Preliminary Investigation for more information about parking congestion management practices used or planned for the Muir Woods site.

Intelligent Transportation System Solutions

The citations in this section are organized in five sections:

- Background Information.
- Examination of Alternatives.
- Highway Advisory Radio and Dynamic Message Signs.
- Reservation Systems.
- Smart Parking for Commercial Vehicles.

Background Information

Intelligent Transportation Systems in the National Parks System and Other Federal Public Lands—2011 Update, Volpe National Transportation Systems Center, September 2011. https://www.nps.gov/transportation/pdfs/ITS_In_Parks_2011_Update.pdf
This report "details the state of ITS deployment across all federal land management agencies (FLMAs) in 2011, updating a Volpe Center report completed in 2005. An assessment of the types of ITS technologies in use by public lands units, the prevalence of the deployment of specific technologies, and the technical and institutional barriers towards the advancement of ITS involvement in public lands is included. The report identified little expansion of ITS technologies in recent years, outlining steps which can be taken to improve and further advance the use of ITS in public lands."

Among the report's findings:

Operating and maintaining ITS (page 21 of the report; page 25 of the PDF):

- *Power supply.* Unsatisfactory power and network connectivity is one of the biggest obstacles facing units in operating ITS.
- *Shared technologies.* Establishing strong relationships with local, regional, and state agencies, such as state departments of transportation, local governments, regional planning organizations and public safety agencies, fosters a collaborative environment in resolving transportation-related issues.
- *Traveler information.* Units could benefit from the development of a data management system which compiles data from multiple sources, analyzes the data, and disseminates the appropriate information to multiple outlets.
- *Social media.* Social media represents an untapped opportunity for public lands units to disseminate traveler and other visitor-related information.

Approaching and carrying out ITS projects (page 23 of the report; page 27 of the PDF):

- *Knowledge, skills and abilities.* Units interested in deploying ITS technologies are often overwhelmed, both in terms of labor and expertise.
- *Contractor assistance.* Operating ITS through an outside contractor can be very beneficial for units.
- *Systems engineering.* For larger ITS projects, following a systems engineering process is essential.
- *Early intervention solutions.* Units often have a higher tolerance for transportation issues such as traffic and parking congestion and may not seek ITS solutions "early."
- *Simple ITS projects.* Small-scale ITS projects, such as the provision of DMS or installation of traffic counters, offer the most cost-effective and straightforward solutions.

Examination of Alternatives

Traffic Congestion Management Plan, Arches and Canyonlands National Parks, *Preliminary Alternatives Newsletter*, National Park Service, October 2015.
https://parkplanning.nps.gov/showFile.cfm?projectID=59437&MIMEType=application%252Fpdf&filename=Oct%202015%20Preliminary%20Alternatives%20Newsletter%20Traffic%20Congestion%20Management%2Epdf&sfid=223523
The public was invited to comment on five preliminary alternatives "to improve the visitor experience by reducing traffic congestion and related crowding problems" in Arches and Canyonlands national parks. In addition to no action (Alternative 1), the alternatives considered by the public include:

- *Alternative 2.* Timed entry to manage vehicle entrances. A third-party vendor would be used to manage online time slots that leave opportunities for drive-up access.
- *Alternative 3.* Build additional parking and infrastructure to accommodate visitation.
- *Alternative 4.*Timed entry and private shuttle service to manage vehicle entrances. Visitors have the opportunity to enter the park using their own vehicle or with a privately run shuttle service.
- *Alternative 5.* Combination of development, access and vehicle management. This is a combination of alternatives 2, 3 and 4. Triggers would be established and monitored to determine the appropriate response.

An Environmental Assessment of the alternatives expected in the spring of 2016 was not available on the National Park Service web site at the time of publication of this Preliminary Investigation.

Related Resource:

Traffic Congestion Management Plan, Arches and Canyonlands National Parks, *Public Scoping Newsletter*, National Park Service, July 2015.
https://parkplanning.nps.gov/showFile.cfm?projectID=59437&MIMEType=application%252Fpdf&filename=TrafficCongestionManagement%5FARCH%5FCANY%5FScoping%20newsletter%5F2015%5FJuly1%2Epdf&sfid=216980
This newsletter soliciting public comment on a series of alternatives to address traffic congestion provides the pros and cons of:

- Off-peak rates.
- Time-limited parking.
- Charging a fee for parking.
- Timed-entry ticket.
- Shuttle service.

Note: A 2012 National Park Service congestion management study completed in connection with Arches National Park recommended a pilot shuttle bus service. That recommendation was scrapped by the park due to cost concerns. See page 19 of this Preliminary Investigation for more information.

