SURFACE VEHICLE INFORMATION REPORT

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Development of Design and Engineering Recommendations for In-Vehicle Alphanumeric Messages

RATIONALE

This technical report is being stabilized because the technical committee has determined that the using community is moving towards newer technology and would like to alert users that this new technology exists which may want to be considered for new design.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Driver Vehicle Interface (DVI) Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE

This Information Report provides recommendations for alphanumeric messages that are supplied to the vehicle by external (e.g., RDS, satellite radio) or internal (e.g., infotainment system) sources *while the vehicle is in-motion*. Information/design recommendations contained in this report apply to OEM (embedded) and aftermarket systems.

Ergonomic issues with regard to display characteristics (e.g., viewing angle, brightness, contrast, font design, etc.) should review ISO 15008.

2. REFERENCES

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SAE J2395. ITS In-Vehicle Message Priority

ISO/TS 16951 (2004). Road vehicles - Ergonomic aspects of transport information and control systems (TICS) - Procedures for determining priority of on-board messages presented to drivers (15 March, 2004).

ISO/FDS 15006 (2011). Road vehicles - Ergonomic aspects of transport information and control systems - Specifications for in-vehicle auditory presentation

3. IN-VEHICLE INFORMATION SYSTEM (IVIS) INFORMATION SOURCES

A wide range of information and the potential for a great volume of messages suggests that it is important to systematically examine and categorize messages a driver may receive. As described in Figure 1, this Information Report identifies six different in-vehicle information system sources. Coordinating information sources so that the driver receives the most important messages in a pronounced, timely, and salient manner is one of the challenges of integrating diverse sources of data (e.g., message priority is relative). Such an approach begins with an analysis of the types of information that are likely to confront drivers. This analysis helps define the technology and products, but not the characteristics that are most relevant to driver interaction with the messages. This requires an analysis of the display relevant message characteristics. These characteristics are separate from the particular product or in-vehicle technology, but define the messages in terms of what they communicate to the driver, such as a high urgency message or long complex message.

Once an alphanumeric message is assigned to an information source category, the designer must identify the communication requirements of in-vehicle information system functions. After the communication functions are identified, these requirements can then define display format and flow parameters. This approach is detailed in the next section.

