Grand Canyon National Park
Dynamic Message Sign (DMS)/Highway Advisory Radio (HAR) Pilot Deployment/Evaluation

Final Report

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EXECUTIVE SUMMARY

During the summer of 2008, a pilot shuttle bus program was implemented from Tusayan, Arizona, to the Canyon View Information Plaza in Grand Canyon National Park (GRCA). The program offered visitors an opportunity for car-free travel to the park. As part of the pilot shuttle bus program, a traveler information system was deployed that included Portable Dynamic Message Signs (PDMS), Highway Advisory Radio (HAR), and HAR static signs in the cities of Valle and Tusayan. The Concept of Operations for the devices was for the HAR and PDMS to function in tandem with the purpose of increasing the influence on visitors' mode choices, increasing transit usage, improving parking management, alleviating traffic congestion at the South Entrance, and improving visitor experience through better dissemination of traveler information. An Operations Plan was created to:

- establish procedures for using the PDMS/HAR systems;
- outline the protocols required for the design, implementation, maintenance, and administration of the PDMS/HAR Systems; and
- develop data collection plans and evaluation methods for the PDMS/HAR systems.

In order to learn from the traveler information system pilot study, an evaluation of the traveler information system was conducted that included three components: mode choice analysis, visitor surveys and focus groups. The specifics and findings are contained in the report.

Based on the pilot shuttle bus program and traveler information system pilot study purpose and objectives the findings for this report are as follows:

- **Increase opportunities for visiting the park without the use of a personal vehicle—** Shuttle ridership was more than 100,000 people for the duration of the pilot shuttle bus program. With half of the riders having a vehicle that could have been used to transport them into the park, the shuttle provided a *vehicle-mile reduction of more than 250,000 miles and a fuel savings of over 10,000 gallons. Between twenty five and thirty seven percent of this savings was due to the deployment of the HAR/PDMS systems.*

- **Reduce vehicle congestion on park roads and parking areas—**Focus group participants said that wait times were reduced at the GRCA gate and that there was essentially no congestion at the gate during the summer of 2008; however, this was attributed to the park recently adding another gate and lane at the entrance a*nd not necessarily due to the pilot shuttle bus program implementation.* They also said that parking seemed to be smoother this year, even though there was no notable decrease in parking demand.

- **Improve visitor experience by providing accurate traveler information—**Survey respondents said that the *PDMS and HAR were accurate* (94 and 86 percent respectively).

- **Improve shuttle bus and park and ride lot use—**An analysis of ridership data from the pilot shuttle bus program estimated that the HAR/PDMS had a positive effect, *increasing shuttle ridership by 368 riders per day, and that the signs increased the mode share of* *transit by 32 to 46 percent, depending on analysis method used.* Focus group participants said that parking ran smoother this year although there was no notable decrease in parking demand.

- **Successfully collaborate with Tusayan Community—**Stakeholders from the Tusayan community said that the *2008 pilot shuttle bus program was a success* and should be continued.

- **Evaluate the effectiveness of PDMS and HAR—**The PDMS and HAR contributed to *32 to 46 percent of shuttle riders shifting their mode of travel* from private automobile to public transportation, depending on analysis method used.

- **Keep the operations and maintenance of PDMS and HAR simple—**To keep operations and maintenance for GRCA simple, the maintenance of the PDMS was the responsibility of the PDMS subcontractor, Bob's Barricade. The operations and maintenance of the HAR was the responsibility of the HAR subcontractor, Info Guys. GRCA was only responsible for scripting and pre-approving the messages for the HAR and PDMS and for changing the message on the PDMS as needed.

- **Recommend an appropriate PDMS/HAR system based on the results of the study—**In the future, the PDMS should be utilized in real-time in order to provide more benefit to travelers. To keep operations and maintenance of devices simple for GRCA, it is recommended that, rather than purchasing permanent HAR, *GRCA consider leasing permanent systems from a vendor.*

Based on the data gathered and our observations, the following recommendations are provided:

Short-term (immediately to one year)

- *Deploy a Permanent Traveler Information System*—For inclusion in the permanent traveler information system, it is recommended that GRCA purchase two PDMS and lease one HAR. The costs as well as the benefits and drawbacks of leasing versus purchasing this equipment are shown in Table 4. The HAR and one of the PDMS should be located in Tusayan at the traveler information system pilot study locations with the focus of continuing to encourage mode shift during the shuttle operation. The other PDMS should be located within the park with a focus of providing travelers with better parking availability information. The advantage of PDMS is that they can be moved to new locations as needs arise to allow for real-time information. To facilitate parking availability collection, GRCA should utilize the remainder of its budget to purchase three to six pan-tilt zoom cameras. Location suggestions for these cameras are discussed below in the "Village Area Parking Management System" recommendation.
- *Utilize PDMS and HAR more actively by providing real-time, rather than static, information*—This can be accomplished in a number of ways; including providing additional information/content on the HAR/PDMS such as weather, parking information, road conditions, construction alerts, park hours and fees, and activities in the park. To further help accomplish this goal, it is recommended that GRCA deploy a static sign with solar powered flashing beacons for the HAR in Tusayan so the PDMS can also be used

for real-time information without continuously having to inform travelers of the presence of the HAR. The static sign should be either a blue guide sign with a white border and text or a brown recreational sign with a white border and text (the brown sign would require approval from Arizona Department of Transportation to be used outside the park). The static sign should have no more than four rows of text. With the addition of flashing beacons, the sign should also include a yellow warning sign with a black border and text. While the flashing beacons may increase usage of the HAR, the "urgent" text option may cause travelers to misunderstand the sign and believe that a message is only playing when the beacons are flashing. Another consideration is that if one of the first two options is chosen, a threshold for when the message is "urgent" will need to be created. GRCA should also be careful to ensure that the HAR and therefore the flashing beacons are not continuously activated or travelers will become complacent to the flashing beacons and believe the signs are untrustworthy. Due to the fact that the HAR will be portable, the static sign with flashing beacon that is purchased should also be portable, as well as have remote capabilities for activating and deactivating the beacons. Power and communications will be necessary for the beacons and therefore solar power and cellular communications should be investigated. The cost for a static sign with flashing beacons is approximately $5000 (1).

- *Consider a partnership with Arizona Department of Transportation*—This would allow GRCA to display public transportation information (DMS, HAR, 511) farther away from the park to increase mode shift and allow visitors to consider alternatives as they drive to GRCA.

Medium-term (one year to five years)

- *Intelligent Transportation Systems Architecture and Strategic Deployment Plan*—As the integration of traveler information, parking management, transit utilization and coordination with organizations and agencies outside the park become an increasing need, park officials should consider developing an ITS Architecture and Strategic Deployment Plan. The plan typically includes the following topics being addressed:
  - Vision - stakeholder perspectives, mission, goals/ objectives, strategic direction
  - System Architecture – physical, logical, communications
  - Implementation priorities
  - Costs – capital, operations and maintenance, time frame
  - Funding opportunity – state, regional, partnering
  - Future direction

- *Village Area Parking Management System*—Parking management systems are used to gain real-time data on parking lot availability that can be provided to travelers through the ITS devices, allowing them to seek out alternative parking areas. The purpose of a parking management system is to enhance visitors' experience by helping them find parking spots. This is accomplished by utilizing traffic detectors to record the number of vehicles that are using a specific parking lot and calculating available parking spots. This availability or lack of parking spots as well as alternative parking areas is then communicated to visitors through traveler information systems such as HAR and PDMS.

Based on 2006 data collected on parking activities in the South Rim study a number of parking lots are candidates for parking management. Parking management systems can take many forms and applications including parking garage monitoring systems with signing to indicate full, open and closed, or, lots with one entry and exit (closed system) with signing to indicate full, open and closed or park and ride transit lots that provide real-time signing for available remaining parking spaces (California BART Park and Ride). In each of these typical systems, lots can be monitored by individual parking space sensors, detection devices at points where traffic enters/exits, or a closed circuit television camera (with or without video image processing system) that is automated to provide space availability. For GRCA, the individual parking space sensor would be cost prohibitive due to the number of parking spaces. Detection devices at points of entry is also not an optimal option for GRCA due to each parking lot having two (or more) entries/exits and therefore requiring that the detectors have a very high accuracy, which is usually an issue with some detectors such as loops. Therefore GRCA should consider the closed circuit television camera alternative with two cameras per parking lot to obtain as large an area of coverage as possible. Prior to deployment, further study should be done to determine installation locations and to ensure that two cameras will be sufficient for parking lot length and obstacles (e.g., trees). A strategy that Park officials may want to consider is developing a Village Area Parking Management System that is focused on Lot D and Bright Angel Lodge lots. These two lots are at or near capacity, 78 percent full and 100 percent full respectively. The Parking Management System would include monitoring and diversion/wayfinding signing that would direct motorists to Lot E, when Lot D and Bright Angel Lodge lot are near or at capacity. Signs that provide direction and space availability would be placed on Village Drive westbound upstream of the Lot D turnoff road and also on Hermit Road eastbound upstream of the Lot E turnoff road.

1. INTRODUCTION

Over 4.4 million visitors enjoy Grand Canyon National Park (GRCA) each year. During summer peak season, the Grand Canyon Village area on the park's South Rim experiences extreme traffic and parking congestion with parking supply falling short of parking demand. To provide visitors with better information on traffic and parking congestion, alternate routes, and other general park information, GRCA submitted a proposal to the Alternative Transportation for Parks and Public Lands (ATPPL) Program administered through the Federal Transit Administration (FTA). GRCA 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 grant, the 2008 summer traveler information system pilot study was evaluated. The results of this evaluation will be used as guidance for future ITS deployments and will provide lessons learned. As will be described later, the deployed system consists of two HAR, static signs announcing the Valle HAR frequency, and one PDMS.

The concept for the devices was for the HAR and PDMS to function in tandem with the purpose of increasing the influence on visitors' mode choices, increasing transit usage, improving parking management, alleviating traffic congestion at the GRCA South Entrance, and improving visitor experience through better dissemination of traveler information. An operations plan was created to:

- establish procedures for using the PDMS/HAR systems;
- outline the protocols required for the design, implementation, maintenance, and administration of the PDMS/HAR systems; and
- develop data collection plans and evaluation methods for the PDMS/HAR systems (2).

The operations plan, as shown in Appendix A, contains (1) operational guidelines, (2) maintenance guidelines, and (3) data collection and evaluation methodologies.

This report summarizes the results of the evaluation of the traveler (PDMS and HAR) information system pilot study deployed for GRCA. Chapter 2 provides additional background on this research project. Chapter 3 summarizes the evaluation methodology used. Chapters 4 through 6 describe the evaluation results according to various metrics, including mode choice analysis, visitor surveys, and focus groups. Chapter 7 summarizes the findings of this evaluation and offers some conclusions and recommendations.

2. SYSTEM IMPLEMENTATION

This chapter will describe the project purpose, HAR and PDMS opportunities and limitations, locations where the traveler information system was deployed, messages displayed, and rental sources, as well as information about the pilot shuttle bus program.

2.1. Project Purpose

Through meeting with stakeholders, it was determined that the purpose of the pilot shuttle bus program and traveler information system pilot study should be to:

1. Increase opportunities for visiting the park without the use of a personal vehicle
2. Reduce vehicle congestion on park roads and parking areas
3. Improve visitor experience by providing accurate traveler information
4. Improve shuttle bus and park and ride lot use
5. Successfully collaborate with the Tusayan community
6. Evaluate the effectiveness of PDMS and HAR
7. Keep the operations and maintenance of PDMS and HAR simple
8. Recommend an appropriate PDMS/HAR system based on the results of the study

2.2. Opportunities and Limitations

Like all intelligent transportation systems, HAR and PDMS have both benefits and limitations.

One benefit of HAR is that between 30 and 90 seconds of information can be broadcast. This allows GRCA to provide detailed information about the shuttle to travelers. Another benefit is that travelers receive the HAR information by listening rather than having to read the information. One of the limitations of HAR is that to hear the message, travelers must choose to tune their radio to the station (i.e., it is a two-step process: first they see a sign that tells them what frequency to tune to, then they must tune to it to receive the information).

A benefit of PDMS is that they are highly visual and attention grabbing, more so then a static sign. Another benefit with a PDMS is that there is no second step required (such as tuning to a radio station) to receive the information. A limitation of the PDMS is the amount of information that can be placed on the sign. A PDMS can only hold three lines of text (called a frame). Each line of text has a limit on the number of letters it can hold (eight for a portable sign like the one used in this project). Frames can be alternated on one PDMS to increase the length of the message. While it is suggested that only two frames be used, as long as the full message is legible twice at the posted speed limit, three frames can be used.

To offset the limitations of each device and to accentuate the benefits, it was decided to use a combination of these devices. GRCA deployed two portable HARs, one in Valle and one in Tusayan as well as one PDMS.

While the HAR in Valle only had static signs to announce its presence, the HAR and PDMS were used in tandem in Tusayan. The purpose of the tandem placement was to increase the influence on visitors' mode choice by incorporating the advantages of both devices. As stated in the operations plan shown in Appendix A, the PDMS were intended to be operated in real-time with updates based on congestion of roads and parking lots. It was expected that not only would the presence of the PDMS catch the travelers' attention better than a static sign, but the message may also catch their attention.

2.3. HAR and PDMS Location

The Tusayan HAR was placed approximately 0.4 miles upstream of milepost (MP) 234 on the crest of a hill. This location was chosen with the intention that the HAR broadcast would reach both the PDMS location near MP 232 and Tusayan. The Tusayan PDMS was placed southbound on US 180/SR 64 about four miles from Tusayan near the Grand Canyon airport. Its location was approximately 0.1 miles downstream of MP 232.

The Valle HAR was placed along SR 64 near MP 214, with HAR static signs placed about 0.4 miles downstream of MP 211 on SR 64 northbound and MP 264 on US 180 northbound.

The locations of these devices are shown in Figure 1 while pictures of the devices are shown in Figure 2 and Figure 3. The encroachment permit for the locations is shown in Appendix B.

