Appendix A. Controls Included In The Handbook

To tailor the handbook to the requirements of the automated highway system, candidate controls were rated based on several tradeoff factors chosen because of their, importance to control use on the AHS. Tradeoff factors were each written as binary choices, and each control was rated on each factor. Having no good basis for assigning weights to the tradeoff factors, they were all weighted equally. Thus, the score for each control was simply the sum of the unweighted ratings on the various tradeoff factors. Also, it should be noted that cost was not used to rate the controls. Although cost is clearly an important consideration, deciding how to use it as an evaluation factor was not clear. It may be that cost should be an initial filter through which a control type must pass to merit further consideration, or a final filter to decide between otherwise "equal" choices, but what cost cutoff should be used in any case was not obvious.

Evaluation Factors

The following factors were used to evaluate controls:

- Will the amount of vibration encountered inside an automobile traveling at highway speeds on a reasonably maintained concrete or asphalt roadway have a negative effect on the usability of the control?
- Can the control be used with (relatively) equal facility if the user moves around within the workspace?
- How much space is required for the control, relative to the other controls being rated?
- Is the control operable over the anticipated temperature range that might be encountered in the AHS environment? This was taken to be approximately -34.4 °C to +54.4 °C (-30 °F to +130 °F).
- Does the position of the control indicate its state (e.g., ON vs. OFF) and/or the state of the controlled function?
- Can the control be used effectively in ambient noise conditions with randomly occurring noise disturbances?
- Is the use of the control negatively affected by modest amounts of dirt, grease (including that from the oils in the user's fingers), etc.?
- Can the control be used if the user's hands are otherwise occupied?

Controls Rated

The following controls were rated on the factors stated above:

- Continuous controls:
  - Joystick.
  - Knob.
  - Mouse.

- Pedal.
- Slide.
- Thumbwheel.
- Trackball.

- Discrete controls:
  - Foot pushbutton.
  - Keyboard.
  - Knob.
  - Legend switch.
  - Lever.
  - Light pen.
  - Low resistance/low travel switch.
  - Pushbuttons: alternate action, single button; alternate action, two button interlocked; momentary contact; reconfigurable; single action.
  - Rocker.
  - Rotary selector.
  - Thumbwheel.
  - Touch screen.
  - Toggle.
  - Voice recognition.
- Security devices:
  - Card reader.
  - Cipher lock.
  - Key operated switch.

The Ratings and Final Controls Selection

The ratings for each of the controls stated above against each of the evaluation criteria are shown in table 38. To decide which controls to include in the handbook based on the ratings, it was necessary to determine a cutoff score below which a control would be eliminated from further consideration. There was no a priori basis for determining that score. Thus, the final selection was made after examination of the scores and discussion among the authors and other human factors professionals at the authors' place of business. On that basis, it was decided that only controls with an unweighted score of six would be included in the handbook, with the exceptions noted below. Those controls are as follows:

- Foot pushbutton.
- Joystick (isometric and isotonic).
- Key operated switch.

Table 8. Controls tradeoffs.

	Usability Under Vibration Conditions[1]	Usability from Multiple Locations	Space Required	Operability Over Temperature Range[2]	Has Built-in Display Properties?	Usability in Noise	Susceptibility to Dirt, Grease, Etc.	Allows Hands-Free Use?	SCORE	Comment Key
	Poor = 0 Good = 1	Poor = 0 Good = 1	A lot = 0 A little = 1	Poor = 0 Good = 1	No = 0 Yes = 1	Poor = 0 Good = 1	High = 0 Normal = 1	No = 0 Yes = 1		
CONTINUOUS										
Joystick	1	0	1	1	1	1	1	0	**6**	a
Knob	1	0	1	1	0	1	1	0	**5**	
Mouse	1	0	1	1	0	1	0	0	**4**	
Pedal	1	0	0	1	0	1	1	1	**5**	
Slide	1	0	1	1	1	1	1	0	**6**	
Thumb wheel	1	0	1	1	0	1	1	0	**5**	
Trackball	1	0	1	1	0	1	1	0	**5**	
DISCRETE										
Foot pushbutton	1	0	1	1	0	1	1	1	**6**	
Keyboard	1	0	0	1	0	1	1	0	**4**	b
Knob	1	0	1	1	1	1	1	0	**6**	
Legend switch	1	0	1	1	1	1	1	0	**6**	d
Lever	1	0	0	1	1	1	1	0	**5**	e
Light pen	0	0	0	1	0	1	0	0	**2**	h
Low resistance/low travel switch	1	0	1	1	0	1	1	0	**5**	i

(Table continued on next page.)

