SERVICE TIMES AND CAPACITY
AT NATIONAL PARK ENTRANCE STATIONS

Prepared for the National Park Service

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February, 2006

Second Edition: This document will continue to be updated and revised as additional data become available.

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This document is a revision of the First Edition, which was published in June, 2005.

Additional data and comments are welcome from all sources. Please contact the author if you have information to contribute to future editions.

ABSTRACT

As many recreational tourists know, long queues of vehicles at Park entrance stations during peak season is a problem for many National Parks and Monuments. In some instances, on holiday weekends, the lines are known to extend one mile or more. The delays to Park visitors are substantial.

In the field of traffic engineering, "capacity" is defined as the maximum number of vehicles that can pass a given point on a roadway in a given period of time under the prevailing conditions. Prior to the data collection efforts described in this report, the "capacity" of a Park entrance station had never been determined through a traffic engineering study.

The transaction at a Park entrance station has multiple components. The visitor pays a fee or shows a previously purchased pass, the Park staff hands printed information to the visitor, and the visitor may have many questions to ask about the Park, services, tour availability, campgrounds, etc.

The average time per vehicle at a Park entrance station will vary from Park to Park depending upon: 1) the proportion of visitors who hold a previously purchased pass (short transaction time); 2) the amount of printed information and safety advisories given to the visitor; 3) the proximity of a visitor center at which the visitor could ask questions, and 4) other factors discussed in this report.

This report presents information on the capacity of entrance stations as determined from data collected at Arches National Park in Utah, supplemented by data collected at Grand Canyon National Park, Arizona.

At Arches National Park the capacity of an entrance station lane is 112 vehicles per hour. This value can be used as a general guide by other Parks. However, capacity at other Parks will be affected by the service times at those Parks and the mix of types of transactions that occur at those Parks. This report describes how a Park can calculate capacity for its particular conditions.

The capacity of an entrance station lane is important and useful information to the National Park Service. Capacity information is useful in analyzing: the number of needed lanes at an entrance station; the benefits of a lane dedicated to automated entry; and other possible solutions to the queueing problem. It can also be useful in managing existing entrance stations by making informed decisions on number of staff to deploy and number of lanes to be open.

Three case studies are described in which service times and capacity information was applied to solve entrance station problems at National Park Service units.

In addition, this report presents strategies to reduce waiting times at Park entrance stations.

A number of National Parks have implemented automated lanes at entrance stations. This report also provides a brief overview of the operation of automated lanes, the technology that is used, the classes of vehicles that are eligible to use automated lanes, and measures that can facilitate the implementation of automated lanes.

INTRODUCTION

The operation of entrance stations at National Parks, National Monuments, and other units of the National Park System is of intense interest to the National Park Service. At many Parks the entrance station is the first point of contact with the visitor. Entrance stations are important in providing information to the visitor, warning the visitor of potential hazards within the Park, responding to visitor questions about the Park, services, tour availability, campgrounds, etc.; and collection of fees (by paying a fee or showing a previously purchased pass). The visitor's experience at an entrance station can leave a lasting impression – positive or negative.

At many Parks the visitation level is very seasonal, with peaking at predictable times of year. High levels of visitation often lead to lengthy queues of vehicles awaiting entry to a Park and long waiting times. Among the more extreme examples is Sunday, May 26, 2002, Memorial Day weekend, at the South (Tusayan) Entrance to Grand Canyon National Park. Even with four lanes in operation at the entrance station, the line of vehicles stretched for 1.7 miles to the

Four lanes open at Grand Canyon South Rim Entrance Station

Queue at Grand Canyon South Rim

Queue 1 mile from Entrance Station

End of Queue at village of Tusayan, 1.7 miles from Entrance Station

community of Tusayan (see photos). Grand Canyon National Park staff report that May 26, 2002 was not an unusual day. There were no special events, just a large demand to visit the Park. This entrance station frequently has long queues during spring break, summer holiday periods, and other days during the summer. A one mile long queue at Grand Canyon National Park results in a 40 minute waiting time.

As another example of long wait times, the San Francisco Chronicle reported waiting times of one and one-half hours at the State Route 140 entrance to Yosemite National Park on the weekend of May 21-22, 2005.

Long queues not only result in unreasonable wait times but can also create unsafe conditions. Until 2004, Arches National Park had a single lane at its entrance station. Vehicle queues on days of high visitation would back up on the short Park entrance road and spill over onto U.S. Route 191, creating vehicle conflicts and unsafe conditions. This was of great concern to the Utah Highway Patrol and it is said that one or more crashes occurred related to the queue of vehicles on the highway. White Sands National Monument has vehicle queues that spill over onto U.S. Route 70 on days of peak visitation. This creates an unsafe condition on a four-lane divided, high speed highway.

WHY SERVICE TIME AND CAPACITY INFORMATION IS USEFUL TO NPS

Information on service times and capacity of Park entrance stations can be very useful to the National Park Service for the following reasons.

1. For existing entrance stations with multiple lanes, the information is useful in managing the staffing of the entrance station. Decisions can be made on the number of staff to deploy (number of open lanes) from day to day and by time of day.

2. For new entrance stations, the information will be important in determining the number of lanes needed to efficiently process visitors.

3. For existing – and perhaps outdated - entrance stations, the information can be useful in designing replacement facilities. Again, the information can help to determine the

number of lanes needed. The West Entrance to Yellowstone is a recent example of an entrance station under redesign.

4. A few Parks have implemented automated lanes for entry of selected vehicles or classes of users. Service times and capacity for manual lanes will be useful in evaluating automated lanes and comparing the efficiency of manual and automated lanes.

5. In December, 2004 Congress has designated a new America the Beautiful Pass that will replace the existing National Parks Pass, Golden Eagle, Golden Age Passport, and Golden Access Passport. As decisions are made on implementation of the America the Beautiful Pass, its potential use for entry in automated lanes can be more fully evaluated in the context of the capacity of manual lanes.

Although many units of the National Park System do not have an entrance station, there are probably about 107 units that do have an entrance station. For the most part, these are the units with the highest annual visitation.

OBJECTIVES

The objectives of this study were:

1. To determine the service times and capacity of National Park entrance stations so that the information can be applied to the issues listed above.

2. To develop recommendations for application of service time and capacity information.

3. To recommend strategies to reduce waiting time.

4. To document use of automated lanes at entrance stations.

TERMINOLOGY

In this "service time" is defined as the length of time required for the Visitor Use Assistant (the National Park Service staff member at the entrance station) to process a customer at an entrance station. Service time begins when the vehicle comes to a stop at the entrance booth (arrival time). Service time ends when the vehicle begins to pull away from the entrance booth (departure time). Service time is measured in minutes and seconds.

"Move-up time" occurs between the departure time of one vehicle and the arrival time of the following vehicle when there is a continuous supply of vehicles waiting to be served.