Assateague Island National Seashore: Alternative Transportation Systems Planning Study and Business Plan for Alternative Transportation, Volpe National Transportation Systems Center, August 2012.
http://ntl.bts.gov/lib/46000/46000/46047/DOT-VNTSC-NPS-12-11.pdf
This report considers new alternative transportation systems in and around the Maryland District of Assateague Island National Seashore. Table 44, Management Actions and Strategies Based on Future Conditions (see page 135 of the report; page 141 of the PDF), includes these strategies to deal with parking-related challenges:

- Develop policy to temporarily close the park to entering traffic when parking is full (with exceptions).
- Provide additional parking on mainland.
- Provide shuttle service from mainland to park.

Innovative Transportation Planning Partnerships to Enhance National Parks and Gateway Communities, Katherine F. Turnbull, NCHRP Project 08-36, Task 83, AASHTO Standing Committee on Planning, October 2009.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36%2883%29_FR.pdf
From the abstract:

> This report examines the innovative partnerships among national parks, gateway communities, state departments of transportation, federal transportation agencies, foundations, and other groups to address transportation issues with creative solutions. Case studies are presented highlighting new and existing transit services and other approaches in and around national parks, wilderness areas, and wildlife refuges. The information presented in this report should benefit staff and policy makers with the national parks,

transportation agencies, gateway communities, and other groups interested in developing and operating transit services and supporting programs in, and adjacent to, national parks and federal lands.

Highway Advisory Radio and Dynamic Message Signs

The two ITS technologies highlighted below are sometimes used in tandem. Federal Highway Administration defines HAR in this way:

> HAR uses a special radio station to give information to travelers. A HAR system consists of a radio transmitter to transmit the information, and signs telling motorists what radio station to tune to. The signs usually include beacons that flash when there is an important HAR message. Although primarily used for freeways, HAR may be used in limited ways on surface streets. HAR may be permanent or portable.

A DMS is sometimes referred to as a changeable message sign (CMS). The Manual on Uniform Traffic Control Devices defines a CMS as "a sign that is capable of displaying more than one message (one of which might be a "blank" display), changeable manually, by remote control, or by automatic control."

Cape Cod National Seashore Parking Management System Pilot Synthesis, William Baron, Darryl Song and Joshua Hassol, Volpe National Transportation Systems Center, December 2013.
http://ntl.bts.gov/lib/52000/52600/52601/CACO_PMS_Pilot_2013_Final_Report_rev1.pdf
This report describes the results of a pilot project launched in response to the implementation plan cited as a **Related Resource** below. This synthesis provides details on the pilot parking management system's components, location, installation, testing and monitoring. The system keeps track of the rate at which vehicles are entering and exiting the parking lot, and displays a clock showing the time the lot is expected to reach capacity.

Related Resource:

> **Cape Cod National Seashore: Intelligent Transportation Systems Implementation Plan**; Final Report, Kenneth Miller, Joshua Hassol and Ingrid Bartinique, Volpe National Transportation Systems Center, March 2011.
> http://ntl.bts.gov/lib/38000/38000/38094/DOT-VNTSC-NPS-11-07.pdf
> The major ITS applications in the implementation plan to ease congestion at the Cape Cod National Seashore's six beaches include (from page 2 of the report; page 12 of the PDF):
>
> > **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.

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.

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.

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.

Transportation Management Plan: 150th Anniversary of the Battle of Gettysburg, Johnson, Mirmiran and Thompson, June 2013.
http://www.rabbittransit.org/Portals/0/PDF/GETTYSBURG%20150th%20TMP%20%206-10-13%20PART%201.pdf
See page 35 of the report (page 53 of the PDF) for a discussion of the use of HAR and DMS in managing traffic and parking for special events commemorating the 150th anniversary of the Battle of Gettysburg.

Evaluation of an Intelligent Transportation System for Rocky Mountain National Park and Estes Park, Natalie Villwock-Witte and Kourtney Collum, Paul S. Sarbanes Transit in Parks Technical Assistance Center, 2012.
http://www.fedlandsinstitute.org/Documents/RepositoryDocuments/ROMO_Eval_ReportCOMB.pdf
From the report's executive summary:

> This document presents the results of an evaluation of a pilot intelligent transportation system for Rocky Mountain National Park (ROMO) and the Town of Estes Park …. The pilot intelligent transportation system is composed of dynamic message signs and highway advisory radio. They are used in tandem to inform visitors of the availability of shuttles services and in particular, the presence of a new park-and-ride at the east end of Estes Park. Lessons learned from the pilot intelligent transportation system can be used for future intelligent transportation system deployments.