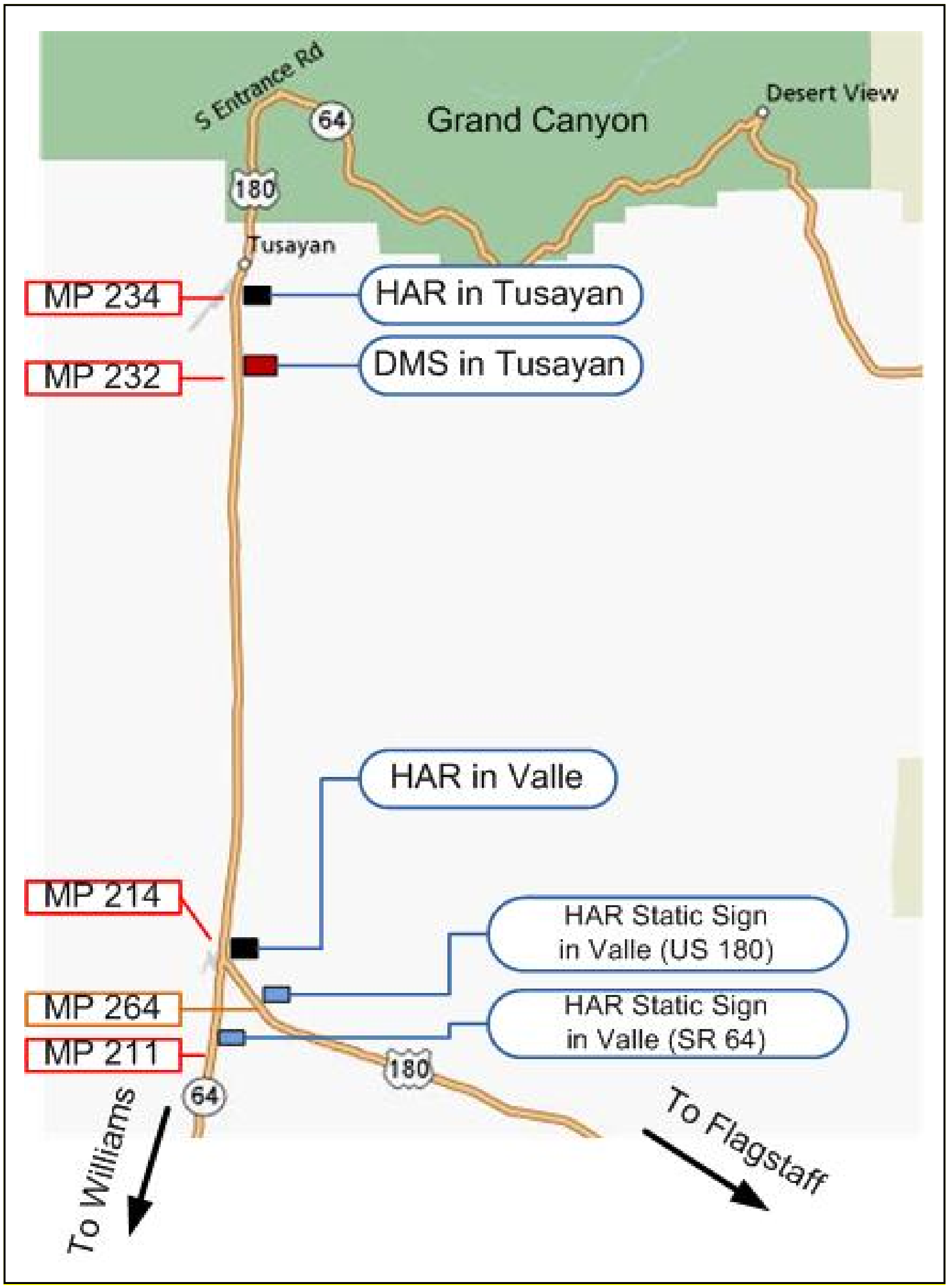


Figure 1: Site Locations on SR 64/US 180

Figure 2: PDMS in Tusayan

Figure 3: HAR in Tusayan

2.4. HAR and PDMS Messages

The HAR were used to inform travelers about the 2008 summer pilot shuttle bus program. The messages were designed to (1) let travelers know the availability of shuttle buses, (2) convince travelers to use the shuttle, and (3) provide them with information they need to take the shuttle (i.e., shuttle locations and where to buy entrance passes). Two key considerations when creating the messages were to make sure people realized the shuttle was voluntary and that it was free, although they would still need to pay the entrance fee for GRCA.

The messages on both HAR were similar, as shown in Appendix C; however, the Valle message included the Valle Gas Station in the list of places where GRCA entrance passes could be purchased, and the Valle message did not include the location of all shuttle stops.

The HAR static signs read: GRAND CANYON SHUTTLE INFO TUNE RADIO TO 1630 AM. The PDMS sign read: PARK AND RIDE IN TUSAYAN TUNE TO AM 1630. As shown in Appendix D, several other PDMS messages were pre-approved for use on the PDMS.

HAR (Appendix E) and PDMS (Appendix F) logs were created to document changes in the HAR and PDMS messages. The HAR messages were static, and matched those in Appendix C, from June 2, 2008, through September 28, 2008. On June 2, 2008, the message in Appendix C was alternated with Federal Highway Administration (FHWA) public service announcements (PSAs). This occurred due to Info Guys typically alternating the Arizona Department of Transportation (ADOT) message with the FHWA PSAs (e.g. Don’t Drink and Drive) when they subcontract for ADOT, and therefore Info Guys assumed that GRCA would want the same arrangement . This was rectified for subsequent days so that the GRCA message was the sole message on the HAR to make evaluation of the HAR easier. The PDMS message was static with exception of the Fourth of July weekend when the message read: CANYON PARKING LIMITED PARK AND RIDE IN TUSAYAN TUNE TO AM 1630 AND SLOW TRAFFIC AHEAD PREPARE TO STOP.

The HAR and PDMS were kept on twenty-four hours a day, seven days a week for the entire traveler information system pilot study.

2.5. HAR and PDMS Rental

The two portable HAR were rented from Info Guys in Phoenix, Arizona. The portable HAR systems are manufactured by Information Station Specialists (ISS) located in Zeeland, Michigan. They are portable, solar-powered roadside systems with video cameras. These systems are controlled via satellite. Although Info Guys provided the HAR systems, GRCA was responsible for providing the static signs. The cost for the HAR systems was $1600 per month, which included the cost of power and communications as well as the FCC license. One benefit of renting the portable HAR through Info Guys was that the vendor recorded and changed the messages based on GRCA’s requests. GRCA did not have to operate the HAR. Another benefit was that Info Guys already has an FCC license for the state of Arizona, therefore it only had to submit the locations where the devices would be located. This took a few days rather than the months it would have taken to apply for FCC licenses, making for expedient set-up. Not only did this vendor offer the most operational benefits but it was also the most cost effective.

The portable PDMS were rented from Bob’s Barricade in Phoenix, Arizona. This vendor offered the most cost effective option at $50 per day rental fee and a $300 delivery/pick-up fee. The device was manufactured by Wanco located in Arvada, Colorado. It was solar powered with a battery back-up system. The message had to be changed at the sign. Normally Bob’s Barricade would control the messages on the sign for the renter. However, because that would require GRCA to pay $600 round trip for them to physically access the sign, the vendor’s staff trained GRCA on how to change the message themselves and provided the proper equipment for it. To make the process easy and for quick deployment, the contracts with Bob’s Barricade and Info Guys were handled by Fann Contracting, Inc. GRCA already had a contract with Fann Contracting, and that contract was amended to include rental of these devices.

2.6. Shuttle Information

The pilot shuttle bus ran from Tusayan to the Canyon View Information Plaza from June 1 to September 28, 2008. The shuttle ran from 8 a.m. to 9 p.m. daily with 20-minute headways (i.e. time between shuttle buses). There were five shuttle stops, including Grand Canyon National Park Airport; Canyon Flight and Trading Company; Canyon View Information Plaza; the IMAX Theater and RP's Stage Stop; and the Best Western Grand Canyon Squire Inn.

The shuttle served a total of 102,501 passengers over the four months. The shuttle carried between 375 and 1650 riders per day, averaging 860 riders per day.

3. METHODOLOGY

If success is demonstrated, the traveler information system pilot study would not only provide lessons learned and guidance for the ATTPL project, but also guidance for future GRCA ITS deployments. This chapter presents the methodology that was used to evaluate the effectiveness of the HAR and PDMS through qualitative and quantitative means.

Evaluation methods included visitor surveys, focus groups, and data analysis of travel patterns.

3.1. Mode Choice Analysis

HAR and PDMS messages were designed to elicit a response among visitors traveling to the park. This response may be quantified by examining the extent to which visitors use alternative transportation. This part of the methodology sought to examine how shuttle usage changed in correlation to usage of the HAR and PDMS. Logs of shuttle ridership and traffic volume data were obtained from GRCA and used in a linear regression model to determine whether the HAR and PDMS had any correlation with ridership levels and, if so, to what degree the systems affected shuttle ridership. Vehicle-mile reduction and fuel savings was also calculated based on shuttle ridership.

3.2. Visitor Surveys and Focus Groups

The visitor surveys and focus groups were conducted in conjunction with Nelson Nygaard Consulting Associates. While WTI was evaluating the traveler information system pilot study, Nelson Nygaard was concurrently evaluating the pilot shuttle bus program. Rather than conduct separate visitor surveys with the same participants, GRCA requested that WTI choose the most important questions from its surveys to be incorporated into the Nelson Nygaard surveys.

3.2.1. Visitor Survey

The purpose of the visitor survey was to determine whether visitors had seen the HAR and PDMS and how they responded to the information that was presented on the devices.

The survey questionnaire was prepared for on-site administration by park staff on board the shuttle bus. The respondents were to include one adult (18 or older) per party on board the shuttle, and would include both respondents who saw the HAR and PDMS and respondents who did not. If they decided to fill out the survey, they would return it to park staff upon arrival at the shuttle stop. Because the survey was administered on national park lands, the survey form and administration methodology required approval by the National Park Service and the Office of Management and Budget.

3.2.2. Focus Groups

The focus groups were used to determine stakeholders’ perceptions of the HAR and PDMS. Three focus groups were planned: National Park Service staff; owners, managers and frontline staff of businesses in Tusayan; and shuttle operators.

4. MODE CHOICE ANALYSIS

One important evaluation piece is to quantify the extent to which the information conveyed by the HAR and PDMS affected travel patterns to the park. It is expected that visitors headed toward the park will respond to the information on the PDMS and HAR about the pilot shuttle bus program in a measurable way.

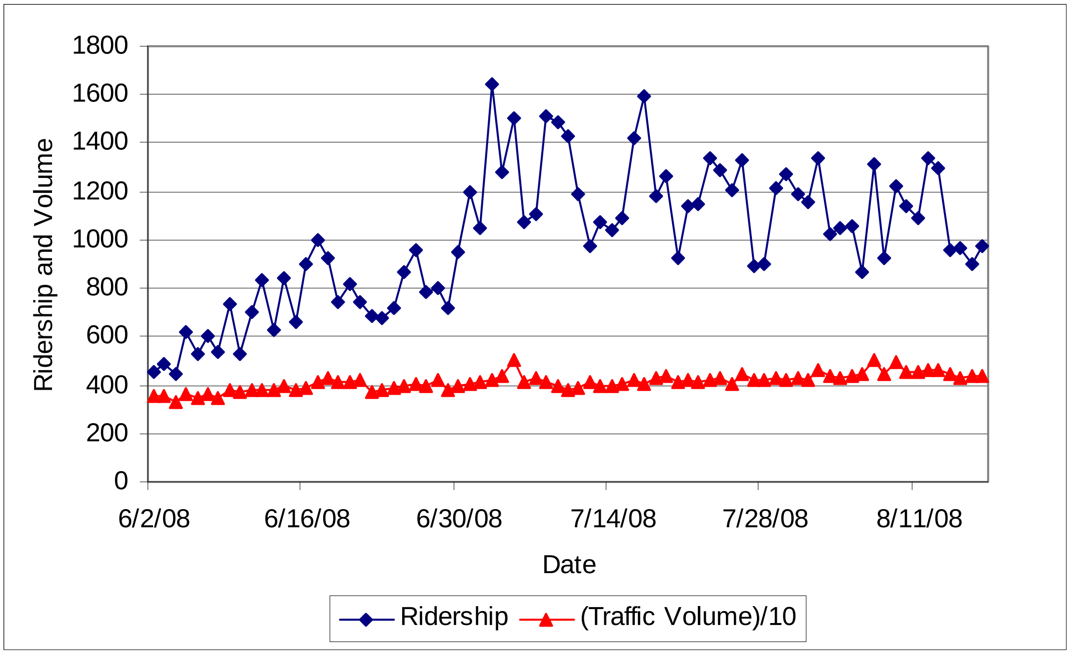
Data regarding shuttle usage and visitation were collected in order to quantify the effects of the HAR and PDMS on travel patterns for visitors going to GRCA. This chapter summarizes the results of analyzing this data.

4.1. Shuttle Usage

Visitors traveling by car on SR 64 or US 180 toward GRCA would be expected to tune in to either (or both) the Valle HAR with static signage or the Tusayan HAR with the PDMS. It is expected that the information on the HAR about the pilot shuttle bus program would cause mode shift (i.e., travelers choosing to switch from driving their personal vehicle to taking the bus) with the result that more visitors will take shuttle.

Shuttle ridership was first analyzed against GRCA traffic volumes to determine if changes in traffic volumes (i.e., visitation) affected shuttle ridership. As shown in Figure 4, GRCA traffic volumes were relatively flat and there is no direct correlation in slope between shuttle ridership and GRCA visitation (i.e., traffic volumes).

Figure 4: Correlation of Ridership and Traffic Volume



4.1.1. Linear Regression

In order to test the hypothesis that the HAR and PDMS system caused mode shift, a linear regression analysis was performed on shuttle usage statistics. The linear regression model sought to express shuttle ridership (y) as a linear function of several variables, including whether or not the HAR and PDMS were providing a message (x_1) and the GRCA South Entrance traffic counts (x_2), as shown in the following equation:

$$y = ax_1 + bx_2 + c$$

where y = shuttle ridership (riders per day)
x_1 = whether the HAR and PDMS were providing a message that day
x_2 = GRCA South Entrance traffic counts on a given day

The actual values of y, x_1, and x_2 were used to calculate a, b, and c. The value of a shows how strongly the HAR and PDMS message(s) tended to increase shuttle ridership. As other factors may also increase shuttle ridership, including the number of vehicles going to GRCA in a given day (which will relate to weather and other factors not associated with the shuttle), this is reflected by the b parameter.

The regression analysis only focused on shuttle usage data from June 2, 2008, to August 17, 2008. This was due to lack of GRCA visitation data for August and September because of a traffic counter malfunction. A correlation of 2007 and 2008 visitation counts was completed to see if this data could be used to fill in the gap (i.e., August 18, 2008, to September 28, 2008); however, it was determined that the low R^2 value (coefficient of correlation) of 0.40, indicated a weak correlation between 2007 and 2008 traffic data. Thus, the linear regression analysis did not include samples between August 18 and September 28, 2008.

The results of the regression analysis (i.e., the values of *a*, *b*, and *c*) are shown in Table 1. Of the two variables included in the regression, the variable (*a*) representing HAR and PDMS usage (x_1) had the highest ratio of parameter value to standard error (i.e., parameter value divided by standard error). This suggests that it is the most robust of the two variables in the model. The parameter estimate for *a* indicates that, all else being equal, usage of the sign would add 368 shuttle passengers per day. For example, when using the equation to predict what the shuttle ridership would be for a particular day given the GRCA South Entrance visitation for that day, it is estimated by this equation that 368 of the total number of passengers calculated would be due to the HAR and PDMS displaying a message.

Table 1: Linear Regression Results for Estimation of Shuttle Usage

Variable	Parameter Value	Standard Error	Ratio of Parameter Value to Standard Error
PCMS Usage (*a*)	367.83	53.99	6.81
Visitation (*b*)	0.2067	0.0777	2.66
Y-intercept (*c*)	-81.51	300.06	0.27

With the values of *a*, *b*, and *c* calculated, an estimated number of shuttle riders per day was calculated for the period of June 1 to August 17, 2008, using the known GRCA South Entrance visitation and the HAR/PDMS usage. This estimate is based on the trends in the data and shows a smoother, more of an average, ridership. This estimate could be used, for instance, to plan shuttle capacity. Although the actual ridership for June had some low valleys of 400 riders per day and some peaks of 1000 riders per day, the average ridership that should be planned for is between 600 and 800 riders per day. The average ridership during this time period (June 1 to August 17, 2008) is 1005 riders per day.