"Interval between arrivals", as used in this report, is the sum of service time and move-up time.

In the field of traffic engineering, "capacity" is defined as the maximum number of vehicles that can pass a given point on a roadway during a specified period under prevailing roadway, traffic and control conditions.

In this report, "capacity" for an entrance station is defined as the maximum number of vehicles per hour that can be processed in a lane (or lanes) at an entrance station. Capacity is expressed in vehicles per hour, but the rate can also apply to a shorter period of time. If capacity is 120 vehicles per hour, this means that 20 vehicles per ten minute period can be processed. Prior to the data collection efforts described in this report, the "capacity" of a Park entrance station had never been determined through a traffic engineering study.

WHEN DO HIGH VOLUME DAYS OCCUR ?

As noted above, visitation at many Parks is very seasonal. Inadequate capacity, long queues, and long waiting times become an issue on the higher volume days of the year. These days will vary from Park to Park. High volume days may follow a seasonal and / or weekly pattern.

Figure 1 presents information on the number of vehicles entering Arches National Park on each day in 2003. The highest number of vehicles (1394) entered Arches a Saturday in May. The prominent spikes at seven day intervals from March through October represent higher volume days on weekends.

Figure 2 presents similar information for Mesa Verde National Park. At Mesa Verde, the highest number of vehicles entered the Park on Memorial Day weekend. The weekend phenomenon does not occur at Mesa Verde. In fact, the highest volume days during mid-summer are on Wednesdays.

Figure 3 presents similar information for the South Entrance of Grand Canyon National Park. At that location, the highest number of vehicles (4775) entered the Park on the Fourth of July weekend. The weekend phenomenon is very minor at the Grand Canyon.

The data on number of vehicles entering the Parks in Figures 1, 2 and 3 represent the number of vehicles processed at the Park entrance station. The data was obtained from the Parks' fee collection software.

FACTORS AFFECTING SERVICE TIMES AND CAPACITY

Service times and, in turn, capacity are influenced by many different factors. The factors include the following.

1. The type of entry into the Park. A visitor who presents a previously purchased pass can be processed quickly. In contrast, a visitor who wants to purchase a National Parks Pass or an entry permit with a credit card requires much greater time. A more complete list of different types of entry into a Park is presented later in this report.

2. The mix of transactions. The proportion of visitors who hold a previously purchased pass versus those who do not will significantly affect average capacity. If all visitors hold a