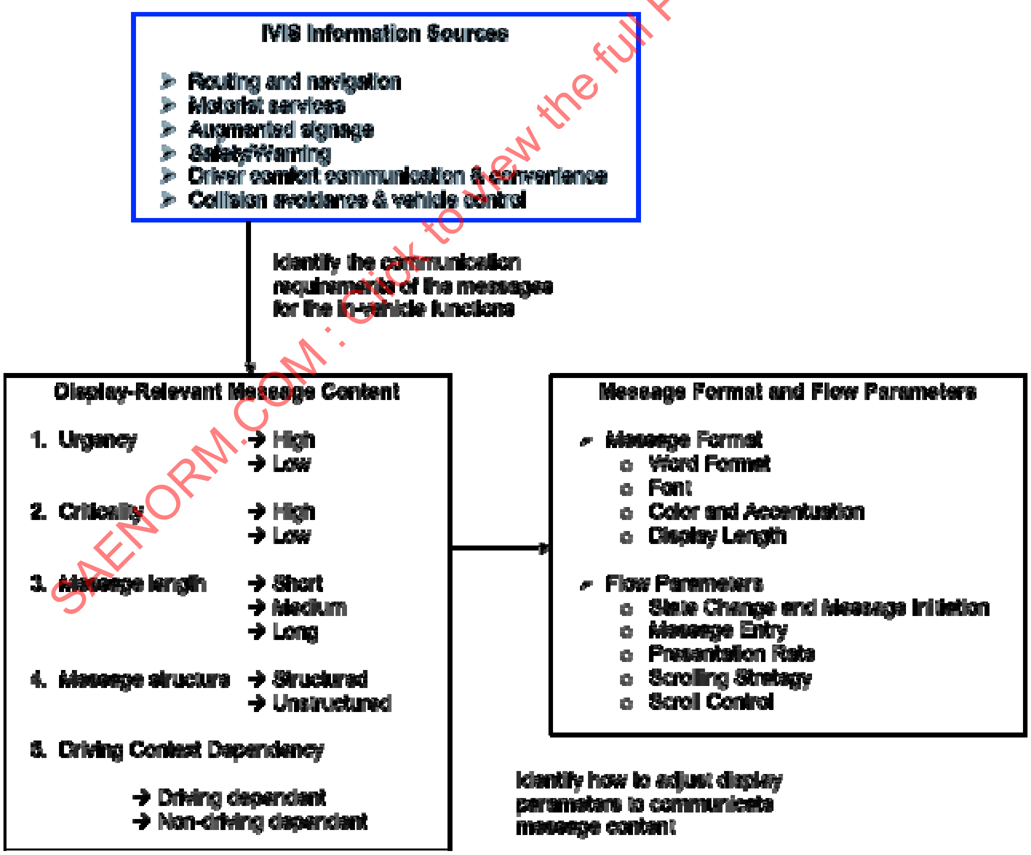

FIGURE 3-1 - FRAMEWORK GUIDING THE DESIGN RECOMMENDATIONS (ADAPTED FROM LEE ET AL., 1999)

3.1 IVIS Information Sources

By understanding the scope of the issues associated with the type of data being displayed, a more efficiently design alphanumeric-based message can be designed. For instance, the content of messages are divided into six different categories:

- Routing and Navigation
- Motorist Services
- Augmented Signage
- Safety/Warning
- Driver Comfort, Communication, and Convenience
- Collision Avoidance and Vehicle Control

Dividing these message types by content, a prioritization method can be developed to reduce driver overload when important messages must be interpreted and acted on. Each of these categories of information can be further decomposed by assessing the urgency, criticality and driving context of the message (see also SAE J2395; ISO CD 16951). Using this method, a comprehensive set of recommendations can be developed that answer immediate design questions. A critical step in the design of in-vehicle alphanumeric messaging display is to identify the type of information to be presented to the driver (Hoffman et al., 2005). Carney et al. (1998) reviewed several reports and extracted an extensive set of driver information requirements. Their list of driver information requirements with regards to IVIS capabilities was further expanded by Lee & Kantowitz (2005) and is described in Table 3-1. This list will change as messaging is a dynamic field.

TABLE 1 - EXAMPLES OF TYPES OF DRIVER INFORMATION REQUIREMENTS FOR KEY IVIS MESSAGE SOURCES

IVIS MESSAGE SOURCES	INFORMATION TYPES/FUNCTIONS
Routing and Navigation	Trip planning Pre-drive route and destination selection Off-route recalculation Route guidance Route navigation Automated toll collection Route scheduling Post-trip summary
Motorist Services	Broadcast services/attractions Services/attractions directory Destination coordination Delivery related information
Augmented Signage	Guidance sign information Notification sign information Regulatory sign information
Safety/Warning	Immediate hazard warning Road condition information Automatic aid request Manual aid request Vehicle condition monitoring Driver monitoring devices Sensory augmentation
Collision Avoidance and Vehicle Control	Forward collision avoidance Road departure collision avoidance Lane change and merge collision avoidance Intersection collision avoidance Railroad crossing collision avoidance Backing aid Advanced cruise control
Driver Comfort, Communication, and Convenience	Real-time communication (e.g., electronic road signs) Asynchronous communications Contact search and history Entertainment and general information Interactive entertainment Heating, ventilation, air conditioning, and noise Automatic system configuration

Identifying these driver information sources does not necessarily dictate how the information should be displayed. However, it does influence how the message will be structured and what its content will be. As a result, the message content will influence how the information should be displayed. For instance, safety and warning information and augmented signage are generally yoked to the context of the drive. These messages will require more urgent attention than the other categories and will consequently consist of short and structured messages. Other information sources such as infotainment may be less context critical and thus have longer and less structured messages.

It should be noted that collision avoidance and vehicle control are not part of the scope of this Information Report that focuses on alphanumeric-based messages. They have been included because there are some elements that could be relevant in terms of sensitivity settings or post warning/event messages. More specifically, elements such as adaptive cruise control and railroad crossing warnings could fit into an alphanumeric warning structure. In general, imminent collision warnings should not be solely visual in nature (SAE J2400).

3.2 Basic Driver Performance Limits

The information sources dictate the content and structure of messages to be displayed which, in turn, determine the most effective display characteristics. The combination of these factors influences the drivers' visual sampling strategy, the primary factor guiding how information is extracted inside and outside of the vehicle. Simply put, the more eyes-off-road time, the less time the driver has to respond to changing roadway conditions. Senders, Kristofferson, Levison, Dietrich, and Ward (1967) were the first to quantify this, and found that on a closed section of new highway, a vehicle could be driven with only intermittent visual sampling. Using a helmet with a visor that periodically occluded the forward view they found:

- A driver can maintain vehicle control with periodic samples of the roadway.
- Between samples, the driver becomes increasingly uncertain about the state of the vehicle relative to the roadway.
- When the uncertainty exceeds a threshold, the driver samples the forward view.
- Drivers' are generally well-calibrated regarding the buildup of uncertainty relative to the vehicle dynamics and roadway characteristics.