A graph comparing the actual with estimated shuttle ridership is provided in Figure 5. The regression model has an R^2 value of 0.64, which indicates a reasonably good fit.

The percent increase in shuttle ridership will also shed light on the influence of the HAR and PDMS. The equation is as follows:

$$\text{Percent increase of ridership} = [(R_{1\_bar} – R_{2\_bar})/R_{2\_bar}]*100$$

where R_{1_bar} = mean value of actual shuttle ridership during the period (June 30 to August 17) of system implementation;

R_{2_bar} = estimated mean value of shuttle ridership if the HAR/PDMS system is not implemented during the June 30 to August 17 period (i.e., the linear regression model is used to calculate estimated shuttle ridership, except that it is assumed that the PDMS/HAR is turned off/not present for the June 30 to August 17 period and therefore x_1 is zero. The average of this data is then calculated).

During system implementation from June 30 to August 17, the mean value of the actual measured ridership (R_{1_bar}) is 1173 visitors per day. Based on the results of the linear regression, the ridership is predicted, assuming that the systems were not present. The mean value of this predicted ridership data (R_{2_bar}) is 805 riders per day. Thus, the average effect of the systems on shuttle ridership is 368 visitors per day (R_{1_bar}- R_{2_bar}), which equals the value of a in the regression equation. With this, it is concluded that the use of the PDMS/HAR systems increase shuttle ridership by 45.7 percent.

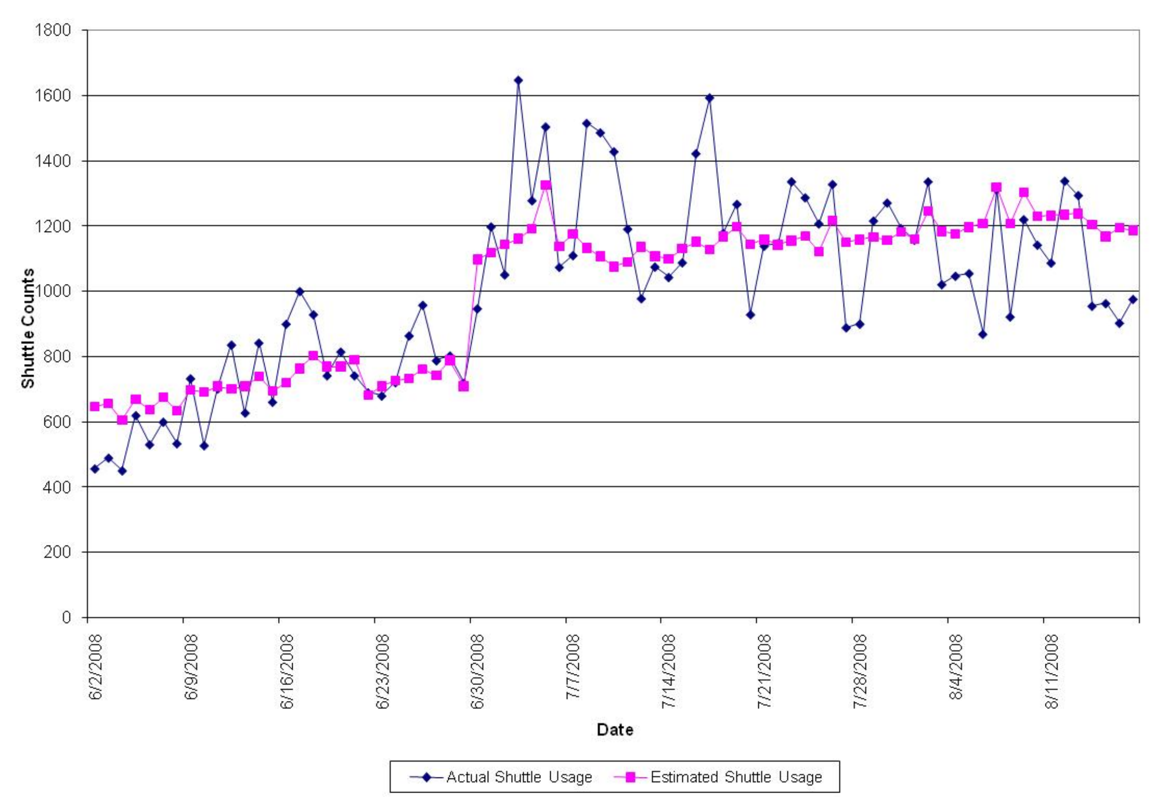


Figure 5: Actual vs. Estimated Shuttle Ridership

4.2. Mileage and Fuel Savings

Resource protection is a part of the National Park Service mission and one of the benefits of the pilot shuttle bus program mentioned on the HAR system was saving gas. Therefore, the number of vehicle-miles reduced by travelers taking the shuttle was calculated, as well as the amount of fuel saved (in gallons). The equations are as follows:

$$\text{Vehicle miles} = \frac{\text{(\% shuttle riders with vehicle * total ridership * trip length)}}{\text{average vehicle occupancy}}$$

$$\text{Gallons of fuel saved} = \text{vehicle miles/25 mpg}$$

The percentage of shuttle riders with a vehicle is calculated from the mode-of-travel question asked in the visitor survey. Respondents answering that they took a tour bus, drove their own car, or drove a rental car were combined and totaled 50 percent. Trip length was calculated based on the approximate distance between the GRCA South Rim and the Grand Canyon National Park airport in Tusayan, and was approximated at 14 miles round trip. Average vehicle occupancy was assumed to be 2.8 visitors per vehicle based on past GRCA information.

As shown in Table 2, shuttle ridership has provided a vehicle-mile reduction of more than 250,000 and a fuel savings of over 10,000 gallons. With the HAR/PDMS systems influencing 32 (shown in section 5.2) to 46 percent of shuttle riders, the HAR/PDMS systems resulted in an estimated reduction of between 66,000 and 99,000 vehicle-miles driven and a fuel savings of 2600 and 2800 gallons or 25 to 37 percent of the total vehicle-mile reduction and fuel savings.

Table 2: Vehicle-Mile Reduction and Fuel Savings

	Total Ridership			
	All shuttle riders (june–sept)	Shuttle riders during ITS depl. (june 30–sept)	46% of shuttle riders during ITS depl. (june 30–sept)	32% of shuttle riders during ITS depl. (june 30–sept)
Vehicle-mile reduction	256,253	206,413	94,950	66,052
Fuel savings	10,250	8257	3798	2642

5. VISITOR SURVEY

Visitor surveys were conducted in August of 2008 by Nelson Nygaard Consulting Associates. A total of 377 shuttle passengers completed the survey. In total, 31 questions were asked on this survey, and of these, 12 were questions relevant to the HAR and PDMS provided by WTI. An overview of the HAR and PDMS questions will be discussed below. To view the remainder of the analysis or more detailed information, reference the "Grand Canyon National Park Tusayan Pilot Shuttle Evaluation" (3).

The questions asked included:

- How did you find out about this shuttle?
- Did you see the highway message signs on State Route 64?
- Did the highway message signs influence your decision to take the shuttle bus from Tusayan to Grand Canyon?
- Please rate the information on the highway message signs for ease of understanding the message and for accuracy of the message sign.
- Overall, how useful was the highway message sign?
- Did you tune in to the highway advisory radio?
- Did the highway advisory radio influence your decision to take the shuttle bus from Tusayan to the Grand Canyon?
- Please rate the information on the highway advisory radio for ease of understanding and the accuracy of information on highway advisory radio.
- Overall, how useful was the highway advisory radio?
- What type of information would you want to see on the signs or hear on the radio?

5.1. Analysis

The largest share of respondents, 36 percent, had heard of the shuttle through the park newspaper/flyer; however, eleven percent of the respondents heard about the shuttle by seeing the highway message sign and subsequently tuning in to the highway advisory radio.

5.1.1. PDMS

Forty-one percent of respondents reported seeing the highway message sign, and 5 percent of those indicated it was blank. Thirty-three percent of the respondents who saw the PDMS, or 14 percent of all respondents, said the sign influenced their decision to take the shuttle. Of the 41 percent who saw the highway message sign, 89 percent said the ease of understanding was “very good” or “good,” 85 percent said the accuracy was “very good” or “good,” and 94 percent said it was “very useful” or “useful.”

5.1.2. HAR

Sixty-two percent of respondents said they knew the HAR was available; however, only 25 percent tuned in to the HAR. Seventy-three percent of the respondents who listened to the HAR, or 18 percent of all respondents, said it influenced their decision to take the shuttle. Of the 25 percent who tuned in to the HAR, 80 percent said the ease of understanding was “very good” or “good,” 86 percent said the accuracy was “very good” or “good,” and 96 percent said it was “very useful” or “useful.”

Respondents were asked what type of information they would like to see/hear on the PDMS/HAR in the future. As shown in Figure 6, “no opinion,” “weather at park,” “whether parking areas were full,” “transit/shuttle information,” “road work/construction,” “park hours and fees,” and “activities at park” were the most popular choices and all ranked similarly. People choosing “other” were asked to specify, and their responses included: “campground information,” “entry wait time,” “entrance fees,” and “music.”

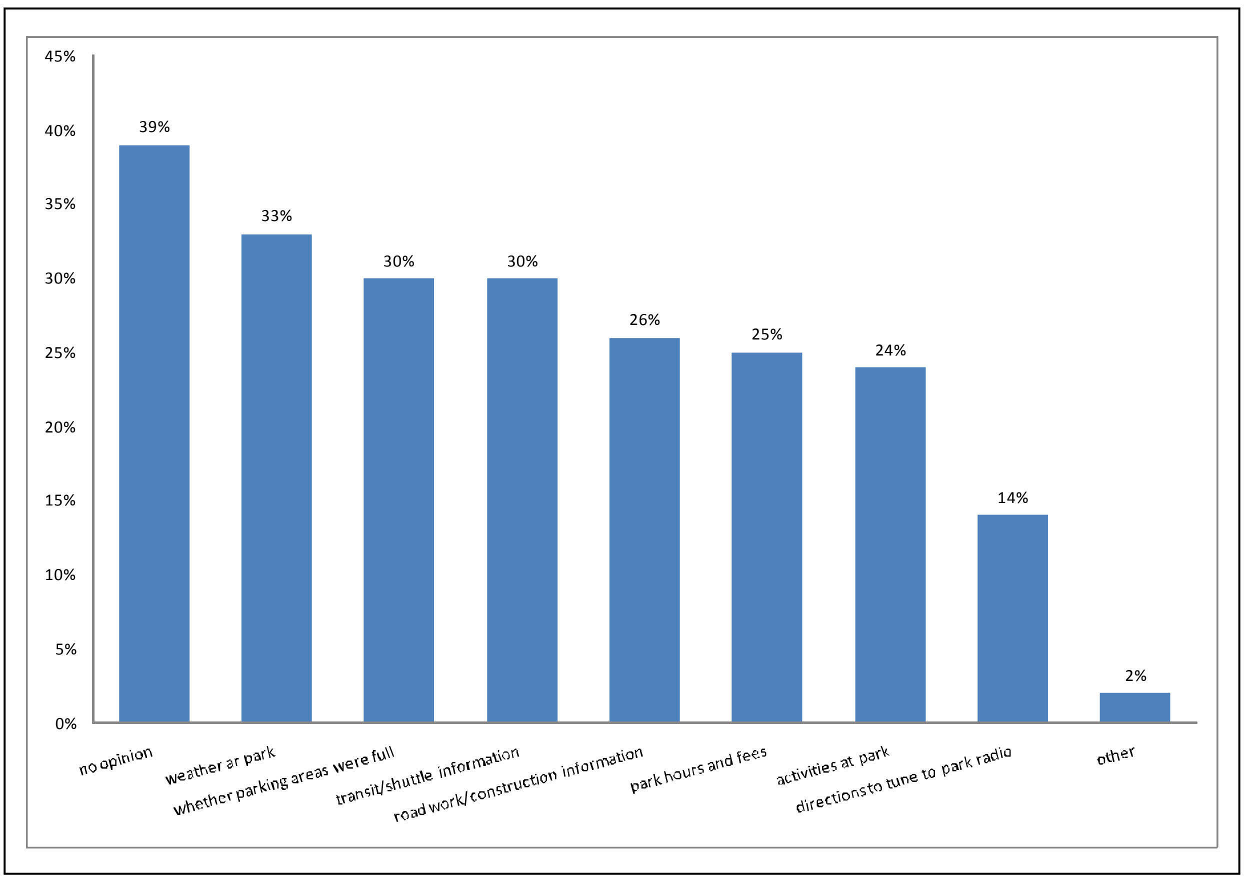


Figure 6: Type of Information Wanted on DMS and HAR

5.2. Summary

Overall, the tandem system of the HAR and PDMS may have affected 32 percent, or one-third, of motorists taking the shuttle (i.e., PDMS affected 14 percent and HAR affected 18 percent). Note that this number may be slightly lower as some respondents may have been influenced by both devices. Also, based on the observations discussed in the next two paragraphs, the findings 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. Additional information respondents said they would like to see on the PDMS and HAR included weather information, parking area status, road construction information, park hours and fees, and activities at the park. It is interesting to note that directions to tune to the park radio, such as was on the PDMS, gained the lowest response, indicating that respondents prefer "real-time" information to the static information provided on PDMS.

Although similar numbers of respondents (approximately half) said they were aware of the existence of both the PDMS and HAR, the PDMS was utilized by twice the number of respondents. As discussed previously, this is most likely due to the PDMS message not requiring action on the part of the traveler (i.e., unlike the HAR, which requires listeners to adjust their radio). Although the PDMS was used by twice the number of respondents, the HAR influenced more people to take the shuttle (three-quarters versus one-third). As was discussed earlier, this is most likely due to the larger quantity of shuttle information available on the HAR. Moreover, it is possibly due to the fact that those people tuning in to radio were more eager to know about shuttle information than others.

Ease of understanding was slightly less for HAR than the PDMS, probably due to significantly more information being provided by the HAR. Although the majority of respondents found both the HAR and PDMS useful, the HAR was found to be more useful than the PDMS (76 percent versus 54 percent, respectively, reporting them to be "very useful"), again probably due to the HAR providing more information that the PDMS and due to their different functions. As the PDMS was not used for real-time management, it only provided information to tune to the HAR.

6. FOCUS GROUPS

Focus groups were conducted in October 2008 by Nelson Nygaard Consulting Associates in order to gather the opinions of GRCA and Tusayan stakeholders about the pilot shuttle bus program and traveler information system pilot study. An overview of the discussions related to the traveler information system (HAR and PDMS) will be detailed below. To view the remainder of the discussions, please refer to (3).

The questions for discussion, created from the original WTI stakeholder survey, included:

- Do you feel that there is a need to provide better traveler information to Grand Canyon National Park visitors about congested roads, parking lot status, and the availability of shuttle bus services?