FIGURE 1 - NUMBER OF VEHICLES ENTERING ARCHES NATIONAL PARK BY DAY - 2003

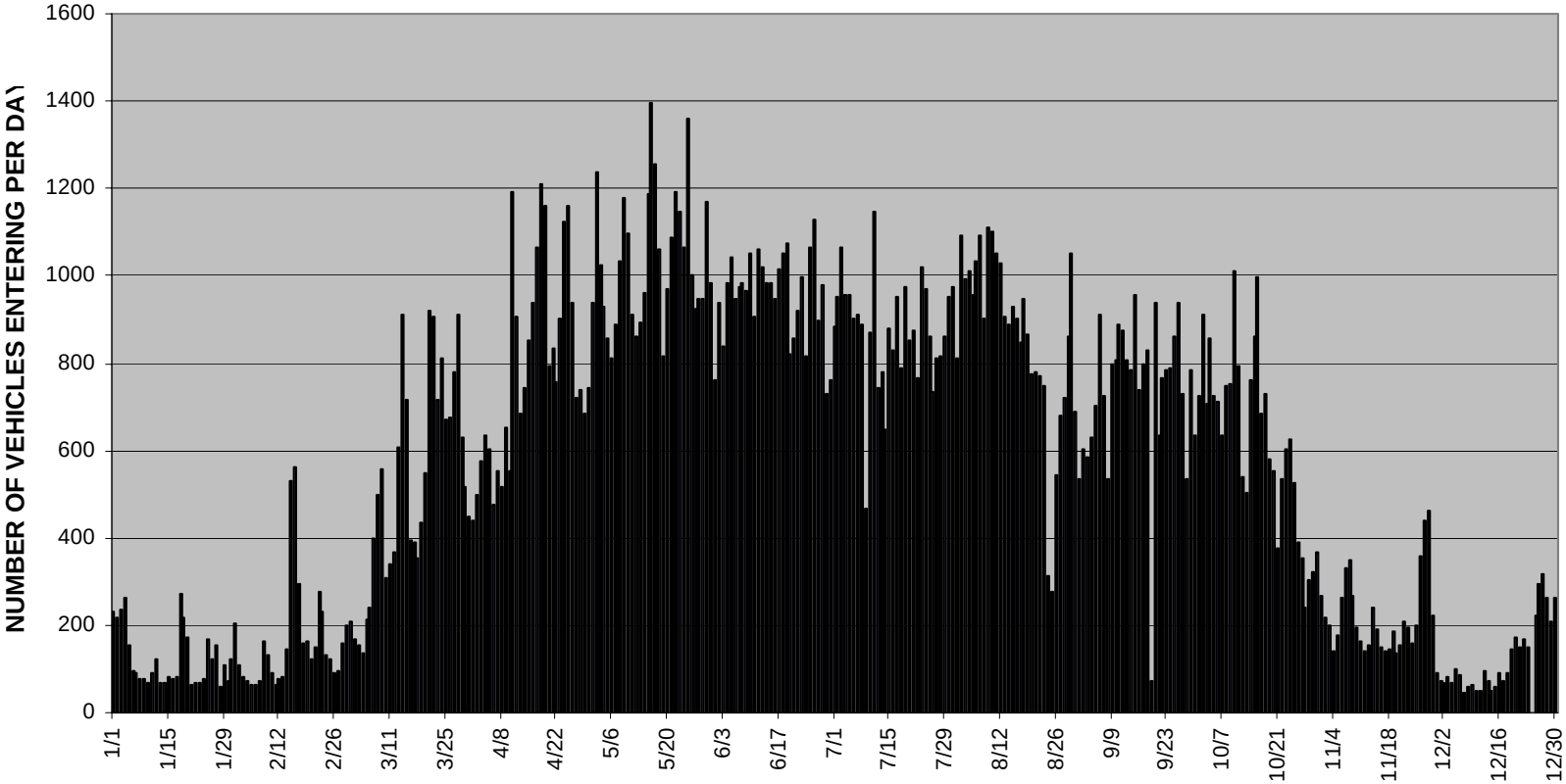


FIGURE 2 - NUMBER OF VEHICLES ENTERING MESA VERDE NATIONAL PARK BY DAY - 2004

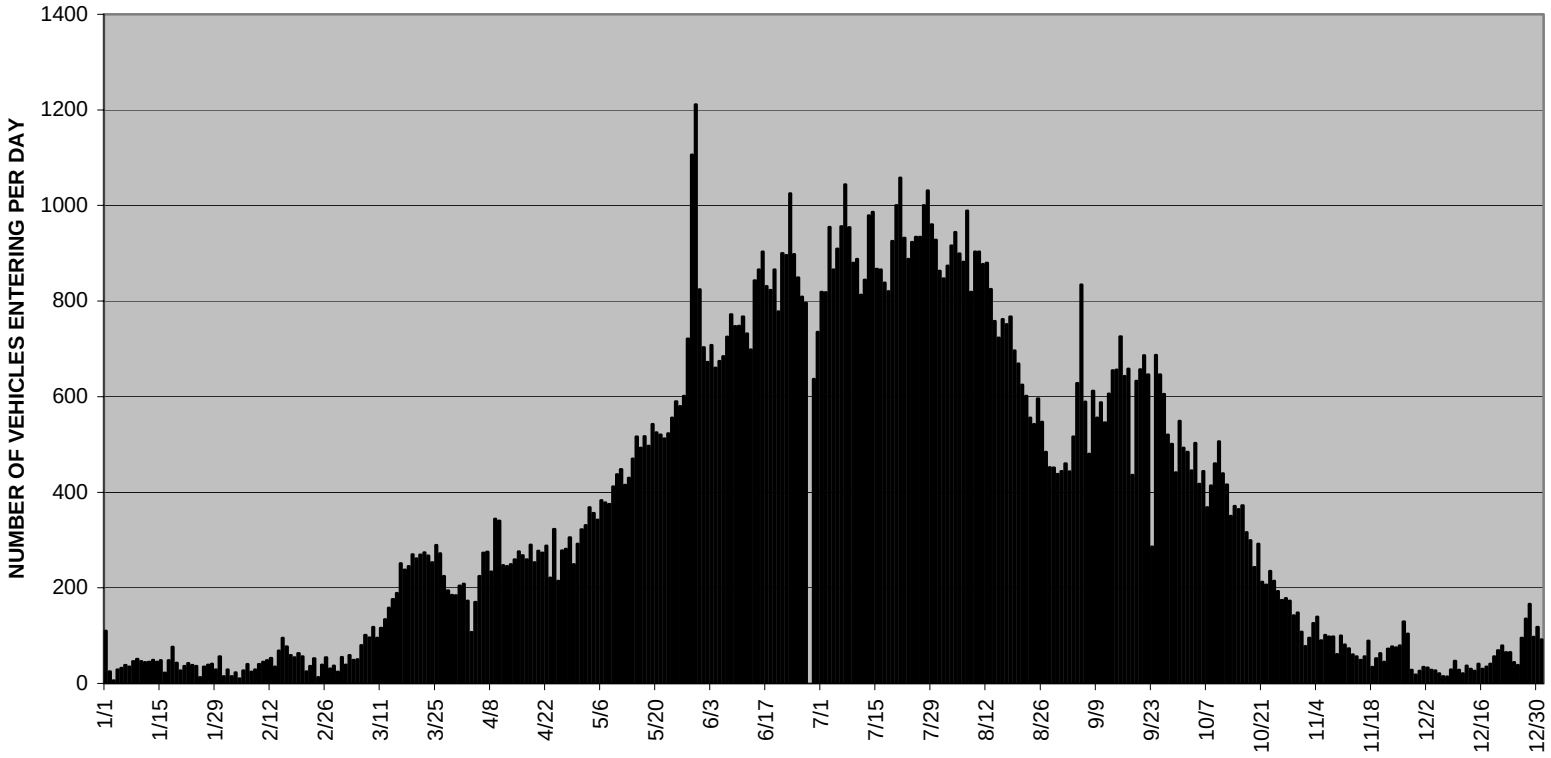
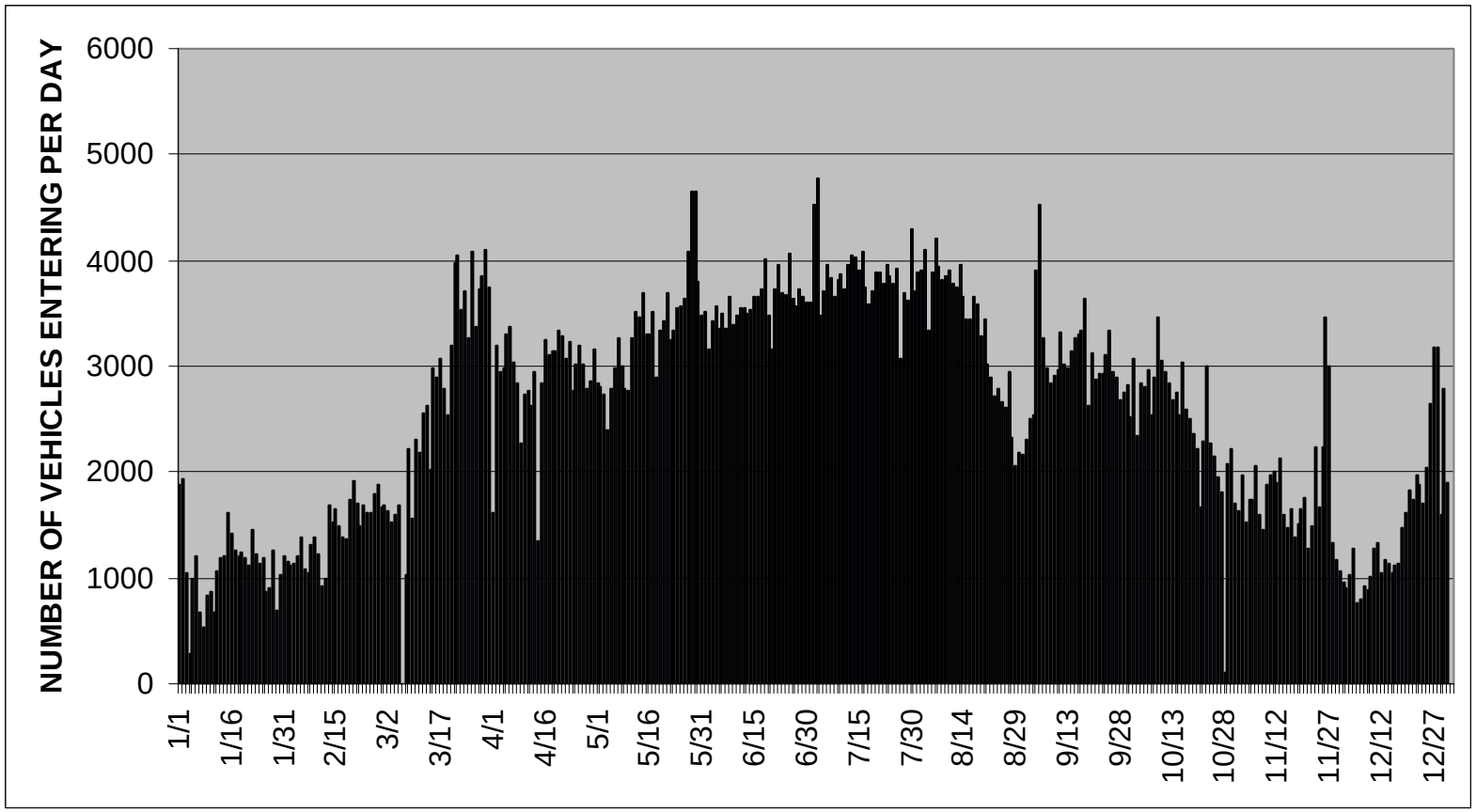