1 "Vibration conditions" means those normally encountered inside an automobile traveling at highway speeds on a reasonably maintained concrete or asphalt roadway. This was a purely subjective judgment: no attempt was made to determine the frequencies and/or amplitudes of vibration encountered.

2 The anticipated temperature range is approximately -34.4 °C to +54.4 °C (-30 °F to +130 °F).

Table 38. Controls tradeoffs (continued).

	Usability Under Vibration Conditions[1]	Usability from Multiple Locations	Space Required	Operability Over Temperature Range[2]	Has Built-in Display Properties?	Usability in Noise	Susceptibility to Dirt, Grease, Etc.	Allows Hands-Free Use?	SCORE	Comment Key
	Poor = 0 Good = 1	Poor = 0 Good = 1	A lot = 0 A little = 1	Poor = 0 Good = 1	No = 0 Yes = 1	Poor = 0 Good = 1	High = 0 Normal = 1	No = 0 Yes = 1		
DISCRETE (CONTINUED)										
Pushbutton, alternate action, single button	1	0	1	1	0	1	1	0	**5**	
Pushbutton, alternate action, two button interlocked	1	0	1	1	1	1	1	0	**6**	
Pushbutton, momentary contact	1	0	1	1	0	1	1	0	**5**	
Pushbutton, reconfig-urable	1	0	1	1	1	1	1	0	**6**	
Pushbutton, single action	1	0	1	1	0	1	1	0	**5**	
Rocker	1	0	1	1	1	1	1	0	**6**	f
Rotary selector	1	0	1	1	1	1	1	0	**6**	
Thumb wheel	1	0	1	1	0	1	1	0	**5**	
Touch screen	1	0	1	1	0	1	0	1	**5**	
Toggle	1	0	1	1	1	1	1	0	**6**	g *(Table continued on next page.)*

Table 38. Controls tradeoffs (continued).

	Usability Under Vibration Conditions[1] Poor = 0 Good = 1	Usability from Multiple Locations Poor = 0 Good = 1	Space Required A lot = 0 A little = 1	Operability Over Temperature Range[2] Poor = 0 Good = 1	Has Built-in Display Properties? No=0 Yes = 1	Usability in Noise Poor = 0 Good = 1	Susceptibil-ity to Dirt, Grease, Etc. High = 0 Normal = 1	Allows Hands-Free Use? No=0 Yes= 1	SCORE	Comment Key
DISCRETE (CONTINUED)										
Voice recognition	1	1	1	1	0	0	1	1	6	C
SECURITY DEVICES										
Card reader	1	0	1	1	0	1	1	0	5	
Cipher lock	1	0	0	1	0	1	1	0	4	
Key operated switch	1	0	1	1	1	1	1	0	6	

Comments:

a Joysticks that do not return to center have built in display properties.

b It is assumed that sealed keyboards can be used to keep out dirt, etc.

c With respect to usability in noise, what is assumed is unwanted noises present at random times, rather than a constant noise background

d A legend switch has a legend on its front face that is illuminated when the function is actuated; it is visible but not illuminated when the function is not actuated.

e Ability to tell what function has been actuated based on position alone (built in display) may depend on total number of lever positions and/or distance between positions.

f Rocker switches that do not return to center have built in display properties.

g Toggle switches that do not return to center have built in display properties.

h Off axis approach to the touch area may lead to reading and pointing errors.

i Very susceptible to accidental actuation.

- Knob (continuous).
- Legend switch.
- Pushbutton (momentary action, alternate action, and reconfigurable).
- Rocker switch.
- Rotary selector.
- Slide switch.
- Toggle switch.
- Voice recognition.

Note that the continuous knob has been included instead of the discrete knob, although the latter had a score of five and the former had a score of six. It is believed that the continuous knob is more likely to be used as part of the in-vehicle AHS interface (e.g., for brightness control on a visual display, for volume control on an auditory display) than will the discrete knob, which is used for push-pull functions (e.g., a headlight switch). In addition, guidelines have been provided for touch screens, even though they scored fairly poorly on the tradeoffs. An exception was made in this case because touch screens are appealing for a relatively untrained population, and thus may be worth considering for reasons that are not necessarily reflected in the tradeoffs.