- Were the message signs a good way to get visitors information about the shuttle? How about the Highway Advisory Radio? Where else should information about the shuttle be presented?

- Based on the outcome of traveler information system pilot study, the NPS will consider implementing a long-term or permanent system utilizing PDMS and HAR. Their use could be broadened to provide real-time information about a variety of transportation conditions including availability of shuttle bus service. Do you feel that use of these technologies would be effective in addressing traffic congestion and parking challenges at the South Rim?

- How do you believe PDMS and HAR affected driver behavior? (The pilot shuttle bus program was implemented on June 2, 2008, nearly a month prior to implementation of the PDMS and HAR)

- Do you feel that the PDMS and HAR were in good locations for providing traveler information about shuttle bus service and Grand Canyon National Park? If you answered no, please indicate where better locations would be. If you feel there are additional locations where the PDMS and HAR should be placed, please indicate where those locations would be.

- What additional information would you have liked to see displayed on the PDMS and/or HAR?

Participants all agreed that the pilot shuttle bus program was a success and that it should continue to be operated on a permanent basis with some modification. However, the success/failure of the traveler information system pilot study was less clear.

The focus group participants gave limited input on the highway message signs and highway advisory radio. The business community had differing opinions about the usefulness of the HAR and PDMS, with some finding the messages helpful and others not. The National Park Service staff found the HAR and PDMS to be of limited usefulness, with one person commenting that they were “very ineffective,” while the bus operators found them to be “helpful and comprehensive." Weaknesses of the devices included the location of the PDMS and the message on the HAR. Most participants said that few visitors saw the message signs or tuned in to the radio. This could have been caused by the fact that, although the PDMS/HAR systems were effective, traffic volume also increased during the implementation, which could affect their intuition about the effectiveness of the systems. Some bus operators said that the PDMS were easy to miss near the airport due to distractions from other activities. Although it was suggested that alternate locations may be better, the airport location was chosen due to being a less cluttered area than the originally chosen Tusayan location. Most participants said that the radio messages were clear; however, some participants said that these messages may have contributed to confusion about having to pay entrance fees to ride a free shuttle.

It was also noted that the airport saw the greatest parking demand and therefore experienced some crowding. As the airport was the first available place to park to take the shuttle after a traveler passed the HAR and PDMS, it could stand to reason (although is not quantifiable from the data collected) that the HAR and PDMS contributed to the number of people choosing to park at the airport.

Although there were reports from participants on travel pattern changes, respondents said this was not due to the PDMS or HAR. For example, the business community noted that wait times were reduced at the GRCA gate and that there was essentially no congestion at the gate during the summer of 2008; however, this was attributed to the park recently adding another gate and lane at the entrance and not due to the pilot shuttle bus program implementation. The National Park Service staff mentioned that they did not see a notable decrease in parking demand inside the park during the pilot shuttle bus program, however parking seemed to be smoother this year. They noted that the parking demand generally exceeds the available supply, so even if the shuttle reduced demand, many of the parking lots would continue to fill. National Park Service staff did feel, however, that the shuttle may decrease demand for RV parking which would be beneficial.

7. SUMMARY AND RECOMMENDATIONS

7.1. Summary

This report summarized an evaluation of the traveler information system pilot study deployed to help market the 2008 summer pilot shuttle bus program between GRCA and Tusayan. Three primary methods were used to evaluate the HAR and PDMS effectiveness: mode choice analysis, visitor surveys, and focus groups.

The Grand Canyon National Park traveler (DMS/HAR) information system pilot study was a success based on meeting the defined objectives:

- Shifting visitors' mode of travel from private automobile to public transportation (between 32 to 46 percent)
- The ease of use of the systems (between 80 (PDMS) and 89 (HAR) percent)
- Effect of the traveler information on influencing visitors to use transit (368 riders per day)
- Reduction of 66,000–95,000 vehicle-miles driven and a fuel savings of 2600–3800 gallons
- Findings 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

The following eight goals were addressed in this evaluation:

1. **Increase opportunities for visiting the park without the use of a personal vehicle—** The shuttle saw a ridership of more than 100,000 people for the duration of the pilot shuttle bus program. With half of riders having a vehicle that could have been used to transport them into the park, the shuttle provided a vehicle-mile reduction of more than 250,000 and a fuel savings of over 10,000 gallons. Between twenty five and thirty seven percent of this savings was due to the deployment of the HAR/PDMS systems.

2. **Reduce vehicle congestion on park roads and parking areas—**Focus group participants said that wait times were reduced at the GRCA gate and that there was essentially no congestion at the gate during the summer of 2008; however, this was attributed to the park recently adding another gate and lane at the entrance and not due to the pilot shuttle bus program implementation. They also said that parking seemed to be smoother this year, even though there was no notable decrease in parking demand.

3. **Improve visitor experience by providing accurate traveler information—**Survey respondents said that the PDMS and HAR were accurate (94 and 86 percent, respectively).

4. **Improve shuttle bus and park and ride lot use—**An analysis of ridership data from the pilot shuttle bus program estimated that the HAR/PDMS had a positive effect, *increasing shuttle ridership by 368 riders per day, and that the signs increased the mode share of transit by 32 to 46 percent, depending on analysis method used.* Focus group participants said that parking ran smoother this year although there was no notable decrease in parking demand.

5. **Successfully collaborate with Tusayan Community—**Stakeholders from the Tusayan community said that the *2008 pilot shuttle bus program was a success* and should be continued.

6. **Evaluate the effectiveness of PDMS and HAR—**The PDMS and HAR contributed to *32 to 46 percent of shuttle riders shifting their mode of travel* from private automobile to public transportation, depending on analysis method used.

7. **Keep the operations and maintenance of PDMS and HAR simple—**To keep operations and maintenance for GRCA simple, the maintenance of the PDMS was the responsibility of the PDMS subcontractor, Bob's Barricade. The operations and maintenance of the HAR was the responsibility of the HAR subcontractor, Info Guys. GRCA was only responsible for scripting and pre-approving the messages for the HAR and PDMS and for changing the message on the PDMS as needed.

8. **Recommend an appropriate PDMS/HAR system based on the results of the study**— In the future, the PDMS should be utilized in real time in order to provide more benefit to travelers. To keep operations and maintenance of devices simple for GRCA, it is recommended that rather than purchasing HAR, GRCA should consider leasing systems from a vendor.

7.2. Recommendations and Future Work

Based on the data gathered and our observations, the following recommendations are provided:

Short-term (immediately to one year)

- *Deploy a Permanent Traveler Information System*—for inclusion in the permanent traveler information system, it is recommended that GRCA purchase two PDMS and lease one HAR. The costs as well as the benefits and drawbacks of leasing versus purchasing this equipment are shown in Table 4. The HAR and one of the PDMS should be located in Tusayan at the traveler information system pilot study locations with the focus of continuing to encourage mode shift during the shuttle operation. The other PDMS should be located within the park with a focus of providing travelers with better parking availability information. The advantages of PDMS is that they can be moved to new locations as needs arise to allow for real-time information. To facilitate parking availability collection, GRCA should utilize the remainder of its budget to purchase three to six pan-tilt zoom cameras. Location suggestions for these cameras are discussed below in the "Village Area Parking Management System" recommendation.

- *Utilize PDMS and HAR more actively by providing real-time, rather than static, information*—This can be accomplished in a number of ways; including providing additional information/content on the HAR/PDMS such as weather, parking information, road conditions, construction alerts, park hours and fees, and activities in the park. Additional PDMS messages to consider are shown in Table 5. To further help accomplish this goal, it is recommended that GRCA deploy a static sign with solar-powered flashing beacons for the HAR in Tusayan so the PDMS can also be used for real-time information without continuously having to inform travelers of the presence of the HAR. The static sign should be either a blue guide sign with a white border and text or a brown recreational sign with a white border and text (the brown sign would require approval from Arizona Department of Transportation to be used outside the park). The static sign should have no more than four rows of text. Table 3 shows the options for these four rows of text (see rows 1 through 4). The row 1 text is optional. With the addition of flashing beacons, the sign should also include a yellow warning sign with a black border and text. The text options for this sign are shown in row 5 of Table 3. While the flashing beacons may increase usage of the HAR, the "urgent" text option may cause travelers to misunderstand the sign and believe that a message is only playing when the beacons are flashing. Another consideration is that if one of the first two options is chosen, a threshold for when the message is "urgent" will need to be created. GRCA should also be careful to ensure that the HAR and therefore the flashing beacons are not continuously activated or travelers will become complacent to the flashing beacons and believe the signs are untrustworthy. Due to the fact that the HAR will be portable, the static sign with flashing beacon that is purchased should also be portable, as well as have remote capabilities for activating and deactivating the beacons. Power and communications will be necessary for the beacons and therefore solar power and cellular communications should be investigated. The cost for a static sign with flashing beacons is approximately $5000 (4).

Table 3: HAR Static Sign Text

1	GRAND CANYON NATIONAL PARK			
2	TRAVELER INFO	TRAFFIC INFO	TOURIST INFO	PARK INFO
3	TUNE RADIO TO	TUNE TO	DIAL	
4	XXXX AM			
5	URGENT WHEN FLASHING	URGENT MESSAGE WHEN FLASHING	WHEN FLASHING	

- *Consider a partnership with Arizona Department of Transportation*—This would allow GRCA to display public transportation information (DMS, HAR, 511) farther away from the park to increase mode shift and allow visitors to consider alternatives as they drive to GRCA.

Table 4: Lease versus Own Options

	Portable HAR Lease (5 yrs)	Portable HAR Purchase	Permanent HAR Purchase	PDMS Lease (5 yrs)	PDMS Purchase	Camera Purchase
Cost	$60,000[1] (5)	$30-38,000[2] (4)	$15-35,000[2] (4)	$91,250 (4)	$18-24,000 (4)	$9-19,000[3] (4)
Pros	• **Operations responsibility of vendor** • Maintenance responsibility of vendor • Transport responsibility of vendor • Storing responsibility of vendor • FCC license responsibility of vendor	• More cost effective	• More cost effective	• Maintenance responsibility of vendor • Vendor could be paid to transport the PDMS • Storing responsibility of vendor • No additional communications (i.e. cell phone) charges	• More cost effective • Specifications should include: r**emote operation, training, and extended maintenance**	• **Allow information gathering for more real-time parking information**
Cons	• Less cost effective	• **Operations responsibility of GRCA** • Maintenance responsibility of GRCA • Transport responsibility of GRCA • Storing responsibility of GRCA • FCC license responsibility of GRCA	• **Operations responsibility of GRCA** • Maintenance responsibility of GRCA • Transport responsibility of GRCA • Storing responsibility of GRCA • FCC license responsibility of GRCA	• Less cost effective • **Must be operated at the sign (i.e., not remotely controlled)** • Vendor is too far from location to make it cost effective for them to operate PDMS	• Transport responsibility of GRCA • Storing responsibility of GRCA • Communications costs responsibility of GRCA	• **Information cannot be used without staff to view monitor and put information on HAR and PDMS**

[1] Set-up and license fees waived by vendor. $80,000 for seven years. Does not include cost for flashing beacon sign.
[2] Does not include costs for flashing beacon sign and FCC License.
[3] Does not include tower costs if needed.

Table 5: Additional PDMS Messages

PARK TRAFFIC INFO	TUNE TO AMXXX
EXPECT DELAYS AT	PARK SOUTH ENTRANCE
DELAYS AT PARK ENTRANCE	PARK AND RIDE IN TUSAYAN
PARK ENTRANCE FEE	INFO TUNE TO AMXXX
CANYON PARKING LIMITED	TUNE TO AMXXX
ROAD WORK AHEAD	TUNE TO AMXXX
PARKING LOT X FULL	CONTINUE TO LOT X

Medium-term (one year to five years)

- *Intelligent Transportation Systems Architecture and Strategic Deployment Plan*—as the integration of traveler information, parking management, transit utilization and coordination with organizations and agencies outside the park become an increasing need, park officials should consider developing an ITS Architecture and Strategic Deployment Plan. The plan typically includes the following topics being addressed:
    - Vision – stakeholder perspectives, mission, goals/ objectives, strategic direction
    - System Architecture – physical, logical, communications
    - Implementation priorities
    - Costs – capital, operations and maintenance, time frame
    - Funding opportunity – state, regional, partnering
    - Future direction

- *Village Area Parking Management System*—Parking management systems are used to gain real-time data on parking lot availability that can be provided to travelers through the ITS devices, allowing them to seek out alternative parking areas. The purpose of a parking management system is to enhance visitors' experience by helping them find parking spots. This is accomplished by utilizing traffic detectors to record the number of vehicles that are using a specific parking lot and calculating available parking spots. This availability or lack of parking spots as well as alternative parking areas is then communicated to visitors through traveler information systems such as HAR and PDMS.

  Based on 2006 data collected on parking activities in the South Rim study a number of parking lots are candidates for parking management as shown in the Parking Occupancy Table (Table 6). Parking management systems can take many forms and applications including parking garage monitoring systems with signing to indicate full, open and closed, or, lots with one entry and exit (closed system) with signing to indicate full, open and closed, or park and ride transit lots that provide real-time signing for available remaining parking spaces (e.g., California BART Park and Ride). In each of these typical systems lots can be monitored by individual parking space sensors, detection devices at points were traffic enters/exits, or a closed circuit television camera (with or without video image processing system) that is automated to provide space availability. For GRCA, the individual parking space sensor would be cost prohibitive due to the number of parking spaces. Detection devices at points of entry is also not an optimal option for GRCA due to each parking lot having two (or more) entries/exits and therefore requiring that the detectors have a very high accuracy, which is usually an issue with some detectors such as loops. Therefore GRCA should consider the closed circuit television camera alternative with two cameras per parking lot to obtain as large an area of coverage as possible. Prior to deployment, further study should be done to determine installation locations and to ensure that two cameras will be sufficient for parking lot length and obstacles (e.g. trees). A strategy that Park officials may want to consider is developing a Village Area Parking Management System that is focused on Lot D and Bright Angel Lodge lots. These two lots are at or near capacity, 78 percent full and 100 percent full respectively. The Parking Management System would include monitoring and diversion/wayfinding signing that would direct motorist to Lot E, when Lot D and Bright

Angel Lodge lot are near or at capacity. Signs that provide direction and space availability would be placed on Village Drive westbound upstream of the Lot D turnoff road and also on Hermit Road eastbound upstream of the Lot E turnoff road.