FIGURE 3 – NUMBER OF VEHICLES ENTERING GRAND CANYON SOUTH ENTRANCE BY DAY



previously purchased pass, a large number of vehicles per hour can be processed (high capacity). If all visitors must purchase an entry permit, a much smaller number of vehicles per hour can be processed (low capacity). For example, Zion National Park (one of the first Parks on the itinerary of many visitors touring the Grand Circle) sells a high number of National Parks Passes.

3. How well informed is the visitor about the various payment options for entering the Park? There are many options, and some options apply only to certain groups of individuals, such as the Golden Age Passport. The information displayed on signs approaching the entrance station may not display all of the choices. The visitor may need to ask questions about their choices.

4. Whether or not staff are deployed to "work the line" of vehicles to provide information and answer questions before the customer arrives at the booth.

5. The type of fee collection software and equipment and its reliability.

6. The amount of printed information and safety advisories given to the visitor. Some Parks must warn visitors of safe behavior around wildlife or roadway conditions. Parks with scheduled activities, such as the ticketed tours to Mesa Verde Cliff Dwellings, must provide information. As another example, Petrified Forest National Park asks each inbound visitor, "Do you have any rocks or petrified wood in your vehicle?" Glacier National Park measures the length of vehicles to ensure that they do not exceed the length limit for Going to the Sun Road.

7. The number of questions asked by the visitor. The variety of questions is broad, including questions about camping, activities in the Park, concession services, etc.

8. Whether or not a Visitor Center exists outside of the Park entrance (such as at Acadia National Park, Grand Teton National Park at Moose, and White Sands National Monument) and whether the visitor has stopped there. Visitors who have stopped at a Visitor Center are less likely to have questions to ask at the entrance station.

9. The proximity of a Visitor Center to the Park Entrance. If vehicle queues are long and a Visitor Center is nearby (just inside the Park entrance) the Visitor Use Assistant can encourage a visitor to stop at the Visitor Center to ask their questions, thus reducing the service time.

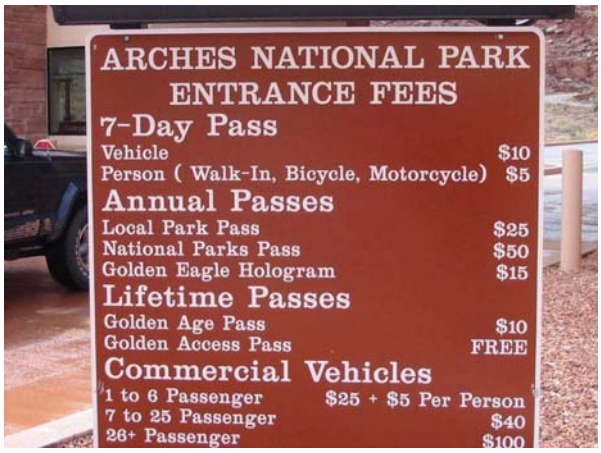
10. The length of the queue. A long queue may result in more rapid processing by the Visitor Use Assistant while the lack of any queue may result in more leisurely processing, extended conversation, and inviting the visitor to ask more questions than if the queue is long.

11. Service time will vary among Visitor Use Assistants, depending upon their length of experience as a VUA and their "style" of serving the visitor.

12. Whether or not it is the practice of the Park to check for photo identification for holders of National Parks Passes, Golden Age Passports, and Golden Access Passports.

SERVICE TIMES – ARCHES NATIONAL PARK

Data on service times were collected at the Arches National Park entrance station (see photo) on Friday, March 25 and Saturday, March 26, 2005. Data were collected from a single lane for a total of six hours over the course of the two days. The times of arrival and departure (hours:minutes:seconds) were recorded on a laptop computer in a spreadsheet. A macro feature was installed in the spreadsheet so that the arrival, and the departure, could each be entered with a single keystroke and the macro automatically inserted the current time. The type of transaction was also recorded on the spreadsheet. The type of transaction was later confirmed with a time-stamped record produced by the fee collection system. Almost 400 usable transactions were recorded. The transactions were sorted by transaction type and the average service time for each type was computed.



At Arches, like most Parks, there are many different payment choices for entering the Park. In fact, only some of the choices are posted on the sign approaching the entrance station (see photo). A description of the choices at Arches is shown in Table 1. As indicated in Table 1, the most common payment choices during the six hours of data collection were purchase of a 7-day auto permit with cash (152 such transactions during the data collection period), and presentation of a previously purchased National Parks Pass (101 transactions).

Average service times for each type of transaction are also presented in Table 1. It is emphasized that service time varies from vehicle to vehicle; the values shown in Table 1 are simply average values. Some observations about average service times include the following.

1. There is a great difference in service time for payment by cash compared to payment by credit card. If a 7-day auto permit is being purchased, the service time is over three times as long for a credit card purchase (1 minute, 44 seconds) as for a cash purchase (30 seconds).

