

APPENDIX A – IVIS SUBSYSTEM DESCRIPTIONS

IN-VEHICLE INFORMATION SYSTEM (IVIS)

A detailed description of the information that can be provided by each of the IVIS subsystems is listed below (Wierwille, Dingus, Neale, and Gallagher, 1996).

- In-vehicle Routing and Navigational Systems (IRANS)
- In-vehicle Motorist Services and Information Systems (IM SIS)
- In-vehicle Signing and Information Systems (ISIS)
- In-vehicle Safety Advisory and Warning Systems (IVSAWS)

IN-VEHICLE ROUTING AND NAVIGATIONAL SYSTEMS (IRANS)

INFORMATION DESCRIPTION FOR TRIP PLANNING

- Current criteria for automated trip planning
- Time to get to each destination from previous destination
- Cost of each toll along the route
- Total charges along the trip
- Total time for trip
- Total distance for trip
- Location of attractions and points of interest
- Forecast weather information
- Historical traffic information
- Street or roadway names on the route
- States, regions, communities, and districts that the route will traverse
- Landmarks or topographical features along route
- Number of turns or roadway changes required
- Types of roads used on route (interstate highway, two lane street)
- Distance to each destination from previous destination

INFORMATION DESCRIPTION FOR MULTI-MODE TRAVEL COORDINATION AND PLANNING

- Bus, train, airline, ferry, and trolley schedules
- Location of park and ride facilities
- Park and ride parking facilities

- Combined travel mode schedules
- Start time required to catch other mode of transportation
- Arrival time at destination
- Arrival time at end of each segment of travel
- Layover time between travel segments
- Mode of travel to take for each segment of travel
- Current constraint or optimization criteria mode, such as cost, time, etc.
- Total time to complete travel
- Car pool instructions
- Car pool requests/inquiries
- Car pool member and address information
- Car pool member and community and district information
- Minimum layover required to make next connection
- Real time schedule updates for alternate modes of transport
- Notification of plan change to arrive at destination on time
- Interesting things to do during layover
- Alternate mode ticket purchase enroute to destination
- Schedule of segment arrival and departure times
- Order of trip segments
- States, regions, communities, and districts that the route will traverse
- Segments by type of transport mode
- Park and ride costs
- Diagrams of alternate transport mode facilities
- Parking instructions for using different travel modes
- Location of next segment of travel
- Area view of all segments of travel
- Notification of unanticipated delays
- Alternate mode of transport ticket availability

INFORMATION DESCRIPTION FOR PRE-DRIVE ROUTE AND DESTINATION SELECTION

- Listing of routes and roadway names
- Listing route available optimization routines
- Routing constraints, such as cost, time, etc.
- Distance to destination
- Time to get to destination
- Cost of completing route
- Notification of a more optimal alternative route
- Preview of proposed alternative route
- Historical congestion information
- Real time congestion information
- Location of tolls
- Weather forecast information
- Regions, communities, and districts the route will traverse
- Type of road, such as interstate, two lane, controlled access, one way, etc.
- Landmarks along route

INFORMATION DESCRIPTION FOR DYNAMIC ROUTE SELECTION

- Updated traffic information that might affect the driver's route
- Updated weather information that might affect the driver's route
- Notification that driver is off route
- Suggested procedure for getting back on route
- Vehicle's current position
- Weather forecast
- Cost comparisons between current and alternative routes
- Type of road, such as interstate, two lane, controlled access, one way, etc.
- Time to complete current route versus proposed route
- Directional heading information (North, south, east, west)
- Real time road surface condition information

INFORMATION DESCRIPTION FOR ROUTE GUIDANCE

- Distance to next turn
- Name of street or route to turn on
- Lane suggestion for setup of next turn
- Direction to turn
- Name of current street
- Indicate that the driver is off route
- Total distance remaining to destination
- Time to next turn at current speed
- Distance to toll booth
- Cost of toll
- Type of road, such as interstate, two lane, controlled access, one way, etc.
- Diagram of next intersection
- Maximum speed to negotiate exit ramp safely
- Directional heading (North, South, East, West)
- Total estimated time to reach destination
- Location of major landmarks (to assist driver in identifying turns)

INFORMATION DESCRIPTION FOR ROUTE NAVIGATION

- Distance to get to destination
- Time to get to destination
- Cost to get to destination
- Indicate when a driver gets off route
- Streets or roadways that make up the new route
- States, regions, communities, and districts that the route will traverse
- Landmarks or topographical features along route
- Number of turns or roadway changes required
- Areas that the new route will traverse
- Notification of incidents
- Descriptions of incidents

- Notification of accidents
- Updated weather information for the route
- Type of road surface, such as dirt, gravel, etc
- Type of road, such as interstate, two lane, controlled access, one way
- Current elevation
- Degree of curvature in the road
- Road construction
- Types of roadways and streets the new route will use
- Presentation of re-route options
- Indicate that a faster route exists

INFORMATION DESCRIPTION FOR AUTOMATIC TOLL COLLECTION

- Current toll cost
- Remaining balance in “toll” account
- Number of tolls left to be paid along the unplanned route
- Notification of successful toll charge
- Interface to buy more credits

IN-VEHICLE MOTORIST SERVICES AND INFORMATION SYSTEMS (IMSIS)

INFORMATION DESCRIPTION FOR BROADCAST SERVICES/ATTRACTIONS

- Listing of driver’s interests and preferences
- Indication of IMSIS system status (on, off, mode of operation)
- Preferences mode for which services to broadcast
- Restaurant locations and costs
- Restaurant reservation availability
- Restaurant reservation establishment
- Services information (fuel price and availability)
- Distance to attraction, restaurant, accommodation, service
- Attraction location
- Attraction description and costs

- Attraction ticket availability
- Accommodation location
- Accommodation description and costs
- Accommodation reservation availability

INFORMATION DESCRIPTION FOR SERVICES/ATTRACTIONS DIRECTORY

- Directory (index of yellow pages)
- Description of type of service/attraction provided
- List of services that are open
- Closest service
- Closest, open service
- View currently selected preferences
- Address of service/attraction
- Phone number of service/attraction
- List of alternative related services
- Restaurant locations and costs
- Restaurant reservation availability
- Restaurant reservation establishment
- Services information (fuel prices and availability)
- Attraction description and costs
- Attraction hours of operation
- Attraction restrictions
- Attraction ticket availability
- Attraction ticket purchase
- Accommodation location
- Accommodation description and costs
- Accommodation reservation availability
- Accommodation reservation establishment

INFORMATION DESCRIPTION FOR DESTINATION COORDINATION

- Confirmation of reservations
- List of other times available, if time wanted is not available
- Locate the nearest parking to destination
- Type of parking facility
- Cost of parking nearest to destination
- Is transportation available from parking to destination
- Routing from destination to parking
- Directions from parking to destination
- Payment methods supported
- Reservation details (number in party, time of arrival)
- Real time, time of arrival updates
- Diagram of parking facility
- Parking hours of operation
- Other transportation available from parking to destination
- Notification of transport arrival

IN-VEHICLE SIGNING AND INFORMATION SYSTEMS (ISIS)

INFORMATION DESCRIPTION OF DISPLAYED ROADWAY SIGN INFORMATION

- Guidance information, such as street name signs, exit numbers, mile posts, highway route markers, etc.
- Signs associated with driving to specific destinations, such as ferries, stadium, opera house, etc.
- Signs associated with driving to specific services, such as phone, food, gas, lodging, etc.
- Inform driver of potential traffic, such as truck crossing, farm machinery, pedestrian crossing, etc.
- Inform driver of changes in the roadway, such as merge signs, curve ahead, divided highway ends, etc.
- Inform driver of temporary or dynamic notification, such as road construction, traffic light ahead, etc.

- Regulatory information (driver action required) -- stop sign, wrong way, left lane closed ahead, speed limit
- Inform driver of distance to sign or point in question
- Filtering status of system (status mode)

IN-VEHICLE SAFETY ADVISORY AND WARNING SYSTEMS (IVSAWS)

INFORMATION DESCRIPTION FOR HAZARD WARNING

- Inform driver of the location of the hazard
- Inform driver of the distance to the hazard
- Inform driver if a route is available that would avoid the hazard
- Inform driver of the type of hazard
- Inform driver of the approach of emergency vehicles
- Warn driver of accident immediately ahead
- Warn driver of a stopped school bus ahead
- Inform driver of the location of specific localized incidents
- Location of the vehicle
- The status of the hazard
- Inform the driver of action required to get out of the emergency vehicle's way

INFORMATION DESCRIPTION FOR ROAD CONDITION INFORMATION

- Inform driver of road traction
- Informs driver of road visibility
- Informs driver of road construction activity
- Informs driver of weather conditions
- Distance to congestion or construction activity
- Suggestions for driving in visibility or weather conditions
- Inform driver of any relevant information regarding bridges, such as one lane bridge or icing.
- Inform driver of strong cross winds
- Type of road surface, such as dirt, gravel, paved

- Inform driver if water is flowing over road

INFORMATION DESCRIPTION FOR AUTOMATIC AID REQUEST

- Location information
- Inform driver of time until emergency unit will arrive
- Inform driver that aid has been requested

INFORMATION DESCRIPTION FOR MANUAL AID REQUEST

- Location information
- Inform driver of time and distance until emergency unit will arrive
- Phone number of fire, ambulance, police, towing
- Inform driver that phone will automatically dial requested aid if desired
- Display messages from the emergency response center
- Update real time information from the emergency center

INFORMATION DESCRIPTION FOR VEHICLE CONDITION MONITORING

- Inform the driver of current problems
- Inform driver of ways to correct problem
- Inform driver of actions to take until problem can be corrected
- Provide more detailed information at drivers request
- Inform the driver of potential problems
- Inform the driver of needed warranty services due
- Inform the driver of immediate danger after an accident, such as “the car is in danger of exploding”
- Coordination information with a service center

APPENDIX B – HCI GUIDELINES

Table B.1. Eight golden rules of dialogue design (Shneiderman, 1992).

Rule	Description
Strive for consistency	Use consistent sequence of actions in similar situations; identical terminology; consistent commands
Enable frequent users to use	As frequency of use increases, so does user's desire to reduce number of interactions and speed up interactions
Offer informative feedback	For every operator action, there should be some system feedback
Design dialogs to yield closure	Sequence of actions should be organized into groups with a beginning, middle, and end
Offer simple error handling	Design the system so that the user cannot make a serious error
Permit easy reversal of	Actions should be reversible
Support internal locus of control	Avoid acausality; convey to users that they are in charge of the system
Reduce short-term memory	Keep displays simple For example, consolidate multiple pages; provide on-line access to abbreviations

Table B.2. Data display guidelines (Lockhead, as cited in Shneiderman, 1992).

Data Display Guidelines
Be consistent in labeling and graphic conventions
Standardize abbreviations
Use consistent format in all displays
Present a page number on each display page, and allow actions to call up a page via entry or page number
Present data only if they assist the operator
Present information graphically, where appropriate
Present digital values only when knowledge of numerical values is necessary/useful
Use high-resolution monitors
Design a display in monochromatic form, using spacing and arrangement for organization, and then add color where it will aid the user
Involve operators in the display development

Table B.3. Data entry guidelines (Sneiderman, 1992).

Data Entry Guidelines	Description
Consistency of data entry transactions	Use similar sequences of actions for all conditions For example, use similar abbreviations
Minimal input actions by user	Fewer input actions mean greater operator productivity and few chances for error; avoid redundant data entry
Minimal memory load on user	Operator should not be required to remember long lists
Compatibility of data entry with data display	Format of data entry should be linked to format of displayed information
Flexibility for user control and data entry	Experienced operators may prefer to enter information in a sequence that they can control

Table B.4. Effective wording guidelines (Brown, 1988).

Wording Guidelines	
Use abbreviations only if they are significantly shorter	Use meaningful codes
Use only one abbreviation for a word	Use familiar terms
Use consistent abbreviation rules	Define terms carefully
Provide a dictionary of definitions	Minimize jargon
Abbreviate only when necessary	Use consistent wording
Avoid obscure abbreviations	Use unambiguous words
Avoid multiple abbreviations	Use short simple sentences
Define abbreviations on the same screen	Begin sentences with the main topic
Regarding hyphenation, end lines with whole words	Use affirmative statements
Complete a sentence on the same screen	Use consistent statement structure
Present information in the form that it is used	State sentences in the active voice
Follow appropriate user conventions	Describe steps in order of use
Use clear labels to describe data	Use a conversational language style
Use consistent codes	

**APPENDIX C – SPECIFICATIONS FOR TEXT AND ICONS PRESENTED
ON IVIS DISPLAYS**

The following sections provide the specifications of the presentation of information on the visual display.

TABLE AND PARAGRAPH FORMATS

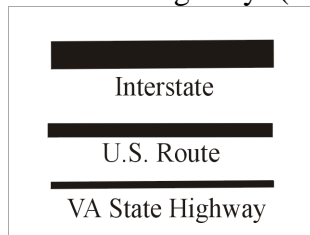
Font Size: Headings-36 point, Body-18 point
Font Type: Courier New

GRAPHIC MAP FORMATS

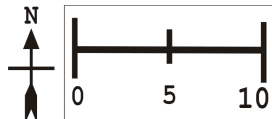
GENERAL INFORMATION FOR BOTH GRAPHIC TEXT AND GRAPHIC ICON

Width of Roadways

Interstate: 12 point
U.S. Routes (4-lane roads): 6 point
VA. State Highways (2-lane roads): 3 point



Distance



Map distance scale and North arrow located in bottom left corner of display

Route Number Icons

Icon size: 0.38" x 0.38"
Font size: 22 point
Font type: Courier New



Interstate



U.S. Route



VA. State Highway

Current Location on Map Indicator



Icon size: 0.69" x 0.65"

Indicates Location of Hotel on Map



Icon size: 0.318" x 0.318"

Indicates Location of Gas Station on Map



Icon size: 0.25" x 0.25"

GRAPHIC TEXT

Hotel Information

Font Size: Headings - 24 point, Body -18 point

Font Type: Courier New

Ramada
Vacancy
\$195.00
Four star
Restaurant
18 miles

Route Information

Font Size: 18 point

Font Type: Courier New

Height of single line text box: 0.32"

Height of double line text box: 0.55"

Width of text box: varies, depends on length of text.

Traffic Delays

15 min

Length of delay
specified in minutes

School Bus

Description of delay
specified

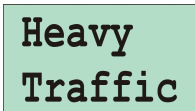
.75" of roadway is highlighted in orange, text states either the exact length of delay or states the type of delay

Traffic Safety Hazards



0.75” of roadway is highlighted in yellow, text states type of hazard

Traffic Density

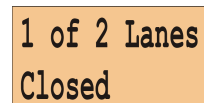


.75” of roadway is highlighted in light green block, text states amount of traffic density (light, moderate, heavy)

Other Text Messages



Indicates amount of congestion caused by a delay. Specified as light, moderate, or heavy.



Indicates the number of lanes closed/blocked, in the driver’s direction of travel, as a result of a delay.



Indicates location of hospital.



Indicates location of airport.



Indicates location of gas station.

GRAPHIC ICON

Hotel Information

Hotel Names



Icon size: 0.694” x 0.694”
Marriott
Hotel



Double-Tree
Hotel



Hilton
Hotel



Sheraton
Hotel



Comfort
Inn



Embassy
Suites



Best Western
Hotel

Hotel Characteristics



Icon size: 0.281" x 0.281"
Vacancy



No Vacancy



Restaurant



No Restaurant

Symbol height: 0.281"

\$ — \$\$\$\$\$\$ Cost (1-5 levels of expense; 1 low, 5 high)

☆ — ☆☆☆☆☆ Quality rating (1-5 star rating; 1 low, 5 high)



Hotel Box Descriptor (Icons and symbols used to describe hotels were placed in a box and located with the appropriate hotel name icon)

Route Information

Traffic Delay Icons

Icon size: 0.6" x 0.6"



Accident



Fire Truck



Construction
Flagman



Construction
Work



Farm
Machinery



Traffic
Signal



Railroad
Crossing



Heavy Truck
Traffic



20 min Delay

Traffic Hazard Icons

Icon size: 0.6" x 0.6"



Slippery Road



Pedestrian Crossing



Deer Crossing



School Crossing



Icy Bridge

Other Icons

Icon size: Gas stations, tolls, hospital, traffic density: 0.6" x 0.6";

Lanes closed – 0.372" x 0.772" two lane roads; and

Lanes closed – 0.372" x 0.331" one lane roads.



Gas Station



No Gas



Toll Road



No Tolls



Hospital



1 of 2
Lanes
Closed



2 of 2
Lanes
Closed



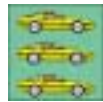
1 of 1
Lane
Closed



Low
Traffic
Density



Medium
Traffic
Density



High
Traffic
Density



Length of roadway
highlighted in red
indicates the amount of
congestion caused by a
delay

APPENDIX D – SPECIFICATIONS FOR EXPERIMENTAL VEHICLE

An instrumented 1995 Oldsmobile Aurora four-door sedan (Figure D.1) was used to investigate on-road driver behavior. Details for the following components of the experimental vehicle are listed below:

- 1) Cameras and sensors,
- 2) Software and hardware interfaces for data collection,
- 3) An in-vehicle information system (IVIS), and
- 4) Safety considerations.

CAMERAS AND SENSORS

The vehicle was instrumented with cameras and sensors to monitor and record driver behavior.

Cameras were positioned to monitor and record:

- 1) Eye glance movements of the driver,
- 2) Forward roadway,
- 3) Position of the vehicle relative to the lane markers, and
- 4) Information being displayed on the IVIS.

Sensors were installed to monitor and record the following measures:

- 1) Longitudinal and lateral accelerations of the vehicle,
- 2) Speed of the vehicle,
- 3) Steering wheel position,
- 4) Headway distance, and
- 5) In-vehicle auditory sounds.

Each of these cameras and sensors are discussed in more detail below.

EYE GLANCE CAMERA

The eye glance camera allowed for monitoring of eye movements. Its field-of-view accommodated drivers of varying heights and seat positions. The view of the driver's eyes was clear and in focus, allowing for eye movement classification in the laboratory. The eye glance camera was located in the center rear-view mirror and did not obscure the driver's view or impair his/her use of the mirror.

FORWARD-VIEW CAMERA

The forward-view camera provided a wide view of the forward roadway without substantial distortion. The camera had an auto-iris and provided a high-quality picture in all but the most severe daylight glare conditions. The forward-view camera was located in the center rear-view mirror and did not obscure any part of the driver's view of the roadway or impair his/her use of the mirror.

LANE MARKER CAMERA

The lane marker camera provided a view of the right side roadway, along the outside edge of the right front tire. The lane marker camera was located inside the right side passenger mirror. The camera did not obscure the driver's view of the roadway nor did it interfere with his/her use of the mirror.

INTERIOR CAMERA

The interior camera provided a view of the dashboard, steering wheel, and IVIS display. The interior camera was located above the driver's head, mounted in the interior of the vehicle. This camera did not interfere with the driver's sitting position and was only noticeable upon close inspection of the vehicle's interior.

SENSORS

Sensors measured steering wheel position, lateral and longitudinal accelerations, speed, and headway distance. The steering wheel sensor provided steering position data accurate to within +/- 1 degree. The accelerometers provided values at a rate of 10 times per second for vehicle acceleration and deceleration, up to and including hard braking behavior as well as intense turning. An Eaton Vorad radar system was used to measure headway distance and had a range of 3-350 feet. A microphone was located in the dashboard, and an audio track of the videotape record contained commentary of the experimenter, driver communication, and IVIS-generated audio.