Table 6: Parking Occupancy

Parking Lot/ Roadside Parking Location	**Capacity**	**Maximum Occupancy**		**Time of Maximum Occupancy**
		Vehicles	Percentage	
Lot A	101	24	25%	2:00 pm
Lot A Annex	38	5	14%	1:00-2:00 pm
Lot B	254	210	85%	3:00 pm
Lot C	40	11	29%	4:00 pm
Lot D	111	87	78%	12:00 pm
Lot E	185	75	50%	2:00 pm
Bright Angel Lodge Lot (does not include tour bus spaces)	50	50	100%	6:00 – 8:00 am & 10:00 am – 8:00 pm
Mather Point Lot	111	111	104%	11:00 am, 1:00 pm – 4:00 pm, & 6:00 pm – 7:00 pm
Mather Point Informal Roadside	NA**	195	NA	3:00 pm
Yavapai Lot	89	81	93%	2:00 pm
El Tovar/Hopi House Lot	76	71	99%	5:00 pm
Village Loop Drive Roadside	58	64	110%	7:00 pm
Bright Angel Trailhead Lot	NA**	29	NA	Noon & 4:00 pm
Community Building Lot	26	22	85%	7:00 pm
Power House Area Informal Roadside	NA**	33	NA	6:00 pm
Bright Angel Tour Bus Loading/Unloading Zone	6	6	100%	12:00 p.m.
Tour Bus Lot at CVIP	24	6	25%	3:00 pm

Source: DEA Data collection on Saturday, July 22, 2006.

* Capacity of the lot includes spaces for all types of vehicles, including handicapped spaces.

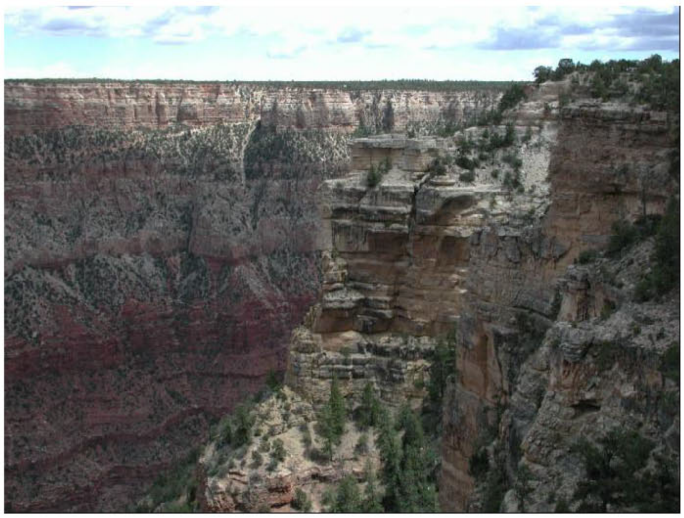
** NA = Not Applicable. (Mather Point Informal Roadside parking, Bright Angel Trailhead, and Power House Area do not have a set capacity. A percentage of occupancy cannot be calculated.)

APPENDIX A: OPERATIONS PLAN

Grand Canyon National Park

Dynamic Message Sign/Highway Advisory Radio

Operations Plan



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GLOSSARY OF ABBREVIATIONS

ADOT	Arizona Department of Transportation
CPU	Central Processing Unit
DMS	Dynamic Message Sign
FCC	Federal Communications Commission
FDOT	Federal Department of Transportation
FLHD	Federal Lands Highway Division
GRCA	Grand Canyon National Park
HAR	Highway Advisory Sign
ITS	Intelligent Transportation Systems
MUTCD	Manual on Uniform Traffic Control Devices
WTI	Western Transportation Institute

1. INTRODUCTION

1.1. Background

Over 4.4 million visitors enjoy Grand Canyon National Park (GRCA) each year. During summer peak season, the Grand Canyon Village area on the Park's South Rim experiences extreme traffic and parking congestion. Parking supply falls short of parking demand. The GRCA will start a pilot shuttle service to/from Tusayan to offer visitors an opportunity for car free travel to the park, to reduce traffic congestion along Highway 64 through the South Entrance and within Grand Canyon Village, and improve access to the Canyon View Information Plaza and South Rim of the Grand Canyon, where parking is limited at key destinations. The park will operate the pilot shuttle route to serve visitors traveling to / from Tusayan to Canyon View Information Plaza from June 1 to September 1, 2008.

1.2. Goals and Objectives

This project is initiated by the problems as described above. Through the deployment of Dynamic Message Sign (DMS)/Highway Advisory Radio (HAR) on State Route (SR) 64/US 180, the project aims to:

- Improve shuttle bus use and parking spaces
- Successfully collaborate with Tusayan Community
- Keep the operations and maintenance of DMS/HAR simple

The GRCA DMS/HAR operations plan is designed to evaluate the effectiveness of DMS/HAR in increasing transit usage, improving parking management, and alleviating traffic congestion at South Entrance. Visitor experience is expected to be improved through better dissemination of traveler information.

1.3. Project Overview

The GRCA DMS/HAR systems include two portable HARs, two HAR static signs, and one portable DMS. The signs will be placed at two sites along the northbound of SR 64/US 180. The DMS/HAR systems will be used to inform travelers about parking availability, shuttle bus service, general park information/fee options, etc. Figure 1 shows the DMS and HAR that will be deployed for this pilot program.

This project serves as a pilot program, and the operations plan and evaluation of this program will be used as guidance for future Intelligent Transportation Systems (ITS) deployments.

1.4. Document Overview and Content

This document establishes procedures for using the DMS/HAR systems and outlines the protocols required for the design, implementation, maintenance, and administration of the DMS/HAR Systems. The document also develops data collection plans and evaluation methods for the DMS/HAR systems.

WANCO's DMS

ISS's HAR

Figure 1: DMS/HAR Systems

2. OPERATIONAL GUIDELINES

2.1. Conditions for Use

The HAR system with static signs is designed to disseminate traveler information and be always on the air from its use to the end of the pilot program. The broadcast message is dependent on the priority of events associated with different conditions (e.g., traffic, weather, and hazardous conditions, transit service, general park information/fee options).

When DMS and HAR are coordinated and used in tandem, the DMS is designed to display a summary of the specific condition (e.g., parking availability, traffic congestion) and action (e.g., park and ride) to be taken by the motorists with reference to an HAR frequency that motorists can tune to for more information. When no specific safety condition exists (under "normal" conditions), the DMS system will also advise motorists to tune to radio for transit service and transportation-oriented park information/fee options to maximize the use of DMS/HAR systems. In every case, the HAR should be programmed before the message is displayed on the DMS and the display should be taken off the DMS before the message is taken off the HAR.

2.2. Coordination and Deployment

Placement of the DMS/HAR within the right-of-way along SR 64/US 180 requires permit/authorization by both GRCA and Arizona Department of Transportation (ADOT). As will be demonstrated below, the deployment, operations, maintenance, and evaluation of the DMS/HAR system requires interagency cooperation.

2.3. Personnel and Responsibilities

Below is a general list of the agencies and departments that will be taking part in the operations and execution of the operations plan. A list of personnel and contact information is located in Appendix A.

2.3.1. GRCA

Responsibilities of GRCA include:

- Encroachment permit request
- Fabrication, placement, and removal of HAR static signs
- DMS operation in conjunction with Fann Contracting, Inc.
- GRCA interpretative staff (aka transportation ambassadors) will operate DMS (e.g., turn on/off, change messages) during weekends
- Contacting vendor if DMS system is not functioning and logging this information including date, time, location, how long not functioning for, and when/how restored
- Once a week (or more frequently as needed) driving by the DMS/HAR systems (tune into the HAR system) to ensure that they are working properly. Keep a log of this test including date, time, device, operation, if subcontractor needed to be contacted, and when/how device fixed (A system test log form can be found in Appendix B.)

- GRCA interpretative staff in conjunction with Paul Revere will monitor traffic and parking conditions
- Keeping a message log including date, time turned on, location, message placed on DMS, time message changed/DMS turned off

2.3.2. Fann Contracting Inc (Contractor)

The contractor shall be responsible for:

- Rental of DMS/HAR systems
- Arranging for subcontractor to place and test DMS/HAR systems (in conjunction with WTI as needed)
- Arranging for subcontractor to relocate DMS/HAR systems if needed within the rental period
- Arranging for subcontractor to perform maintenance to DMS/HAR systems if needed within rental period
- Once a week (or more frequently as needed) driving by the DMS/HAR systems (tune into the HAR system) to ensure that they are working properly. Keep a log of this test including date, time, device, operation, if subcontractor needed to be contacted, and when/how device fixed (A system test log form can be found in Appendix B.)
- Operating DMS during weekdays (i.e. physically going to the DMS sign, turning it on and off, and changing the message as requested by GRCA)
    - Contacting GRCA and vendor if DMS system is not functioning; logging this information including date, time, location, how long not functioning for, and when/how restored; and contacting GRCA again once it is functioning again
    - Keeping a message log including date, time turned on, location, message placed on DMS, time message changed/DMS turned off
- Being the point of contact between the subcontractors and GRCA if needed within the rental period
- Arranging for subcontractor to pick-up DMS/HAR system at the end of the rental period

2.3.3. Info Guys (HAR Subcontractor)

The subcontractor shall be responsible for:

- Placement and testing of HAR systems in conjunction with WTI
- Relocating HAR systems if needed within the rental period
- Performing maintenance to HAR systems if needed within rental period
- Contacting GRCA if HAR systems are not functioning; logging this information including date, time, which location, how long not functioning for, and when/how restored; and contacting GRCA again once they are functioning again

- Turning HAR system in Valle on and off when requested by GRCA (system in Tusayan should remain on at all times as it will not have a flashing beacon sign).
- Operating the HAR systems by recording and changing the messages as requested by GRCA
- Keeping a message log including date, time turned on, location, message placed on HAR, time message changed/HAR turned off
- Picking-up HAR systems at the end of the rental period

2.3.4. Bob's Barricade (DMS Subcontractor)

The subcontractor shall be responsible for:

- Placement and testing of DMS system in conjunction with WTI
- Training GRCA how to change the message on the DMS upon DMS placement
- Relocating DMS system if needed within the rental period
- Performing maintenance to DMS system if needed (as requested by GRCA or contractor) within rental period
- Picking-up DMS system at the end of the rental period

2.3.5. Paul Revere

Paul Revere shall be responsible for:

- Monitoring of conditions together with GRCA interpretative staff

2.3.6. Western Transportation Institute (WTI)

WTI shall be responsible for:

- Preparation of siting recommendations
- Development of pre-approved DMS/HAR message with GRCA
- Evaluation of the effectiveness of the DMS/HAR systems.

Figure 1 displays the execution of the DMS/HAR Operations Plan. Data collection and survey will be described later in Chapter 4.

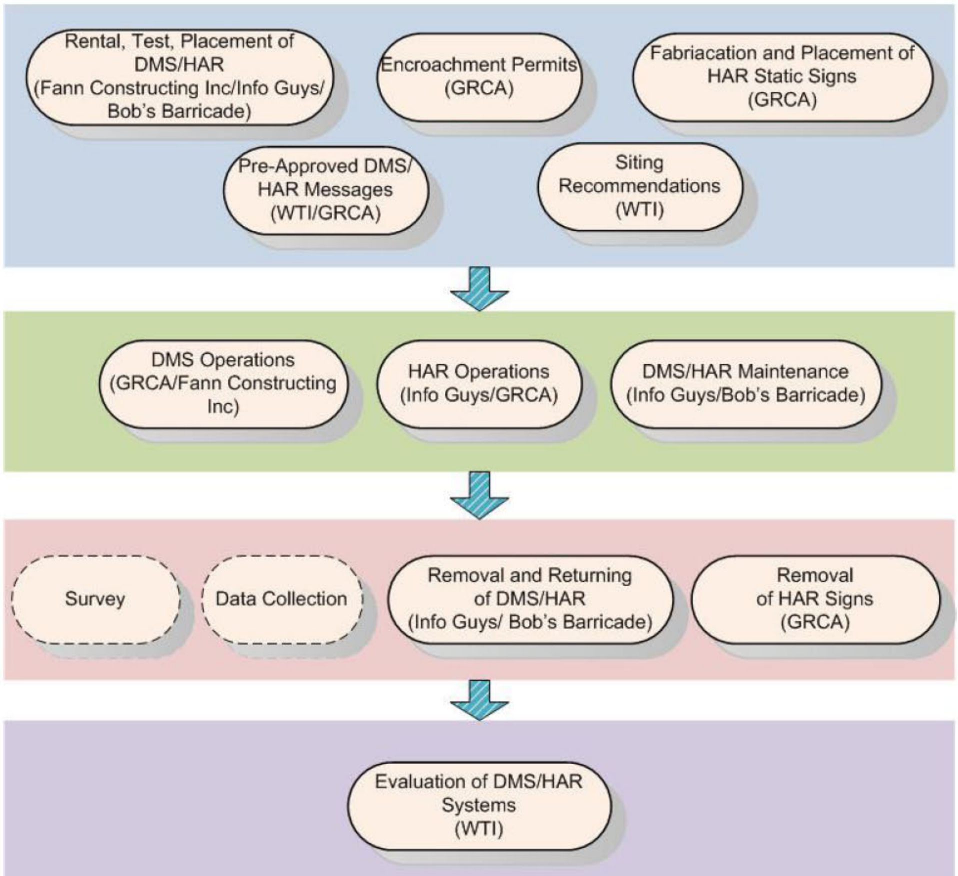


Figure 2: Execution of DMS/HAR Operations Plan

2.4. Guidelines on Placement

In this section, the guidelines for the placement of DMS, HAR, and HAR static signs are described, respectively.

2.4.1. DMS

Placement of DMS should follow general regulations to guarantee optimal viewing of the sign to motorists including sight distance, horizontal and vertical alignment, delineation and positive protection, and physical security.

2.4.1.1. Sight Distance

The signs should be visible from 800 m (0.5 mile) under ideal day and night conditions. Each sign message should be legible from all lanes at the specified distance and in accordance with the current revision of Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD) [1]. In the field, the Portable DMS should be sited and aligned to optimize visibility.

The Chapter 6F of 2003 MUTCD specifies standard and guidance on the placement and use of Portable DMS, which are described as follows.

Standard:

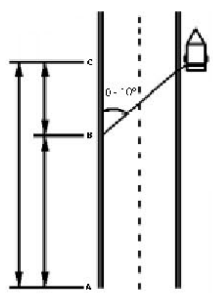
- Portable DMS shall automatically adjust their brightness under varying light conditions, to maintain legibility
- The control system shall include a display screen upon which messages can be reviewed before being displayed on the message sign. The control system shall be capable of maintaining memory when power is unavailable
- Portable DMS shall be equipped with a power source and a battery back-up to provide continuous operation when failure of the primary power source occurs
- The mounting of Portable DMS on a trailer, a large truck, or a service patrol truck shall be such that the bottom of the message sign panel shall be a minimum of 2.1 m (7 ft) above the roadway in urban areas and 1.5 m (5 ft) above the roadway in rural areas when it is in the operating mode
- The text of the message shall not scroll or travel horizontally or vertically across the face of the sign

Guidance:

- The front face of the sign should be covered with a protective material. The color of the elements should be yellow or orange on a black background
- For a trailer or large truck mounted sign, the letter height should be a minimum of 450 mm (18 in). For DMS mounted on service patrol trucks, the letter height should be a minimum of 250 mm(10 in)

- The message panel should have adjustable display rates (minimum of 3 seconds per phase), so that the entire message can be read at least twice at the posted speed, the off-peak 85th-percentile speed prior to work starting, or the anticipated operating speed.
- Message should be designed taking into account the following factors:
  - Each phase should convey a single thought
  - The message should be as brief as possible
  - When a message is longer than two phases, additional Portable DMS should be used
  - When abbreviations are used, they should be easily understood

To clarify the importance of minimizing the number of message panels, the following charts and diagrams for reading time of DMS @ 650 feet and @ 1000 feet shall be referenced from the latest revision of the MUTCD.