TABLE 1 - TYPES OF TRANSACTIONS AND AVERAGE SERVICE TIMES

PRODUCT CODE (A code used by the fee collection system)	**DESCRIPTION OF TYPE OF TRANSACTION** (As used by fee collection system)	**EXPLANATION OF TYPE OF TRANSACTION**	**ENTRANCE FEE** (per vehicle unless otherwise noted)	**AVERAGE SERVICE TIME** (MM:SS) *Standard Deviation shown in [brackets]	**SAMPLE SIZE FOR AVERAGE SERVICE TIME**	**MOVE-UP TIME** (MM:SS)	**INTERVAL BETWEEN ARRIVALS** (MM:SS)
1100	Individual Permit	Entry fee for a pedestrian or bicyclist	$5 / person	0:32	1	0:07	0:39
1200	Auto Permit	Entry fee for a vehicle. Provides 7-day admission to Park. Payment in cash	$10	0:30 [0:19]	152	0:07	0:37
1201	C-Auto Permit	Entry fee for a vehicle. Provides 7-day admission to Park. Payment by credit card.	$10	1:44	10	0:07	1:51
2300	Hologram	Purchase of Golden Eagle hologram for placement on National Parks Pass	$15		ND		
2410	Return Receipt				ND		
2411	C-Return Receipt				ND		
4000	Comm 1-6	Entry fee for commercial vehicle with 1 to 6 passengers.			ND		
4200	Comm 7-25	Entry fee for commercial vehicle with 7 to 25 passengers	$40		ND		
4201	C-Comm 7-25	Entry fee for commercial vehicle with 7 to 25 passengers. Payment by credit card.	$40		ND		
4300	Comm 26 +	Entry fee for commercial vehicle (bus) with 26 or more seats	$100		ND		
1210	SEUG Ann.	An annual pass for the calendar year that provides admission to four Parks in the Southeast Utah Group - Arches, Canyonlands, Natural Bridges, and Hovenweep. Payment in cash.	$25	1:29	1	0:07	1:36
1211	C-SEUG Ann.	SEUG Annual Pass. Payment by credit card	$25	2:11	1	0:07	2:18
2200	Golden Age	Golden Age Passport. Provides the holder lifetime entry to all NPS units for a one-time fee of $10. Holder must be age 62 or older.	$10	1:49	2	0:07	1:56
2205	Issue New GA	The Park Service will provide a new, plastic, Golden Age Passport in exchange for an old carboard Passport	$0	1:19	3	0:07	1:26
2206	Return Old GA	Old cardboard Golden Age Passport exchanged for new plastic Passport	$0			0:07	
2400	NPS Pass	National Parks Pass. Provides the holder and accompanying passengers entry to all NPS units for a 12-month period. Payment in cash.	$50	0:59	8	0:07	1:06
2401	C-NPS Pass	National Parks Pass. Payment by credit card.	$50	1:47	10	0:07	1:54
9100	Entrance Auto	Re-entry of a vehicle that previously purchased an Auto Permit within the past 7 days.	$0	0:06 [0:05]	43	0:07	0:13
9110	Entrance Indv.	Re-entry of an individual that previously purchased an Individual Permit	$0		ND		
9140	Fee Waiver	Vehicle that has received a fee waiver, prior to their visit, from the NPS for the purpose of their visit.	$0	0:29	3	0:07	0:36
9200	Entrance G-Age	Entry of a holder of a Golden Age Passport	$0	0:18	31	0:07	0:25
9210	Entrance G-Access	Entry of a holder of a Golden Access Passport	$0	0:15	10	0:07	0:22
9220	Entrance SEUG	Entry of a holder of a Southeast Utah Group Annual Pass	$0		ND		
9230	Entrance GE	Entry of a holder of a Golden Eagle	$0		ND		
9240	Entrance NPP	Entry of a holder of a National Parks Pass	$0	0:16 [0:11]	101	0:07	0:23
9260	Non-Recreation	Entry of Park employee, vendor, construction personnel, or other individuals to whom an entry fee does not apply	$0	0:07	5	0:07	0:14
OTHER TYPES OF TRANSACTIONS (not coded in fee collection system)							
	Aborted Entry	Individuals who decided not to enter the Park		0:45	3	0:07	0:52
TOTAL					384		
ND = No Data for this type of transaction							
* Standard Deviation is shown in brackets for large sample sizes							
Data collected at Arches National Park, March 25 and 26, 2005							

2. Similarly, purchase of a National Parks Pass by credit card (1 minute, 47 seconds) takes almost twice as long as payment by cash (59 seconds).

3. Purchase of some type of pass (Southeast Utah Group Annual Pass, Golden Age Passport, or National Parks Pass), even when paid by cash, takes considerably longer than a 7-day auto permit. Each of these types of passes must be signed at point of purchase.

4. Re-entry by vehicles that previously purchased an Auto Permit within the past 7 days is exceptionally fast – only 6 seconds.

5. Entry by presentation of a previously purchased pass results in a short service time (National Parks Pass – 16 seconds, Golden Age Passport – 18 seconds, Golden Access Passport – 15 seconds). The service time is longer than Auto Permit re-entries because the identity of the passholder is often checked. In addition, each National Parks Pass is swiped in a cardreader to gather use statistics.

CALCULATION OF CAPACITY – ARCHES NATIONAL PARK

To determine capacity of an entrance station lane, the "move-up time" between vehicles must also be considered. "Move-up time" occurs between the departure time of one vehicle and the arrival time of the following vehicle when there is a continuous supply of vehicles waiting to be served. The average move-up time between vehicles was observed to be 7 seconds. Adding the average service time plus the move-up time yields the interval between arrivals shown in Table 1.

For a given Park, service times, move-up times, and the mix of transaction types can be used to generate an hourly value for capacity for average conditions. For example, for Arches National Park, the average time to process a vehicle can be computed as shown in Table 2.

Table 2 simply calculates a weighted average of the times associated with each type of transaction. The number of transactions shown is for a high volume day in 2003. The average time for all vehicles is 32 seconds. This includes both service time and move-up time.

As there are 3600 seconds in an hour, an average time per vehicle of 32 seconds means that 3600 / 32 = 112 vehicles per hour can be processed. Thus, the capacity of one entrance lane would be 112 vehicles per hour under average conditions.

This value of 112 vehicles per hour was further substantiated by data collected at Arches National Park on Saturday, May 14, 2005. Between 10:00 and 11:00 a.m. on this date there were 230 transactions processed by the two lanes at the entrance station. During this hour there was a continuous supply of vehicles waiting in queue throughout the hour. The actual number of vehicles processed was 115 vehicles per lane per hour, which is in very close agreement with the calculated value of 112 vehicles per lane per hour.

TABLE 2 - AVERAGE TIME TO PROCESS A VEHICLE - ARCHES

PRODUCT CODE (A code used by the fee collection system)	**DESCRIPTION OF TYPE OF TRANSACTION** (As used by fee collection system)	**INTERVAL BETWEEN ARRIVALS** (MM:SS)	**NUMBER OF TRANSACTIONS IN A GIVEN TIME PERIOD - ARCHES**	**INTERVAL BETWEEN ARRIVALS X NUMBER OF TRANSACTIONS**
1100	Individual Permit	0:39	64	41:36
1200	Auto Permit	0:37	462	4:44:54
1201	C-Auto Permit	1:51	13	24:03
2300	Hologram			
2410	Return Receipt			
2411	C-Return Receipt			
4000	Comm 1-6			
4200	Comm 7-25			
4201	C-Comm 7-25			
4300	Comm 26 +			
1210	SEUG Ann.	1:36	2	3:12
1211	C-SEUG Ann.	2:18		
2200	Golden Age	1:56	17	32:52
2205	Issue New GA	1:26		
2206	Return Old GA	0:07		
2400	NPS Pass	1:06	39	42:54
2401	C-NPS Pass	1:54	24	45:36
9100	Entrance Auto	0:13	137	29:41
9110	Entrance Indv.			
9140	Fee Waiver	0:36	8	4:48
9200	Entrance G-Age	0:25	155	1:04:35
9210	Entrance G-Access	0:22	8	2:56
9220	Entrance SEUG			
9230	Entrance GE			
9240	Entrance NPP	0:23	352	2:14:56
9260	Non-Recreation	0:14	60	14:00
OTHER TYPES OF TRANSACTIONS (not coded in fee collection system)				
	Aborted Entry	0:52		
			TOTAL TRANS-ACTIONS = 1341	TOTAL TIME = 12 hours, 6 minutes, 3 seconds
			AVERAGE TIME TO PROCESS A VEHICLE = 32 SECONDS	

CAPACITY FOR OTHER PARKS

As pointed out earlier in this report, service times and capacity at other Parks may vary due to a variety of factors. To supplement the Arches National Park data, data on service times was collected at Grand Canyon National Park's South Entrance Station on September 3, 4, and 5, 2005. Nine hours of data were collected representing four different lanes. Over 600 usable transactions were recorded.