To complement this early work, Wierwille (1993) described a conceptual sampling model that begins when the driver initiates an in-vehicle task by glancing to a location of interest—in this case the alphanumeric message display. Information extraction begins and time elapses. If drivers can chunk information at about 1 s or less, they will return their glance to the forward scene. However, if chunking takes longer, drivers will continue to glance at the display. If this occurs, uncertainty will build as the eyes remain off the road and drivers will quickly feel pressured to return their eyes to the forward scene. If the glance to the in-vehicle location exceeds approximately 1.5 s and the information cannot be obtained (or chunked), drivers will return their eyes to the forward scene and try again later. If chunked information can be obtained within approximately 1.5 s, drivers will extract the information and return to the forward scene. Additional samples are handled in the same way, until all required information is obtained (see Figure 3-2).

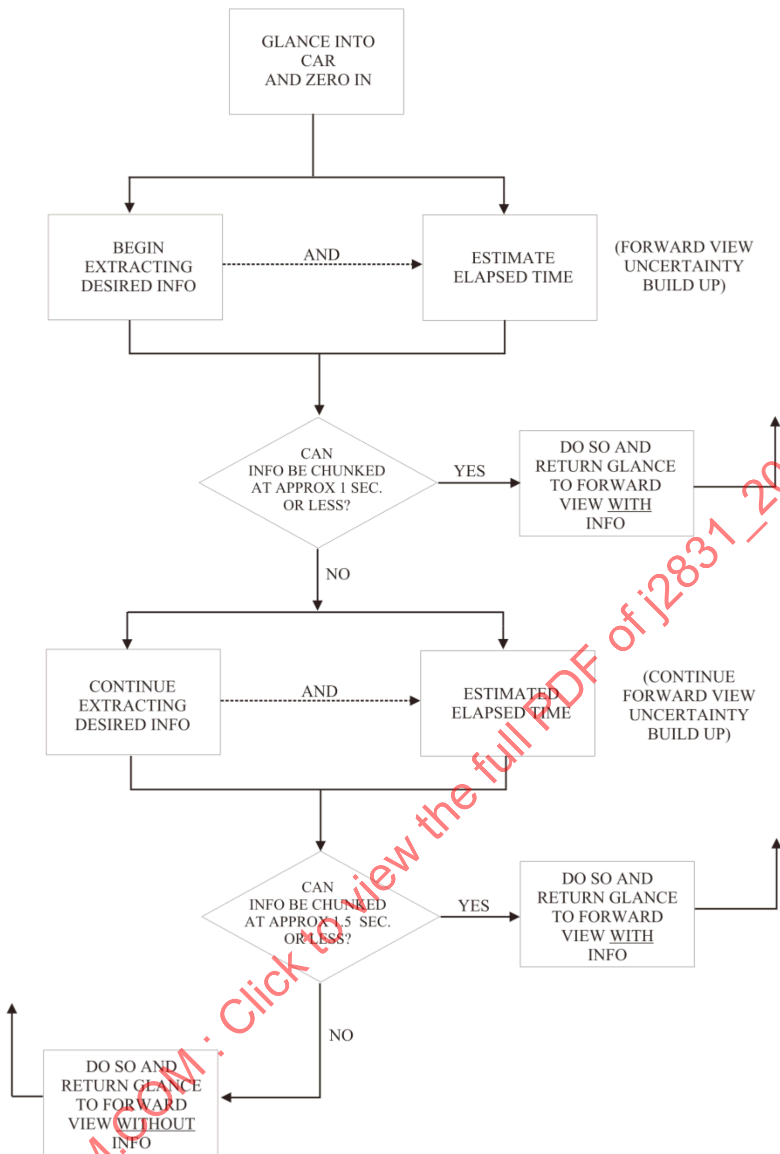

FIGURE 3-2 - WIERWILLE'S (1993) MODEL OF VISUAL SAMPLING FOR IN-VEHICLE TASKS

Additionally, as drivers enter curves and encounter uncertain roadway situations such as traffic, more closely spaced samples become necessary. A byproduct of the early Senders et al. work is Time-to-Line Crossing (TLC), a measure developed by Godthelp, Milgram, and Blaauw (1984). TLC specifically examines uncertainty buildup related to the amount of time it would take for the vehicle to cross the center line or shoulder line assuming the steering wheel is held constant. Godthelp et al. showed that in-vehicle devices must be designed so that the driver can get enough samples per unit time of the forward view to ensure efficient lane position maintenance. In other words, the acceptable length and number of samples to an in-vehicle device is quite limited, but the duration and timing rather than the total number of glances may have a greater impact on driving performance.