SOFTWARE AND HARDWARE INTERFACES

Data received from the cameras and sensors were time stamped and recorded both on a videotape and in a data file on a computer installed in the vehicle. The IVIS was controlled by a second computer installed in the vehicle, which was responsible for both presenting information on the IVIS display and signaling the confederate vehicle that information was being displayed. The software and hardware interfaces utilized are discussed below.

MULTIPLEXER AND PC-VCR

A quad-multiplexer integrated the four camera views and included a time stamp onto a single videotape record. A PC-VCR received a time stamp from the data collection computer and displayed the time stamp continuously on the multiplexed view of the videotaped record. The PC-VCR operated in an S-VHS format so that each multiplexed camera view had 200 horizontal lines of resolution.

DATA COLLECTION SYSTEM

The vehicle's data collection system provided the capability to store, on a computer, multiple data inputs at a rate of 0.1 seconds during each data run. The videotape record of the camera views was time stamped and synchronized with the computer data stream so that post-test data reduction and data set merging could occur in the laboratory. All data collection records were time stamped to an accuracy of +/- 0.1 seconds.

COMMUNICATIONS EQUIPMENT

A small FM band transmitter/receiver unit was used to communicate with the confederate vehicle. When a key was depressed on the experimenter's keyboard to activate/deactivate the IVIS, the transmitter sent a signal that instantaneously activated a buzzer in the confederate vehicle.

EXPERIMENTER DATA FLAG INPUT SWITCH

A button was located in the front passenger seat area that, when depressed, flagged the data set. This allowed the experimenter to flag the occurrence of unusual/unexpected events for later analysis, such as an ambulance passing, or the experimenter hitting the emergency brake pedal.

IN-VEHICLE INFORMATION SYSTEM (IVIS)

Specifications for the IVIS used in this study are located in Table D.1.

Table D.1. Mechanical specifications of the Dolch Computer Systems, Inc. 10-inch VGA DataView Display.

Parameter	Specification
Display Addressability	640 x 480 pixels
Active Viewing Area	8.31" x 6.24" (211.2mm x 158.4mm)
Diagonal of Viewing Area	10.4" (26cm)
Display Technology	TFT Active Matrix
Colors	262,144 (R/G/B 6 bits each)
Contrast Ratio	100:1 Typ.
Vertical Viewing Area	10 ⁰ center-to-top/ 30 ⁰ center-to-right
Horizontal Viewing Area	40 ⁰ center-to-left/ 40 ⁰ center-to-right
Luminance	70 cd/m ² Typ.
Lamp MTBF	10,000 POH
Response Time	30ms Typ.
Faceplate Material	Tempered antiglare glass: 60 +/- 20 Gloss Units (per ASTM D 1003) Thin film anti-reflective coating

SAFETY CONSIDERATIONS

The following safety precautions were provided as part of the instrumented vehicle system to help minimize risks to participants during the experiment:

- All data collection equipment was mounted such that it did not pose a hazard to the driver in any foreseeable instance.
- The test vehicle had driver-side and passenger-side air bags.
- An experimenter's brake pedal was mounted in the front passenger side.
- A fire extinguisher, first aid kit, and cellular phone were located in the test vehicle.
- None of the data collection equipment interfered with any part of the driver's normal field-of-view.
- Two trained experimenters were present in the test vehicle at all times.

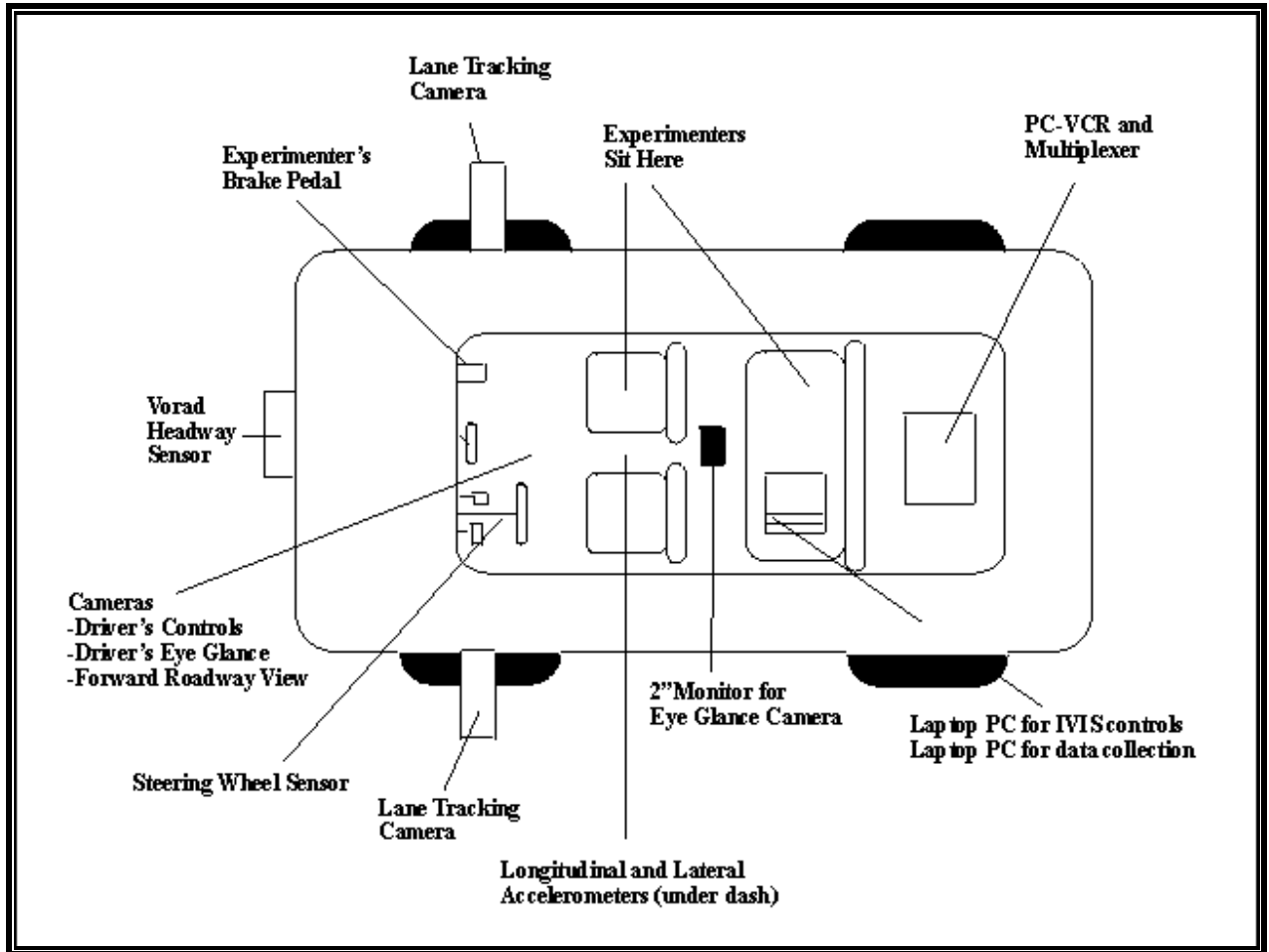


Figure D.1. Diagram of the instrumented vehicle.

APPENDIX E – IVIS DISPLAYS PRESENTED

Hotels On-route

The Sleep Inn is 46 miles away. The Super 8 Hotel is 22 miles away. The Double Tree is 34 miles away.

Low density (3x2)

Hotels On-route

The Ramada has no vacancy and is 17 miles away. The Holiday Inn has a vacancy and is 25 miles away. The Marriott has a vacancy and is 43 miles away.

Medium density (3x3)

Hotels On-route

The Hotel 8 has a vacancy, costs \$52, and is 198 miles away. The Ramada has no vacancy, costs \$59, and is 200 miles away. The Holiday Inn has no vacancy, costs \$64, and is 128 miles away. The Howard Johnson has a vacancy, costs \$75, and is 149 miles away. The Best Western has no vacancy, costs \$84, and is 201 miles away.

High density (5x4)

Figure E.1. Paragraph format — SP-hotel tasks.
Instructions: Select a hotel.

Hotels On-route	
Name	Distance
Sleep Inn	91
Howard Johnson	34
Kamada	17

Low density (3x2)

Hotels On-route		
Name	Vacancy	Distance
Best Western	Yes	18 miles
Marriott	No	35 miles
Sheraton	Yes	58 miles

Medium density (3x3)

Hotels On-route			
Name	Vacancy	Cost	Distance
Marriott	Yes	\$85	32 miles
Howard Johnson	No	\$65	47 miles
Comfort Inn	Yes	\$58	59 miles
Kamada	Yes	\$125	29 miles
Holiday Inn	No	\$55	99 miles

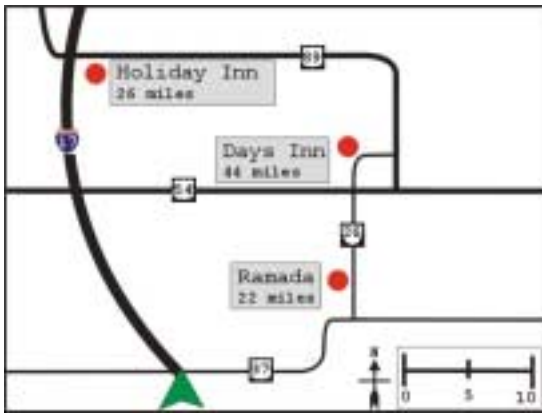
High density (5x4)

Hotels On-route					
Name	Vacancy	Cost	Rest- aurant	Quality Rating	Distance
Kamada	Yes	\$90	Yes	3 star	60 miles
Howard Johnson	Yes	\$65	No	2 star	88 miles
Sheraton	No	\$145	Yes	4 star	52 miles
Sleep Inn	Yes	\$75	No	2 star	91 miles
Best Western	No	\$60	Yes	3 star	15 miles

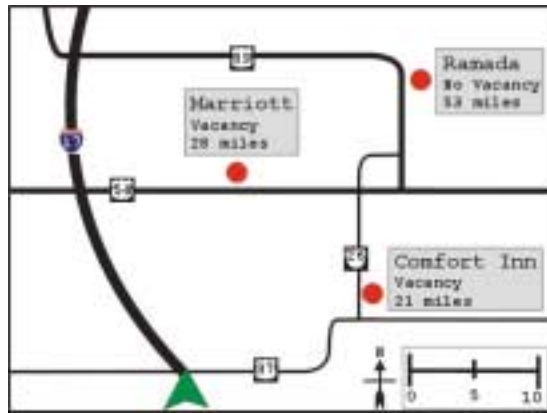
Very high density (5x6)

Figure E.2. Table format — SP-hotel tasks.

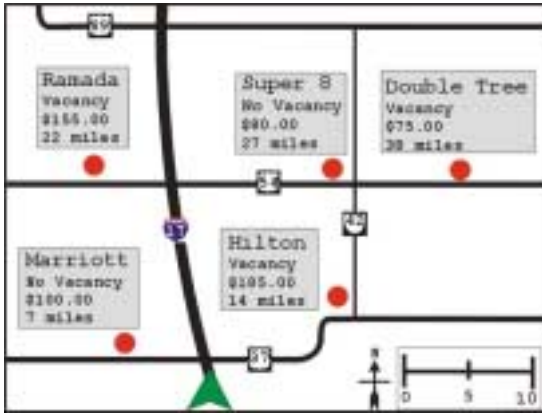
Instructions: Select a hotel.



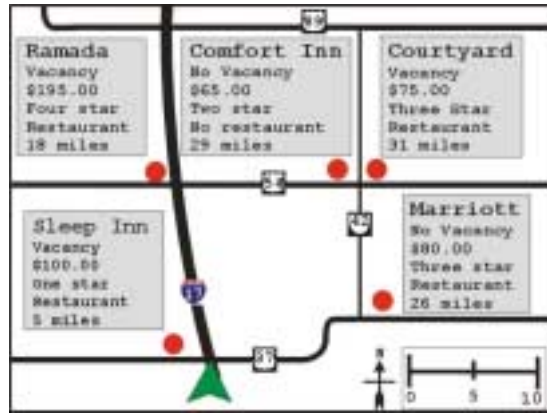
Low density (3x2)



Medium density (3x3)



High density (5x4)



Very high density (5x6)

Figure E.3. Graphic text format — SP-hotel tasks.
Instructions: Select a hotel.

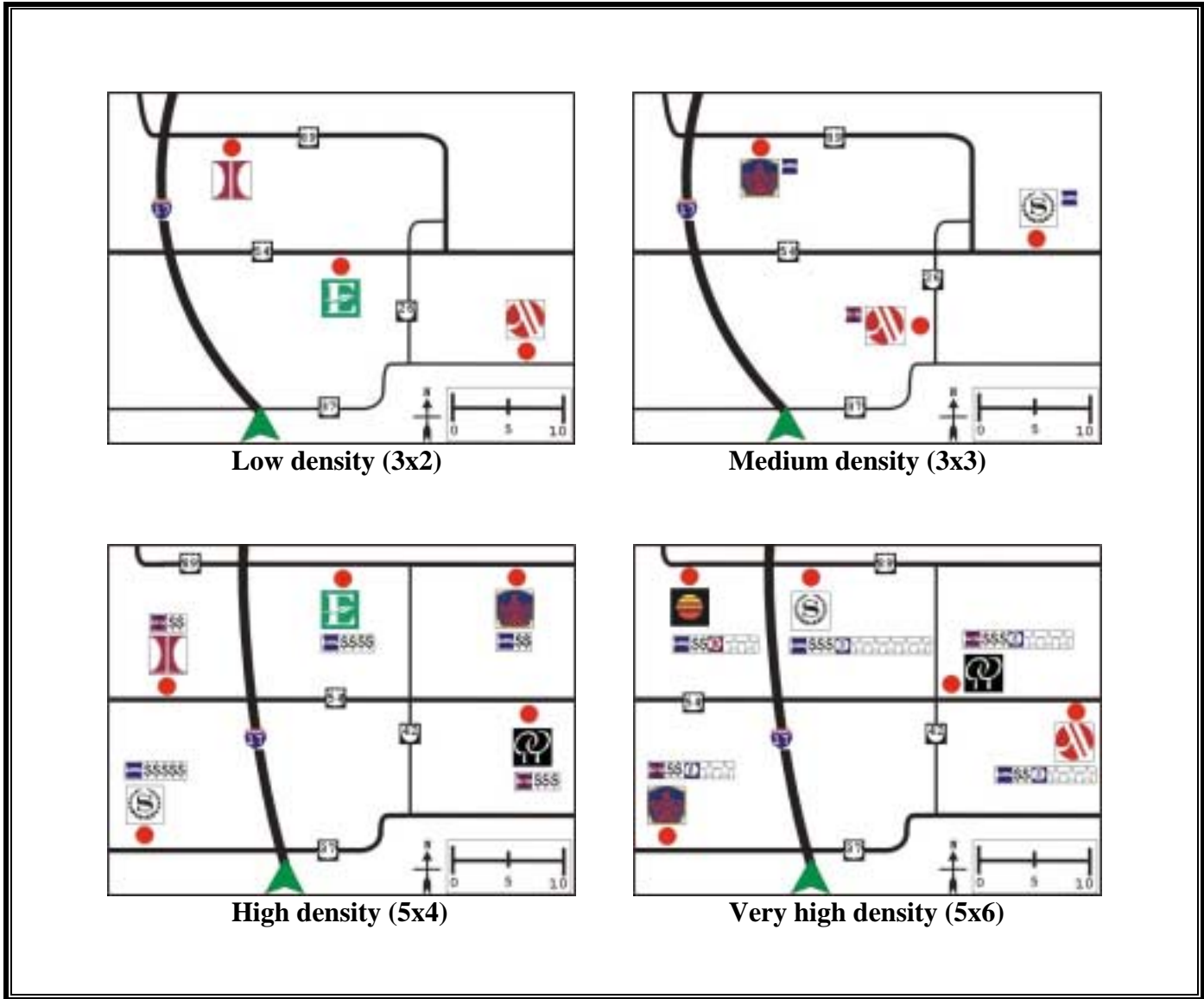


Figure E.4. Graphic icon format — SP-hotel tasks.

Instructions: Select a hotel.

Route Planning	
Route	Distance
I-34, US-Rte. 71	125 miles
US-68, Hwy. 64	85 miles
I-34, Hwy. 16	32 miles

Low density (3x2)

Route Planning		
Route	Distance	Delays
I-34, US-Rte. 71	105 miles	28 min
US-68, Hwy. 16	85 miles	45 min
I-34, Hwy. 64	160 miles	15 min

Medium density (3x3)

Route Planning			
Route	Distance	Delays	Hazards
I-34, US-Rte. 33	125 miles	5 min	Icy Bridge
US-Rte. 68, Hwy. 16	85 miles	30 min	Narrow Road
I-34, US-Rte. 71	80 miles	45 min	Fallen Rock
US-Rte. 68, Hwy. 64	115 miles	10 min	Unlined Highway
I-34, Hwy. 16	85 miles	20 min	Windy Road

High density (5x4)

Figure E.5. Table format — SP-route tasks.
Instructions: Select a route to the hospital.

Route Planning

I-29 to US-Rte. 18 is 89 miles. I-29 to Hwy. 38 is 124 miles. I-29 to Hwy. 23 is 72 miles.

Low density (3x2)

Route Planning

US-Rte. 64 to Hwy. 38 is 80 miles and has a 23 minute delay. I-29 to Hwy. 23 is 39 miles and has a 31 minute delay. US-Rte. 64 to US-Rte. 59 is 73 miles and has a 12 minute delay.

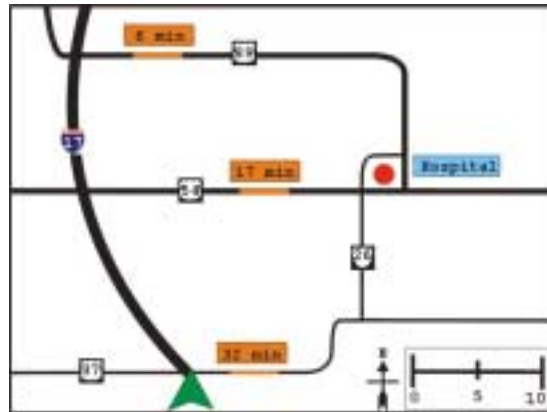
Medium density (3x3)

Route Planning

US-Rte. 74 to Hwy. 38 is 43 miles, has a 25 minute delay, and has a slippery road hazard. US-Rte. 74 to Hwy. 23 is 64 miles, has a 42 minute delay, and has a deer-crossing hazard. I-29 to US-Rte. 64 is 85 miles, has a 15 minute delay, and has a fallen rock hazard. US-Rte. 74 to US-Rte. 59 is 95 miles, has a 25 minute delay, and has a slippery road hazard. I-29 to US-Rte. 18 is 73 miles, has a 37 minute delay, and has a low visibility hazard.

High density (5x4)

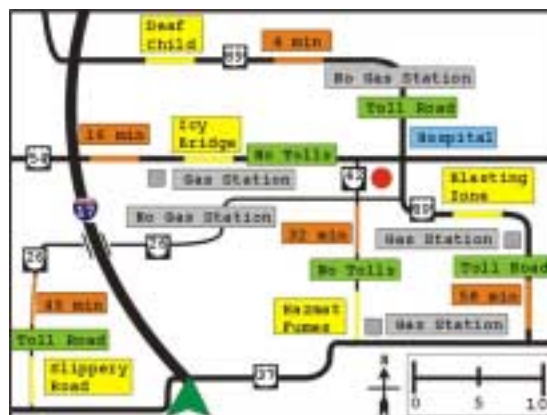
Figure E.6. Paragraph format — SP-route tasks.
Instructions: Select a route to the hospital.



