# 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.


**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.

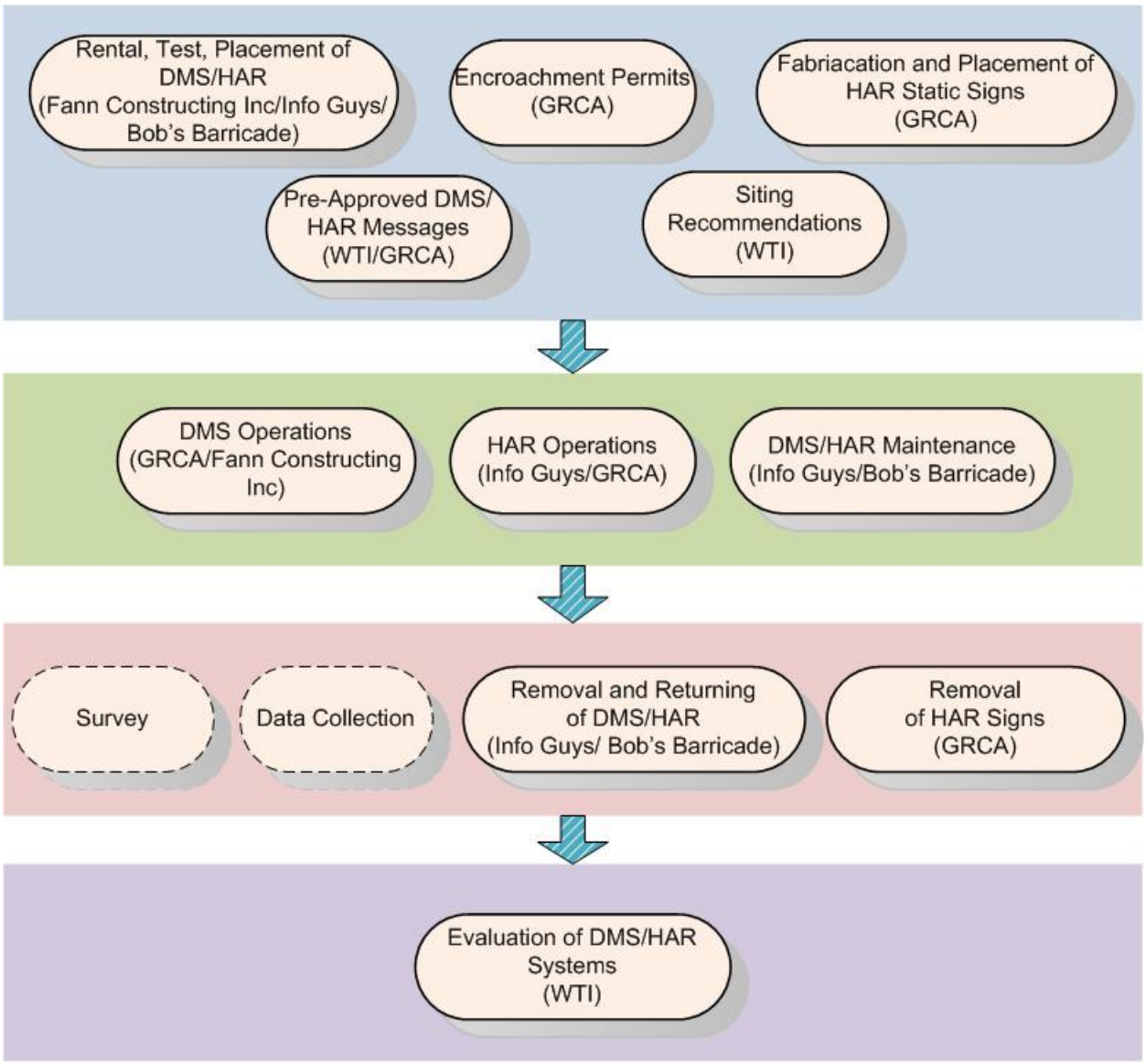



**Figure 2: Execution of DMS/HAR Operations Plan**

## 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:

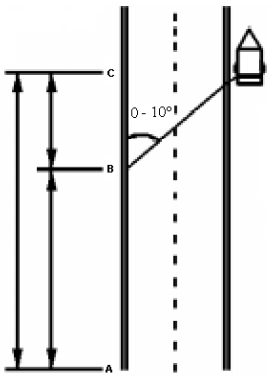
- Portable DMS shall automatically adjust their brightness under varying light conditions, to maintain legibility
- The control system shall include a display screen upon which messages can be reviewed before being displayed on the message sign. The control system shall be capable of maintaining memory 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 85$^{th}$-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:

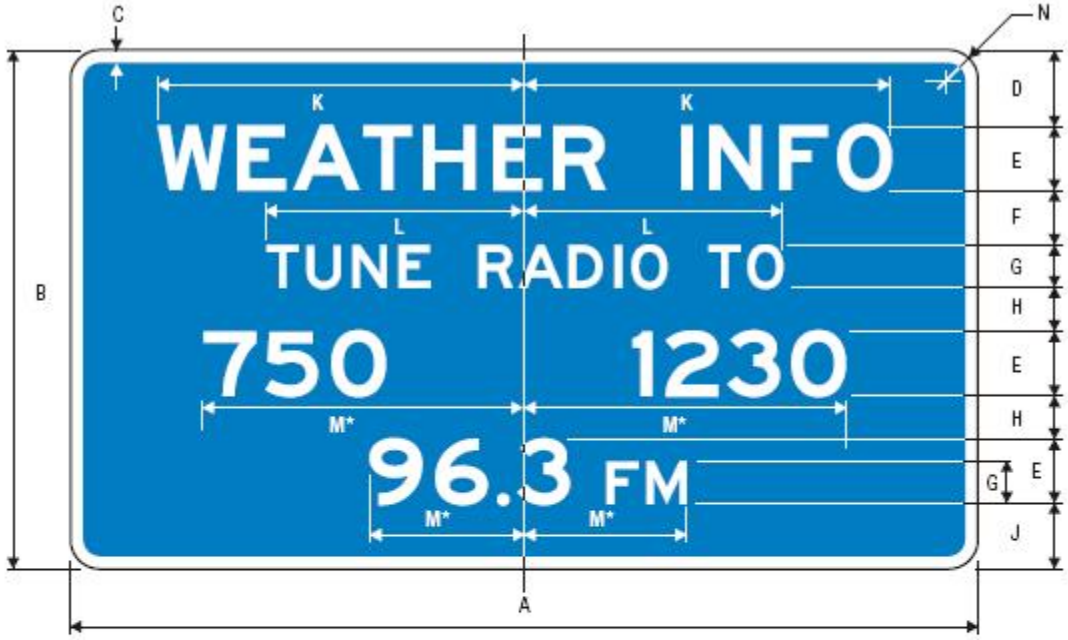
- Before deciding where to place HAR static signs, install HAR and have it operating at legal field strength. Thus, the recommended locations can be tested under working conditions.
- Drive through the HAR's coverage zone with different vehicles; range is determined in part by the types of receivers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




D12-1

WEATHER INFO

*Optically space characters about vertical centerline.

| 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

## Series E Modified 2000

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

| 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.