One of the project's eight goals was to "peak spread" the arrival of people and vehicles into the park using an "Insider's Tip" on HAR. The project was deemed "partially successful" in meeting this goal. The limited success of this goal is addressed in the report's executive summary (from page 10 of the PDF):

> The stakeholders did not feel the highway advisory radio was responsible for peak spreading, or that the use of an "Insider's Tip" has the potential to impact peak spreading if used again. Many stakeholders felt that visitors have already planned their trip and are on

their way to the park by the time they would hear this message; therefore, it would be unlikely that they would change their plans at the last minute. Overall, the stakeholders felt it would be more effective to use some form of an "Insider's Tip" on the associated websites or in printed informational materials.

Related Resource:

Rocky Mountain National Park Dynamic Message Sign/Highway Advisory Radio Operations Plan, Natalie Villwock-Witte, Jaime Eidswick, Zhirui Ye and Stephen Albert, Rocky Mountain National Park and Central Federal Lands Highway Division, July 2011. http://www.westerntransportationinstitute.org/documents/reports/4W3467_ROMO_Ops_Plan.pdf
This report provides the operational details associated with the report of pilot project results cited above. Included in the appendices are an analysis of candidate locations for placement of DMS and HAR technologies and guidelines for their placement "as an interim solution to the congestion issues in the Bear Lake Corridor."

Grand Canyon National Park Dynamic Message Sign (DMS)/Highway Advisory Radio (HAR) Pilot Deployment/Evaluation, Jaime Eidswick, Zhirui Ye and Steve Albert, Grand Canyon National Park and Federal Lands Highway Division, March 2009. http://www.westerntransportationinstitute.org/documents/reports/4W2106_Final_Report.pdf
From the abstract:

> GRCA [Grand Canyon National Park] was awarded $193,000 through this program to implement Intelligent Transportation Systems (ITS), specifically, permanent Highway Advisory Radio (HAR) in four locations. GRCA personnel, however, wondered if a combination of HAR and portable Dynamic Message Signs (PDMS) would be more cost effective and beneficial for providing traveler information. In order to determine if GRCA should purchase the four permanent HAR originally planned or if they should use a combination of HAR and PDMS, a plan was adopted to implement a traveler information system pilot study consisting of a combination of HAR and PDMS during the summer of 2008 and evaluate the results. The traveler information system was deployed along Highway 64, in conjunction with the 2008 summer pilot shuttle bus program from Tusayan to the Canyon View Information Plaza, to help inform visitors of key traveler information for the duration of the pilot shuttle bus program. The pilot shuttle bus ran from June 1 to September 28, 2008. The shuttle offered visitors an opportunity for car-free travel to the park, with the hopes of reducing traffic congestion along Highway 64 through the South Entrance and within Grand Canyon Village, as well as improving access to the Canyon View Information Plaza and South Rim of the Grand Canyon, where parking is limited at key destinations. To enable the park to plan for effective implementation of ITS through its ATPPL [Alternative Transportation for Parks and Public Lands] grant, the 2008 summer traveler information system pilot study was evaluated.

In Chapter 7, Summary and Recommendations, which begins on page 20 of the report (page 29 of the PDF), the authors report that the project was a success, concluding that "[f]indings support the theory that the HAR and PDMS would work better in tandem than separately, as the combination of the devices balances the limitations of individual devices."

Reservation Systems

Muir Woods National Monument Reservation System, Environmental Assessment, National Park Service, October 2015.
http://parkplanning.nps.gov/showFile.cfm?projectID=48272&MIMEType=application%252Fpdf&filename=10%2E21%2E15%20Muir%20Woods%20Reservation%20System%20Final%20EA%20SMALL%2Epdf&sfid=224707
This proposal to manage visitation levels "would allow the park to manage demand for parking both within the monument's parking lots and on the adjacent road (Muir Woods Road which is owned and managed by the County of Marin). Access would be managed to a level that meets goals while providing visitors with a high-quality arrival experience. The proposed action would also reduce the visitor crowding and traffic congestion currently experienced during peak periods at Muir Woods."

The Preferred Alternative in the proposal is for the National Park Service to:

> … actively manage access to Muir Woods through establishment of a reservation system for all modes of motorized access to Muir Woods. The reservation system (hereinafter referred to as "reservation system" or "system") includes two separate, but coordinated systems. Reservations for personal occupancy vehicle (POV) and for the Muir Woods Shuttle would be made through directly through a reservation system operated by a third-party operator. Commercial carriers would be required to obtain a reservation for one of the parking spaces designated for commercial carrier use through another, separately-managed system.