0 ° - 10° (ANGLE NOT TO SCALE)

AC = LEGIBILITY DISTANCE

AB = READABLE DISTANCE

BC = UNREADABLE DISTANCE

(DISTANCES PROPORTIONS ARE APPROXIMATE)

FORMULAS:

UNREADABLE DISTANCE = [S+(N-0.33)*L+0.5*W]*5.67

WHERE S =DISTANCE FROM THE SIDE OF THE ROAD TO THE DMS IN FEET

N = NUMBER OF LANES

L = WIDTH OF THE LANES IN FEET

W = WIDTH OF THE PCMS IN FEET

READABLE DISTANCE = LEGIBILITY DISTANCE – UNREADABLE DISTANCE

$$\text{READABLE TIME} = \frac{\text{READABLE DISTANCE}}{\text{TRAVEL SPEED}}$$

Figure 3: Reading Time of DMS

A rule of thumb found in the literature states that one word requires one second to read, a simple phrase takes two seconds to read so a panel could take from 3 to 6 seconds to read. According to the charts, there is usually not enough time to display three panels. Therefore, only two panels should be used to display message. Table 1 and Table 2 illustrate reading times at distances of 650 ft and 1000 ft respectively.

Table 1: Reading time of DMS at 650 ft.

Distance of DMS from edge of Travel Way (ft.)	4 lanes at 65 MPH (95 ft/s) (sec.)	3 lanes at 65 MPH (95 ft/s) (sec.)	3 lanes at 65 MPH (95 ft/s) (sec.)	4 lanes at 55 MPH (95 ft/s) (sec.)	3 lanes at 55 MPH (95 ft/s) (sec.)	2 lanes at 55 MPH (95 ft/s) (sec.)	3 lanes at 45 MPH (95 ft/s) (sec.)	2 lanes at 45 MPH (95 ft/s) (sec.)
2	3.8	4.6	5.3	4.5	5.4	6.3	6.6	7.7
6	3.6	4.3	5.1	4.3	5.1	6.0	6.3	7.3
10	3.4	4.1	4.8	4.0	4.8	5.7	5.9	7.0
20	2.8	3.5	4.2	3.3	4.1	5.0	5.0	6.1
30	2.1	2.9	3.6	2.5	3.4	4.3	4.0	5.2

Table 2: Reading time of DMS at 1000 ft.

Distance of DMS from edge of Travel Way (ft.)	4 lanes at 65 MPH (95 ft/s) (sec.)	3 lanes at 65 MPH (95 ft/s) (sec.)	3 lanes at 65 MPH (95 ft/s) (sec.)	4 lanes at 55 MPH (95 ft/s) (sec.)	3 lanes at 55 MPH (95 ft/s) (sec.)	2 lanes at 55 MPH (95 ft/s) (sec.)	3 lanes at 45 MPH (95 ft/s) (sec.)	2 lanes at 45 MPH (95 ft/s) (sec.)
2	7.6	8.4	9.1	9.0	9.9	10.7	12.1	13.1
6	7.4	8.1	8.8	8.7	9.6	10.5	11.7	12.8
10	7.1	7.9	8.6	8.4	9.3	10.2	11.4	12.4
20	6.5	7.3	8.0	7.7	8.6	9.4	10.5	11.5
30	5.9	6.7	7.4	7.0	7.9	8.7	9.6	10.7

2.4.1.2. Horizontal and Vertical Alignment

DMS should not be placed in sags or just beyond crests of roadways. DMS should be level and angled approximately three degrees away from perpendicular to the roadway to minimize glare. DMS, if facing either the East or West, should be checked at sunrise and sunset to ensure that their reflection of the sun does not blind motorists.

2.4.1.3. Delineation and Positive Protection

Where possible, DMS should be placed behind existing rigid or semi-rigid protection (barrier or guardrail). This will help to avoid potential injury to errant motorists, while simultaneously aiding in the protection of this valuable equipment. When DMS systems are required for long terms in locations where no protection exists, a temporary guardrail or barrier should be considered. Where positive protection is not feasible DMS should be delineated with drums. If a DMS is placed on a 10 ft shoulder, a shoulder closure should be installed. If a DMS is placed adjacent to a 4 ft shoulder, it should be delineated with a minimum of three drums. If possible, DMS should not be placed closer than 6 ft or farther than 20 ft from the edge of the roadway. A sign placed closer than 6 ft from the edge of the roadway becomes an obstruction that causes a reduction in traffic flow. A sign placed farther than 20 ft from the edge of the roadway becomes unreadable for many motorists.

2.4.1.4. Physical Security

When the controller door is open, the operator is to stand in front to block the box so that passing motorists cannot see the internal components of the compartment. Blocking this door may decrease glare on the screen. When checking the message on the sign face close the door to ensure passing motorists are not aware of cabinet's contents.

The DMS systems keyboard box should be locked with a sturdy lock. Ensure all locks are sturdy and never leave any door open even for a moment. Chain and lock the trailer to a fixed object if possible. If the DMS is to be left for a long period of time, then its trailer wheels should be removed.

2.4.2. HAR

The quality of selected site determines the level of effectiveness of a HAR system. When selecting a site, quality checks such as clear frequency, terrain, clear area around antenna, and coordination with DMS should be reviewed to identify the optimum HAR location. The use of HAR should have a license certified by the Federal Communications Commission (FCC).

2.4.2.1. FCC License

Under Title 47, Section 90.242 of FCC's rules and regulations[2], a license is required before the operation of Travelers' Information Stations (*Travelers' Information Stations* is the FCC term for HAR). TIS operate in the AM Broadcast Band (530kHz-170kHz) and are limited to a 10 watt transmitter output power; the antenna shall not exceed 15 meters (49.2 feet); TIS shall not transmit commercial information. The maximum height of antenna is important for those planning roof-mounted systems. This requirement usually limits mounting to building to no more than two stories tall.

Two types of operations can be issued by FCC: fixed operation for a specific location and mobile operation for a region. Application for a TIS license must be made on FCC Form 601 (formerly Form 574). In addition, licensees are required to submit maps showing the proposed station's 2mV/m contours and to identify adjacent commercial stations within the region.

2.4.2.2. Clear Frequency

The following actions can be taken to search for clear frequencies. By driving through the area and tuning to the desired frequency on a good digital radio, ensure the frequency is quiet without regular splashes from adjacent frequencies. If regular beats of static or noise are heard, tune to the adjacent frequencies to see if strong signals exist. For 530 kHz band, monitor 540 kHz, 550 kHz, etc. For 1610 kHz and other frequencies in the 1610-1700 kHz band, listen to the two adjacent frequencies on either side of your frequency for strong signals. [3]

2.4.2.3. Terrain

Terrains should be fully considered for site selection. The site should be at a location such that a circle of 2.5-3 mile radius from the antenna site will cover the primary areas where listening is desired. Check 2.5-3 mile radius from antenna site for high terrain features such as large numbers of tall building, or extremely tall, dense foliage. These factors will reduce transmission range. The area around the transmitter should be checked for rocks, sand, and tree roots, which are not good conduits and might affect the performance of the system. [3]

2.4.2.4. Clear Area around Antenna

For optimum transmission, there should be plenty of clear area around the antenna. [3]

- Objects within 50 feet of antenna: These objects should be no higher than the antenna's base. This height is typically 17 feet for pole-mounted antennas and 4 feet from the root surface for roof-mounted antennas.
- Objects between 50 and 100 feet of antenna: These objects should be no higher than the antenna's tip. This is typically 32 feet for pole-mounted antennas or 19 feet from the roof surface for roof-mounted antennas. This includes trees, buildings, walls, towers, other antennas, etc. The 530 kHz frequency is especially sensitive to this, and the distances of 50 and 50-100 feet specified above should be doubled to give the required protection.

The following sites should be avoided when selecting a site for HAR antenna:

- Directly beneath high-tension power lines
- On the side of existing radio towers or water tower supports
- In close horizontal proximity to large structures such as water towers, stadiums or buildings
- In locations overshadowed or crowded by terrain features of foliage

2.4.2.5. Coordination with DMS

When possible, HAR should be coordinated with an existing or planned DMS. This type of coordination will allow for DMS messages to be used to advise the motorists to tune to HAR for more detailed information. [3]

2.4.2.6. Message Development

The following general guidelines should be considered for the development of HAR messages[1,4]:

- Be concise: HAR should contain the minimum number of words needed to convey the situation. Use phrases and short sentences. The motorist should be able to hear the entire message twice while within the effective transmission range.
- Follow a standard format:
  - An introductory statement (agency name, location of HAR, date and time)

 - An attention statement (to address a certain group of motorists or destination)
 - A problem statement
 - A location statement
 - An effect station (lane closure, delay, etc)
 - An action statement

- Follow FCC requirements (non commercial, etc)
- Use clear and accurate messages without inappropriate background noises

2.4.2.7. Security

The HAR system may be activated and deactivated locally, via a dial-up system, cellular phone/tough tone phone, or even satellite from a remote location. Thus, the system should be protected by a security code.

2.4.3. HAR Static Sign

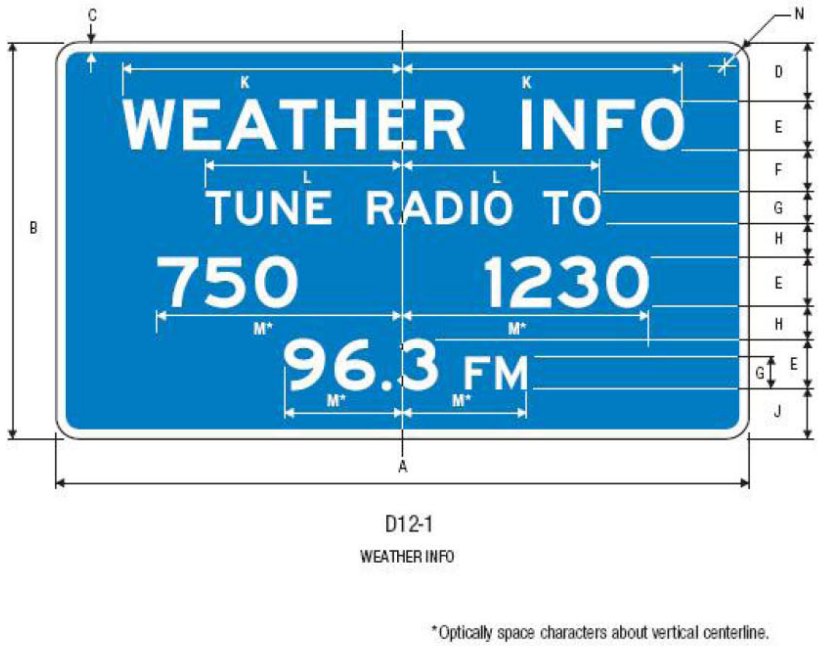
HAR static signs are used to alert motorists about the availability of HAR. The siting and placement of HAR static signs need to consider the following actions:

- Before deciding where to place HAR static signs, install HAR and have it operating at legal field strength. Thus, the recommended locations can be tested under working conditions.
- Drive through the HAR's coverage zone with different vehicles; range is determined in part by the types of receivers in different cars.
- Note where the HAR begins to fade.

In addition, the MUTCD provides the following guidelines for radio information signs[1]:

- The radio-weather and radio-traffic information signs shall have a white legend and border on a blue background.
- Only the numerical indication of the radio frequency shall be used to identify a station broadcasting travel-related weather or traffic information.
- No more than three frequencies shall be shown on each sign.
- If advisory signs are equipped with flashing beacons, the beacons shall be activated when a message is being broadcast.
- If a station to be considered operates only on a seasonal basis, its signs shall be removed or covered during the off season.

The design for HAR advisory signs are described in the following. Figure 4 illustrates the design for a radio information sign with English unit (inch). The colors are white (retroreflective) for legend and blue for background (retroreflective). As shown in the lower part of the figure, the sizes of characters are determined by the length (column "A") and width (column "B") of the advisory sign (e.g., 84×48, 106×66, 132×84). In column "E," "6E" means that the character should be 6-inch height and use series E 2000 of standard alphabets. The standard alphabets spacing chart for series E 2000 (modified) is shown in Figure 5. It should be noted that the measurements are based on 4-inch upper case letter height. In this figure, "left" and "right" represent left and right margins of a character. For example, the letter "D" has .560-inch left margin, .4-inch right margin, and 3.242-inch width (totally 4.2 inches).



A	B	C	D	E	F	G	H	J	K	L	M	N
84	48	1.5	7	6 E	5	4 E	4	6	33.5	24	VAR	3
108	66	2	9	8 E	7	6 E	6	8	44.75	36	VAR	4
132	84	2	11	10 E	9	8 E	8	10	55.875	48	VAR	5

Figure 4 Design for HAR Advisory Signs

Standard Alphabets Spacing Chart

Measurements based on four inch (4") upper case letter height

Series E Modified 2000

Character	Left (inch)	Width (inch)	Right (inch)
A	.160	4.043	.160
B	.560	3.242	.320
C	.400	3.242	.320
D	.560	3.242	.400
E	.560	2.962	.280
F	.560	2.962	.280
G	.400	3.242	.400
H	.560	3.242	.560
I	.560	.800	.560
J	.160	3.042	.560
K	.560	3.282	.080
L	.560	2.962	.080
M	.560	3.722	.560
N	.560	3.242	.560
O	.400	3.362	.400
P	.560	3.242	.160
Q	.400	3.362	.400
R	.560	3.242	.280
S	.440	3.242	.440
T	.160	2.962	.160
U	.560	3.242	.560
V	.160	3.682	.160
W	.160	4.243	.160
X	.280	3.482	.280
Y	.160	4.043	.160
Z	.280	3.242	.280
a	.440	2.642	.800
b	.800	2.642	.440
c	.440	2.642	.440
d	.440	2.642	.800
e	.440	2.642	.440
f	.400	1.681	.440
g	.440	2.642	.800
h	.800	2.642	.800
i	.800	.800	.800
j	.080	1.481	.800
k	.800	2.642	.440
l	.800	.800	.800
m	.800	4.403	.800
n	.800	2.642	.800

Character	Left (inch)	Width (inch)	Right (inch)
o	.440	2.722	.440
p	.800	2.642	.440
q	.440	2.642	.800
r	.800	2.000	.160
s	.360	2.642	.440
t	.360	2.081	.480
u	.800	2.642	.800
v	.360	3.082	.360
w	.360	4.083	.360
x	.440	3.202	.440
y	.360	3.402	.360
z	.480	2.722	.480
1	.480	1.200	.560
2	.440	3.242	.440
3	.120	3.242	.400
4	.120	3.722	.560
5	.440	3.242	.440
6	.400	3.242	.400
7	.240	3.242	.400
8	.400	3.242	.400
9	.400	3.242	.400
0	.400	3.362	.400
&	.400	3.602	.400
!	.560	.800	.560
"	.560	2.281	.560
#	.400	3.522	.400
$	.440	3.242	.440
¢	.400	2.682	.280
/	0	4.283	0
aster	.320	2.241	.320
period	.160	.800	.160
comma / apos	.160	.800	.160
colon	.160	.800	.160
(	.400	1.521	.160
)	.160	1.521	.400
hyphen	.120	1.401	.120
@	.400	4.043	.400
=	.120	2.601	.120
+	.120	2.601	.120
?	.280	2.762	.280

REFER TO FORWARD IN STANDARD ALPHABETS METRIC VERSION FOR NOTES ON APPLICATION OF SPACE VALUES

Figure 5 Series E Modified 2000 for Standard Alphabets

2.5. Site Locations

Site locations for the deployment of DMS/HAR systems were identified through field visits by FLHD, ADOT, and WTI staff. Figure 6 shows the locations of different devices in the field. Detailed information for these locations is described as follows. Refer to Appendix C for more information about candidate locations for DMS/HAR systems.