The Grand Canyon's choices for fee payment vary somewhat from Arches. There are more fee classes for commercial vehicles carrying passengers and commercial vehicles are much more numerous. These are classes with longer service times. There are also a large number of Park resident and business entries at Grand Canyon, while Arches has virtually no entries in these categories. At the Grand Canyon, only about 12 percent of the transactions are National Park Pass re-entries compared to about 26 percent of all transactions at Arches. For these reasons, and others, the mix of transaction types at the two Parks are very different. In addition, the Grand Canyon is a larger, more complex Park that may prompt more visitor questions at the entrance station. Unlike Arches, the Grand Canyon does not have a visitor center immediately inside the entrance to which visitors can be referred with their questions.

At the Grand Canyon, the average time for all vehicles is 39 seconds, including both service time and move-up time. This translates to a capacity of 92 vehicles per hour per lane at the Grand Canyon, compared to a capacity of 112 vehicles per hour per lane at Arches.

A more detailed comparison of service times and capacity at Arches and Grand Canyon National Parks, as well as some information on service times at Yellowstone National Park, is presented in Reference 1.

The Arches National Park value of 112 vehicles per hour per lane can be used as a very general guide for other Parks. However, because there is known variation from Park to Park, it is suggested that other Parks collect their own data on service times and mix of transaction types so that they can compute a value of capacity for their own local conditions. Most Parks can easily determine the mix of transaction types from their fee collection statistics, as was done in this study. The same software used by Arches is used at over 50 other National Park Service units including Acadia, Arches, Bryce Canyon, Cape Hatteras, Crater Lake, Death Valley, Glacier, Grand Teton, Lake Mead, Mount Rainier, Olympic, Rocky Mountain, Sequoia, Kings Canyon, Shenandoah, Yellowstone, and Zion.

The importance of local data is illustrated by the Table 3 comparison between Arches, Mesa Verde, and Grand Canyon National Parks.

TABLE 3 - COMPARISON OF TRANSACTION TYPES - THREE PARKS

	Percent of all Transactions		
	Arches	Mesa Verde	Grand Canyon
Purchase a 7-Day Auto Permit	33 percent	42 percent	36 percent
Admission on a previously purchased 7-Day Auto Permit	10 percent	2 percent	14 percent
Admission on a previously purchased National Parks Pass	25 percent	25 percent	12 percent
Other types of transactions	32 percent	31 percent	38 percent
TOTAL	100 percent	100 percent	100 percent

APPLICATION

Application for Design of New or Replacement Facilities

For the design of new or replacement facilities, a key question is: "How many lanes do we need?". A new or redesigned facility will likely serve for 40 years or more, so this is an important decision. Over the lifetime of the facility the number of visitors will change, the mix of transaction types will change, and the average service time will change. On the one hand, visitation may increase. On the other hand, more widespread use of Park passes and the implementation of automated entry systems may reduce service time. All of these uncertainties make it difficult to answer the key question. The information presented in this report, however, will make it easier to answer this question.

One of the important inputs to determining the needed number of lanes is the current demand, i.e., traffic volume during peak periods. Some Parks have a traffic counting station at or near the entrance station. Ideally, the counting station would provide historical information on hourly traffic volumes during the entire peak season for at least the previous year. If counts from a traffic counting station are not available, the Park's fee collection software may provide comparable historical information.

It is recommended that Parks designing new or replacement entrance stations obtain the assistance of a traffic engineering professional to forecast future demand, future capacity, and to determine the number of lanes needed to provide visitors with an acceptable level of service. The three following case studies describe situations in which Parks utilized a traffic engineering professional as a resource in evaluating their entrance station needs.

Case Study – White Sands National Monument

In the fall of 2005 White Sands National Monument was in the process of designing a new entrance station to replace an existing facility. One of the questions in the design process and Value Analysis was to determine the number of lanes needed at the new entrance station.

White Sands National Monument is characterized by extreme peaking in traffic volumes on about one dozen days of the year and by high hourly peaking characteristics on certain days of

the year. These peaking characteristics are caused by special events such as "Full Moon Nights" in summer, an Easter Sunday worship service, a Balloon Fiesta in September, and other holiday weekends.

Historical hourly traffic volume counts were reviewed. One example of high peaking in traffic volumes was on the day of a Full Moon night. Over 28 percent of all vehicles arriving on that day arrived during a one hour time period (accounting for 261 vehicles). A more typical peak hour percentage for a National Park or Monument is for 12 to 18 percent of the vehicles to arrive during the peak hour.

Historical traffic volumes provided information on hourly demand. The new entrance station was "sized" to accommodate current demand, plus allow for some increase in future visitation. The methods described in this report were used to determine the capacity of a lane at White Sands. At a Value Analysis workshop a decision was made to construct a three lane entrance station. Two of the lanes will have booths. The third lane will provide additional capacity during the highest volume hours of the year when it will serve as a bypass for vehicles already holding a credential (National Park Pass, Golden Age, Golden Access, etc.)

Case Study – Sequoia National Park

The Big Stump Entrance Station at Sequoia National Park was removed in the fall of 2005 because it was in the "fall zone" of a giant Sequoia in danger of dropping limbs or falling. The Park then proceeded to design a new entrance station at a different location along the entrance roadway.

Again, the needed number of lanes was an important question in the design process. Historical hourly traffic volume counts for the peak season of the three most recent years were reviewed. In addition, the Park's fee collection software was used to determine the mix of transaction types on both an average day of the year and also on peak holiday weekends. Using transaction times from Arches and Grand Canyon, it was estimated that the capacity on an average day is 106 vehicles per hour per lane at Big Stump. For peak holiday weekends, it was estimated that capacity may be as low as 97 vehicles per hour per lane.

Comparing the historical traffic volume counts and the estimated capacity, the new entrance station was "sized" to accommodate current demand using the methods described in this report. As of January, 2006, the Park is planning to construct a two lane entrance station. The site will be designed and constructed to allow for the addition of a third lane if Park visitation grows in the future.