Rockwell (1988) examined in-car glance durations and number of glances for radio and mirror tasks on the open road—in traffic. He found that individual glance times into the car clustered around 1.27 to 1.42 s and that for radio tasks such as tuning, four or five glances were required. Rockwell concluded that drivers develop a fairly consistent time-sharing strategy for performing instrument panel tasks while driving, that individual glance length is relatively consistent, and that for complex tasks, more glances are required. Gellatly & Kleiss (2000) also found that drivers completed a range of in-vehicle tasks using a series of 1 to 1.5 s glances to the in-vehicle display/control system and that total task time depended on the number of glances and not the mean duration of glances. Likewise, Bhise, Forbes, and Farber (1986) found that single glance times to the instrument panel vary relatively little with the type of task, but that number of glances varies greatly with the type of task.

3.3 The Life of a Message

To apply these findings and models of visual sampling models to alphanumeric message design, the life of a message has been decomposed. This decomposition reveals that there is more to an alphanumeric message than just reading; drivers must manage the timing and display of the message (see Figure 3-3). Although the number of characters, words, and information units in a message has a strong effect on the drivers sampling behavior, the display characteristics that influence how a driver manages the message display may also influence visual sampling. By using this basic model to check each aspect of the alphanumeric message design, overly demanding designs can be identified and mitigated.

The first phase following a nominal state (e.g., blank screen) is the initial state change signifying the arrival of a new message. Initiation of the display of a message may be controlled manually by the driver or automatically by the system. Message initiation and display play a critical role in visual sampling because they can influence whether drivers defer reading a message until after demanding roadway situations have passed. The display of the message begins with the process of message entry. Messages can either appear simply by 'turning on' or enter dynamically (e.g., either by sliding in horizontally or vertically). Understanding the factors influencing when the message is initiated is particularly important because the timing of the demands of reading a message relative to the roadway demands may be more important than the absolute demands of reading the message itself. The ability of the driver to appropriately manage the message reading task relative to negotiating turns and intersections may be critically dependent on alphanumeric message system design.