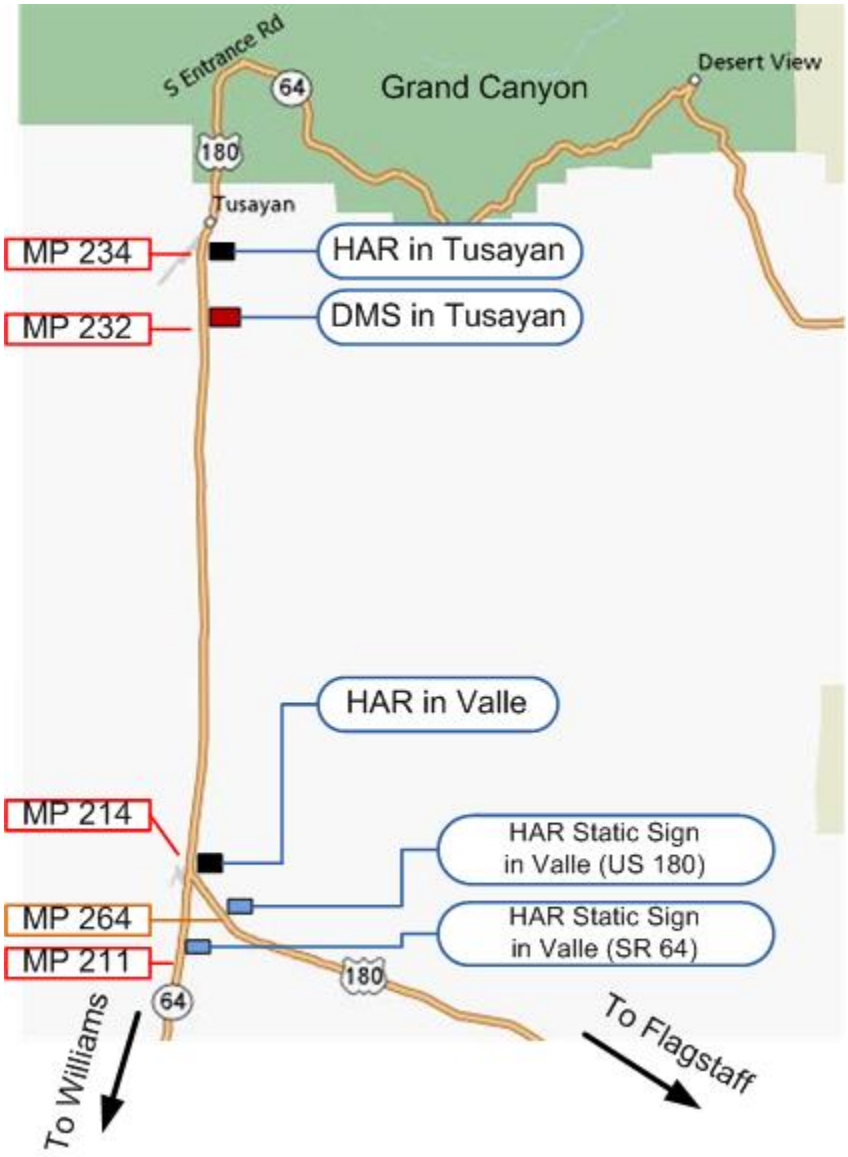



**Figure 6: Site Locations on SR 64/US 180**

### 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 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

#### 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) |
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## 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) |
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**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 |
|---|---|---|---|---|---|---|---|---|
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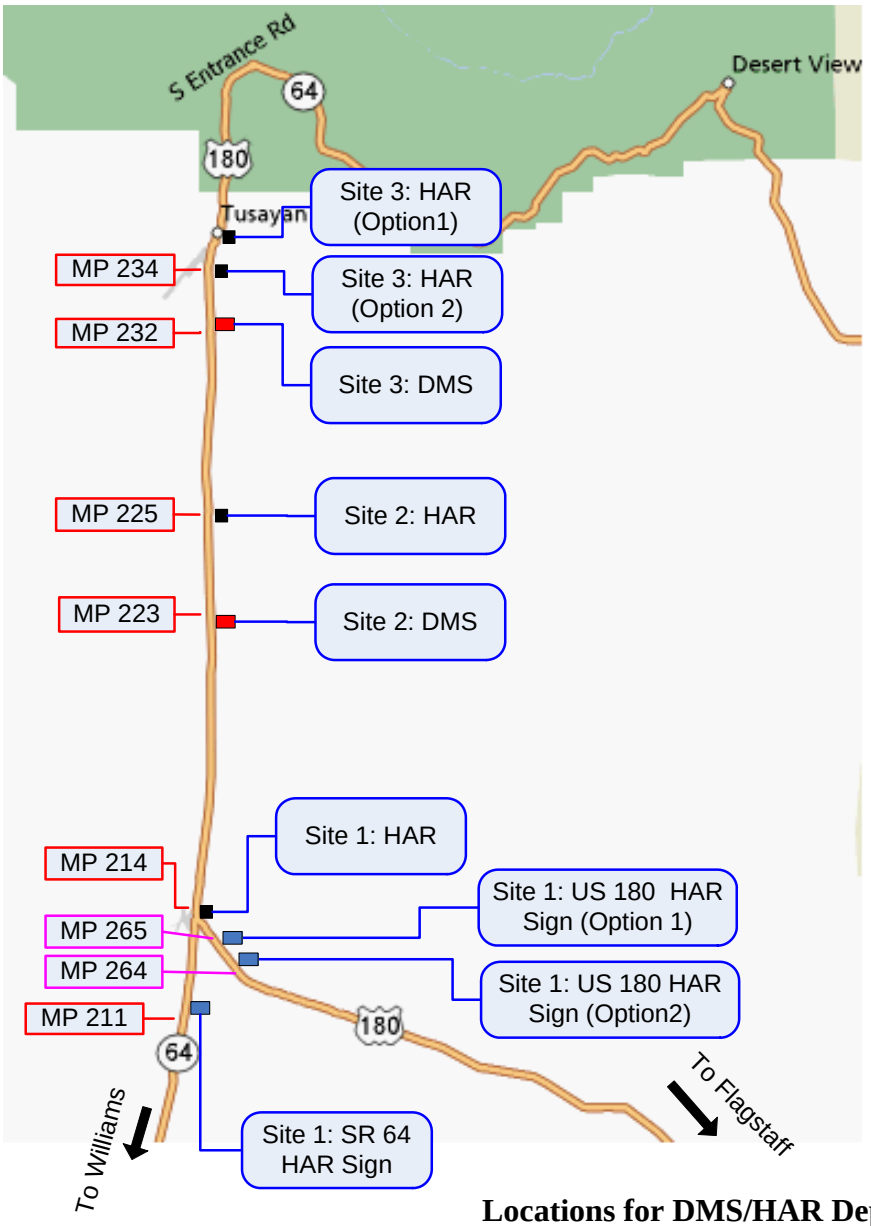
# APPENDIX C: CANDIDATE LOCATION ANALYSIS

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