Medium density (3x3)



High density (5x4)



Very high density (5x6)

Figure E.7. Graphic text format — SP-route tasks.

Instructions: Select a route to the hospital.

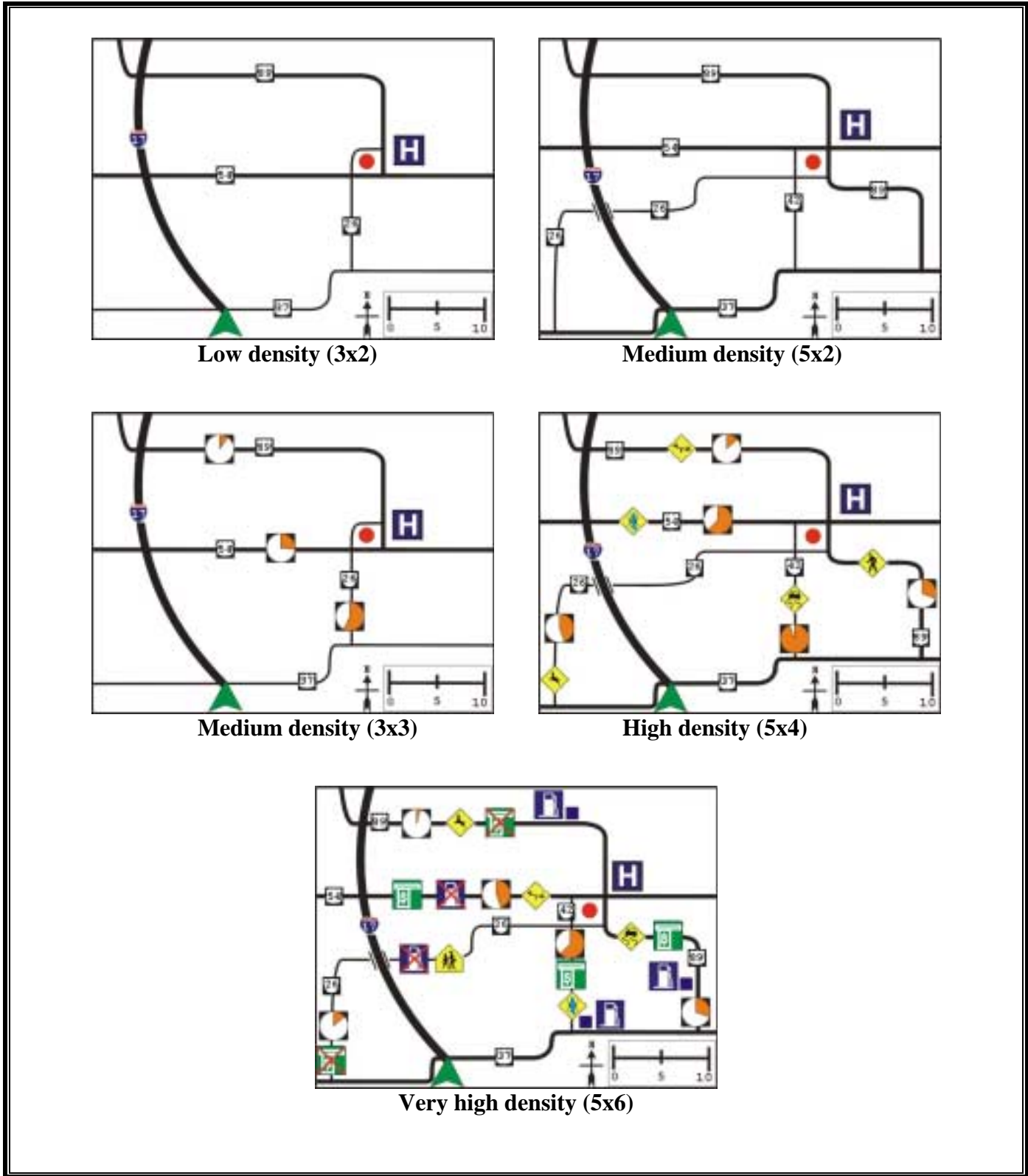


Figure E.8. Graphic icon format — SP-route tasks.

Instructions: Select a route to the hospital.

Route Planning

I-29 to US-Rte. 18 has an accident delay. I-29 to Hwy. 38 has a construction delay. I-29 to Hwy. 23 has a hazmat spill delay.

Low density (3x2)

Route Planning

I-29 to US-Rte. 64, US-Rte. 64 has a train crossing delay and 2 of 2 lanes are closed. US-Rte. 74 to Hwy. 23, Hwy. 23 has a utility work delay and 1 of 1 lane is closed. US-Rte. 59 to US-Rte. 64, US-Rte. 59 has a fire truck delay and 1 of 2 lanes is closed.

Medium density (3x3)

Route Planning

I-29 to US-Rte. 64, US-Rte. 64 has an accident delay and 2 of 2 lanes are closed. US-Rte. 74 to Hwy. 38, Hwy. 38 has a parade route delay and 1 of 1 lane is closed. I-29 to US-Rte. 59, I-29 has a construction delay and 1 of 2 lanes is closed. US-Rte. 74 to Hwy. 23, Hwy. 23 has a road work delay and 1 of 1 lane is closed. I-29 to US-Rte. 18, US-Rte. 18 has a drawbridge delay and 2 of 2 lanes are closed.

High density (5x4)

Figure E.9. Paragraph format — SPI-all tasks.

Instructions: Select a route to the hospital.

Route Planning	
Route	Delays
I-34, US-Rte. 71	Funeral Procession
US-88, Hwy. 54	Bike race
I-34, Hwy. 16	Accident

Low density (3x2)

Route Planning		
Route	Delays	Lanes Closed
I-34, US-Rte. 71	Funeral Procession	1 of 2 Lanes, US-Rte. 71
I-34, Hwy. 54	Accident	1 of 1 Lanes, Hwy. 54
US-Rte. 68, Hwy. 16	Road Work	1 of 2 Lanes, US-Rte. 68

Medium density (3x3)

Route Planning			
Route	Delays	Lanes Closed	Congestion
I-34, US-Rte. 71	Farm Machinery	2 of 2 Lanes, US-Rte. 71	Heavy
US-Rte. 49, Hwy. 54	Bike Race	1 of 1 Lanes, Hwy. 54	Moderate
I-34, Hwy. 16	Accident	1 of 2 Lanes, I-34	Moderate
I-34, US-Rte. 46	Helmet Spill	1 of 2 Lanes, US-Rte. 46	Light
US-Rte. 33, Hwy. 54	Ambulance	1 of 1 Lanes, Hwy. 54	Light

High density (5x4)

Figure E.10. Table format — SPI-all tasks.
Instructions: Select a route to the hospital.

Route Planning

I-29 to US-Rte. 59 is 25 miles and has a train crossing delay. US-Rte. 74 to Hwy. 38 is 84 miles and has a school bus delay. US-Rte. 59 to US-Rte. 64 is 91 miles and has a construction delay.

Medium density (3x3)

Route Planning

I-29 to US-Rte. 64 is 30 miles. US-Rte. 64 has a drawbridge delay, and 2 of 2 lanes are closed. US-Rte. 74 to Hwy. 38 is 22 miles. Hwy. 38 has a funeral procession delay, and 1 of 1 lane is closed. I-29 to US-Rte. 59 is 76 miles. I-29 has an accident delay, and 1 of 2 lanes is closed. US-Rte. 74 to Hwy. 23 is 32 miles. Hwy. 23 has a school bus delay, and 1 of 1 lane is closed. I-29 to US-Rte. 18 is 74 miles. US-Rte. 18 has a train crossing delay, and 2 of 2 lanes are closed.

High density (5x4)

Figure E.11. Paragraph format — SPI-partial tasks.
Instructions: Select a route to the hospital.

Route Planning		
Route	Distance	Delays
I-34, US-Rte. 71	45 miles	School Crossing
I-34, Hwy. 54	25 miles	Farm Machinery
US-Rte. 68, Hwy. 16	55 miles	Utility Work

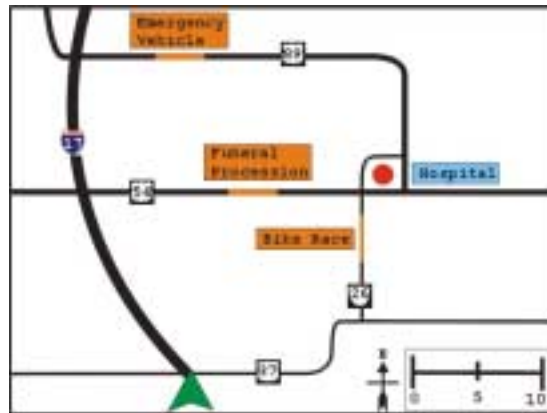
Medium density (3x3)

Route Planning			
Route	Distance	Delays	Lanes closed
I-34, US-Rte. 71	25 miles	Parade Route	2 of 2 Lanes, US-Rte. 71
US-Rte. 68, Hwy. 16	45 miles	Utility Work	1 of 1 Lanes, Hwy. 16
I-34, Hwy. 54	60 miles	Accident	1 of 2 Lanes, I-34
I-34, US-Rte. 33	35 miles	Object in Roadway	1 of 2 Lanes, US-Rte. 33
US-Rte. 68, Hwy. 54	55 miles	Emergency Vehicle	1 of 1 Lanes, Hwy. 54

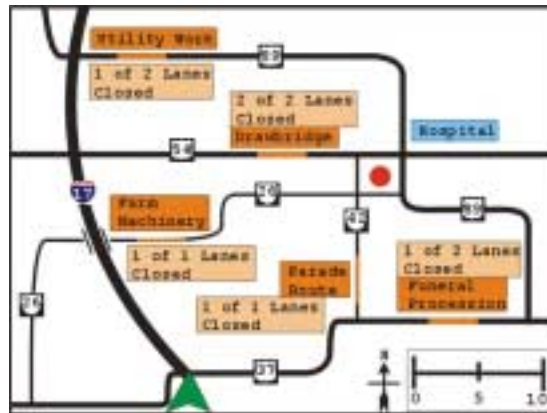
High density (5x4)

Figure E.12. Table format — SPI-partial tasks.

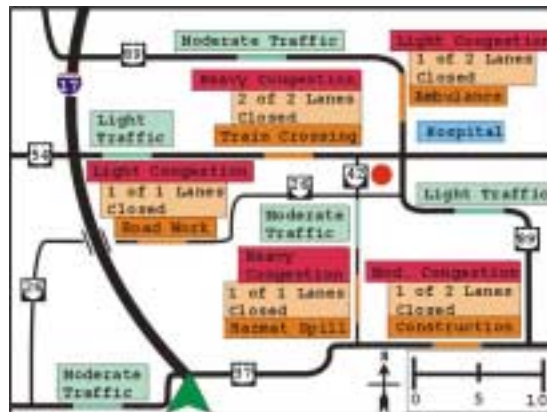
Instructions: Select a route to the hospital.



Medium density (3x3)

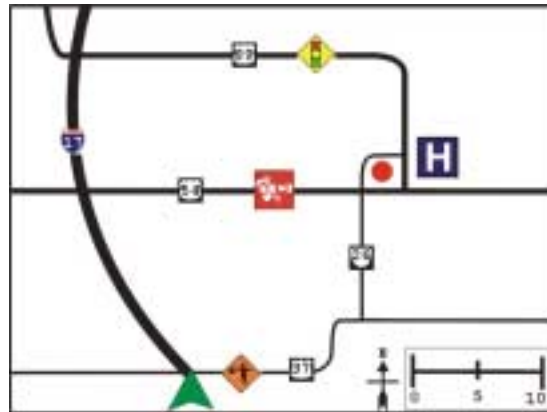


High density (5x4)

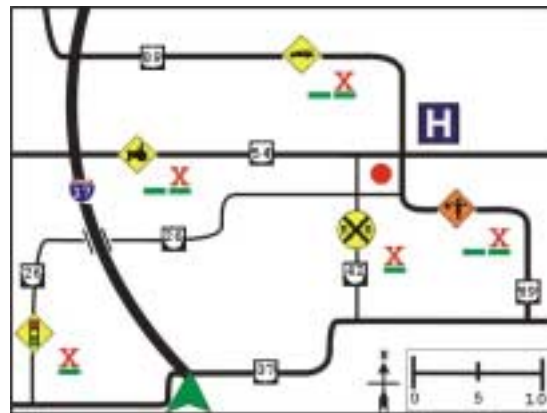


Very high density (5x6)

Figure E.13. Graphic text format — SPI-partial tasks.
 Instructions: Select a route to the hospital.



Medium density (3x3)



High density (5x4)



Very high density (5x6)

Figure E.14. Graphic icon format — SPI-partial tasks.
Instructions: Select a route to the hospital.

Route Planning

I-29 to US-Rte. 64 has a \$5.25 toll and a \$4.25 toll. US-Rte. 74 to US-Rte. 64 has a \$5.50 toll and a \$3.75 toll. US-Rte. 74 to Hwy. 23 has a \$6.25 toll and a \$3.75 toll.

Medium density (3x3), addition computation
Instructions: Select the cheapest route to the airport.

Route Planning

I-29 to US-Rte. 18 is 109 miles and has a speed limit of 65 mph. I-29 to Hwy. 38 is 114 miles and has a speed limit of 55 mph. I-29 to Hwy. 23 is 100 miles and has a speed limit of 45 mph.

Medium density (3x3), division computation
Instructions: Select the quickest route to the airport.

Route Planning

US-Rte. 74 to Hwy. 38 is 35 miles, and has a \$6.25 toll and a \$4.25 toll. I-29 to US-Rte. 64 is 12 miles, and has a \$7.50 toll and a \$2.50 toll. US-Rte. 74 to Hwy. 59 is 47 miles, and has a \$6.25 toll and a \$1.75 toll. I-29 to US-Rte. 59 is 58 miles, and has a \$6.50 toll and a \$2.25 toll. US-Rte. 74 to Hwy. 23 is 62 miles, and has a \$3.75 toll and a \$4.75 toll.

High density (5x4), addition computation
Instructions: Select the cheapest route to the airport.

Route Planning

US-Rte. 74 to US-Rte. 18 is 135 miles, has a speed limit of 65 mph, and has a \$3.75 toll. I-29 to US-Rte. 59 is 176 miles, has a speed limit of 55 mph, and has a \$1.50 toll. US-Rte. 74 to Hwy. 38 is 154 miles, has a speed limit of 65 mph, and has a \$4.50 toll. I-29 to US-Rte. 64 is 183 miles, has a speed limit of 45 mph, and has a \$2.25 toll. I-29 to US-Rte. 18 is 129 miles, has a speed limit of 55 mph, and has a \$6.50 toll.

High density (5x4), division computation
Instructions: Select the quickest route to the airport.

Figure E.15. Paragraph format — SC tasks.

Route Planning		
Route	Toll Cost	Toll Cost
I-34, Hwy. 16	\$2.50	\$5.25
US-Rte. 68, Hwy. 54	\$6.00	\$3.50
I-34, US-Rte. 33	\$4.75	\$3.75

Medium density (3x3), addition computation

Instructions: Select the cheapest route to the airport.

Route Planning		
Route	Distance	Speed Limit
I-34, US-Rte. 33	264 miles	65 mph
US-Rte. 68, Hwy. 16	199 miles	50 mph
I-34, Hwy. 54	245 miles	55 mph

Medium density (3x3), division computation

Instructions: Select the quickest route to the airport.

Route Planning			
Route	Distance	Toll Cost	Toll Cost
I-34, US-Rte. 71	98 miles	\$3.75	\$4.25
I-34, US-Rte. 33	31 miles	\$5.50	\$3.25
US-Rte. 68, Hwy. 16	82 miles	\$3.25	\$4.90
US-Rte. 68, US-Rte. 28	64 miles	\$7.25	\$4.50
I-34, Hwy. 16	19 miles	\$8.50	\$2.25

High density (5x4), addition computation

Instructions: Select the cheapest route to the airport.

Route Planning			
Route	Distance	Speed Limit	Toll Cost
I-34, Hwy. 54	260 miles	55 mph	\$6.25
US-Rte. 68, US-Rte. 15	105 miles	45 mph	\$2.50
US-Rte. 68, Hwy. 16	346 miles	45 mph	\$3.75
I-34, US-Rte. 71	231 miles	50 mph	\$7.75
US-Rte. 68, Hwy. 54	180 miles	45 mph	\$1.50

High density (5x4), division computation

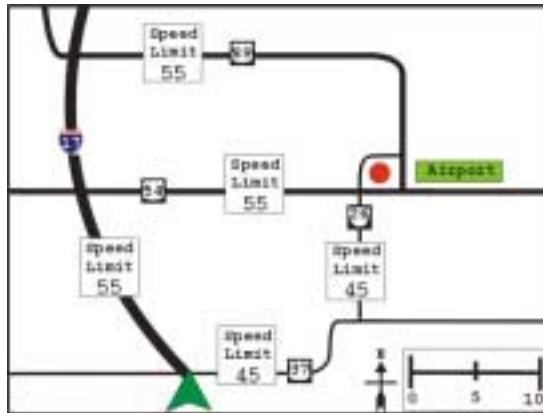
Instructions: Select the quickest route to the airport.

Route Planning			
Route	Distance	Speed Limit	Delays
US-Rte. 68, Hwy. 54	270 miles	50 mph	40 min
US-Rte. 68, Hwy. 16	205 miles	55 mph	28 min
I-34, US-Rte. 33	325 miles	45 mph	5 min
I-34, Hwy. 28	131 miles	50 mph	72 min
I-34, US-Rte. 71	180 miles	55 mph	30 min

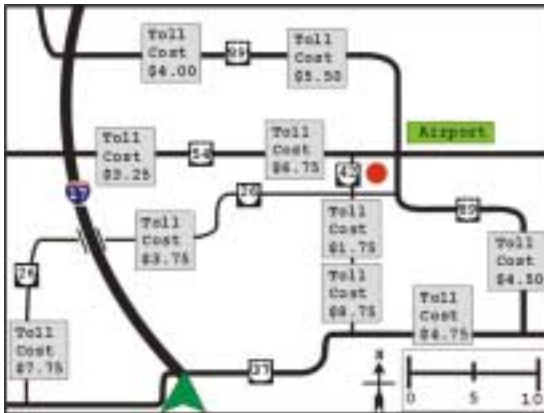
High density (5x4), division and addition computation

Instructions: Select the quickest route to the airport.

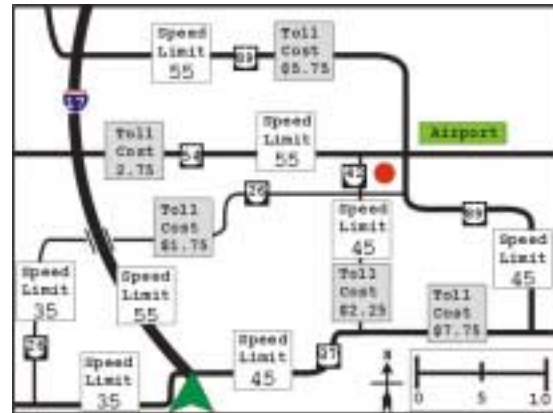
Figure E.16. Table format — SC tasks.