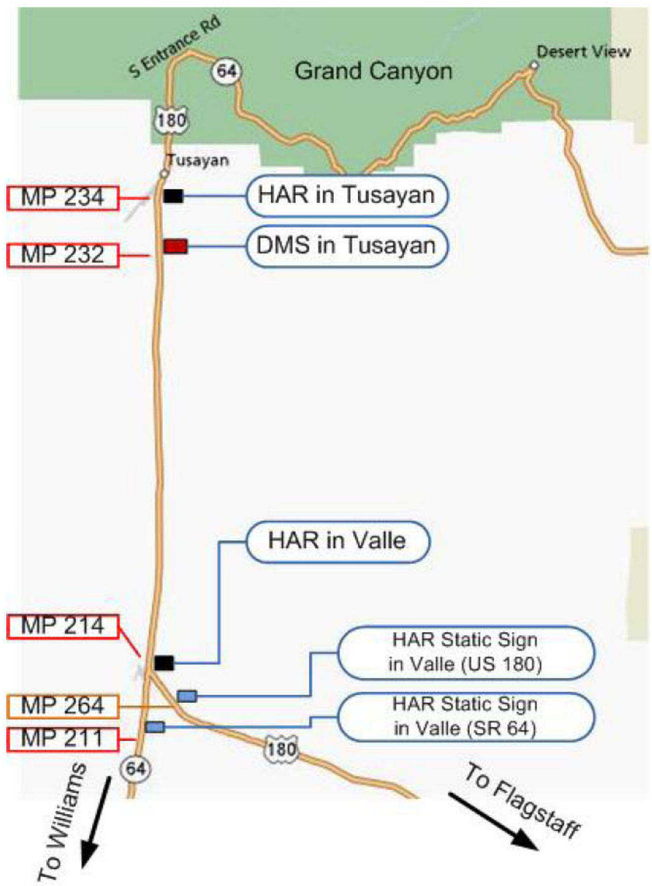


Figure 6: Site Locations on SR 64/US 180

2.5.1. DMS Location in Tusayan

The DMS can be placed at approximately 0.1-mi downstream of Mile Post (MP) 232, close to an Arizona Department of Transportation (ADOT)'s "BMS" sign on southbound of the roadway. This location is about 4 miles from Tusayan.

Figure 7: DMS Location on Site 3

2.5.2. HAR Location in Tusayan

The HAR can be placed approximately 0.4-mi upstream of MP 234 on the crest of hill, with two speed limit signs on each side of the roadway, as shown in Figure 8. It is anticipated that the placement of HAR will cover both the DMS location near MP 232 and Tusayan.

Figure 8: HAR Location on Site 3

2.5.3. HAR Location in Valle

The HAR can be placed along SR 64 near to MP 214. The figure shows the northeast area of the intersection that is within 0.1-mi north of the junction of US 180 and SR 64. Eastbound of the intersection goes to a Gas Station.

Figure 9: HAR Location in Valle (North of the Junction of SR 64/US 180)

2.5.3.1. HAR Static Sign on SR 64 in Valle

As indicated in the following picture, the HAR sign can be placed about 0.4 mile downstream of MP 211 and close to a “No Passing Zone” sign on the other side of roadway. The location should have enough distance from the shoulder.

Figure 10: HAR Static Sign Location on SR 64

2.5.3.2. HAR Static Sign Location on US 180 in Valle

The HAR sign can be placed at downstream of MP 264 and upstream of speed limit signs (northbound "Speed Limit 50" sign and southbound "Speed Limit 65" sign). The location of HAR sign should have enough distance from the northbound speed limit sign to make it visible to traffic.

Figure 11: HAR Static Sign Location on US 180

2.6. Message Display and Broadcast

All messages must be approved and prioritized according to need and chosen accordingly when an event occurs.

2.6.1. Prioritized Messages

In the occurrence of more than one event, certain events are given priority over others. The priority of event messages should be placed on DMS or broadcasted through HAR in the following order:

- Hazardous Conditions: events happening either inside the park or along SR 64/US 180
  - Extreme weather conditions
  - Fire
  - Accidents and/or emergency vehicles in a lane or on the shoulder
  - Severe congestion/traffic
- Transit Service and Parking Information
  - Full parking lots
  - Park and ride
  - Shuttle bus service
- General Information
  - Fee options
  - General Park Information

For this pilot program, shuttle bus and parking messages will be used. In addition, a message for special events (e.g., parades) is designed.

2.6.2. Approved Messages

WTI has developed DMS/HAR messages for this pilot program with the approval of GRCA. The approved messages for DMS and HAR are presented as follows. The message on HAR static signs is also described.

2.6.2.1. DMS Message

Note:

- Message 1-1 will be used 80 percent of the time
- Message 2-2 will be used 20 percent of the time such as during busy weekends and holidays. This message MUST be checked at the site to make sure all three frames can be read at the given speed limit. If all three frames cannot be read, another message will need to be chosen.

TRANSIT INFORMATION

Message 1-1:

PARK AND RIDE IN TUSAYAN	TUNE TO AMXXX

Message 1-2:

GRAND CANYON SHUTTLE	PARK AND RIDE IN TUSAYAN

PARKING INFORMATION

Message 2-1:

CANYON PARKING LIMITED	PARK AND RIDE IN TUSAYAN

Message 2-2:

CANYON PARKING LIMITED	PARK AND RIDE IN TUSAYAN	TUNE TO AMXXX

SPECIAL EVENT

Message 3-1:

SLOW TRAFFIC AHEAD	PREPARE TO STOP

2.6.2.2. HAR Message Sets

The messages for HAR broadcast in Tusayan and Valle are presented as follows:

TUSAYAN HAR

Grand Canyon National Park and the Gateway Community of Tusayan invite you to participate in a voluntary shuttle service operating between Tusayan and the park's visitor center at Canyon View Information Plaza in Grand Canyon National Park. Once there, you can take a short walk to Mather Point and the rim trail, or connect with the in-park shuttle bus system, which serves many South Rim attractions, viewpoints and visitor services.

This park and ride shuttle service will allow your party to avoid entrance lines and traffic congestion and will make it convenient and easy for you to explore Grand Canyon's South Rim in comfort. By using this service, you will also help the National Park Service preserve natural resources.

To use this service, just look for the brown signs identifying the five parking locations and shuttle stops in Tusayan including the Airport, Squire Inn, the IMAX Theater, RP's Stage Stop, and Canyon Flight Trading Company. Shuttles run between Tusayan and the park every 20 minutes from 8 am to 9 pm daily. The shuttle ride is free, but you will be required to purchase your 7-day entrance pass before boarding the bus in Tusayan. You may also use an annual or lifetime pass, such as the America the Beautiful Pass, to board the bus. Passes are available at the businesses hosting parking as well as most hotels in Tusayan. One pass will allow your entire group to ride the shuttle or may also be used to enter the park via private vehicle. Passes cost 25 dollars and may be used for multiple entries for up to seven days from purchase whether entering the park via car or shuttle. Thank you for considering this service and remember…this summer "save gas and leave the driving to us" by taking the free Grand Canyon National Park shuttle.

VALLE HAR

The following is traveler information for Grand Canyon National Park. Grand Canyon National Park and the Gateway Community of Tusayan invite you to participate in a voluntary shuttle service operating between Tusayan and the South Rim of Grand Canyon National Park. Once in the park, visitors can connect with the in-park shuttle bus system, which serves many South Rim attractions, viewpoints and visitor services. While you will still need to pay the park entrance fee, the shuttle ride is free.

This park and ride shuttle service will allow your party to avoid entrance lines and traffic congestion and will make it convenient and easy for you to explore Grand Canyon's South Rim in comfort. By using this service, you will also help the National Park Service preserve natural resources.

To use this service, just look for the brown signs identifying five parking locations and shuttle stops in Tusayan and at the Grand Canyon National Park Airport. Shuttles run every 20 minutes from 8 am to 9 pm daily with return service to Tusayan. The shuttle ride is free, but you will be required to purchase your entrance pass before boarding the bus in Tusayan. You may also use an annual or lifetime pass, such as the America the Beautiful Pass, to board the bus. Passes are available at the Valle Travel Stop, at Tusayan businesses with shuttle bus parking, as well as most hotels in Tusayan. Passes purchased are good for a total of seven days and can be used whether entering the park via car or shuttle. Thank you for considering this service and remember…this summer "save gas and leave the driving to us" by taking the free Grand Canyon National Park shuttle.

2.6.2.3. HAR Static Sign Message

Both HAR advisory signs in Valle are used to inform travelers to tune to radio for the information broadcasted by the HAR. The message that will be shown on the signs is:

GRAND CANYON	(Column "E" in Figure 4 for character size)
SHUTTLE INFO	(Column "E" for character size)
TUNE RADIO TO	(Column "G" for character size)
XXXX AM	(XXXX: Column "E" for character size; AM: Column "G")

2.6.3. Displaying/Broadcasting Messages

Messages should help motorists be aware of transit service, parking availability, hazardous conditions, and general park information. Messages displayed should convey real-time information and be simple and short in order to accommodate the vast majority of the motorists reading the sign, and help accommodate motorists with low reading skills. Each displayed message should convey a complete thought. Broadcast messages should be concise, accurate, and clear. The appropriate speed of delivery for radio messages is about 175 words per minute[4].

2.7. Documenting and Logging Messages

All DMS/HAR messages should be logged in databases. The logged messages may include the following information:

- Message displayed or broadcasted
- Reason for use
- Time message activated
- Time message deactivated
- Name of operator
- Initiating agency

These logs will help demonstrate to what extent the park is utilizing DMS/HAR and for what purposes; the logs will also provide information on whether there were multiple simultaneous requests for messages and, if so, which is given priority.

The forms for logging DMS/HAR messages are presented in Appendix B.

2.8. Deactivating Systems and Relocation

When DMS/HAR are not placed in good locations due to restricted sight distance, weak signal strength and other reasons, the systems need to be relocated for better performance. The subcontractors will be responsible for deactivating and relocating the systems. The reason, time deactivated, time re-active and other information should be documented.

3. MAINTENANCE GUIDELINES

3.1. Roles and Responsibilities

As mentioned earlier, the subcontractors will be responsible for the maintenance of DMS/HAR systems during the pilot program. The section provides general guidelines for the maintenance of DMS/HAR systems. Maintenance of systems should strictly follow the instructions provided by vendors.

3.2. Maintenance of DMS

Refer to the Wanco maintenance manuals for in-depth maintenance instructions[5]. The following is a brief summary of preventative maintenance requirements to keep the DMS, hydraulic lift, batteries and trailer in good working condition.

3.2.1. Hydraulic lift

With the sign lowered, periodically check the hydraulic fluid reservoir and add the appropriate fluid as necessary. Reference the Wanco guidelines as needed.

3.2.2. Batteries

Periodically inspect the battery terminals, clean and tighten as necessary. Check the battery fluid level monthly and fill with distilled water when needed.

3.2.3. Trailer

Check brake fluid (if applicable), tires and lug nuts, and lubricate the jack. Tire pressure should be in accordance with the manufacturers' recommendations. Periodically inspect for loose connections and hardware and tighten as required.

3.2.4. Communications and Controller

Ensure all connections for Central Processing Unit (CPU) cabinet are seated. It is convenient and generally helpful to place labels on switches and positions. Placing warning labels such as "SWITCH TO OFF POSITION TO AVOID BATTERY DRAIN" may avoid some unnecessary maintenance.

3.3. Maintenance of HAR

Maintaining the HAR system includes regular inspection of radio signal, batteries, transmitter, etc. Maintenance of HAR systems should follow the maintenance guidelines provided by the vendor. The general guidelines for maintenance are briefly described as follows.

3.3.1. Signal Inspection

Periodically (e.g., once a week) tune in to radio when traveling through the desired coverage area, especially on the edges of the area (where DMS or HAR static signs are placed), to make sure that the radio is on the air and functioning. If the radio signal drops off when approaching to the HAR station (e.g., within ½ mile away), or no signal at all, the transmitter needs to be checked and adjusted.

3.3.2. System Inspection

Regularly inspect the transmitter, power supply (e.g., solar panel), batteries, and recording device to observe any physical damage to the system or lightening damage to the antenna and other external components. Look for cables and wires that may have been damaged.

3.3.3. System Cleaning

After shutting down the system, clean dust and dirt from the surfaces of panes and components with a damp cloth or spray cleaner. If insects or other pests are in the cabinet, check for holes/entryways and seal them with silicone, or duct seal.

3.4. Contact Information

3.4.1. Info Guys

Location: Phoenix, AZ

Phone: (602)614-9494

3.4.2. Bob's Barricade

Location: Phoenix, AZ

Phone: (602)272-3434

4. DATA COLLECTION AND EVALUATION

4.1. Purpose

The primary purpose of this project is to evaluate the effectiveness of DMS/HAR systems in improving shuttle usage and visitors' experience. The evaluation of DMS/HAR systems will help GRCA recognize the usefulness of DMS/HAR systems, identify potential problems that may affect the effectiveness of systems, and guide future deployment of ITS systems.

4.2. Evaluation Methodologies

To evaluate the usefulness of the DMS/HAR systems, quantitative and qualitative methodologies are proposed as follows:

- Quantitative evaluation
  - Measure of DMS/HAR messages used
  - Shuttle usage with/without deployment of DMS/HAR systems
- Qualitative evaluation
  - On-board transit survey
  - Stakeholder survey

4.3. Roles and Responsibilities

WTI and GRCA will work together to evaluate the effectiveness of the DMS/HAR systems. The responsibilities for each agency are described as follows:

- GRCA will collect data related to the use of DMS/HAR messages and shuttle usage, carry out on-board transit survey[1], and provide traffic volume data.
- WTI will conduct stakeholder survey, analyze all necessary data (message use, shuttle usage, traffic volume, and survey results), evaluate results, and provide recommendations for future ITS deployments.

4.4. Data Collection

Based on the proposed methodologies, the requirements for collecting various data include:

- DMS/HAR Message Use: The duration for collection this type of data is from the date the DMS/HAR systems are implemented to the end date (September 1, 2008) of the pilot study. Data can be retrieved from message logs.

[1] Survey questions are developed by Nelson Nygaard, Inc. and WTI.