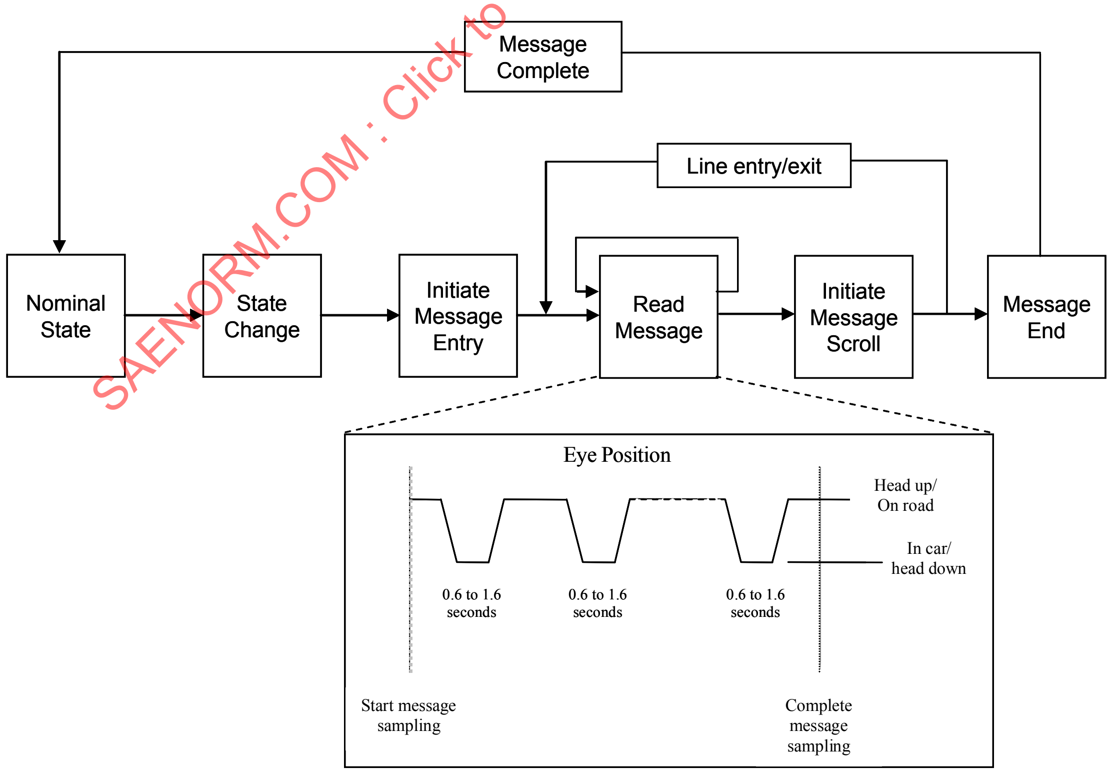

FIGURE 3-3 - THE LIFE OF A MESSAGE

Once the message has entered or is turned on, the reading phase begins. This is where visual demands can begin to build, depending on the complexity of the message. The driver samples the message, returns his/her vision to the forward roadway, samples the message again, and returns to the roadway, until the displayed portion of the message has been completely sampled. Importantly, before drivers begin extracting information, they may need to orient themselves within the message. This may be particularly important in displays that have many lines of text. Wierwille (1993) found that these samples range from 0.6 to 1.6 s. If the message is too long or complex, it may require the driver to look away from the forward roadway more often and for greater periods in order to chunk the information (Figure 2). Figure 3 shows how this sampling pattern might represent the driver's visual sampling during the reading phase of the message.

After the displayed portion of the message has been read, the message content may need to be scrolled, and the reading phase reinitiated. In other words, a message that is four to five lines long might be presented in three instances, each divided by the need to scroll to the next. The overall visual demands associated with reading a message on a multi-line display compared to scrolling through a message on a display containing fewer lines of text has not been empirically investigated or analytically modeled.

4. DESIGN RECOMMENDATIONS FORMAT

From the literature review, a set of recommendations that follow the same process that was discussed in Figure 3-1 are provided. Subsequent sections of the Information Report will provide specific design recommendations and rationale for the conceptualization, development, design, testing, or evaluation of in-vehicle alphanumeric displays. Specific designs for such systems are not provided. The most important fundamentals of such information display types are provided.

4.1 Display-Relevant Message Content

First, the content of display-relevant messages should be considered to functionally group driver information requirements. The second box in Figure 3-1 describes a number of factors related to message content: urgency; criticality; length; structure; information processing elements; driving context dependency; and message structure. According to Lee et al. (1999), within the same IVIS function there might be messages that either requires a driver to respond immediately to a critical situation or simply informs the driver of a situation they will need to be aware of later. It makes sense that these two messages would be designed quite differently in order to make them more useful to the driver. The context of a message is, therefore, extremely important for several reasons: it can change the meaning of a message, it defines the salience of the message, and design tradeoffs may be made based on the context. Overall the context characteristics define messages in a way that identifies design tradeoffs associated with integrating a message with other messages and driving activities.

From Lee et al. (1999), five characteristics that define the context of an IVIS message, which can be seen in Table 4-1 are adapted.

TABLE 4-1 - SUMMARY OF URGENCY, CRITICALITY, CONTEXT, MESSAGE LENGTH AND STRUCTURE (ADAPTED FROM LEE ET. AL, 1999)

MESSAGE CHARACTERISTICS	DEFINITION	RANGE
Time Urgency	Time available for driver to respond to message	Emergency: 0-3 s Immediate: 3-10 s Near Term: 10-20 s Preparatory: 20-120 s Discretionary: >120 s
Criticality	Consequence for not responding	Low = Delay or annoyance High = Increase risk of danger to occupant or vehicle
Driving Context Dependency	Relationship to driving context	Related = linked to driver control Unrelated = No relation to driving context
Message length	Length of message	Short message: ≤ 3 information units Medium message: 4-6 information units Long message: ≥ 7 information units
Message Structure	How a message is structured in terms of succinctness	Structured or unstructured

Time Urgency is defined in terms of the amount of time available for the driver to respond to a message. Greater than 10 s for low urgency and less than 10 s for high urgency was chosen. Lee's analyses include greater resolution because their analyses included true imminent alerts that must be responded to immediately (e.g., less than 3 s). They also used 3 to 10 s; 10 s to 2 min; 2 to 10 min; greater than 10 min. The 10 s threshold was chosen for two reasons: first because it is the midpoint of Lee et al.; and second, 10 s represents about 1000 ft of driving at freeway speeds (65 mph). For alphanumeric messages in general, there should not be any imminent messages, so the context of urgent information should concentrate more on driver maneuvers related to the roadway environment. Many navigation systems utilize the 900 to 1000 ft decision times for final navigation-based alerts.