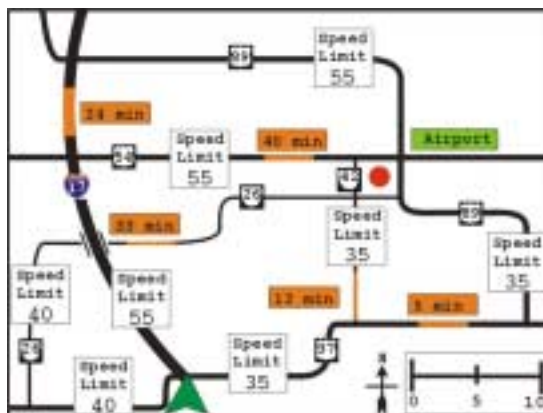
Medium density (3x3), division computation
Instructions: Select the quickest route to the airport.



High density (5x4), addition computation
Instructions: Select the cheapest route to the airport.



High density (5x4), division computation
Instructions: Select the quickest route to the airport.



High density (5x4), division & addition computation
Instructions: Select the quickest route to the airport.

Figure E.17. Graphic text format — SC-tasks.

Route Planning

I-29 to US-Rte. 59 is 109 miles and has a speed limit of 55 mph. I-29 to Hwy. 28 is 114 miles and has a speed limit of 45 mph. I-29 to Hwy. 38 is 100 miles and has a speed limit of 40 mph.

Medium density (3x3), division computation

Route Planning

US-Rte. 74 to Hwy. 28 is 97 miles, has a speed limit of 45 mph, and has a \$4.50 toll. I-29 to US-Rte. 64 is 108 miles, has a speed limit of 50 mph, and has a \$1.75 toll. US-Rte. 74 to Hwy. 23 is 138 miles, has a speed limit of 45 mph, and has a \$6.50 toll. I-29 to US-Rte. 59 is 120 miles, has a speed limit of 55 mph, and has a \$5.50 toll cost. I-29 to US-Rte. 18 is 142 miles, has a speed limit of 45 mph, and has a \$3.25 toll.

High density (5x4), division computation

Route Planning

US-Rte. 74 to Hwy. 23 is 87 miles, and has a \$4.25 toll and a \$2.75 toll. I-29 to US-Rte. 59 is 34 miles, and has a \$6.50 toll and a \$3.50 toll. US-Rte. 74 to Hwy. 38 is 82 miles, and has a \$2.75 toll and a \$3.75 toll. I-29 to US-Rte. 64 is 19 miles, and has a \$5.25 toll and a \$6.25 toll. US-Rte. 74 to US-Rte. 18 is 49 miles, and has a \$1.75 toll and a \$5.50 toll.

High density (5x4), addition computation

Figure E.18. Paragraph format — SPC task.

Instructions: Select a route to the airport.

Route Planning		
Route	Distance	Speed Limit
I-34, US-Rte. 71	244 miles	50 mph
US-Rte. 68, Hwy. 49	298 miles	65 mph
I-34, Hwy. 54	138 miles	35 mph

Medium density (3x3), division computation

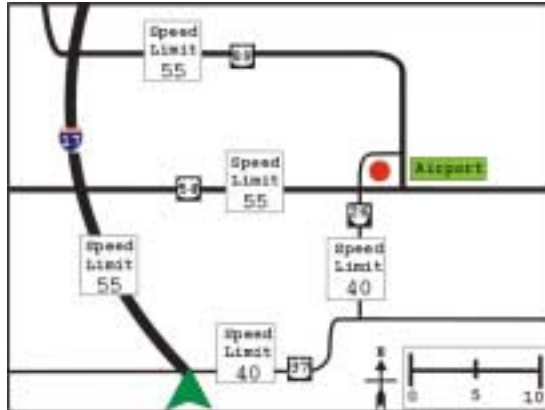
Route Planning			
Route	Distance	Speed Limit	Toll cost
US-Rte. 68, Hwy. 16	228 miles	50 mph	\$1.25
I-34, Hwy. 16	303 miles	65 mph	\$8.50
I-34, US-Rte. 71	236 miles	55 mph	\$4.75
US-Rte. 68, Hwy. 54	228 miles	50 mph	\$2.50
US-Rte. 68, US-Rte. 28	198 miles	45 mph	\$6.25

High density (5x4), division computation

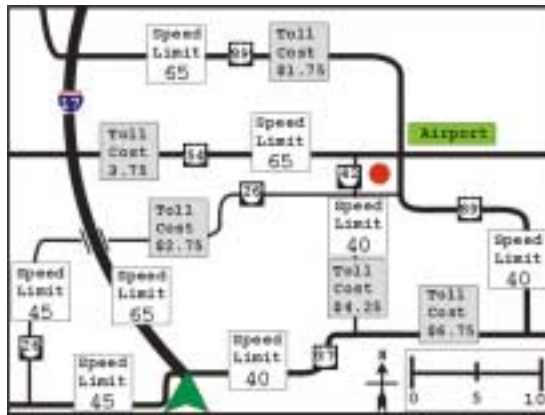
Route Planning			
Route	Distance	Toll Cost	Toll Cost
I-34, Hwy. 16	71 miles	\$2.50	\$6.50
I-34, US-Rte. 71	14 miles	\$4.50	\$9.00
US-Rte. 68, Hwy. 54	33 miles	\$2.50	\$3.75
US-Rte. 68, US-Rte. 28	52 miles	\$1.50	\$5.25
I-34, US-Rte. 33	26 miles	\$1.75	\$4.00

High density (5x4), addition computation

Figure E.19. Table format — SPC tasks.
Instructions: Select a route to the airport.



Medium density (3x3), division computation



High density (5x4), division computation



High density (5x4), addition computation

Figure E.20. Graphic text format — SPC tasks.

Instructions: Select a route to the airport.

Route Planning

I-29 to US-Rte. 64 has a \$5.75 toll and a \$1.25 toll, and has an emergency vehicle delay. US-Rte. 74 to Hwy. 38 has a \$2.50 toll and a \$2.25 toll, and has a school crossing delay. US-Rte. 74 to Hwy. 23 has a \$4.75 toll and a \$2.75 toll, and has an accident delay. I-29 to US-Rte. 18 has a \$1.25 toll and a \$3.75 toll, and has a drawbridge delay. US-Rte. 74 to Hwy. 38 has a \$9.50 toll and a \$2.50 toll, and has a train crossing delay.

High density (5x4), addition computation

Route Planning

I-29 to US-Rte. 64 is 212 miles, has a speed limit of 65 mph, and has a drawbridge delay. US-Rte. 74 to US-Rte. 64 is 151 miles, has a speed limit of 43 mph, and has a construction delay. I-29 to Hwy. 23 is 162 miles, has a speed limit of 50 mph, and has a school crossing delay. US-Rte. 74 to US-Rte. 18 is 210 miles, has a speed limit of 63 mph, and has a train crossing delay. I-29 to US-Rte. 18 is 172 miles, has a speed limit of 55 mph, and has a funeral procession delay.

High density (5x4), division computation

Figure E.21. Paragraph format — SPIC tasks.

Instructions: Select a route to the airport.

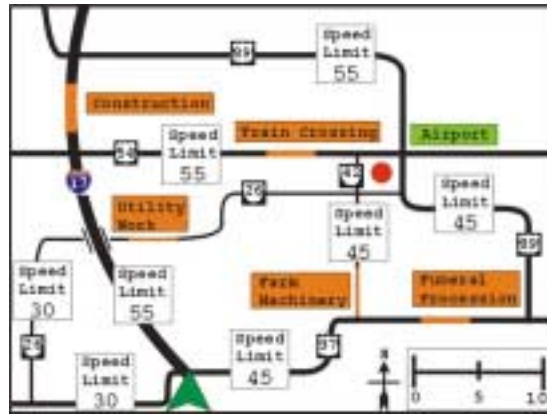
Route Planning			
Route	Delays	Toll Cost	Toll Cost
I-34, Hwy. 54	Farm Machinery	\$4.25	\$4.50
US-Rte. 68, US-Rte. 71	Train Crossing	\$5.50	\$8.50
US-Rte. 68, Hwy. 16	Accident	\$1.50	\$6.75
I-34, US-Rte. 33	Drawbridge	\$4.50	\$5.25
I-34, Hwy. 16	Ambulance	\$6.75	\$3.75

High density (5x4), addition computation

Route Planning			
Route	Distance	Speed Limit	Delays
I-34, US-Rte. 71	320 miles	65 mph	Construction
I-34, Hwy. 16	245 miles	55 mph	School Bus
US-Rte. 68, Hwy. 54	195 miles	45 mph	Hazmat Spill
US-Rte. 68, US-Rte. 28	139 miles	50 mph	Drawbridge
I-34, US-Rte. 33	205 miles	55 mph	Fire Truck

High density (5x4), division computation

Figure E.22. Table format — SPIC tasks.
Instructions: Select a route to the airport.



High density (5x4), division computation

Figure E.23. Graphic text format — SPIC tasks.

Instructions: Select a route to the airport.

Local Attractions

option 1, \$9.00 admission. Option 2, \$0.00 admission. Option 3, \$45.00 admission.

Low density (3x2)

Local Attractions

Option 1, no parking cost and \$4.00 admission. Option 2, low parking cost and \$12.00 admission. Option 3, no parking cost and \$0.00 admission.

Medium density (3x3)

Local Attractions

Option 1, no parking cost, \$15.00 admission, and no toll cost. Option 2, low parking cost, \$85.00 admission, and low toll cost. Option 3, low parking cost, \$0.00 admission, and no toll cost. Option 4, high parking cost, \$0.00 admission, and no toll cost. Option 5, no parking cost, \$0.00 admission, and no toll cost.

High density (5x4)

Local Attractions

option 1, \$50.00 hotel, high food cost, no parking cost, \$60.00 admission, and no toll cost. Option 2, \$135.00 hotel, moderate food cost, low parking cost, \$25.00 admission, and low toll cost. Option 3, \$45.00 hotel, low food cost, moderate parking cost, \$0.00 admission, and no toll cost. Option 4, \$0.00 hotel cost, no food cost, no parking cost, \$0.00 admission, and no toll cost. Option 5, \$35.00 hotel, moderate parking cost, \$0.00 admission, and no toll cost.

Very high density (5x6)

Figure E.24. Paragraph format — S-General tasks.
Instructions: Which option has no monetary cost?

Local Attractions

Option	Admission Cost
1	\$4.50
2	\$0.00
3	\$10.00

Low density (3x2)

Local Attractions

Option	Parking Cost	Admission Cost
1	No cost	\$4.50
2	High	\$0.00
3	No cost	\$10.00

Medium density (3x3)

Local Attractions

Option	Parking Cost	Admission Cost	Toll Cost
1	\$0.00	\$0.00	No cost
2	\$7.00	\$21.00	High
3	\$6.50	\$12.00	Low
4	\$0.00	\$30.00	No cost
5	\$3.00	\$11.50	High

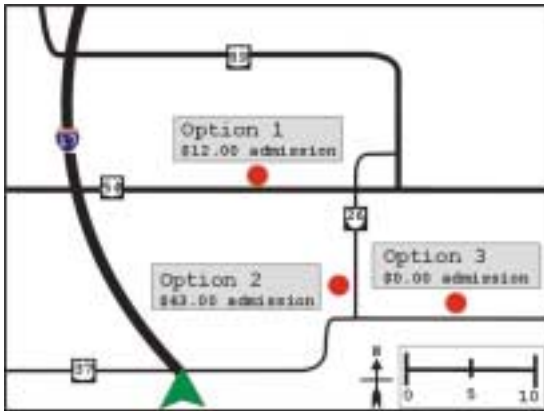
High density (5x4)

Local Attractions

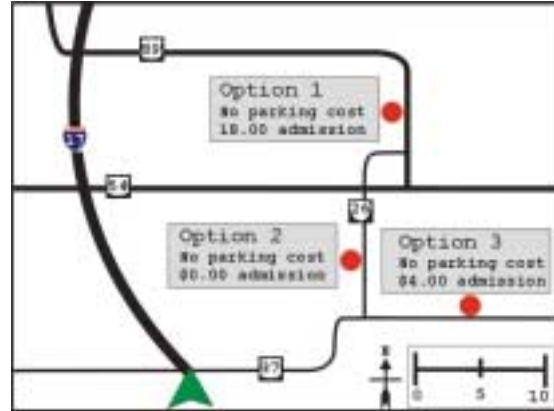
Option	Hotel cost	Food cost	Parking Cost	Admission cost	Toll Cost
1	\$36.00	\$0.00	High	\$4.50	Low
2	\$0.00	\$5.45	Moderate	\$21.00	High
3	\$0.00	\$9.10	No cost	\$12.00	Low
4	\$0.00	\$0.00	No cost	\$0.00	No cost
5	\$0.00	\$9.80	High	\$11.50	No cost

Very high density (5x6)

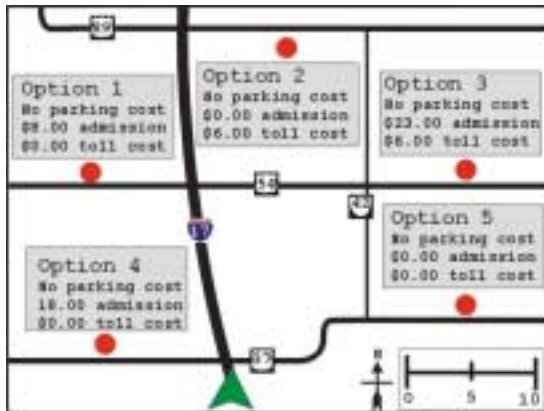
Figure E.25. Table format — S-General tasks.
Instructions: Which option has no monetary cost?



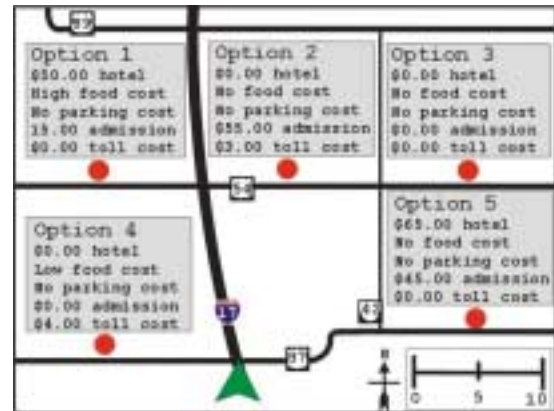
Low density (3x2)



Medium density (3x3)



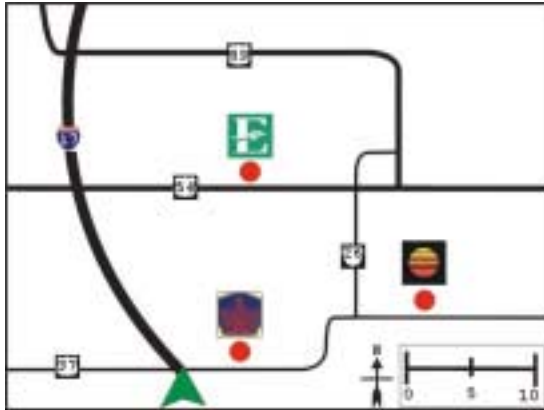
High density (5x4)



Very high density (5x6)

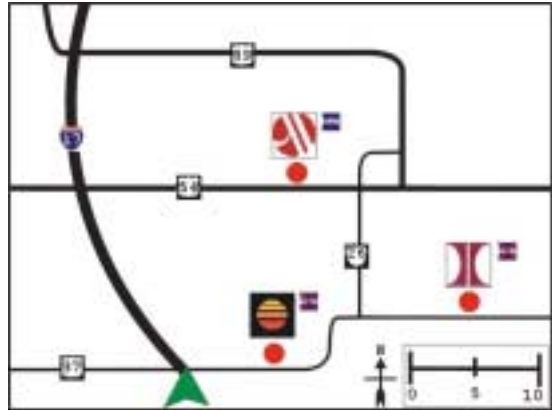
Figure E.26. Graphic text format — S-HP tasks.

Instructions: Which option has no monetary cost?



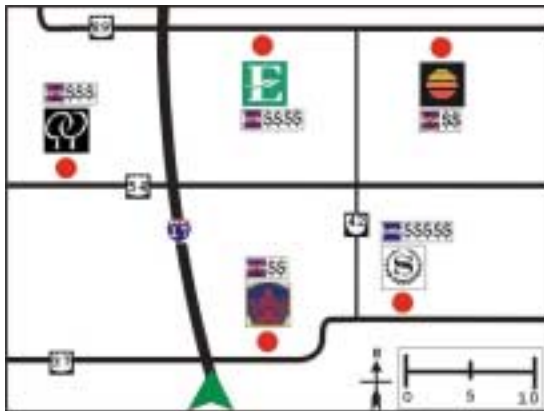
Low density (3x2)

Instructions: Is there a highway 92 on the map?



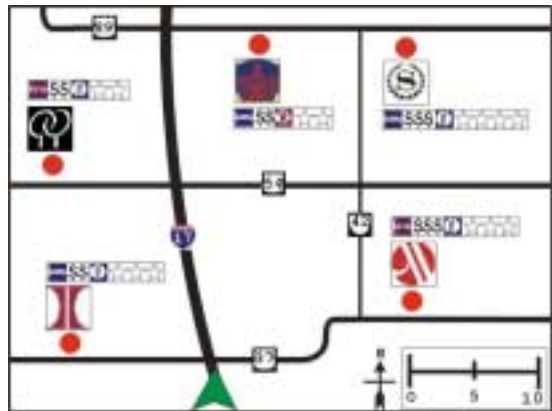
Medium density (3x3)

Instructions: Which hotel has a vacancy?



High density (5x4)

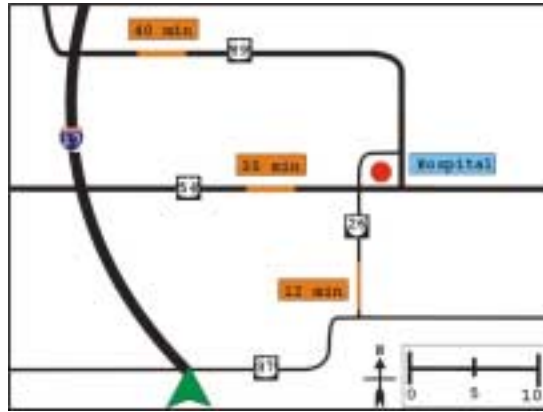
Instructions: Which hotel has a vacancy?



Very high density (5x6)

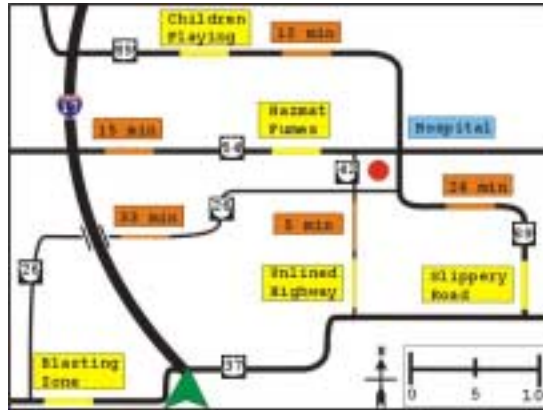
Instructions: Select the four star hotel?

Figure E.27. Graphic icon format — S-HP tasks.