Note: The use of shuttle buses and a public transit route to reduce the demand for vehicular parking at the Muir Woods site is addressed in a 2008 *Transportation Research Record* article. See page 21 of this Preliminary Investigation for more information.

Weir Farm National Historic Site: Alternative Transportation Feasibility Study, Volpe National Transportation Systems Center, July 2012.
http://ntl.bts.gov/lib/45000/45900/45932/DOT-VNTSC-NPS-12-10.pdf
From the abstract:

> This report provides an assessment of the feasibility of alternative transportation options to accommodate visitation at Weir Farm National Historic Site in Ridgefield, Connecticut. Weir Farm, the historic home of artist J. Alden Weir, faces numerous challenges, particularly parking constraints in a residential neighborhood. Accommodating more visitors in private cars will come at a high cost with regard to the landscape and its viewshed, in addition to the strain on narrow, local roads. This feasibility study considers alternatives to parking expansion, namely a parking reservation system and transit. Transit emerges as the transportation alternative most suitable at Weir Farm.

A description of a parking management reservation system that begins on page 43 of the report (page 51 of the PDF) addresses required infrastructure, software and signage. The authors also consider enforcement, saying:

> The park could install parking space occupancy sensors able to detect the presence of a vehicle in a particular space. In lieu of this, park staff may need to periodically check if every vehicle in the parking lot has a reservation, and issue fines if they do not. An automatic

system, with sensors, could send an alert to park staff in the event of a violation, reducing the need for random checks.

The reservation system is expected to:

- Reduce the chance that the park will have to turn visitors away on short notice.
- Reduce the need for a shuttle service (except for special events).
- Provide a relatively low-cost solution. As the authors note, "[o]nce up and running, the reservation system should have relatively low maintenance costs. If the park decides to charge a fee per reserved parking slot, the fee could help offset these costs. Further, this option reduces the need for staff to manage overflow parking, freeing up staff resources for other purposes. This option is also much less costly to maintain and operate relative to a shuttle service."

Disadvantages include a decrease in visitor satisfaction and capacity, the need for enforcement, and the cost to develop and maintain the reservation system.

Smart Parking for Commercial Vehicles

The parking-related ITS technologies applied to commercial vehicles described in the citations below may inform the use of this technology with passenger vehicles or a mix of vehicle types.

Domestic Practices

SmartPark Technology Demonstration Project, Von López-Jacobs, Jason Ellerbee and Michael Hoover, Federal Motor Carrier Safety Administration, October 2013.
http://ntl.bts.gov/lib/51000/51400/51423/13-054-SmartPark-Demonstration-Project-508slim.pdf
From the abstract:

> The purpose of FMCSA's [Federal Motor Carrier Safety Administration's] SmartPark initiative is to determine the feasibility of a technology for providing truck parking space availability in real time to truckers on the road. SmartPark consists of two phases. Phase I was a field operational test (FOT) to determine the accuracy and reliability of a technology for counting truck parking space availability. Phase II focuses on disseminating truck parking availability information and determining whether the technology can be deployed to divert trucks from a filled to an unfilled parking area. This document is the final report for Phase I. In Phase I, three combinations of different technologies were subjected to field testing to ascertain their feasibility for determining truck parking space availability in real time: side (SID) scanners, overhead (OH) scanners, and light curtains (CURs), each combined with Doppler radar.
>
> The most optimal configuration of technologies is a SID scanner combined with Doppler radar at both the ingress and egress points of the selected truck parking area. Other findings and recommendations pertain to the trade-off between accuracy and the frequency of ground-truth correction, qualitative reporting of truck parking availability to address uncertainty when the parking area is nearly full, required time for stabilizing the system, use of a vehicle classification scheme that reduces the number of vehicle classes, increased bandwidth in data transmission, and enhanced surveillance and monitoring with closed circuit television (CCTV) cameras.

Related Resource:

"TDOT, FMCSA & SmartParkingUSA," SmartParking USA, 2014.
http://www.smartparkingusa.com/2014-11-44_TNDOT_Flyer.v2.pdf
This brochure describes the collaboration among the Federal Motor Carrier Safety Administration, Tennessee Department of Transportation, Tennessee Highway Patrol and Gannett Fleming to implement the SmartParkingUSA truck parking information system on northbound I-75 in Tennessee. From the brochure:

> SmartParkingUSA gives you parking information on your smartphone, the web, a hands-free telephone system and dynamic signage on the roadway. Using the system, truckers can view availability at the parking areas in real time, view the likelihood of finding parking at a time in the future (using historical data), and even make reservations at one of the sites!