Case Study – Grand Canyon National Park

As noted in the Introduction to this report, the four lane South Entrance Station at Grand Canyon National Park often experiences waiting lines during peak season. It is estimated that there are 515 hours per year when the demand exceeds the capacity of the entrance station.

A detailed analysis of service times and capacity at the South Entrance Station gave Park planners and transportation experts a better understanding of the existing conditions. It also allowed them to identify strategies that could be implemented to provide relief and to estimate the effectiveness of each of the strategies.

In December, 2005 two dozen strategies were identified for short term implementation. While one of these strategies was to add one additional temporary lane for processing vehicles, the remainder of the strategies provided for more efficient operation of the existing four lane entrance station. Reference 1 provides additional information on these strategies.

Application for Staffing of Entrance Stations

For existing entrance stations with multiple lanes, service time and capacity information is useful in managing the staffing of the entrance station. Decisions can be made on the number of staff to deploy (number of open lanes) from day to day and by time of day.

A Park can utilize historical information on entrance station transactions by day of year and time of day to estimate hourly demand during upcoming weeks. A comparison of estimated hourly demand versus capacity per lane can be used to determine the number of lanes that should be staffed, hour by hour. However, making a decision on number of lanes to be open, based on this simple comparison is likely to lead to periodic queueing for the following reasons.

- Computed average capacity is only for average conditions. The mix of transaction types will vary from day to day, hour to hour, and minute to minute. Thus, actual capacity during any given hour will depend upon the mix of transaction types during that hour. There will be periods when actual capacity is less than the average capacity.

- Arrival distributions (peaking of demand during the hour) will strongly influence waiting times and queue lengths. Waiting times and queue lengths will also be strongly affected when there are consecutive, multiple transactions with long service times. For example, three consecutive transactions to purchase some type of pass using a credit card.

For these reasons, it is recommended that hourly demand be compared to a value that is 0.8 times the average capacity. This value is referred to as “practical capacity”. Table 4 presents an example of this application. It is for a Park that has determined its average capacity to be 112 vehicles per hour per lane and that has a three lane entrance station.

TABLE 4 - APPLICATION FOR STAFFING OF ENTRANCE STATIONS

A	B	C	D	E	F
HOUR OF THE DAY	PREDICTED HOURLY DEMAND (vehicles per hour) BASED UPON HISTORICAL EXPERIENCE	AVERAGE CAPACITY PER LANE (vehicles per hour)	PRACTICAL CAPACITY (COLUMN C x 0.8)	RATIO OF PREDICTED HOURLY DEMAND DIVIDED BY PRACTICAL CAPACITY * (COLUMN B / COLUMN D)	STAFFING DECISION (NUMBER OF LANES TO BE OPEN)
7:00 - 8:00 a.m.	60	112	90	0.67	1
8:00 - 9:00 a.m.	126	112	90	1.40	2
9:00 - 10:00 a.m.	190	112	90	2.11	3
10:00 - 11:00 a.m.	139	112	90	1.54	2
11:00 - 12:00	135	112	90	1.50	2
12:00 - 1:00 p.m.	105	112	90	1.17	2
1:00 - 2:00 p.m.	100	112	90	1.11	2
2:00 - 3:00 p.m.	78	112	90	0.87	1
3:00 - 4:00 p.m.	96	112	90	1.07	2
4:00 - 5:00 p.m.	78	112	90	0.87	1
5:00 - 6:00 p.m.	72	112	90	0.80	1
6:00 - 7:00 p.m.	34	112	90	0.38	1

* When ratio is 1.0 or less, open one lane
When ratio is between 1.0 and 2.0, open two lanes
When ration is between 2.0 and 3.0, open three lanes

NPS-WIDE STRATEGIES TO REDUCE WAITING TIME

In terms of business strategy, there is one important lesson to be learned from the service time data. It is clear that service times are much shorter when the visitor already holds a pre-purchased pass. The Park Service could market and promote the sale of passes and entry permits at other points of sale.

Grand Canyon National Park sells passes and entry permits at three off-site locations. One site is at Tusayan, 2 miles south of the entrance (1 staff person). A second site is at Williams, Arizona, 54 miles south of the entrance (3 staff persons). In addition, the Park has automated fee machines that sell 7-day auto permits. The machines are located at the Tusayan and Williams locations and also at Valle, Arizona (24 miles south of the entrance). Similarly, Acadia National Park entry permits are sold multiple locations outside the Park. In the case of Acadia, 48.6 percent of the passes and permits are sold at locations prior to the visitor's arrival at the entrance station.

Purchase of passes and entry permits have longer transaction times than do a simple entry on a pass or permit that has already been purchased. The greater the number of purchase transactions that can be made before arrival at the entrance station, the lower the average service time and the greater the capacity.

As a national strategy, the Park Service could promote the sale of the National Parks Pass via the Internet and at other remote sites. Although the National Parks Pass is currently offered for sale

on the Internet by the National Park Foundation, its sale via the Internet is under-promoted by the Park Service. Direct links could be established between NPS webpages and the National Park Foundation site. An aggressive strategy would be to include a hot link on the webpage of each NPS unit directing users to "Buy Your National Parks Pass Now!".

As a second national strategy, Parks that have Visitor Centers outside of the Park entrance (Acadia and Grand Teton are examples) should offer and promote the sale of passes and other types of entry permits at these locations.

OTHER STRATEGIES TO REDUCE WAITING TIME

The south entrance to Grand Canyon National Park has four entrance lanes. One lane is a "Pass-Only" lane that can be used by holders of a National Parks Pass, Golden Age Passport, Golden Access Passport, visitors who are entering or re-entering the Park on a 7-day auto permit (previously purchased), and Park residents. All of these types of transactions have short service times. Although this lane facilitates entry into the Park, its effectiveness in reducing waiting time is often hindered by the long queues. The approach to the entrance station is four lanes wide for only a short distance upstream, beyond which it is a single lane roadway. The single lane prevents passholders from bypassing the queue until a short distance from the entrance station. The Park is considering a separate bypass roadway long enough to allow passholders to bypass even very long queues. A bypass roadway would provide a motivation to purchase a pass in advance, before arriving at the Park.

AUTOMATED LANES: THE IMPLICATIONS FOR ENTRANCE STATION CAPACITY

A number of National Parks have implemented automated lanes at entrance stations. The following paragraphs provide a brief overview of the operation of automated lanes, the technologies that are used, the classes of vehicles that are eligible to use automated lanes, and measures that can facilitate the implementation of automated lanes.