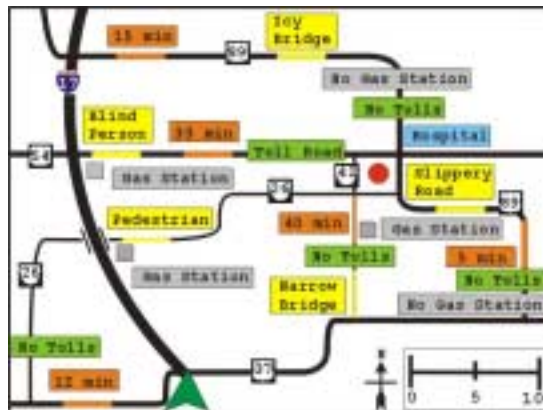
Medium density (3x3)

Instructions: Which roadway has a 35 minute delay?



High density (5x4)

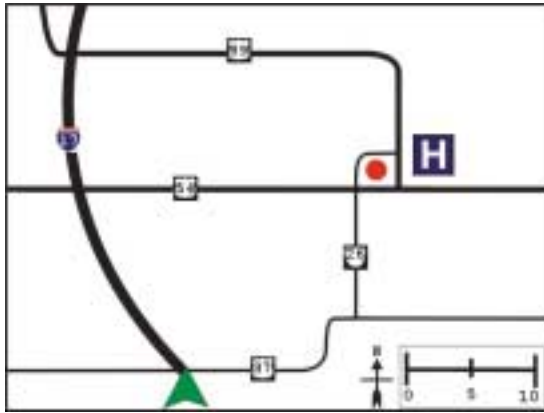
Instructions: Which roadway has 15 minute delay?



Very high density (5x6)

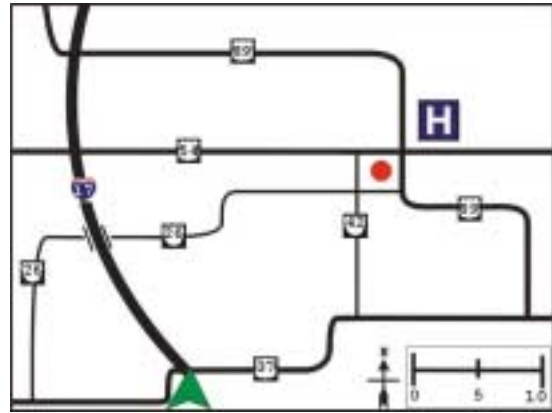
Instructions: Which roadway has a 15 minute delay?

Figure E.28. Graphic text format — S-RP tasks.



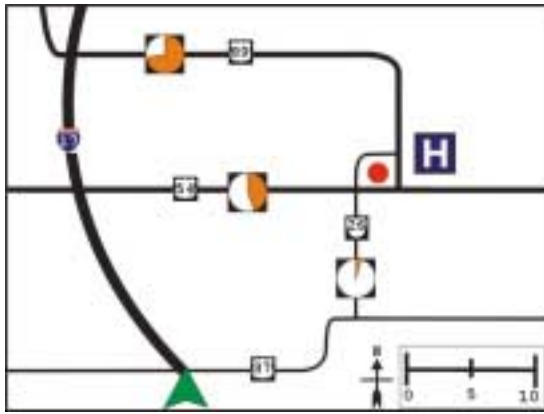
Low density (3x2)

Instructions: Is there a highway 92 on the map?



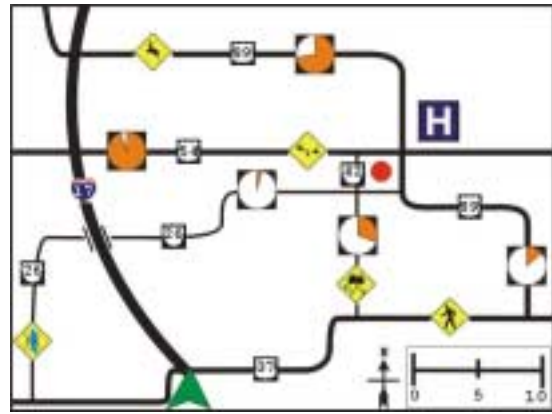
Medium density (5x2)

Instructions: Is there a highway 75 on the map?



Medium density (3x3)

Instructions: Which roadway has a 26 minute delay?



High density (5x4)

Instructions: Which roadway has 42 minute delay?

Figure E.29. Graphic icon format — S-RP tasks.

Route Planning	
Route	Delays
I-34, US-Rte. 71	Drawbridge
US-68, Hwy. 54	Bike race
I-34, Hwy. 16	Accident

Low density (3x2)

Instructions: Select the route with a drawbridge.

Route Planning		
Route	Delays	Lanes Closed
I-34, US-Rte. 71	Funeral Procession	1 of 2 Lanes, US-Rte. 71
I-34, Hwy. 54	Accident	1 of 1 Lanes, Hwy. 54
US-Rte. 68, Hwy. 16	Construction	1 of 2 Lanes, US-Rte. 68

Medium density (3x3)

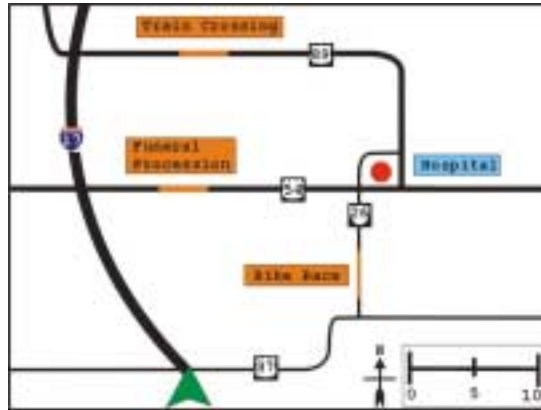
Instructions: Select the route with construction.

Route Planning			
Route	Delays	Lanes Closed	Congestion
I-34, US-Rte. 71	Farm Machinery	2 of 2 Lanes, US-Rte. 71	Heavy
US-Rte. 49, Hwy. 54	Bike Race	1 of 1 Lanes, Hwy. 54	Moderate
I-34, Hwy. 16	Accident	1 of 2 Lanes, I-34	Moderate
I-34, US-Rte. 66	Hazmat Spill	1 of 2 Lanes, US-Rte. 66	Light
US-Rte. 33, Hwy. 54	Ambulance	1 of 1 Lanes, Hwy. 54	Light

High density (5x4)

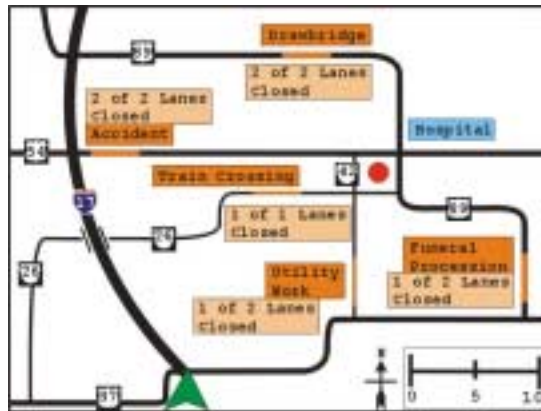
Instructions: Select the route with an accident.

Figure E.30. Table format — S-RPI tasks.



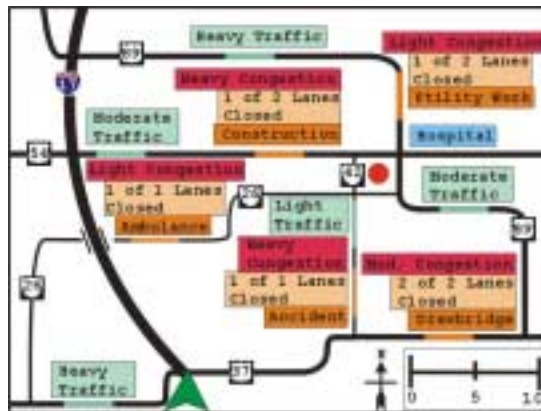
Medium density (3x3)

Instructions: Which roadway has a bike race delay?



High density (5x4)

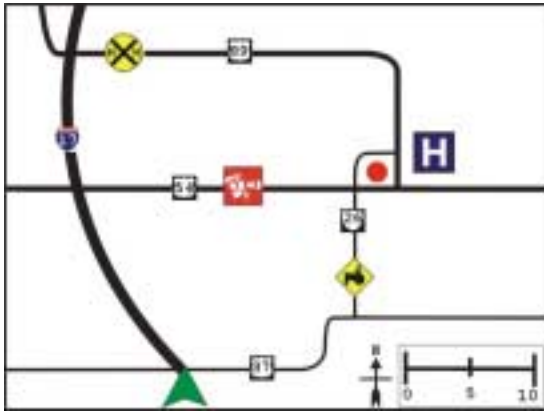
Instructions: Which roadway has a drawbridge delay?



Very high density (5x6)

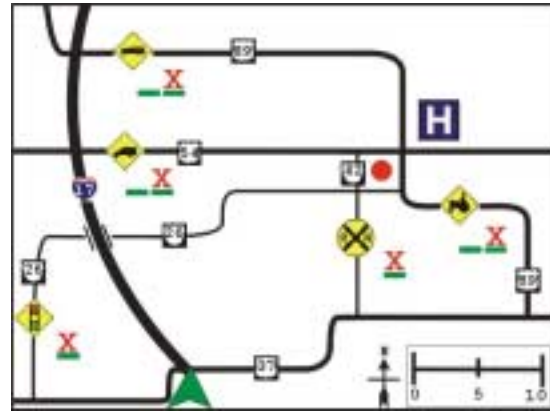
Instructions: Which roadway has a construction delay?

Figure E.31. Graphic text format — S-RPI tasks.



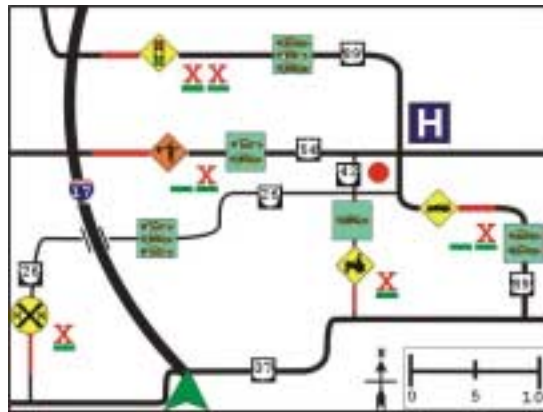
Medium density (3x3)

Instructions: Which roadway has an accident delay?



High density (5x4)

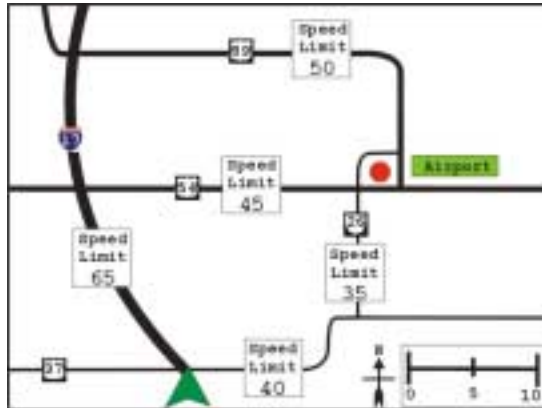
Instructions: Which roadway has a farm machinery delay?



Very high density (5x6)

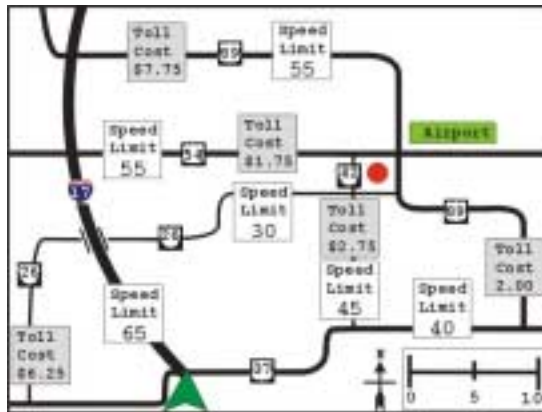
Instructions: Which roadway has fire truck delay?

Figure E.32. Graphic icon format — S-RPI tasks.



Medium density (3x3)

Instructions: Which roadway has speed limit of 35mph?



High density (5x4)

Instructions: Which roadway has \$2.75 toll?

Figure E.33. Graphic text format — S-Compute tasks.

APPENDIX F – SCREENING QUESTIONNAIRE

APPENDIX G – INFORMATION SHEET FOR PARTICIPANTS

Thanks for offering to help with this study. Information about the procedures for the study is explained below. Please feel free to ask any questions you may have.

TASKS TO BE COMPLETED DURING THE DRIVE

- Your primary task is to safely drive the automobile; you should allow nothing to interfere with this. To simulate medium traffic density, there will be an automobile driven in front of you by personnel from the Center for Transportation Research.
- As you are driving, you will be provided information on a visual display or auditorily and will be asked to make decisions from this information. These are secondary tasks and you should NOT allow them to interfere with safely driving the vehicle.
- Periodically along the route you will hear a tone; following the tone, you will hear instructions provided by the computer on how to complete the task, such as select a hotel. After the instructions are completed, information will either be presented on the visual display or will be presented auditorily.

VISUAL TASKS

- Visual information will remain on the screen until you state your decision, such as selecting a hotel based on the information provided. You may repeat the instructions at any time and as many times as you would like by pressing the button on the left side of the steering wheel.
- There is no time limit – take as much time as you want.

AUDITORY TASKS

- Auditory information will be presented once and will stop. If you wish to replay the information, simply press the button on the right side of the steering wheel. You may repeat the information as many times as you like.
- If you would like to replay the instructions at any time, simply press the button on the left side of the steering wheel. You may interrupt the presentation of information to hear the instructions. If you should interrupt the presentation of information after the instructions are repeated, the information presentation will start at the beginning.

- You may provide an answer at any time. If you choose to replay the information, you do not have to wait until the information repeats in its entirety to state your answer.

TASK DESCRIPTION

You will be asked to perform a variety of tasks. Some tasks will ask you to choose a hotel or to choose a route; with these tasks, it is desired that you search the information and identify and use the information you find useful in making your decision. We realize that not everyone will choose to use the same criteria when making a decision. It doesn't matter to us which criteria you use or how many you use. However, it is important that we know which information you used to arrive at your decision. For example, if five items of information were presented, it is important for us to know that you used 1, 2, 3, 4 or 5 items, and which items you used.

Therefore, at the conclusion of each task, the experimenter will ask why you selected your answer. At this time, indicate which criteria you used (for example, you might have considered distance, cost, and quality when selecting a hotel).

When given the task of selecting a route to the hospital or airport, you are not in a rush to get to the hospital or airport. Imagine you are going to visit someone in the hospital, or that you are going to meet someone at the airport.

Some tasks will require that you perform calculations, while other tasks will provide you with the option of doing calculation(s). It is important that we know if you performed a calculation and what type of calculation you performed.

- When you are asked to determine the cheapest route or the quickest route, we would like you to perform a calculation with the information provided. We will prompt you for a numeric answer after you have stated your selected route. As with any task, you can always say "skip" if you do not wish to perform the task while driving.
- If you are asked to select a route and toll costs, speed limit, distance, and/or time delays are provided, you have the option of performing one or more calculations. When asked to select a route, use the information as you normally would while driving. After you provide your route selection, we will ask you if you performed a calculation and if so, what type.

- If at any time you feel a task requires too much attention to ensure safe driving, simply say “skip” and the task will end.
- If at any time you wish to stop and take a break, indicate your desire to the experimenters.
- If at any time you wish to end your participation in the study, simply state your desire to the experimenters and we will return to the Center for Transportation Research.

RATING OF TASK DIFFICULTY

After each task is completed, we will ask you to rate the mental demand, frustration level, and time sharing demand of the task. You will also be asked to rate how aware of your surroundings you were while completing the task.

Rating scales have been developed for you to use in evaluating your experiences during the different tasks. Please read the descriptions of the scales carefully. It is extremely important that they be clear to you; please ask if you have any questions. You may request a description of the scales at any time during the experiment.

After performing each task, you will be asked to evaluate the task by selecting a value from 1 to 100 for each of the scales. Each line has two endpoint descriptors that describe the scale. For example, Frustration Level goes from 1 (not frustrating) to 100 (extremely frustrating). The experimenter will say the name of each scale, at which point you will respond with your evaluation of the task you just completed on a scale from 1 to 100. Please consider your responses carefully in distinguishing among the task conditions. Consider each scale individually. Your ratings will play an important role in the evaluation being conducted; thus, your active participation is essential to the success of this experiment, and is greatly appreciated. Refer to the table on the next page for an illustration of the rating scales.

RATING SCALE DEFINITIONS		
Title	Endpoints	Descriptions
Mental Demand	--- --- --- --- --- --- --- --- --- --- 1 20 40 60 80 100 Easy Hard	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex ?
Frustration Level	--- --- --- --- --- --- --- --- --- --- 1 20 40 60 80 100 Low High	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?
Time Sharing Demand	--- --- --- --- --- --- --- --- --- --- 1 20 40 60 80 100 Easy Hard	How easy did you find it to perform the task and safely drive the vehicle? Was it easy to divide your attention between the two tasks (driving and the secondary task)?
Situation Awareness	--- --- --- --- --- --- --- --- --- --- 1 20 40 60 80 100 Low High	How aware were you of surrounding traffic when you were performing the secondary task? If you had wanted to slam on the brakes or swerve right or left, did you know if you could do so without hitting another vehicle?

SEQUENCE OF EVENTS

- Prior to going outside to the vehicle, you will be shown examples of each type of task.
- After going outside to the vehicle but prior to driving, sample information will be presented on the display.
- You will be shown the controls of the vehicle you will drive.
- Once any questions you have are answered, we will drive around the block so that you can familiarize yourself with the handling of the vehicle.
- When you feel comfortable with driving the vehicle, another short drive will be taken to allow you to practice performing tasks with the information presented by the computer (controlled by the experimenters).
- When you feel comfortable performing the tasks, we will then drive to Route 460.

LIST OF TASKS TO BE COMPLETED ON THE DRIVE

Listed below is a complete list of tasks you will be asked to perform. Information to complete these tasks will be provided on the visual display and auditorily, in different formats, on the drive today.

- Select a route to the hospital
- Select a route to the airport
- Select the cheapest route to the airport
- Select the quickest route to the airport
- Select a hotel
- Which hotel has a vacancy?
- Which hotel is ____ miles away?
- Which roadway has no tolls?
- Which roadway has ____ delay?
- Which roadway has a speed limit of ____ miles per hour?
- Is ____ roadway located on the map?
- Which route has a gas station?
- Which option has no monetary cost?

**APPENDIX H – INFORMED CONSENT FOR PARTICIPANTS OF
INVESTIGATIVE PROJECTS**

Title of Project: In-vehicle Task Performance Study

Investigators: John P. Gallagher, Industrial and Systems Engineering graduate student

Dr. Thomas A. Dingus, Industrial and Systems Engineering Professor and
Director of the Virginia Tech Center for Transportation Research

Dr. Walter W. Wierwille, Paul T. Norton Professor of Industrial and
Systems Engineering and Senior Transportation Research Fellow at the
Virginia Tech Center for Transportation Research

I. The Purpose of this Research Project

The purpose of this research experiment is to evaluate driving behavior and performance while drivers concurrently perform in-vehicle tasks. These tasks will include reading information from in-vehicle displays and operating an in-vehicle information system. The data obtained will be used to evaluate the attention demand of different in-vehicle information systems. Thirty-six drivers, each tested individually, will participate in this experiment.

II. Procedures

In the study you will be asked to perform specific in-car tasks as you drive on U.S. Route 460 and other primary and secondary roads in the New River Valley area. Two trained experimenters will ride in the research vehicle with you during the experiment to assist in the data-gathering process and to help ensure the safe operation of the experimental vehicle. It is your responsibility as the driver to obey all traffic regulations and to maintain safe operations of the vehicle at all times. You must treat the driving task as the primary task and perform the other instructed task only when it is safe to do so. You will be required to have the lap/shoulder belt restraint system securely fastened while driving.