"Video-Based Parking Occupancy Detection," Michael Deruytter, Kevin Anckaert and Kristof Maddelein, *Proceedings SPIE 8663: Video Surveillance and Transportation Imaging Applications*, March 2013.
http://spie.org/Publications/Proceedings/Paper/10.1117/12.2003884
From the abstract:

> Outdoor vehicle detection is one of the most challenging tasks in the world of Intelligent Transportation Systems (ITS). Today, a substantial amount of different technologies such as video detection, microwave radar detection and electromagnetic loop detection are used worldwide to detect vehicles for ITS applications such as traffic signal control, traffic flow measurement, automatic incident detection and many more. A growth in parking management applications has resulted in technologies being adapted to respond to different environments with different needs. This paper will present a video-based approach to detect vehicles at outdoor parking areas.

Automated Low-Cost and Real-Time Truck Parking Information System, Ali Haghani, Sina Farzinfard, Masoud Hamedi, Farshad Ahdi and Mehdi Kalantari Khandani, Maryland State Highway Administration, November 2013.
http://www.roads.maryland.gov/OPR_Research/MD-13-SP209B4M_TRUCK-PARKING_Report.pdf
From the abstract:

> In this project an automated real-time parking information system was developed to improve truck-parking safety through efficient gathering and disseminating information regarding the use of existing parking capacity. The system consists of four main components: sensing, data collection, data processing and user interface (UI). A pilot deployment was conducted on an SHA's truck parking facility located on I-95 northbound prior to MD 32. During the testing period of January 6 through 14, 2013, 1,239 events were detected by the system. Each event refers to any truck arrival or departure activity in a spot. The average overall detection error was 3.75 percent and the maximum error was 5 percent. The error rate can potentially be reduced by using more sensors at each spot and using repeaters to avoid signal blockages.
>
> Unlike imagery based methods, magnetic truck detection is completely anonymous and thus privacy of drivers is not compromised. It is also independent of parking layout. In addition to providing real-time parking availability information to the truckers, analysis of historical data for each spot and for the parking facility as a whole can reveal dynamics of events and facilitate efficient operations.

Commercial Motor Vehicle Parking Trends at Rest Areas and Weigh Stations, Mehmet Emre Bayraktar, Yimin Zhu and Farrukh Arif, Florida Department of Transportation, December 2012.
http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT-BDK80-977-14-rpt.pdf
From the abstract:

> The major objectives of this research included: i) to determine trends for truck parking at public rest areas throughout Florida and ii) to develop a suitable smart parking management system for commercial motor vehicles and conduct a pilot project. The data collection efforts over the course of this research enabled the research team to determine the level of truck parking capacity problem experienced at each rest area in Florida. This information was used to divide the rest areas into three categories, low, medium, and high, based on the "level of truck parking capacity problem," and depicted the rest areas on a color-coded map for I-10, I-75, and I-95; green was used for a low parking capacity problem, yellow for a medium parking capacity problem, and red for a high parking capacity problem. This research also included an assessment of technology that can be used to improve truck parking management at rest areas in Florida and deployment of a pilot project to test implementation. The vehicle detection technology chosen for the pilot project at the Leon County rest areas (eastbound and westbound) on I-10 features wireless ground sensors, which detect the presence of a vehicle as it comes to a stop above it. Over the course of this research, various software tools were developed to complement the wireless vehicle detection system described above, including a GIS mapping application, a report generation module, and an occupancy prediction model.

Commercial Vehicle Parking in California: Exploratory Evaluation of the Problem and Solutions, Caroline J. Rodier, Susan A. Shaheen, Denise M. Allen and Brenda Dix, California PATH Program, March 2010.
https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=1481
This report evaluates alternatives to the truck parking problem in California. A brief history of the use of parking guidance information for vehicles begins on page 12 of the report (page 24 of the PDF):

> **Parking Guidance Information for Autos**
> Smart parking management systems for automobiles have been implemented throughout Europe, the United Kingdom, and Japan since the early 1970s and provide information on available parking locations. Parking guidance information (PGI) systems, and more recently transit-based smart parking systems, provide real-time information to motorists regarding available parking spaces and locations. Lessons learned by evaluating and modeling these systems suggest that awareness and understanding can be relatively high, but that people who are less familiar with the area (i.e., visitors rather than commuters) tend to be the most frequent users (Thompson and Bonsall, 1997). Truckers, however, may be more like visitors and use en-route parking information more frequently because they often cannot or do not plan their parking in advance and/or lack parking information knowledge due to high driver turnover. PGI systems also tend to reduce parking facility queue lengths and provide modest system-wide reductions in travel time and vehicle travel (Thompson and Bonsall, 1997). Recommendations to improve these systems include: (1) targeting messages to the information needs, decision points, and knowledge levels of market segments early on in the system development process; (2) making messages conspicuous and providing some reinforcement; and (3) providing messages that are consistently credible (Thompson and Bonsall, 1997).