- Shuttle Usage: Daily transit ridership data should be collected during the whole shuttle bus pilot program (June1, 2008 to September 1, 2008).
- Daily visitor volumes for Grand Canyon National Park as a whole (South and East Entrances) for June 1 through September 1 in both 2007 and 2008.
- Daily visitor volumes for the South entrance of GRCA for June 1 through September 1 in both 2007 and 2008. If daily visitor volumes are not available, the average vehicle occupancy value is required.
- Traffic Volume: Ideally, hourly traffic volume data need to be collected at a location upstream of Tusayan on northbound of 64. In the case that traffic counter is not available at that location, hourly traffic volume data at the South Entrance will be provided. The duration of data collection is from June 1, 2008 to September 1, 2008.
- On-board Transit Survey Data: For the purpose of evaluating DMS/HAR systems, the survey will be started from the implementation of DMS/HAR systems until the end of the shuttle bus pilot program. The more the surveys are conducted, the better for evaluation.
- Stakeholder Survey: WTI will develop survey questions distribute to stakeholders about their experience with DMS/HAR systems.

APPENDIX A: OVERALL CONTACT INFORMATION

GRCA:

Primary Contact:

Vicky Stinson, 928-774-3026, victoria_stinson@nps.gov

Transportation Ambassador Contact:

Chuck Wahler, 928-638-7835, charles_wahler@nps.gov

Front Desk (for DMS change needs - 20% of time):

928-638-7771

Concessions Specialist (Manager of Paul Revere Transportation Contract):

Robin Martin, 928-638-7684

Fann Contracting, Inc.:

Gary Hickman - 928-713-5769, ghickman@fanncontracting.com

Paul Revere Transportation:

Sharon Cann, 928-638-0591, scann@paulreverebuses.com

Info Guys:

(602)614-9494

Bob's Barricade:

(602)272-3434

WTI:

Steve Albert, (406)994-6126, SteveA@coe.montana.edu

Zhirui Ye (Jared), (406)994-7909, jared.ye@coe.montana.edu

Jaime Eidswick, jaime_helmuth@hotmail.com

APPENDIX B: LOG FORMS

DMS Message Log

Date	Organization Changing Message	Time Message On	Time Message Off	Message Number (if not pre-approved message, type out entire message)

HAR Message Log

Date	Location (i.e. Tusayan or Valle)	Time Message On	Time Message Off	Message Number (if not preapproved message, please type out entire message)

System Test Log

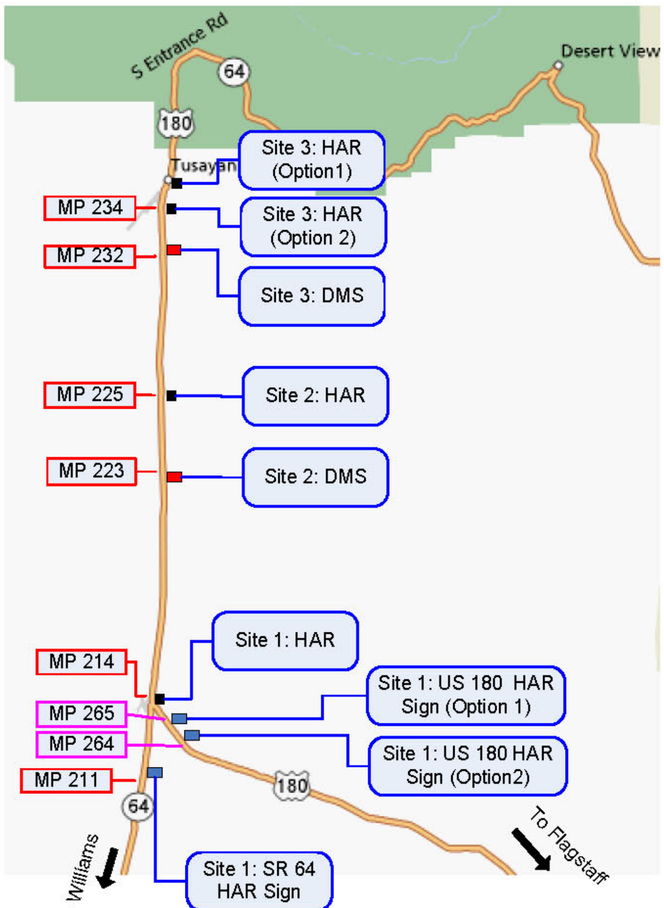
Date	Organization Testing Device	Location (i.e. Tusayan or Valle)	Device (i.e. HAR or DMS)	Time of Test	Operation (i.e. working properly or needs fixing)	Need to Contact subcontractor? (i.e. yes/no answer)	When Device Fixed (i.e. date and time)	How Device Fixed

APPENDIX C: CANDIDATE LOCATION ANALYSIS

Based on the identified goals for the use of DMS/HAR, three initial candidate sites on State Route (SR) 64 and US 180 were identified on May 15th with Federal Lands Highway Division (FLHD) and Arizona DOT staff and a subsequent May 16th field visit by WTI staff. The candidate locations were to support the pilot shuttle use versus traffic management or other strategies. The three recommended locations are:

- Site 1: In the city of Valle near the junction of US 180 and SR 64
- Site 2: MP 223 to 225 on SR 64
- Site 3: Between MP 232 and Tusayan

The following figure and table provide detailed information on the locations of different devices in the field. Combination of ITS devices (e.g., HAR and static sign, DMS and HAR) may be used for each site.



Candidate Locations for DMS/HAR Deployment

Description of Candidate Locations

Site No.	Equipment	Location	Description	Cellular Coverage[2]
1	HAR	In the city of Valle, close to Mile Post (MP) 214		Good (3 bars)
	HAR Sign on SR 64	Downstream of MP 211, about 2.5 upstream of the junction of US 180 and SR 64	On the crest of a little hill and close to a "No Passing Zone" sign on the other side of roadway	Fair ~ Good (2 – 3 bars)
	HAR Sign on US 180 (Option 1)	Upstream of MP 265, about 1 mile away from the junction of US 180 and SR 64	Upstream of the "Grand Canyon Inn" billboard; upstream from sign clutter	Good (3 bars)
	HAR Sign on US 180 (Option 2)	Downstream of MP 264	Upstream of two speed limit signs (speed limits 50 and 65) on both sides	Good (3 bars)
2	DMS	Just upstream of MP 223	Close to the "Fly Grand Canyon Airlines" billboard	Fair (2 bars)
	HAR	MP 225	On the crest of hill; better to be placed on Southbound with flatter ground	Fair ~ Good (2 – 3 bars)
3	DMS	Just downstream of MP 232		Good (3 bars)
	HAR (Option 1)	In Tusayan	The signal may not cover the upstream DMS	Good (3 bars)
	HAR (Option 2)	About 0.4 miles upstream of MP 234	On the crest of hill; close to two speed limits signs (Speed limits 55 and 65) on both sides of roadway	Good

[2] The test of cellular communication coverage is based on the Sprint network. The coverage may vary with different cellular service vendors.

Placement on Site 1

HAR

Placement location: The HAR can be placed along SR 64 near to MP 214. The figure shows the northeast area of the intersection that is within 0.1-mi north of the junction of US 180 and SR 64. Eastbound of the intersection goes to a Gas Station.

HAR Location (North of the Junction of US 180 and SR 64)

HAR Static Sign on SR 64

Placement location: As indicated in the following picture, the HAR sign can be placed about 0.4 mile downstream of MP 211 and close to a "No Passing Zone" sign on the other side of roadway. The location should have enough distance from the shoulder.

HAR Static Sign Placement on SR 64

HAR Sign with Flashing Beacon on US 180 (Option 1)

Placement location: The HAR sign can be placed upstream of MP 265 on US 180 and the "Grand Canyon Inn" billboard, with enough distances from the shoulder and between each sign to keep the billboard visible to traffic. The location is approximately 1 mile from the intersection of US 180 and SR 64.

HAR Static Sign Placement on US 180 (Option 1)

HAR Static Sign on US 180 (Option 2)

Placement location: The HAR sign can be placed at downstream of MP 264 and upstream of speed limit signs (northbound “Speed Limit 50” sign and southbound “Speed Limit 65” sign). The location of HAR sign should have enough distance from the northbound speed limit sign to make it visible to traffic.

HAR Static Sign Placement on US 180 (Option 2)

Placement on Site 2

DMS

Placement location: The DMS can be placed upstream of MP 223 and close to the "Fly Grand Canyon Airlines" billboard, as indicated in the following figure.

DMS Placement on Site 2

HAR

Placement location: The HAR can be placed near MP 225, which is on the crest of hill. Considering that southbound roadside is flatter than northbound and has fewer trees on road side, the HAR is proposed to be placed on southbound, close to the "Right Lane Ends" sign, as indicated in the following figure.

HAR Placement on Site 2

Placement on Site 3

DMS

Placement location: The DMS can be placed at approximately 0.1-mi downstream of MP 232, close to an Arizona Department of Transportation (ADOT)'s "BMS" sign on southbound of the roadway. This location is about 4 miles from Tusayan.

DMS Placement on Site 3

HAR (Option 1)

Placement location: The HAR can be placed in Tusayan. However, it was perceived that the HAR may not cover 4 miles downstream (where the DMS is placed) or have weak signal due to hilly terrain in this area. Thus, the following option 2 is also proposed.

HAR (Option 2)

Placement location: The HAR can be placed approximately 0.4-mi upstream of MP 234 on the crest of hill, with two speed limit signs on each side of the roadway, as shown in Figure 8. It is expected that the placement of HAR will cover both the DMS location near MP 232 and Tusayan.

HAR Placement on Site 3 (Option 2)

REFERENCES

1 Federal Highway Administration, "Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways, 2003 Edition," 2003.

2 http://www.fcc.gov/

3 I-95 Corridor Coalition, "Coordinated VMS/HAR Strategies, Task 2: VMS/HAR Operations Guidelines and Recommended Practices," Final Report No. I-95 CC 9-95-09, June 1995.

4 Oregon Department of Transportation, "Guidelines for the Operations of Highway Advisory Radio and Travelers Advisory Radio on State Highways," June 2006.

5 http://www.wanco.com/contact.htm

APPENDIX B: ENCROACHMENT PERMIT

Note: The Encroachment Permit is available from Victoria Stinson at Grand Canyon National Park, Victoria_Stinson@nps.gov, (928) 774-3026.

APPENDIX C: APPROVED HAR MESSAGES

Tusayan HAR

This is traveler information for Grand Canyon National Park. Grand Canyon National Park and the Gateway Community of Tusayan invite you to participate in a voluntary shuttle service running from Tusayan to the Canyon View Information Plaza, Grand Canyon’s main visitor center. Once you arrive at the Canyon View Information Plaza in Grand Canyon, there are three additional shuttle routes, which will take you to popular park locations around the south rim. While you will still need to pay the park entrance fee, the shuttle ride is free.

This park-and-ride shuttle service will make it convenient and easy for you to explore Grand Canyon’s South Rim in comfort. By using this service, you will also help the National Park Service preserve the natural resources of America by reducing the carbon footprint created by personal vehicles.

To use this service, just look for the brown signs identifying parking locations and shuttle stops in Tusayan, including the Airport, Squire Inn, the IMAX Theater, RP’s Stage Stop, and Canyon Flight Trading Company. Shuttles run every 20 minutes from 8 a.m. to 9 p.m. daily with return service to Tusayan. The shuttle ride is free, but you will be required to purchase your entrance pass before boarding the bus in Tusayan. If you do not already have an America the Beautiful pass, remember to purchase your entrance pass. Passes are available at the businesses hosting parking as well as most hotels in Tusayan. Passes purchased are good for a total of seven days and can be used whether entering the park via car or shuttle. Thank you for considering this service and remember…this summer “save gas and leave the driving to us” by taking the free Grand Canyon National Park shuttle.

Valle HAR

This is traveler information for Grand Canyon National Park. Grand Canyon National Park and the Gateway Community of Tusayan invite you to participate in a voluntary shuttle service running from Tusayan to the Canyon View Information Plaza, Grand Canyon’s main visitor center. Once you arrive at the Canyon View Information Plaza in Grand Canyon, there are three additional shuttle routes, which will take you to popular park locations around the south rim. While you will still need to pay the park entrance fee, the shuttle ride is free.

This park-and-ride shuttle service will make it convenient and easy for you to explore Grand Canyon’s South Rim in comfort. By using this service, you will also help the National Park Service preserve the natural resources of America by reducing the carbon footprint created by personal vehicles.

To use this service, just look for the brown signs identifying parking locations and shuttle stops in Tusayan. Shuttles run every 20 minutes from 8 a.m. to 9 p.m. daily with return service to Tusayan. The shuttle ride is free, but you will be required to purchase your entrance pass before boarding the bus in Tusayan. If you do not already have an America the Beautiful pass, remember to purchase your entrance pass. Passes are available at the gas station in Valle, at the businesses hosting parking, as well as most hotels in Tusayan. Passes purchased are good for a total of seven days and can be used whether entering the park via car or shuttle. Thank you for considering this service and remember…this summer “save gas and leave the driving to us” by taking the free Grand Canyon National Park shuttle.

APPENDIX D: APPROVED PDMS MESSAGES

Message 1-1 will be used 80 percent of the time.

Message 2-2 will be used 20 percent of the time such as during busy weekends and holidays. This message MUST be checked at the site to make sure all three frames can be read at the given speed limit. If all three frames cannot be read, another message will need to be chosen.

TRANSIT INFORMATION

Message 1-1:

PARK AND	TUNE
RIDE IN	TO
TUSAYAN	AMXXX

Message 1-2:

GRAND	PARK AND
CANYON	RIDE IN
SHUTTLE	TUSAYAN

PARKING INFORMATION

Message 2-1:

CANYON	PARK AND
PARKING	RIDE IN
LIMITED	TUSAYAN

Message 2-2:

CANYON	PARK AND	TUNE
PARKING	RIDE IN	TO
LIMITED	TUSAYAN	AMXXX

SPECIAL EVENT

Message 3-1:

SLOW	PREPARE
TRAFFIC	TO
AHEAD	STOP

APPENDIX E: HAR MESSAGE LOG

Date	Location (i.e., Tusayan or Valle)	Time Message On	Time Message Off	Message Number* (if not pre-approved message, please type out entire message)

APPENDIX F: DMS MESSAGE LOG

Date	Organization Changing Message	Time Message On	Time Message Off	Message Number (if not pre-approved message, type out entire message)

REFERENCES

1 Research and Innovative Technology Administration (RITA) ITS Benefits, Costs, and Lessons Learned Database. http://www.benefitcost.its.dot.gov/. Accessed March 1, 2009.

2 Ye, Z., J. Eidswick, and S. Albert. Grand Canyon National Park Dynamic Message Sign/Highway Advisory Radio Operations Plan, prepared for Grand Canyon National Park, Federal Lands Highway Division, June 2008.

3 Nelson Nygaard Consulting Associates. Grand Canyon National Park Tusayan Pilot Shuttle Evaluation, prepared for Grand Canyon National Park, Federal Lands Highway Division, November 2008.

4 Research and Innovative Technology Administration (RITA) ITS Benefits, Costs, and Lessons Learned Database. http://www.benefitcost.its.dot.gov/. Accessed March 1, 2009.

5 InfoGuys 2009, email 6 March <info@goinfoguys.com>.