While there are a variety of levels of high and low urgency, there are also very low urgency messages. For example, when a driver receives vehicle condition monitoring information regarding routine vehicle maintenance schedules (e.g., "oil change needed in 500 miles"), they may not need to address this message for several hours or several days depending on how far they are driving. Urgency should also be considered relative to imminent safety. So messages that might involve more infotainment and other non-safety related information should always be relegated to low urgency. Designers may want to consider that some information is only presented during engine start - such as lower priority maintenance issues like oil change reminders. More imminent engine-related issues (timing belt, low oil pressure/level, alternator) should be displayed in real-time, however.

Criticality is the consequence of not responding to the message in a timely manner. Ignoring messages can bring about consequences ranging from a crash to no driving-related consequence at all. For example, the consequences of ignoring a 'Road Closed' message could end up being very severe and possibly life threatening. However, ignoring a motorist services message will probably produce no real consequences for the driver - other than an inconvenience. Since alphanumeric message displays should not be used for time-critical information (e.g., imminent), the criticality has been limited to two levels: low (delay or annoyance) and high (increase risk of crash). It should be noted that for simplicity, the number levels suggested by Lee et al. have been limited (1999).

Driving Context Dependency is the degree to which a message is related to the context of the drive. The type of message a driver receives may range from those that are directly linked to driving control activities to those that have no relation to the driving task. For example, navigation and signage are directly related to the primary task of driving. On the opposite end of the spectrum, instant messaging, which allows a driver to send and receive personal messages, has no direct link to the driving task. This type of information is not necessary for the driver to operate the vehicle and it could actually interfere with the driving task. Between these two extremes are tactical and strategic driving decisions. Tactical decisions are those that have to do with immediate maneuvers (i.e., turning at an intersection) while strategic decisions are those that have to do with the route as a whole (i.e., trip planning).

Message Length is defined for our purposes as short, medium or long. A short message is one that can be displayed in a set of minimal information units that can be chunked in a single glance. Information units to distinguish the different levels were chosen. As per table two, short messages are those that are less than or equal to three information units; medium messages are those that are 4 to 6 information units; and long messages are those that are greater than or equal to seven units The implication for this rationale is that the Medium length messages may require more than one glance, but are not on multiple pages (i.e., two lines); Long messages are those that are more complex and require multiple glances and paging. For instance, warning and signage messages can be conveyed in brief, short messages, while motorist services and other entertainment messages will require longer messages. It is possible that some driver information categories may be made up of short, medium and long messages. See also recommendations on message length.

Message Structure refers to whether messages are intentionally structured for highly specific information for efficient extraction through brief glances or are more free-flowing and casual. For example, basic warning principles suggest that a message should employ a signal word, a description of the hazard, a description of the consequences, and instructions on actions to be taken (Sanders and McCormick, 1997). Generalizing this framework to a message format for an in-vehicle display: the signal word would convey the reason for the message, i.e. “weather” or “traffic”; the hazard would relay the event that had occurred, i.e., “crash ahead”; the consequences would describe the results of the event, i.e., “road closed”; the instructions would direct the driver to take action, i.e., “exit 2 miles”. While this is related to message length, there can also be structured medium and long messages. In these instances, language style can be used to present more information in a concise manner, such as an entire route to be navigated in turn-by-turn directions. In general, the distinction is most relevant in the design of more succinct messages, relative to longer less important messages.

4.2 Message Format

Once a message is categorized and defined in terms of relevance, it must be appropriately depicted and annunciated. The final box from Figure 4-1 identifies parameters to communicate message content. Message format refers to the graphical characteristics of displaying a message. In terms of the message format itself, there are four general areas to consider:

<u>Word format</u> refers to the manner in which individual words are displayed, either in their entirety or an abbreviated form. Simple rules for abbreviation strategies will be presented in the recommendations. For instance, a common abbreviation rule for changeable/dynamic message signs is to retain only the first letter and syllable of a word while vowels are eliminated with only key consonants being retained.

<u>Font</u> refers to the geometrical characteristics or style of symbology. The design goal for fonts is to avoid extensive flourishes and embellishments of the symbols—so that Alphanumeric messages are easily and quickly read (see also ISO 15008).

<u>Color and Accentuation</u> refers to the use of color and contrasts to display messages in a manner which is easy to read and identifies the most salient information to the driver.

<u>Display Length</u> refers to the total amount of information that is able to be displayed at any given instant. In the context of this report, display length is characterized by the number of lines displayed of an understood length.