International Practices

"Truck Rest Area Vacancy Information System (TRAVIS)," S. Benjamin and S. Polley, *2015 AITPM Traffic and Transport Conference*, July 2015.
Citation at http://trid.trb.org/view/2015/C/1371415
From the abstract:

> The VicRoads Truck Rest Area Vacancy Information System (TRAVIS) is an information system designed to provide truck drivers, travelling South towards Melbourne, information about truck parking bay availability at key rest areas. The project has been funded jointly under the Federal and State Freight Access and Reliability improvement programs, with works likely to begin in August 2015. This paper will outline the significant literature review done to date providing a review of overseas systems as well as the feasibility study, technology review and system design undertaken. TRAVIS will allow six recently improved and expanded rest areas on the Hume Freeway between Wodonga and Benalla to work as a network by sharing the load across all of the available rest area bays. Communication of parking availability to heavy vehicle drivers will allow more efficient use of the rest areas. It will also allow drivers to plan ahead by providing information on the next option should their target rest area be full. TRAVIS will help reduce the likelihood of overloading rest areas, which leads to trucks parking on ramps and potentially the freeway shoulder which can create a significant safety hazard.

Active Parking Management

Some of the publications cited in other sections of this Preliminary Investigation briefly address the use of active parking management strategies such as maximum parking limits, dynamically priced parking, dynamic parking capacity and enforcement. The citations below focus a bit more on these strategies.

Dynamic parking reservations, often considered part of the active parking management suite of practices, are addressed in the **Intelligent Transportation System Solutions** section of this Preliminary Investigation (see page 7).

Glacier National Park Going-to-the-Sun Road Corridor Management Plan: Existing Conditions of the Transportation System, Frances Fisher, Heather Richardson, Ryan Yowell, Nathan Grace and Clark Merrifield, Volpe National Transportation Systems Center, June 2014.
http://ntl.bts.gov/lib/52000/52800/52811/DOT-VNTSC-NPS-14-07.pdf
This report, developed in connection with a corridor management plan for Glacier National Park's Going-to-the-Sun Road, identifies these possible management strategies to consider in limiting the impact of the corridor's finite parking capacity:

- Communicate lot status real time to public.
- Metered entry/reservations.
- Maximum stay limits.
- Variable parking prices.

Mill Creek Canyon Transportation Feasibility Study, Uinta-Wasatch-Cache National Forest and Salt Lake County Public Works, August 2012.
http://wfrc.org/Previous_Studies/Mill_Creek_Canyon_Transportation_Feasibility_Sudy_%20Aug12.pdf
This study sought to address including overcrowding of key parking areas in Mill Creek Canyon in both summer and winter peak seasons. The project team explored concepts in three categories:

- Parking management concepts.
- Transit concepts.
- Bicycle and pedestrian concepts.

The parking management concepts evaluated for this project fall into two categories: systems that provide information about parking to users, and systems that change how parking is priced and managed. These concepts include DMS, staff-based systems, web-based systems, toll increases, paid parking, automobile restrictions and reservation systems. Recommendations are presented as short- and long-term projects, and cost estimates are provided.

Parking Management Plan: Potential Parking Management Strategies, Town of Nantucket, September 2010.
http://www.nantucket-ma.gov/DocumentCenter/View/5528
This plan provides a parking management package for Nantucket, an island located 30 miles off the south coast of Cape Cod. Appendix A, Best Practice Details, which begins on page 61 of the PDF, provides best practices for improved enforcement, demand management, and zoning and incentive alternatives that include establishing maximum limits on parking.

ORV Voucher System and Exhaust System Rules and Testing, Silver Lake State Park, Michigan Department of Natural Resources, undated.
http://www.dnr.state.mi.us/publications/pdfs/RecreationCamping/Silver%20Lake%20ORV%20Updates/ORV_voucher_exhaustrules.pdf
This document describes a parking lot management system that issues vouchers to off-road vehicle users to address parking congestion in Silver Lake State Park and the surrounding community.