An automated system to process selected vehicles holds the promise of reducing congestion and waiting times, reducing personnel costs, and providing expedited entry for certain users.
At least four Parks have implemented automated lanes for vehicle entry at entrance stations. The Beaver Meadows Entrance Station at Rocky Mountain National Park allows automated entry to holders of the annual pass for Rocky Mountain National Park, employees, and vendors. Zion National Park has an automated lane that is restricted to employees. Bryce Canyon National Park's automated lane serves employees, vendors, and transit vehicles. Yellowstone National Park has implemented an automated lane at two entrance stations for employees and about 50 concessionaire vehicles. Table 5 summarizes existing use of automated lanes.

Zion Entrance Station – Red SUV in Automated Lane (right hand lane)

Automated Lane at Zion (right hand lane)

TABLE 5 - AUTOMATED LANES AT PARK ENTRANCE STATIONS

PARK UNIT	LOCATION	TECHNOLOGY	ELIGIBLE USERS	CONTACT PERSON
IN OPERATION				
Rocky Mountain	Beaver Meadows Entrance Station	Magnetic Card Reader	Holders of Rocky Mountain National Park Annual Pass	John Hannon 970-586-1365
		Transponder / Electronic Tag	Employees, vendors	
Bryce Canyon		Transponder / Electronic Tag	Employees, vendors, transit vehicles	Dan Cloud 435-834-4200
Zion	South Entrance	Transponder / Electronic Tag	Employees only	Shelagh Forester 435-772-7816
Yellowstone	North Entrance and Northeast Entrance	Transponder / Electronic Tag	Employees and about 50 concessionaire vehicles	Tammy Wert 307-344-2115
PLANNED				
Yellowstone	West Entrance	Transponder / Electronic Tag, Proximity Card		Tammy Wert 307-344-2115
PROGRAMMED				
Rocky Mountain	Fall River Entrance Grand Lake Entrance			John Hannon 970-586-1365

Advantages of an automated lane are that no paid staff are required and that qualified vehicles may “jump” the queue, thus leading to reduced waiting times for those vehicles. A disadvantage is that a separate lane must be set aside for automated entry.

Processing of visitors in an automated lane can be accomplished by multiple technologies. A transponder-based system uses a roadside antenna to “read” an electronic tag on the vehicle. This is referred to as Automatic Vehicle Identification (AVI) and is the technology used by toll roads for electronic toll collection. A vehicle simply approaches the gate and roadside antenna and there is minimum delay. Because of the high cost of the electronic tag, this technology is not practical for the typical tourist visitor. It would, however, have application for repeat users such as employees, Park Service vehicles, commercial vendors who provide services in the Park, transit or shuttle service, and others. The electronic tag technology is used at the Beaver Meadows entrance station in Rocky Mountain National Park for park employees, vendors, maintenance workers, and emergency equipment drivers. It is also used at Bryce Canyon, Zion, and Yellowstone.

A second technology reads a magnetic strip such as exists on a National Parks Pass, Golden Age Passport, and Golden Access Passport. Swiping the Pass in a card reader would provide access to the Park. This type of system is also used at Beaver Meadows (photos below). Holders of the Rocky Mountain National Park annual pass swipe their pass through a magnetic card reader, similar to those used for credit card purchases**.** A gate then opens to allow access to the Park.

Photo Credit: Roger Surdahl, FHWA_CFLHD

Automated Gate at Beaver Meadows

Photo Credit: Roger Surdahl, FHWA_CFLHD

Magnetic Card Reader at Beaver Meadows

A third technology is being considered for a new entrance station at the West Entrance to Yellowstone. Yellowstone Park employees have ID cards that function as proximity cards providing keyless entry to locked buildings and doors. The ID card is waved in front of a reader that identifies the employee as eligible for entry to the building or room. Yellowstone plans to

use the employees' proximity ID cards in the same manner for entry to the Park in an automated lane.

Service times for automated lanes are likely to vary depending upon the technology used. AVI technology is used at the North Entrance to Yellowstone National Park where vehicles are controlled (allowed to proceed) by a traffic signal indication. A service time of 1 second has been reported (Reference 2).

Magnetic card reader technology, as used at Beaver Meadows, requires the user to approach the card reader and swipe the card. A gate arm then opens to allow the vehicle to proceed. Intuitively, service time for magnetic card reader technology and gate arm control is longer than AVI technology. An interesting question for further study is whether the service time for magnetic card reader technology is shorter than the service times offered by Visitor Use Assistants (6 seconds for re-entry of 7-day auto permits and 16 seconds for a National Parks Pass). Although no data is available to the author, it is hoped that data on service times can be collected at Beaver Meadows in the near future.

Proximity card systems may have slightly shorter service times than magnetic card reader technology, because precise placement and orientation of the card is not required.

If automated lanes provide shorter service times than non-automated lanes, the capacity of an entrance lane can be increased.

Additional information on the use of automated lanes at entrance stations can be found in Reference 3.

CONCLUSIONS

Many different factors affect service time and capacity at Park entrance stations and for that reason, service time and capacity will vary from Park to Park. The average time to process a vehicle at Arches National Park is 32 seconds, resulting in a capacity of 112 vehicles per hour per lane. At Grand Canyon National Park the average time is 39 seconds, and the capacity is 92 vehicles per hour per lane.

Information on entrance station capacity can be used effectively for managing the staffing of entrance stations and for designing new or replacement entrance station facilities. Service times for various transaction types can be used to develop strategies to reduce waiting time at entrance stations. Automated lanes are being used in at least four Parks and have the potential to increase entrance station capacity.

ACKNOWLEDGMENT OF SPONSORSHIP

This research was sponsored by the National Park Foundation and its National Park Transportation Scholar Program. Funding for the National Park Transportation Scholar Program is provided by the Ford Motor Company, a Proud Partner of the National Parks.

DISCLAIMER

The opinions and conclusions expressed or implied in this report are those of the author. They are not necessarily those of the National Park Service, the National Park Foundation, or the Ford Motor Company.

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ENHANCEMENTS PLANNED FOR NEXT EDITION OF THIS REPORT

Although there is no known complete list of NPS units with drive-up entrance stations, there are probably about 107 units with such facilities. A goal is to compile a list of NPS units with entrance stations for inclusion in the next edition. The author also hopes to conduct a survey of entrance station facilities to determine: 1) the number of different entrance station locations at each Park, 2) the number of lanes at each entrance station, and 3) the existence of express, bypass, or automated lanes.

The author hopes to have an opportunity to collect service time data for automated lanes at one or more National Park entrance stations that have automated lanes.

NATIONAL PARK TRANSPORTATION SCHOLAR PROGRAM

This program is sponsored by the National Park Foundation. Each year, Parks compete for the opportunity to be assigned a Transportation Scholar to assist the Park with its transportation problems and issues. Individuals also compete for the opportunity to serve as a Transportation Scholar. Parks and individuals are selected for the program and the best matches between an individual's skills and experience and a Park's needs lead to the assignment of individuals to Parks. For additional information about the program, contact the National Park Foundation.

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