The experimental vehicle is a late model American car. The car is equipped with an automatic transmission; analog instrument cluster; cellular phone, entertainment system (audio); and climate-control. The car is also equipped with an advanced traveler information system. In this study, you will drive and perform a variety of in-vehicle tasks.

The vehicle is also outfitted with devices designed to monitor various relevant aspects of your driving behavior (for example, video cameras and recorder, microphones, and computers). These measurement devices do not require that your attention be diverted from the driving task. All equipment will be placed in the vehicle and secured such that it will not present a hazard. Also, a fire extinguisher, a first aid kit, and a cellular phone will be carried in the vehicle at all times in case of an emergency.

The study will consist of four experimental stages. The experiment will proceed as follows.

1. Introductory Stage

This stage consists of preliminaries. You will thoroughly read the informed consent form. Assuming that you sign the informed consent form, we will ask you to fill out a brief medical screening questionnaire. Next, we will give you a simple vision test and we will also ask to see your driver's license. Once you successfully complete all preliminaries, we will begin your training. The first stage is expected to last about 10 minutes.

2. Training Stage

We will take you to the research vehicle where we will train you on the use of the different in-vehicle information systems. Since the instrument panels and controls may differ from the vehicle you normally drive, it is necessary to train you on the in-vehicle tasks that you will be performing throughout the experiment. We will then ask you to perform a series of tasks using the different in-vehicle information systems on which you were just trained. This stage should take approximately 50 minutes.

3. Driving Stage

After a short rest break, you will begin driving the vehicle on a pre-selected route and will be asked to begin performing a series of instructed in-vehicle tasks. The driving stage will alternate between periods of regular driving and driving while performing the various tasks for which you have been trained. This stage is expected to last approximately 3 ½ hours depending on the amount of re-training required. At the end of the drive, you will return to the Center for Transportation Research (CTR).

4. Debriefing and Payment Stage

On returning to CTR, you will be debriefed and paid for your time. This stage should take about 10 minutes.

Your total participation time will be approximately 4 ½ hours, but may be somewhat shorter or longer depending on the length of rest breaks and amount of training needed.

If during the study you feel that you cannot continue for any reason, you have the right to terminate your participation; you will be paid for the amount of time you participated. This includes the right to withdraw at any time after having read and signed the informed consent form. If you withdraw during the driving stage, the experimenter will take over the driving and return you to CTR.

If you have any questions about the experiment or your rights as a participant after reading the informed consent form, please do not hesitate to ask. We will answer your questions as openly and honestly as possible.

III. Risks

There are some risks and discomforts to which drivers are exposed in volunteering for this research. The risks are:

- (1) The risk of an accident normally associated with driving an automobile in light or moderate traffic, as well as on straight and curved roadways.
- (2) The slight additional risk of an accident while performing instructed in-vehicle tasks. Past research indicates that this risk is minimal.
- (3) Possible fatigue due to the length of the experiment. However, you will be given short rest breaks during the experimental session.
- (4) While you are driving the vehicle, you will be videotaped by cameras. As a result, we will ask you not to wear sunglasses. If this at any time during the course of the experiment impairs your ability to drive the vehicle safely, you should notify the experimenter.

The following precautions will be taken to ensure minimal risk to the participants:

- (1) The experimenter will monitor your driving, and will ask you to stop if he feels the risks are too great to continue. However, as long as you are driving the research vehicle, it remains your responsibility to drive in a safe, legal manner.
- (2) You will be required to wear the lap and shoulder belt restraint system anytime the car is on the road. The vehicle is also equipped with a driver's side airbag supplemental restraint system.
- (3) The vehicle is equipped with a fire extinguisher, first-aid kit, cellular phone, and an experimenter's safety brake pedal.
- (4) If an accident does occur, the experimenter will arrange medical transportation to a nearby hospital emergency room. You will be required to undergo examination by medical personnel in the emergency room.

IV. Benefits of this Research Project

While there are no direct benefits to you from this research (other than payment), you may find the experiment interesting. No promise or guarantee of benefits has been made to encourage you to participate. Your participation, along with that of the other volunteers, should make it possible to improve the design of in-vehicle systems. Improvements in the design of automotive in-vehicle systems may have a significant impact on driving safety, system usability, and consumer satisfaction.

V. Extent of Anonymity and Confidentiality

The data gathered in this experiment will be treated with confidentiality. Shortly after you have participated, your name will be separated from your data. A coding scheme will be employed to identify your data by gender and participant number only (e.g., Male, Participant No. 3).

Eye movement behavior is measured using a video camera and recorder during the experiment. A camera, positioned inside the center rearview mirror, is used to record drivers' eye-movements. The video image recorded is of the driver's head, with some additional space around the head to accommodate any head-movements by the driver during data collection. The videotapes will be

stored in a locked filing cabinet at the Virginia Tech Center for Transportation Research. Access to the tapes will be under the supervision of Dr. Thomas Dingus and Dr. Walter Wierwille. John Gallagher will have access to the tapes and will score the eye movement behavior using "frame-by-frame" analysis. The video tapes will be erased one year after the data have been analyzed and the results written-up.

At no time will the researchers release the videotapes from the study to anyone other than individuals working on the project without your written consent.

VI. Compensation

You will be paid \$10 per hour for the time you actually spend in the experiment. Payment will be made immediately after you have finished your participation.

VII. Freedom to Withdraw

You should know that at any time you are free to withdraw from participation in this research program without penalty. No one will try to make you continue if you do not want to continue, and you will be paid for the amount of time you actually participated.

VIII. Approval of Research

This research project has been approved, as required by the Institutional Review Board for Research Involving Human Participants at Virginia Polytechnic Institute and State University, the Department of Industrial and Systems Engineering, and the Virginia Tech Center for Transportation Research.

IX. Participant's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

- 1) I should not volunteer for participation in this research if I am younger than 18 years of age, or if I do not have a valid driver's license, or if I am not in good health, or if I am pregnant.
- 2) I should not take part in the driving task if I have taken any drug, alcoholic beverage, or medication within the previous 24 hours that might affect my ability to safely operate an automobile. It is my responsibility to inform the experimenters of any additional conditions

that might interfere with my ability to drive. Such conditions would include inadequate sleep, hangover, headache, cold symptoms, depression, allergies, emotional upset, visual or hearing impairment, seizures (fits), nerve or muscle disease, or other similar conditions.

- 3) As the driver of the research vehicle, I must obey all traffic regulations and maintain safe operation of the vehicle at all times. I will treat the driving task as the primary task and perform the other instructed tasks only when it is safe to do so.

X. Participant's Permission

I have read and understand the Informed Consent and conditions of this research project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project. If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this research project.

Signature	Date
Should I have any questions about this research or its conduct, I may contact:	
Dr. Thomas A. Dingus Principal Investigator	231-8831
Dr. Walter W. Wierwille Principal Investigator	231-7740
H.T. Hurd Director, Sponsored programs	231-5281

APPENDIX I – HEALTH SCREENING QUESTIONNAIRE

1. Are you in good general health? Yes No
If no, list any health-related conditions you are experiencing or have experienced in the recent past.

2. Have you, in the last 24 hours, experienced any of the following conditions?

Inadequate sleep	Yes	No
Hangover	Yes	No
Headache	Yes	No
Cold symptoms	Yes	No
Depression	Yes	No
Allergies	Yes	No
Emotional upset	Yes	No

3. Do you have a history of any of the following?

Visual Impairment Yes No

(If yes, please describe.)

Hearing Impairment Yes No

(If yes, please describe.)

Seizures or other lapses of consciousness Yes No

(If yes, please describe.)

Any disorders similar to the above or that would impair your driving ability Yes No

(If yes, please describe.)

4. List any prescription or non-prescription drugs you are currently taking or have taken in the last 24 hours.

5. List the approximate amount of alcohol (beer, wine, fortified wine, or liquor) you have consumed in the last 24 hours.

6. Are you taking any drugs of any kind other than those listed in 4 or 5 above? Yes No

7. If you are female, are you pregnant? Yes No

Signature

Date

APPENDIX J – TRAINING PROTOCOL

Note: Drivers participated in two studies; one study presented information visually, and the other presented information auditorily to the drivers via the IVIS. Drivers were trained for both studies prior to performing either study. After the training session, the visual study was performed first; once all the data were collected for this study, the auditory study was conducted.

WELCOME PARTICIPANT

Experimenter

The research you will be helping with is funded by the Federal Highway Administration. The purpose is to gather information that will be made free to the public, including car manufacturers.

The goal is to determine the best format in which to present information to drivers while driving. In the near future, when in-vehicle information systems are readily available in all vehicles, we want to ensure that the information is presented in a format and complexity level that doesn't create a safety hazard.

The study will consist of driving on US Route 460 into West Virginia and back. I will be riding in the front passenger seat and will be asking you questions after you complete each task. There will be an individual riding in the back who will be monitoring the computers and equipment. There will also be another person driving a car in front of us. Do not worry about him, ignore him; if other cars come in between us, don't worry about it. His purpose is to be traffic for us if there are no other vehicles around. We have him there because we didn't want some participants to have a lot of traffic and others to have no traffic. This way everyone will have at least one car in front of them.

Along the drive, we will present information to you and ask you to perform a task with it, such as select a hotel or select a route. Today, we will be presenting information in different formats, both visually and auditorily, to determine which formats are preferred. If at anytime you feel that the information is too complex to read or listen to while driving, simply say skip. We aren't testing your ability to perform a task; rather, we are trying to determine your preference. Saying

“skip” is good data for us so that we know not to present information in that complexity or format to individuals when the vehicle is moving.

I have prepared some paperwork that will provide you with more information about the study. Before we begin, do you have any questions?

(Answer any questions participants may have)

I'd like for you to read and fill out two forms. The first form tells you about the study, your responsibilities, safety concerns, compensation, etc. The second form is a questionnaire about your general health. The purpose is to determine that you don't have any visual, hearing, or other condition that would interfere with safely driving the vehicle. After you read and complete both forms, please sign and date them both. You will be given a copy of the informed consent to keep. Feel free to ask any questions you may have.

PAPERWORK

___ Informed consent

___ Health questionnaire

LICENSE

___ Check to see that it is a current valid driving license

DISTANCE VISION TEST

___ Administer vision test. 40/20 distance vision is required to proceed.

INSTRUCTION HANDOUT

___ Ask participant to read instruction handout, and then answer any questions.

___ Explain mental demand, frustration level, time-sharing demand, and situation awareness

Delays

The following icons indicate delays on roadways: *(Point to each of the following icons on the screen and state the type of delay depicted)*

- Traffic signal ahead
- Heavy truck traffic (18 wheelers)
- Fire truck (moving or stationary, but has its lights on and wants you to know it's there)
- Construction flagman
- Construction work
- Farm machinery
- Accident (this icon depicts two cars that have collided)
- Railroad crossing
- Text description of length of delay. To avoid covering the roadway, the text block is offset from the roadway to which it applies. The location of the delay is indicated by an orange-highlighted roadway. The length of the highlighted area is constant and consequently doesn't indicate the time of delay or amount of congestion.

Congestion

Congestion resulting from each delay is indicated by the roadway highlighted in red. The length of the red highlighted area indicates the amount of congestion. *(Point to the two different red lines and indicate how they can vary in length)*

Hazards

The following icons indicate hazards located on roadways: *(Point to each of the icons, and state the meaning of each)*

- Pedestrian crossing
- Children playing
- School area
- Icy bridge
- Deer crossing
- Slippery road

- Text description of hazards – the location of the hazard is indicated by the yellow – highlighted roadway. The length of the highlighted area is constant and consequently doesn't indicate any measure of time or severity.

More Delay Icons

The following icons indicate the length of time for delays. Think of a clock; the orange represents the amount of time of the delay. These icons are only examples of the icons used to depict time delays. Similar icons will be used in the study to depict different lengths of time:

(Point to each icon and state length of delay)

- 20 – minute delay
- 40 – minute delay
- 55 – minute delay

Lanes Closed

The following three icons indicate the number of lanes of travel in your direction and how many of them are blocked/closed due to the delay: *(Point to each icon, and state number of lanes open and blocked/closed)*

- Two lanes, two lanes blocked
- One lane, one lane blocked
- Two lanes, one lane blocked

Information may state that all lanes are blocked, but this does not necessarily mean all traffic is stopped. It may be possible to drive on the shoulder, or there may be police or construction workers on scene directing traffic (stop traffic in opposing lanes and have you drive in those lanes).

North Direction Arrow and Distance Scale

Directional arrow and scale of distance are present on all maps. Scale indicates distance for 5 miles and 10 miles: *(Point to North Arrow, 5-mile, and 10-mile indicators).*

Roadways

Type of roadway is indicated by roadway thickness and route sign icons. Interstates will be the thickest lines, US routes will have the medium thickness, and VA state highways will be the thinnest: *(Point to each of the roadways as being described)*

- Interstate 17 – Four lanes, limited access, with a median. Two lanes of travel in each direction. Think of Interstate 81.
- US Route 37 – Four lanes, may or may not have a median. Two lanes of travel in each direction. Think of US Route 460.
- VA State Highway 42 – Two lanes, one lane in each direction. Think of the road out front. *(Point to the road that can be seen from the office window)*

In tables or paragraphs, when roadways are referred to, they will be abbreviated as:

- Interstate 17 – I-17.
- US Route 37 – US Rte. 37
- VA State Highway 42 – Hwy. 42

Hotels

The following icons indicate hotels: *(Point to each of the hotels and state name; repeat list twice)*

- Marriott
- Double-Tree
- Hilton
- Comfort Inn
- Best Western
- Sheraton
- Embassy Suites

If you should forget the name associated with the icon while you are driving, simply describe the icon to me that you would choose for example, the “S” hotel to indicate the Sheraton, or red circle to indicate Marriott). It’s not important that you remember the name, just that I know what

hotel you have chosen. The display will be facing toward you; I will not be able to read the information on it.

The following groups of icons will appear with each hotel. Sometimes all four of these icons will be grouped together, sometimes only two, or sometimes only one icon will appear with each hotel: *(Point to each icon and state meaning)*

- Bed icon indicates that hotel has vacancies.
- Bed icon with red cross indicates no vacancies.
- Dollar signs indicate cost of hotel. The number of dollar signs range from 1 to 5: 1 dollar sign indicates low cost, while 5 dollar signs indicate high cost.
- Fork and knife icon indicates restaurant present in hotel.
- Fork and knife with red cross indicates no restaurant in hotel.
- Stars indicate quality of hotel. The number of stars range from 1 to 5: 1 star indicates poor quality, while 5 stars indicate excellent quality.

Traffic Density

Icons indicate low, medium, or high traffic density. These icons indicate the amount of traffic elsewhere on the route, unassociated with any delays. *(Point to each icon and state meaning.)*

Other Icons

(Point to each icon and state meaning.)

- Hospital
- Red circles are used in conjunction with icons or blocks of text to indicate the location of the hospital, airport, and hotels.
- Toll road
- No tolls
- Gas station; location will be indicated with a blue square.
- No gas station on roadway

TESTING OF ICON RECOGNITION

EXPERIMENTER

Please start in the upper left-hand corner of the screen and state the meaning of each icon.
(If participant fails to identify an icon correctly, repeat the meaning of the icon. After the participant has gone through the complete list of icons, he/she will be asked to repeat the icons that they failed to identify. This will be repeated until the participant successfully states the meaning of all icons and he/she states that he/she feels comfortable identifying all the icons. Review as needed.)

PRESENTATION OF SAMPLE SLIDES

TRAINING SLIDE #2: TABLE, SEARCH.

(Display training slide #2 on computer)

Local Attractions					
Option	Hotel Cost	Food Cost	Parking Cost	Admission Cost	Toll Cost
1	\$93.00	\$6.00	High	\$2.50	High
2	\$0.00	\$0.00	No Cost	\$0.00	No cost
3	\$0.00	\$4.10	No cost	\$54.00	Low
4	\$0.00	\$3.00	Low	\$0.00	High
5	\$0.00	\$11.00	High	\$8.50	No cost

Figure J.2. Training Slide #2.

Instructions: Identify the option with no monetary cost.

Experimenter

Complete the task and state your answer.

Participant states answer

Experimenter

(Verify that the correct selection was chosen. If it was not, explain how to do the task and ask the participant to choose again.)

TRAINING SLIDE #3: PARAGRAPH, SEARCH AND COMPUTE.

(Display training slide #3 on computer)

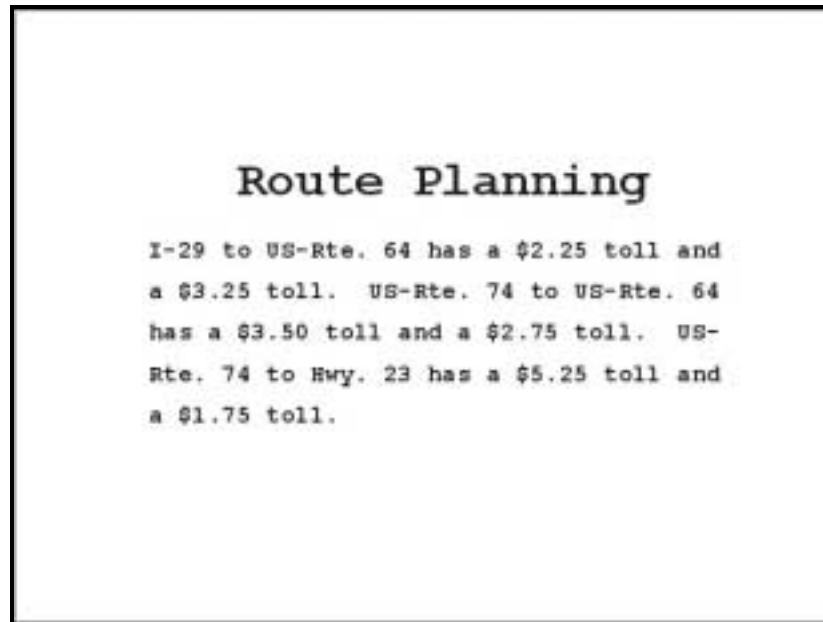


Figure J.3. Training Slide #3.

Instructions: Determine the cheapest route to take to the airport.

Experimenter

When you state your answer, simply state the route numbers. You don't need to state what type of road it is (interstate, U.S. route, or highway). For example, if you want to take I-38 to Highway 24, simply state as your answer "38 to 24".

Whenever your instructions state to determine the cheapest route or the quickest route, I will ask you if you performed a calculation, rough calculation, or a comparison with no calculation. If you feel comfortable performing a calculation, I would like you to perform one to determine the cheapest or quickest route. If you say that you performed a calculation or rough calculation, I will then ask for the numeric answer you calculated or roughly approximated. I will then state each category of information that was displayed and ask if you considered it in making a

decision. I would like for you to follow the instructions stated by the computer, but it is not imperative that you do. However, it is important that I know what information you used in making your decision. When I compile all the data, I will categorize the data by the number of categories of information you used and whether you did any type of calculation. This is why I will ask you if you used categories of information that there was no need to use in order to complete the task as instructed. I'm simply checking to make sure that I understand how you used the presented information.

As with any task, if you feel the task is too difficult to perform, simply say "skip" and the task will end.

Go ahead and complete this task, determine the cheapest route to the airport, and then state your answer; if you feel the task is too difficult to perform, you may say "skip" and the task will end.