Shuttle Bus Services

The shuttle bus services described in the citations that follow are not necessarily used as a peak-time alternative to permitting passenger vehicle parking. However, the development and use of these services, and the public response, may inform the application of bus-only access to the Bowers SRRA.

"Zion National Park, Utah: Enhancing Visitor Experience Through Improved Transportation," Jonathan Upchurch, *Transportation Research Record 2499*, pages 40-44, 2015.
Citation at http://dx.doi.org/10.3141/2499-06
From the abstract:

> In 2000, Zion National Park in Utah introduced the Zion Canyon shuttle to transport visitors into Zion Canyon while alleviating traffic congestion and improving visitor experience. Now in its 16th season of operation, the shuttle is successfully accomplishing those goals and receives kudos from park visitors. The continued and increasing popularity of Zion National Park, with 3.2 million visitors in 2014, has created new transportation challenges at the gateway to the park. At the gateway area, visitors arrive at the park, usually in private automobile, and change modes to ride the shuttle into Zion Canyon. The challenges include waiting times of 10 to 22 min at the park's primary entrance station on many summer days, parking lots at the park visitor center that are routinely filled to capacity between 11:30 a.m. and 2:30 p.m. on most summer days (forcing visitors to park on the streets of Springdale, Utah, the park's gateway community), insufficient parking for recreational vehicles, visitor crowding, and a variety of related issues. This paper offers analyses of the primary transportation issues and describes alternatives for improving transportation and visitor experience. The needed entrance station capacity to avoid queuing and waiting times is presented, along with alternatives for providing that level of capacity. An evaluation of parking demand and parking alternatives being considered by the park is described. An analysis of shuttle bus capacity shows an ability to absorb additional hourly demand created by entrance station improvements.

Arches Alternative Transportation System and Congestion Management Study, Final Feasibility Study, Volume 1, National Park Service, September 2012.
http://parkplanning.nps.gov/showFile.cfm?projectID=34626&MIMEType=application%252Fpdf&filename=Vol%5F1%5FFeasibility%5FStudy%5FSubmitted%5F092612%2Epdf&sfid=143412
From page 2 of the report (page 6 of the PDF):

> This *Final Feasibility Study* provides a detailed description of the final preferred Arches pilot shuttle system with accompanying congestion management strategies (section 1) as well as two non-shuttle alternatives (section 2) that would rely entirely on other congestion management strategies to achieve the park's goals. The report compares the benefits and costs of the shuttle system against those of the congestion-management-only scenario (section 3) and describes the impacts (section 4).

In addition to presenting detailed information about the shuttle alternative, the report also provides information about other alternatives: a reservation system and a congestion management strategy.

Related Resources:

"Arches National Park: Alternative Transportation System and Congestion Management Study," *Rural Public & Intercity Bus Transportation Conference*, October 2012.
http://www.kutc.ku.edu/powerpoints/TRB20/ST%204%20Sullivan%20Arches_RIBTC.pdf
This conference presentation highlights the characteristics of a successful park shuttle bus system and describes two nonshuttle scenarios: transportation demand management and a reservation system.

"Arches Shuttle Bus Program Too Costly to Implement," Steve Kadel, *The Times-Independent* (Moab, Utah), April 18, 2013.
http://moabtimes.com/bookmark/22291537-Arches-shuttle-bus-program-too-costly-to-implement
This newspaper article indicates that the preferred shuttle bus alternative was scrapped due to cost. From the article:

> Arches National Park officials have rejected a possible shuttle bus system for alleviating traffic congestion due to its high cost.
>
> "It is unfeasible financially and even if we could afford it, it wouldn't do enough to solve the problem with the number of buses we could afford," said Kate Cannon, superintendent for the National Park Service's Southeast Utah Group. "We are looking at variations. The problem still exists and we need to solve it."
> ….
> "We are looking at revisions to parking areas that will make the most out of available space," she said. "We are currently working on an environmental assessment that will address road improvements throughout the park as well as parking design and hope to implement parking improvements in the Devils Garden area by next summer."
>
> She added the park service hasn't given up on the shuttle bus idea at Arches, but a scaled down version in conjunction with other congestion management strategies is under consideration.

Note: In 2015, the National Park Service solicited public comment on a traffic congestion plan for Arches and Canyonlands national parks. See page 8 of this Preliminary Investigation for more information.