4.3 Flow Parameters

Flow Parameters refer to the life of a message relative to how it initiates and enters the display and how subsequent information is presented and/or paged. More specifically, flow parameters are made up of state changes and message initiation, message entry types and the display of subsequent information, and how control of flow is allocated.

State Change and Message Initiation refers to how a new message is enunciated and activated. For instance, under nominal conditions, displays will be blank. Upon receipt of new information, the system must inform the driver of a new 'state', indicating that new information has arrived for viewing. Examples of state change indication are auditory icons or flashing displays. On the contrary, state changes may go unidentified, whereby information simply appears. Following a state change, messages are initiated either manually by the driver or automatically displayed by the system.

Message Entry describes the phase where a message enters or appears on the display. Messages can simply appear, or fade in. Entry can be activated by the driver or the system and describes both the entry and exit of the text relative to the field. Alphanumeric information can simply appear in its entirety, as in 'normal page alphanumeric presentation.

4.3.1 Key References

ISO 15008 (2009). Road vehicles - Ergonomic aspects of transport information and control systems - Specifications and test procedures for in-vehicle visual presentation (15 February, 2009).

Lee, J.D., Carney, C., Casey, S.M., and Campbell, J.L. (1999). In-vehicle display icons and other information elements: Preliminary assessment of visual symbols. (Publication No. FHWA-RD-99-196). McLean, VA: Federal Highway Administration.

Sanders, M. and McCormick, E. (1997). Human Factors in Engineering and Design. 7^{th} Addition. McGraw Hill.

5. RECOMMENDATIONS FOR DISPLAY-RELEVANT MESSAGE CONTENT

- Message Priority, Urgency, and Criticality
- Message Length
- Message Structure
- Driving Context Dependency