Participant states answer.

Experimenter

Did you perform a calculation, rough calculation, or did you do a simple comparison with no calculation?

(If a calculation was performed, ask participant to state how much the cheapest route would cost).

(Ask if each category of information was considered: type of road and tolls. Participant will answer yes/no for each category of information.)

(Discuss what constitutes using a category of information – ex. Comparing the type of roadways on one route with the roadways on another route vs. simply looking at one option and determining that the roadways met some criteria.)

TRAINING SLIDE #4: TABLES, SEARCH AND COMPUTE.

(Display training slide #4 on computer)

Route	Distance	Speed Limit	Toll Cost
I-34, Hwy. 54	120 miles	50 mph	\$6.25
US-Rte. 68, US-Rte. 15	145 miles	40 mph	\$1.25
US-Rte. 68, Hwy. 16	162 miles	55 mph	\$3.25
I-34, US-Rte. 71	310 miles	65 mph	\$2.75
US-Rte. 68, Hwy. 54	195 miles	35 mph	\$6.50

Figure J.4. Training Slide #4.

Instructions: Determine the quickest route to the airport.

Experimenter

With this task, we are looking for you to use the distance and speed limits to determine the quickest route. As with the previous task, perform a calculation and then state your answer.

After you state your answer, I will again ask you if you performed a calculation, rough calculation, or a simple comparison. If you performed a calculation or rough calculation, I will ask you for a numeric answer or approximation you calculated for the selected route.

Remember, you may say skip if you would not choose to perform this task while driving.

When information about speed limit is provided to you in paragraph and table format, the average speed limit has been determined and provided to you.

If you use a speed limit that is different from the one that is provided on the display for a route, let me know what value you used in determining the quickest route. For example, if a roadway has a speed limit of 55mph but you normally drive 50mph or 60mph, then make your decision

and/or calculations as you normally would. However, let me know what values you used if they are different than those provided.

Go ahead and determine the quickest route to the airport. Remember that you may say “skip” at any time.

Participant states answer.

Experimenter

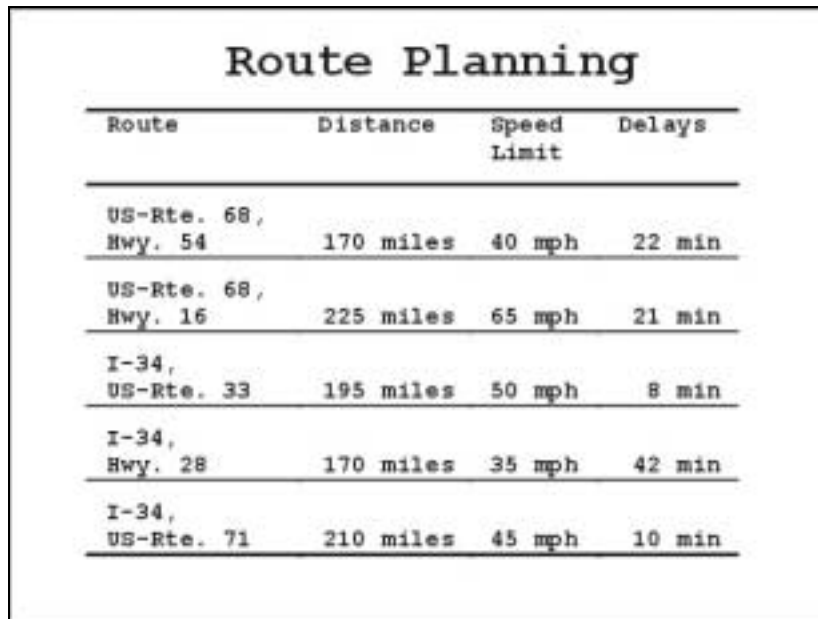
Did you perform a calculation, rough calculation, or did you do a simple comparison with no calculation?

(If a calculation was performed, ask participant to state how long the quickest route would take).

(Ask if each category of information was considered: type of road, speed limit, distance, and toll cost. Participant will answer yes/no for each category of information.)

TRAINING SLIDE #5: TABLE, SEARCH AND COMPUTE.

(Display training slide #5 on computer).



Route	Distance	Speed Limit	Delays
US-Rte. 68, Hwy. 54	170 miles	40 mph	22 min
US-Rte. 68, Hwy. 16	225 miles	65 mph	21 min
I-34, US-Rte. 33	195 miles	50 mph	8 min
I-34, Hwy. 28	170 miles	35 mph	42 min
I-34, US-Rte. 71	210 miles	45 mph	10 min

Figure J.5. Training Slide #5.

Instructions: Determine the quickest route to the airport.

Experimenter

This task is similar to the last task; with this slide, you are also presented information on length of delays in addition to the distance and speed limit. Use the information as you feel comfortable. Go ahead and determine the quickest route to the airport.

Participant states answer.

Experimenter

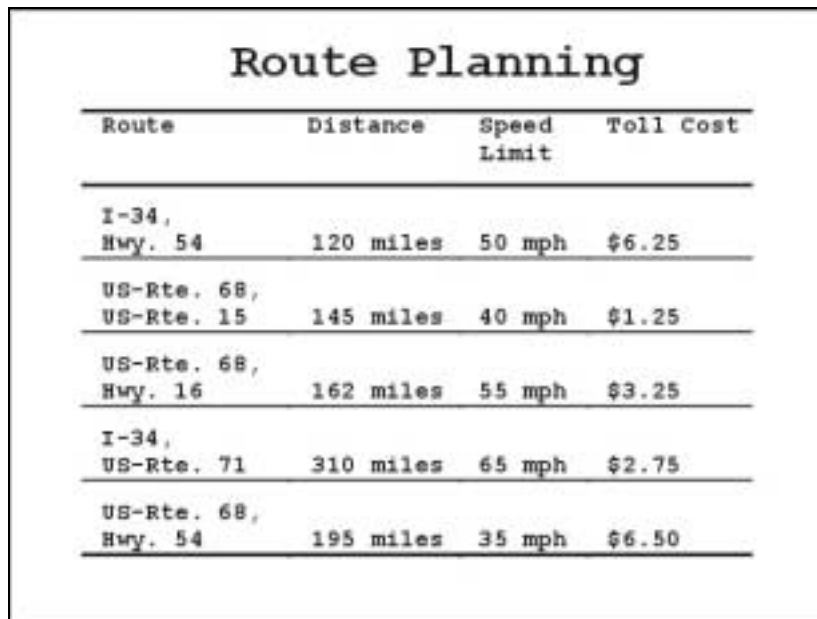
Did you perform a calculation, rough calculation, or did you do a simple comparison with no calculation?

(If a calculation was performed, ask participant to state how long the quickest route would take.)

(Ask if each category of information was considered: type of road, speed limit, distance, and delays. Participant will answer yes/no for each category of information.)

TRAINING SLIDE #6: TABLE; SEARCH, COMPUTE, AND PLAN.

(Display training slide #6 on computer).



Route	Distance	Speed Limit	Toll Cost
I-34, Hwy. 54	120 miles	50 mph	\$6.25
US-Rte. 68, US-Rte. 15	145 miles	40 mph	\$1.25
US-Rte. 68, Hwy. 16	162 miles	55 mph	\$3.25
I-34, US-Rte. 71	310 miles	65 mph	\$2.75
US-Rte. 68, Hwy. 54	195 miles	35 mph	\$6.50

Figure J.6. Training Slide #6.

Instructions: Select a route to the airport.

Experimenter

This slide presents the same information as a previous slide. However, the instructions were different. These instructions asked you to select a route, whereas the previous instructions asked you to select the quickest route. When the instructions ask you to select a route, feel free to use the information in the manner you normally would when making a decision. You may choose to do a calculation or you may choose not to; you may choose to perform comparisons between the different categories of information, or you may simply perform a calculation. It is up to you how you use the information.

However, please remember that when we ask for the quickest route or the cheapest route, we would like for you to perform a calculation.

Go ahead and select a route to the hospital, using the information as you choose.

Participant states answer.

Experimenter

Did you perform a calculation, rough calculation, or did you do a simple comparison with no calculation?

(If a calculation was performed, ask participant to state how long the route they selected would take.)

(Ask if each category of information was considered: type of road, distance, speed limit, and toll costs. Participant will answer yes/no for each category of information.)

TRAINING SLIDE #7: GRAPHIC ICON; SEARCH, PLAN, AND INTERPRET.

(Display training slide #7 on computer).

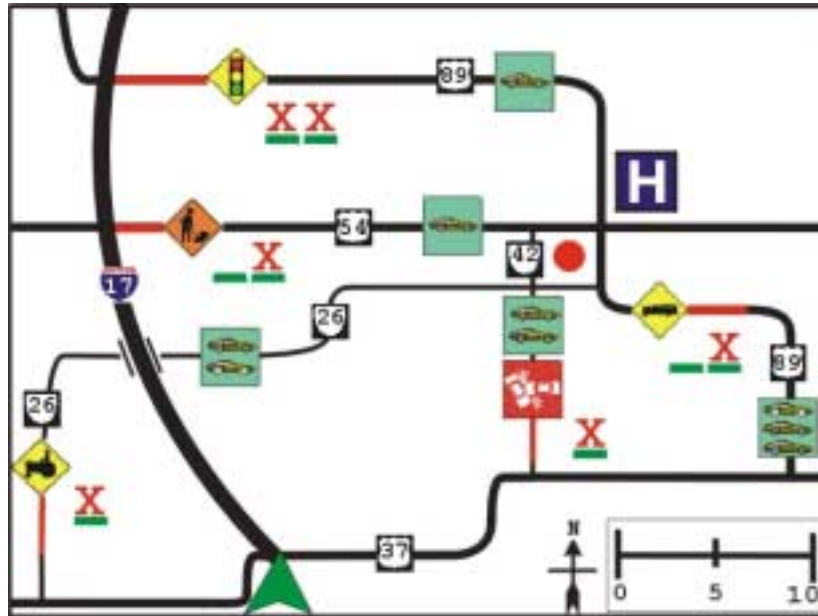


Figure J.7. Training Slide #7.

Instructions: Select a route to the hospital.

Experimenter

Your current position is indicated by the green triangle. You want to go to the hospital; this location is indicated by the red circle. Five routes are possible to get to the hospital. *(Trace 5 routes, point out that it isn't possible to go 17 to 26 because of bridge.)*

Information about each route includes: type of road, distance, type of delays, congestion caused by delays, lanes closed because of delay, and traffic density. *(Point to each category of information)*

Go ahead and select a route to the hospital.

Participant states answer.

Experimenter

(Ask participant if each category of information was considered: delays, number of lanes closed, congestion, type of road, distance, and traffic density. Participant answers yes/no for each category of information.)

TRAINING SLIDE #8: GRAPHIC TEXT, SEARCH AND PLAN.

(Display training slide #8).

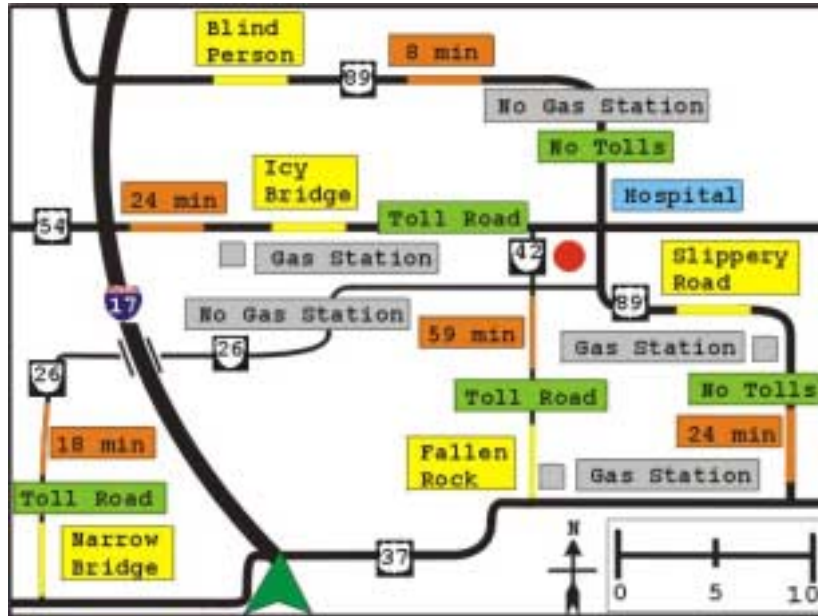


Figure J.8. Training Slide #8.

Instructions: Select a route to the hospital.

Experimenter

This display indicates the type of road, distance, type of delays, safety hazards, toll costs, and gas station. The highlighted areas of orange and yellow do not indicate length of time or amount of congestion. The gray square indicates the location of a gas station. *(Point to each category of information.)*

Go ahead and select a route to the hospital.

Participant states answer.

Experimenter

(Ask participant if each category of information was considered: delays, safety hazards, tolls, gas station, type of road, and distance. Participant answers yes/no for each category of information.)

TRAINING SLIDE #9: GRAPHIC TEXT, SEARCH AND COMPUTE.

(Display training slide #9 on computer).

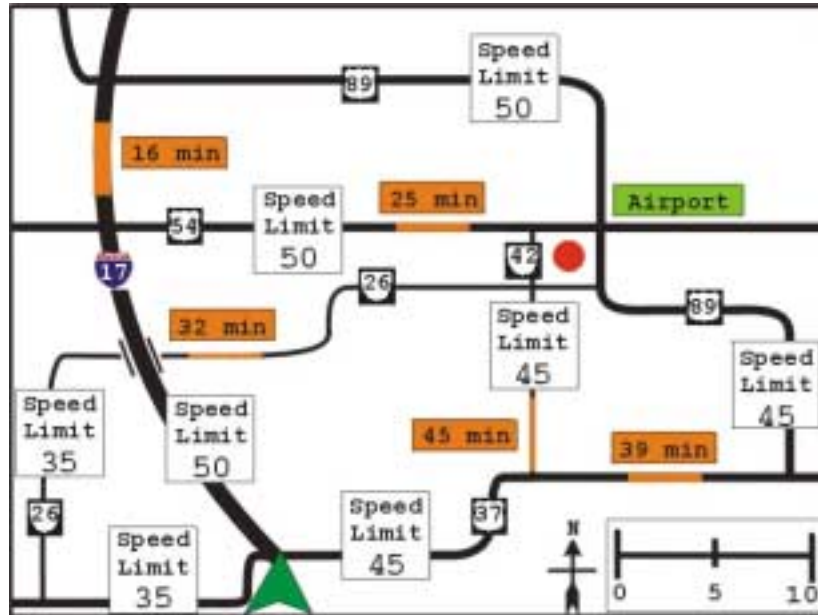


Figure J.9. Training Slide #9.

Instructions: Determine the quickest route.

Experimenter

You are presented with information on distance, speed limit, delays, and type of road. Go ahead and determine the quickest route to the airport.

Participant states answer.

Experimenter

Did you perform a calculation, rough calculation, or did you do a simple comparison with no calculation?

(If a calculation was performed, ask participant to state how long the quickest route would take).

(Ask if each category of information was considered: type of road, distance, speed limit, and delays. Participant will answer yes/no for each category of information.)

TRAINING SLIDE #10: GRAPHIC TEXT; SEARCH, COMPUTE, AND PLAN.

(Display training slide #10 on computer).

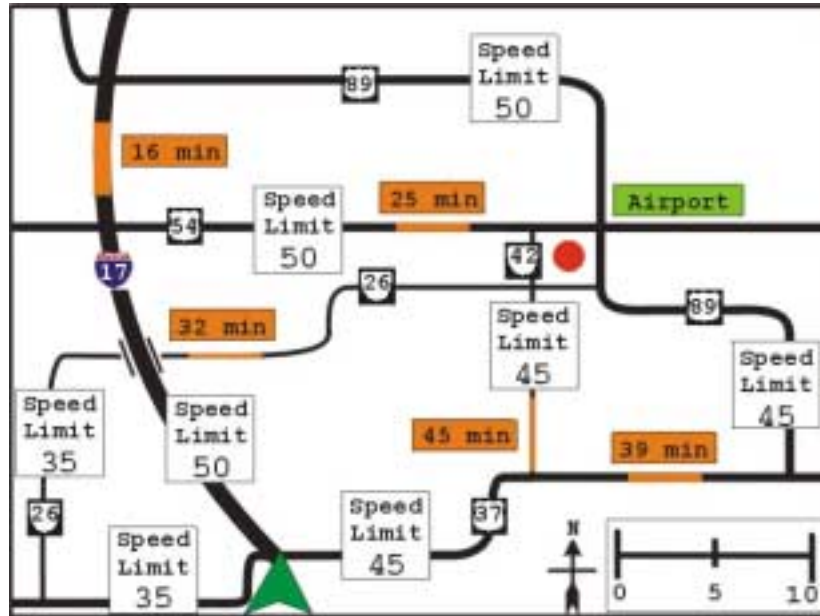


Figure J.10. Training Slide #10.

Instructions: Select a route to the airport.

Experimenter

This slide presents the same information as in the previous slide. However, the instructions are different. These instructions ask you to select a route, whereas the previous instructions asked you to select the quickest route.

Go ahead and select a route to the hospital, using the information as you choose.

Participant states answer.

Experimenter

Did you perform a calculation, rough calculation, or did you do a simple comparison with no calculation?

(If a calculation was performed, ask participant to state how long the route they selected would take.)

(Ask if each category of information was considered: type of road, distance, speed limit, and delays. Participant will answer yes/no for each category of information.)

(Discuss how the same information can be presented with two different types of instructions. One instruction is asking for a calculation to be performed, while the other is not).

TRAINING SLIDE # 11: GRAPHIC TEXT, SEARCH AND PLAN.

(Display training slide #11 on computer).

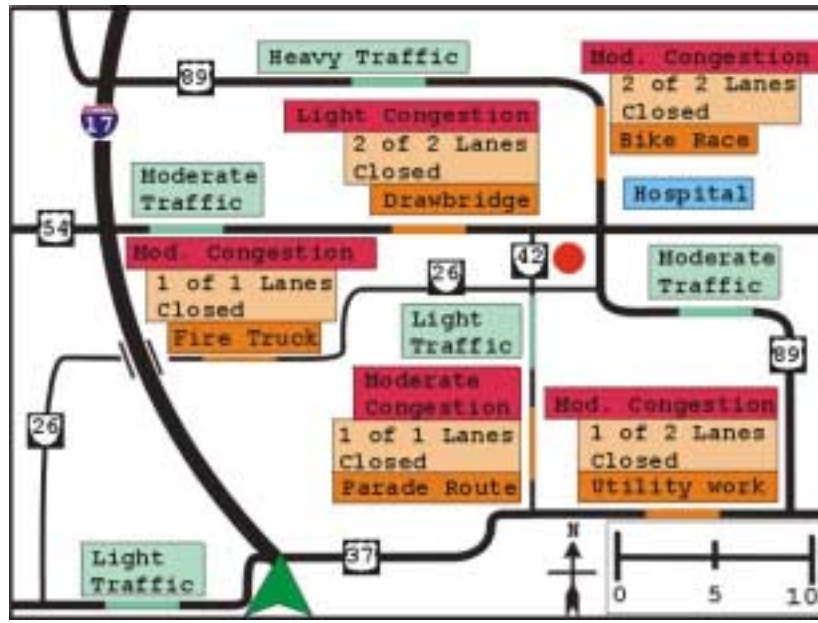


Figure J.11. Training Slide #11.

Instructions: Select a route to the hospital.