"Reducing Congestion at Grand Canyon's South Rim," William Byrne and Jonathan Upchurch, *ITE Journal*, Vol. 81, No. 1, pages 50-55, January 2011.
Citation at https://trid.trb.org/view.aspx?id=1099062
From the abstract:

> More than 1.3 million vehicles travel into the South Rim of the Grand Canyon each year, including over 156,000 in July alone. This huge influx of visitors makes visitor access and personal mobility an ongoing challenge for the National Park Service, especially in terms of parking and congestion at the entrance station. In response to these challenges, a report was completed in 2008 to assess transportation, environmental impacts and visitor experience. Extensive data on traffic, parking, entrance station volumes and shuttle bus

ridership was collected over a two-year period. The plan recommended that service lanes and a bypass lane at the entrance be added, more parking spaces be constructed near the visitor center and the most popular overlook, realignment of the main park access road, implementation of a pilot shuttle bus service from a nearby community, and modifications to the existing shuttle bus service within the South Rim. Implementation of these recommendations began almost immediately after the plan was adopted. The changes that have been implemented thus far have been successful in reducing congestion and improving visitor experience.

"Modeling the Effects of Shuttle Service on Transportation System Performance and Quality of Visitor Experience in Rocky Mountain National Park," Steve Lawson, Robert Chamberlin, Janet Choi, Ben Swanson, Brett Kiser, Peter Newman, Chris Monz, David Pettebone and Larry Gamble, *Transportation Research Record 2244*, pages 97-106, 2011.
https://www.rsginc.com/sites/default/files/publications/101.Modeling%20the%20Effects%20of%20Shuttle%20Service%20on%20Transportation%20System%20Performance%20and%20Visitor%20Experience%20Quality%20in%20Rocky%20Mountain%20National%20Park.pdf
From the abstract:

> Rocky Mountain National Park (RMNP) was one of the first national parks to adopt an alternative transportation system: a shuttle bus system initiated in 1978. To address parking lot shortages while accommodating growing numbers of park visitors, RMNP expanded its shuttle bus service in 2001. Although the expanded shuttle service has helped to alleviate parking congestion at popular trailheads, expansion may also be enabling levels of visitation that cause or exacerbate visitor crowding. Thus, there is a need to evaluate and potentially refine RMNP's shuttle service according to the amount of visitor use that can be accommodated at popular destinations in the park without unacceptable effects on the quality of visitors' experiences. This study evaluated and quantified transportation system performance and visitor crowding at popular recreation sites in the Bear Lake Road corridor resulting from RMNP's shuttle service operations. The study used integrated transportation and visitor use modeling to provide quantitative estimates of the extent of parking congestion, transportation-related greenhouse gas emissions, transit operating costs per passenger, and visitor crowding associated with existing and alternative transit service operations scenarios. The National Park Service will use information from the study to refine the operation of shuttle service in RMNP in a manner that both optimizes transportation system performance and protects the quality of visitors' experiences. Further, the study framework can be generalized to other public lands units to design and operate transit service in accordance with transportation, resource, and visitor experience objectives.

"Shifting Modes of Travel to National Parks: Pilot Study at Muir Woods National Monument, California (With Discussion and Closure)," Bonnie Nelson, Valerie Taylor and Jumana Nabti, *Transportation Research Record 2077*, pages 166-174, 2008.
https://trid.trb.org/view/2008/C/848189
From the abstract:

> The Muir Woods Shuttle is a three-summer (2005–2007) pilot public transit route designed to transport visitors to Muir Woods National Monument in Marin County, California. The shuttle was developed by the County of Marin and the National Park Service and is funded through an FHWA earmark. More than 700,000 people visit Muir Woods every year, primarily in private automobiles; automobile congestion significantly affects park resources and visitor experience. Goals for the shuttle include reducing vehicular parking impact and demand at the park, reducing vehicular traffic in the park, and reducing congestion on nearby roads. Nelson\Nygaard has conducted evaluations of shuttle performance for all

three pilot years to make service enhancement, marketing, and funding recommendations for future service. Evaluation is based on extensive original data collection including ride checks, onboard passenger surveys, and nonpassenger visitor surveys for four weekends per summer. Improvements added in 2007 such as increased frequency and an expanded service area were a direct result of the 2005–2006 studies. Results from evaluations of 2005–2006 service indicate strong demand for public transit to Muir Woods. Almost 14,600 trips (one-way) were made on the shuttle between Memorial Day and Labor Day 2006, representing a 140% increase in ridership over 2005, despite the round-trip charge of $2 added in 2006. In 2006, unlike 2005, ridership was high from the beginning of the season. Evaluation continued through the summer of 2007 with additional focus on identifying sources of funding to continue this very successful service.