When to Use Each Control

To help determine which control to use in a particular situation, the information in tables 39 and 40 is provided. Table 39 tells when to use each of the controls, and table 40 provides priority rankings for some of the controls. Priority rankings were not available for all the controls selected for inclusion in the handbook.

Table 39. Controls: when to use.[1]

Control	When to Use
Foot pushbutton	Foot pushbuttons should be used only in those cases where the user is likely to have both hands occupied at the time the pushbutton is actuated, or where load-sharing among limbs is desirable. Because they are susceptible to accidental actuation, limit their uses to non-critical or infrequent operations (e.g., press-to-talk communications).
Joystick, isometric (stiff stick, force stick, pressure joystick). This stick does not move in response to user commands. The controlled object moves in relation to the amount and direction of force applied to the stick.	Isometric joysticks should be used for applications that require return to center after each entry, in which user feedback is primarily visual from some system response, and where there is minimal delay and tight coupling between control input and system reaction. They should not be used where it is necessary for the user to maintain a constant force on the stick to generate a constant output over a sustained period of time. *(Table continued on next page.)*

[1] Unless otherwise noted, all information is from reference 14.

Table 39. Controls: when to use (continued).

Control	When to Use
Joystick, isotonic (displacement stick). This stick moves in response to user commands. The controlled object moves in relation to the amount and direction of displacement of the stick.	Isotonic joysticks should be used for control of various display functions, such as data pickoff from a cathode ray tube When used for rate control, the joystick should be spring loaded for return to center when the hand is removed
Key operated switch	Key operated switches should be used to prevent unauthorized machine operation.(27) They may also be used to provide ON-OFF functions.
Knob (continuous)	Knobs should be used when low forces or precise adjustments of a continuous variable are required.
Legend switch	Legend switches should be used to display qualitative information on an important system status, to reduce the demands for the user to interpret information, and when functional grouping or a matrix of controls and displays is required but space is very limited.
Pushbutton • Momentary contact. for single push-HOLD/release-OFF functions. • Alternate action. the first press sets the switch to ON and a second press sets it to OFF. • Stepping action successive presses of the switch cycle through three or more states.	Pushbuttons should be used primarily for simple switching between two conditions, selection of alternate ON-OFF functions from an array of related conditions or subsystem functions, release of a locking system (such as on a parking brake), or entry of a discrete control order
Rocker switch	Rocker switches should be used for functions that require two discrete positions, as an alternate to toggle switches They should be considered where the toggle switch handle might snag the user's clothing, etc., or where there is insufficient panel space for separate labeling of switch positions Rocker switches with three positions should be used only where the use of a more suitable three-position switch (see table 40) is not feasible, or where the rocker switch is spring loaded with the center OFF.
Rotary selector	Rotary selectors should be used for discrete functions when three or more detented positions are required. They should not be used for two-position functions unless prompt visual identification is of primary importance and speed of control operation is not critical. *(Table continued on next page.)*

Table 39. Controls: when to use (continued).

Control	When to Use
Slide switch	Slide switches should be used for functions that require two discrete positions. They may also be used for functions that require more discrete positions in which the switches are arranged in a matrix to permit easy recognition of relative switch settings They should not be used where mispositioning is to be avoided.
Toggle switch	Toggle switches should be used for functions that require two discrete positions or where space limitations are severe. They may also be used for three discrete positions, but a rotary selector is usually preferred for this application (see table 40).
Touch screen	Touch screens should be used when the opportunity for training is low; when targets are large, discrete, and spread out; when frequency of use is low; and when the task requires little or no text input.(31)
Voice recognition	Voice recognition should be used for situations where the user's hands are busy, mobility is required, or the user's eyes are busy.(31)

Table 40. Priority use rankings of controls.(14)[1]

	Function							
Control	Select Power State ON-OFF	Select One of Three States (OFF-STNDBY-ON)	Select One of 3 to 24 Discrete Alterna-tives—Sequential Order	Set Value On a Con-tinuous Scale	Select Value In Discrete Steps	Slew Counters or Other Numeric Readout	Adjust Light or Sound Level—Continu-ous	Two Coordinate Tracking
Joystick								1
Knob				1		1 (rate control)	1	
Pushbut-ton	1				1	1		
Rocker Switch	2	3						
Rotary Selector	3	1	1		1			
Toggle Switch	2	2				1		

[1] Not all controls in the handbook were ranked in the source cited. Information on rankings for other functions can be found in the source cited.

1 = most preferred; 3 = least preferred.