Experimenter

This display indicates the type of road, distance, delays, congestion caused by delay, lanes closed, and traffic density. The length of the red-highlighted roadway indicates the amount of congestion caused by the delay. The green-highlighted roadway simply indicates the location of the traffic density measure. The green-highlighted area is similar to the yellow- and orange-highlighted areas in previous slides; the length of the highlighted areas is constant and does not indicate severity or time.

Go ahead and select a route to the hospital.

Participant states answer.

Experimenter

(Ask participant if each category of information was considered: type of road, distance, delay, lanes closed, and congestion. Participant answers yes/no for each category of information.)

TRAINING SLIDE #12: GRAPHIC ICON, SEARCH AND PLAN.

(Display training slide #12 on computer).

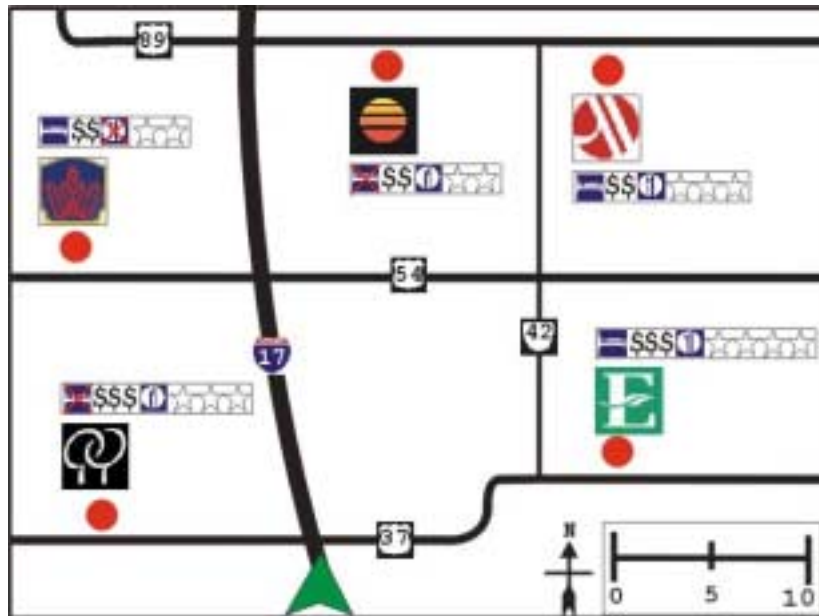


Figure J.12. Training Slide #12.

Instructions: Select a hotel.

Experimenter

The green triangle marks your current position at the intersection of two roads. You are getting tired; select a hotel to stay at for the evening using information provided; assume your normal route is along interstate 17.

(Indicate meaning of vacancy, cost, restaurant, and quality symbols. Also explain hotel name and distance information categories).

Go ahead and select a hotel.

Participant states answer.

Experimenter

(Ask participant if each category of information was considered: hotel name, vacancy, cost, restaurant, quality, and distance. Participant answers yes/no for each category of information.)

AUDITORY, TRAINING TASK #1

(Play audio-tape for auditory, training task #1)

Instructions: Select a route to the hospital.

Experimenter

The next example will be an auditory task. You will hear the instructions, there will be a brief pause, and then the information necessary to complete the task will be presented. You may have the instructions and information repeated as many times as you would like.

With auditory tasks, 3 or 5 options will be presented. Listen to all options before giving an answer when the task instructions are to select a hotel or route, or to select the cheapest or quickest route.

When you state an answer for route questions, you may answer with either option 1, 2, 3, 4, or 5 or by saying the route numbers as you did with the visual tasks. Do whichever is easiest.

(Show illustration of the location of buttons and explain how information is presented and how/when information can be repeated.)

- Push left button to replay instructions and information
- Push right button to replay only the information
- May choose to replay instructions and/or information as many times as desired
- Listen to all options before stating selection
- When you choose to replay information, you may state your selection at any time after the information has been presented once. It is not necessary to repeat all the information.
- You may say “skip” at any time and the task will end.

Participant listens to information.

(Replay information as many times as necessary)

Participant states answer.

(Ask participant if each of the different categories of information was considered: type of road, distance, speed limit, delays, hazards, and gas station. Participant answers yes/no for each category of information.)

AUDITORY, TRAINING TASK #2.

(Play audio-tape for auditory training task #2)

Instructions: Select a route to the hospital.

Experimenter

The next example will be an auditory task. You will hear the instruction, there will be a brief pause, and then the information necessary to complete the task will be presented. Remember, you may have the instructions and information repeated as many times as you would like.

Participant listens to information.

(Replay information as many times as necessary)

Participant states selection.

Experimenter

(Ask participant if each of the different categories of information was considered: type of road, distance, delay, weather, lanes closed, and congestion. Participant answers yes/no for each category of information.)

SUMMARY OF DESK-TOP TRAINING

Experimenter

You've now seen an example of each type of task that you will be shown in the vehicle. These slides had the highest complexity of information that you would be shown while you are driving. There are slides that have significantly less information; we will present these slides with less information to you first during the drive.

I just want to remind you that it is all right to skip a task that is presented. This is good data for us. Say "skip" if you feel that performing the task takes too much attention away from driving, or, if you really had to make this decision in real life, you would want to pull over to the side of the road to look at the display more closely or to take notes while listening to the auditory information. We are not evaluating how much information you can make yourself process, but rather how much you feel comfortable processing and would choose to process based on the attention demand required and your confidence in selecting the correct option.

One last thing: when making decisions, remain stubborn; do not modify the way you make decisions. The same categories of information will be repeatedly used. I will ask if you used each category of information after each task. Don't feel like you should change the way you make decisions because I keep asking if you used a category of information. I don't want you to change the way you normally would make decisions, but I must ask every time to determine which categories of information were used.

Do you have any questions before we go out to the car?

IN-VEHICLE TRAINING

Have Participant Adjust Seat

Have Participant Adjust Mirrors

Verify Eyes in View of Camera

Have rear seat experimenter verify that both of the participant's eyes can be seen clearly in the camera. *(If both eyes are not in clear view, adjust the mirror and/or seat such that the participant feels comfortable with the mirror position and his/her eyes are in view of the camera.)*

Vehicle Controls

Have the participant locate and become comfortable with wiper, signal, and headlight controls.

Point out the instruments on the display:

- Speedometer
- Temperature gauge (really the gas gauge). When the red area is reached, it means we are low on gas.
- Display to right of speedometer will remain blank for the duration of the drive.

VISION TEST, AND HEARING TEST

(Display training slide #13)

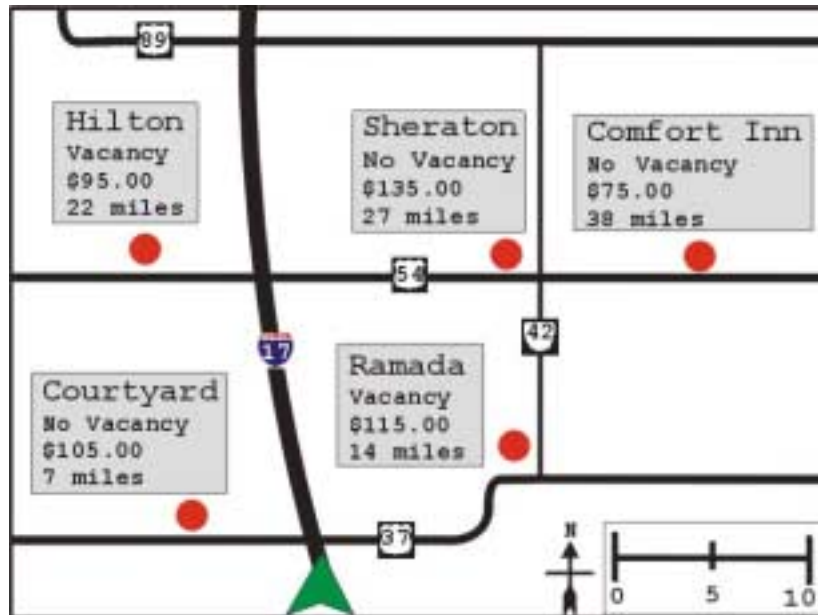


Figure J.13. Training Slide #13.

Instructions: Select a hotel.

Experimenter

(Adjust display position for the participant's comfort.)

Ask the participant to read the information displayed on the screen. If the participant is unable to read the information displayed, thank him/her for offering to help and *end the study*.

Ask the participant to repeat the instructions he/she heard. Ask if he/she would like the volume increased. Repeat until the participant states that the desired level has been obtained. If the participant is unable to understand the information presented auditorily, thank him/her for coming and *end the study*.

Ask the participant to select a hotel.

Participant states selection.

Experimenter

(Ask participant if each category of information was considered — hotel name, vacancy, cost, and distance — in making his/her decision. Participant answers yes/no for each category of information.)

Practice Drive

(Ask participant if he/she is ready. If he/she is ready, drive around the practice route to allow the participant to become familiar with the vehicle.)

Experimenter

Do not worry about keeping up with the lead vehicle or worry if a vehicle comes between you and him. Remember, the purpose of the lead vehicle is to simulate traffic; if other vehicles come between you and him, then they will take his place as traffic.

If I see that you have become overly distracted by the display and are starting to go off the road, I will simply say ROAD. When you hear this, stop looking at the display and put your full attention to the roadway.

I have an emergency brake pedal on my side. If I push it, this is what it will feel like. *(Check to make sure vehicles aren't behind the Aurora, and gently press brake)*

(After driving around the practice route once, ask the participant if he/she feels comfortable with the handling of the vehicle. If he/she would like more practice, allow him/her to drive around the route as many times as needed.)

Practice Slides

(Have participant drive around practice route.)

PRESENT TRAINING SLIDES #14, 15, 16, 17, AND 18

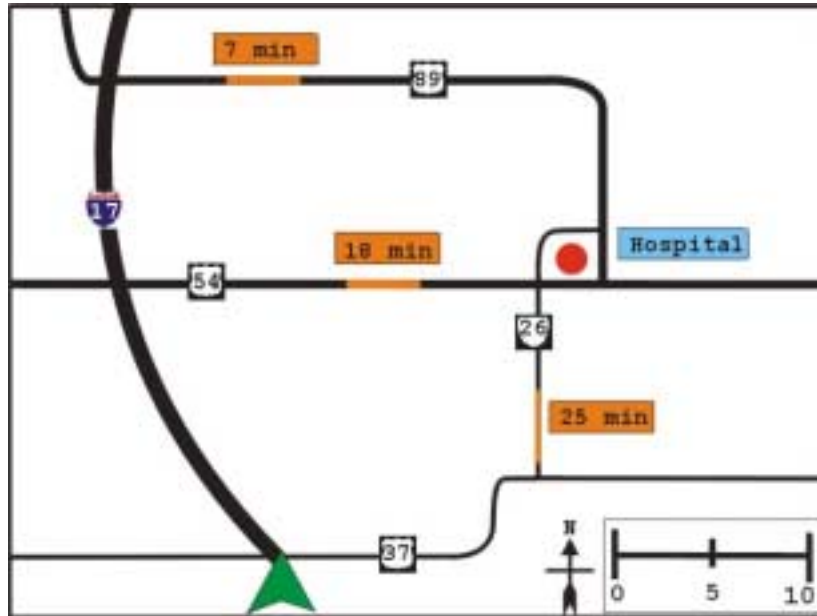


Figure J.14. Training Slide #14.
Instructions: Select a route to the hospital.

Route Planning

Route	Distance	Speed Limit
I-34, US-Rte. 71	110 mile	35 mph
US-Rte. 68, Hwy. 49	297 miles	65 mph
I-34, Hwy. 54	189 miles	50 mph

Figure J.15. Training Slide #15.
Instructions: Select the quickest route to the airport.

Local Attractions

Option 1, high parking cost and \$4.00 admission. Option 2, no parking cost and \$0.00 admission cost. Option 3, no parking cost and \$12.00 admission.

Figure J.16. Training Slide #16.
Instructions: Select a route to the hospital.

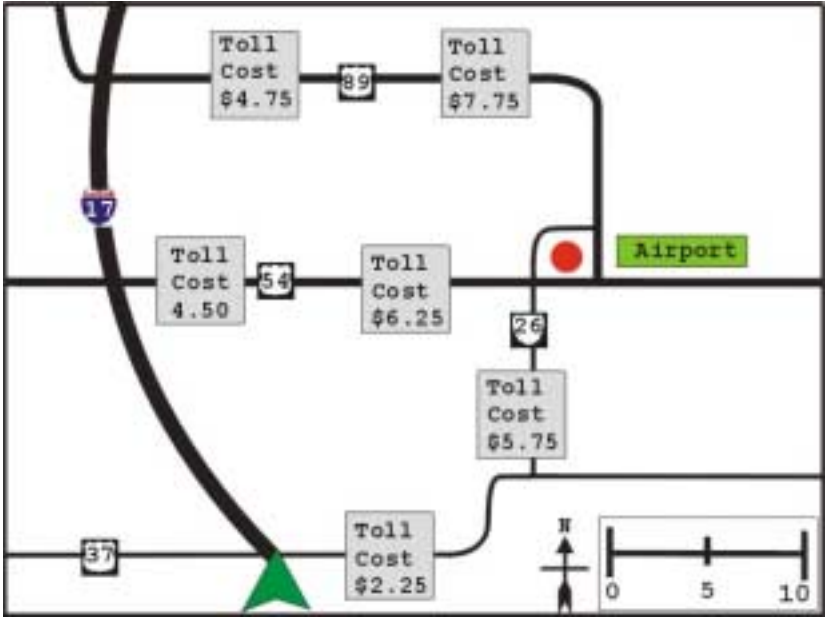


Figure J.17. Training Slide #17.
Instructions: Select the cheapest route to the airport.

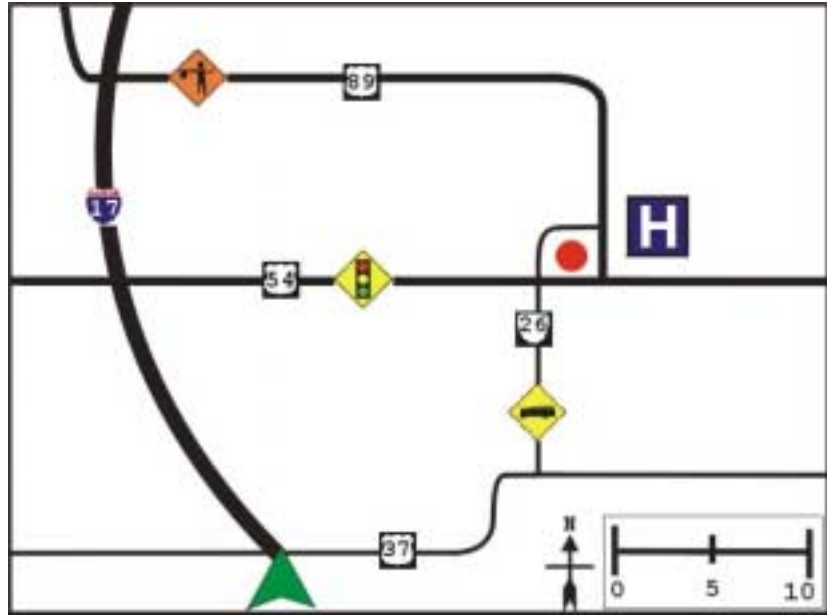


Figure J.18. Training Slide #18.
Instructions: Select a route to the hospital.

(If no problems exist, begin data collection of visual tasks.)

APPENDIX K – FRONT SEAT EXPERIMENTER PROTOCOL

DATA COLLECTION PROCEDURES

TASK PRESENTATION

Timeline

- Present task (Do not present tasks during sharp curves or while driving through towns)
- Allow the participant time to complete each task. If unsafe driving behavior is exhibited, end task.
- Ask participant probe questions to determine what information was used and if any calculation(s) were performed.
- Ask participant subjective evaluation questions for workload and situation awareness.
- Record answers on data collection sheet.

Procedures

- 1) Prior to starting data collection, place task sheets, in a prearranged order, in a binder. Each task sheet has a unique combination of type of task and presentation format. The different slides for this unique combination, each with a different level of complexity, are listed on the sheet.
- 2) During data collection, present one task per page in the notebook.
- 3) Select a complexity level that is suspected to be slightly under the Red-line Threshold.
- 4) State the task to be presented; the rear seat experimenter will type in the slide number and the slide will be presented.
- 5) After the participant provides his/her answer:
 - a) Ask the participant which categories of information he/she used,
 - b) Ask the participant for subjective measures, and
 - c) Ask rear experimenter for number of eye glances.
- 6) Once one task per page has been presented, start on the first page again, and present a second complexity level. If, during the first task presentation, the complexity level resulted in a measure under the Red-line Threshold, then present a more difficult complexity level. For safety reasons, sneak up on the Red-line Threshold. Avoid giving a task that is significantly over the Red-line Threshold. If, during the first task presentation, the complexity level resulted in a measure over the Red-line Threshold, then present a less difficult complexity level.

- 7) After a second complexity level has been presented for each category of task, start at the first page and present a third task if the two previous complexity levels did not yield measures below and above red-line. The goal is to have one task below and one task slightly above red-line. Use nine eye glances to the IVIS display as a rough estimate that a red-line has been reached if driving behavior does not indicate that the Red-line Threshold has been reached.
- 8) When a task is presented, the computer automatically sends a signal to the confederate driver: one beep at the beginning of a task, and two beeps at the end of a task.

BASELINE MEASURES

For every 4-5 visual tasks, there will be a page in the notebook that states that a baseline reading is to be collected for either 5, 10, 20, or 30 seconds. To flag data as baseline data:

- 1) Inconspicuously raise right hand to side of head, put one finger up. This informs the rear seat experimenter to signal the confederate vehicle that a baseline condition is being performed. Note: the confederate driver receives the same signals for the starting and ending of baseline conditions. He/she does not know which is being recorded in the data set.
- 2) Press and hold in the data flagger button for a preset number of seconds.
- 3) Inconspicuously raise right hand to side of head, put two fingers up. This informs the rear-seat experimenter to signal the confederate vehicle that a baseline condition has ended.
- 4) If during baseline data collection an event occurs (for example, participant sneezes, vehicle merges into traffic in between confederate vehicle and test vehicle, etc.) that creates non-baseline conditions, depress the data flagger and signal rear-seat experimenter that the baseline condition has ended. When a baseline condition is present again, repeat steps 1-3.

Breaks

Periodically ask the participant how he/she is feeling and if he/she would like to take a break. Take breaks approximately every 45 minutes, or more often, as needed by the participant.

APPENDIX L – CONFEDERATE DRIVER PROTOCOL

PROCEDURES

GENERAL

- Drive along the predetermined route on U.S. Route 460.
- Maintain a speed, when possible, of ± 5 mph of the posted speed limit. The speed limit, on sections of the route during which tasks are presented ranges between 55mph and 65mph.
- If the experimental vehicle becomes too distant (greater than a 5-second separation), slow down until the distance between the experimental vehicle and the confederate vehicle becomes less than 5 seconds.
- If the experimental vehicle becomes too close (uncomfortable or less than one-second separation), accelerate to allow for a comfortable headway distance.

DURING TASK PRESENTATION

- When a single tone signal is sent via the hand-held radio from the experimental vehicle, indicating the beginning of a task, decelerate approximately 5 mph.
- When decelerating, if possible, do not use the vehicle's brakes. Instead, decelerate by releasing the accelerator pedal when going up a hill or by down-shifting when on a flat or downhill section of road.
- When a double tone signal is sent via the hand-held radio from the experimental vehicle, indicating the end of a task, resume driving at the original speed.
- Remain in the right lane for the completion of a task