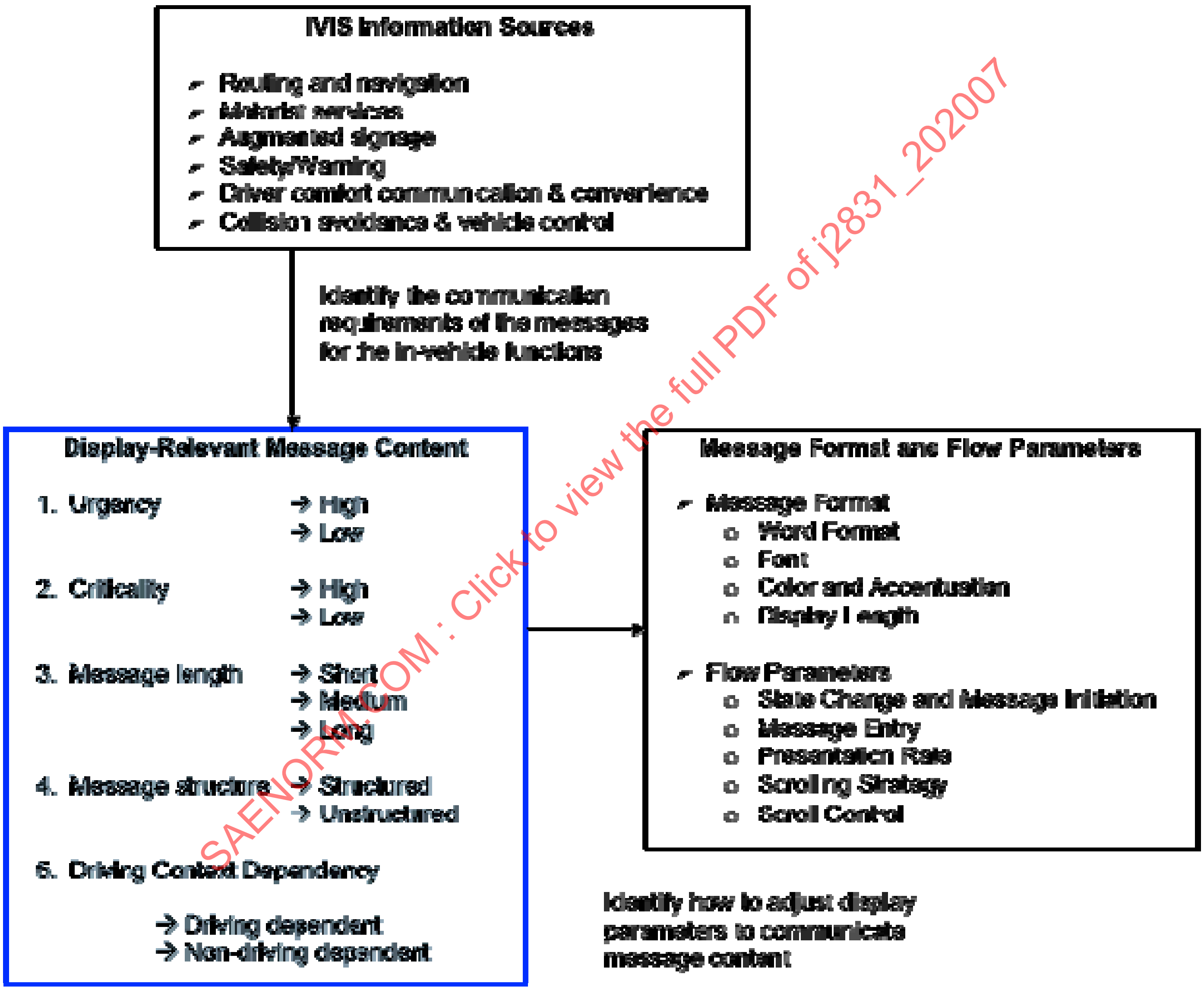

FIGURE 5-1 - FRAMEWORK GUIDING THE DESIGN RECOMMENDATIONS (ADAPTED FROM LEE ET AL., 1999)

5.1 Message Priority, Urgency, and Criticality

5.1.1 Introduction

"Message priority is a function of the urgency of a response and the consequence of failing to make a response." (Reference 1) Message priority encompasses the elements of urgency and criticality (see Figure 5-1). Time urgency refers to the "amount of time available for the driver to respond to a message while criticality is defined as the consequence of not responding to the message in a timely manner." (Reference 2, p. 54)

TABLE 5-1 - DEFINITION AND HEURISTICS FOR ASSESSING TIME URGENCY AND CRITICALITY FOR IVIS MESSAGES

MESSAGE CHARACTERISTICS	DEFINITION	RANGE
Time Urgency	Time available for the driver to respond to a message	Emergency: 0-3 s Immediate: 3-10 s Near Term: 10-20 s Preparatory: 20-120 s Discretionary: >120 s
Criticality	Consequence of not responding to a message in a timely manner	Highly Relevant: Information that, if not received, will cause the driver inconvenience/expense such as delay, error or vehicle damage. For example, notification of an incident ahead resulting in traffic delay, or an engine temperature warning. Moderately Relevant: Information that is not highly relevant, as defined above. Information that may improve the ease and convenience of the driving task, but will not likely result in inconvenience or expense to the driver if not present. For example, the distance to the destination on a navigation system or the price of a toll ahead. Little or No Relevance/ Insignificant: Information that will not impact the ease and convenience of the driving task. For example, a mobile internet feature or the "stereo" indicator on an entertainment system.

(Source: SAE J2395)

DESIGN RECOMMENDATIONS - PRIORITY
• "High-priority information presented on an ATIS visual display should be preceded by an auditory alerting tone. The alerting tone should immediately precede, or be presented at the same time as the high-priority visual information." (Reference 1, pp. 3-46) • "If no alerting tone can be provided, the high-priority visual information should be supplemented by redundant auditory information (e.g., speech)." (Reference 1, pp. 3-46) • High-priority messages must be easy to discriminate and need to highlight status changes. Focus on distinguishing high-priority messages but be aware of not reducing the relative priority of others. (Reference 2, p. 57) • "Use natural hierarchies to indicate priority and importance." (Reference 3, p. 29)

DESIGN RECOMMENDATIONS - TIME URGENCY
• Highly time urgent messages need to be salient and compelling to attract the driver's attention without causing a startling response. (Reference 2, p. 56). Visual only displays should not be used for immediate 3 to 10 s or 0 to 3 s (emergency) (SAE J2395). • Design non-urgent or less-urgent messages in such a way as to avoid startling and distracting the driver. (Reference 2, p. 56)

DESIGN RECOMMENDATIONS - CRITICALITY
• Highly critical messages need to convey priority and relative importance. (Reference 2, p. 57) • Use icons that stand out from the background through the use of size, color, or changes in state (i.e., blinking) to draw attention in a timely manner to critical messages. (Reference 2, p. 56) Note that color is apparent in direct (foveal) vision, not in the periphery. • Use the auditory modality to increase the perceived urgency of a message. (Reference 2, p. 57) • Design non-critical or less-critical messages in such a way as to avoid startling and distracting the driver. (Reference 2, p. 57)

5.1.2 Supporting Rationale

"Reference 1 suggested that information that is considered high priority or that requires a very quick response from the driver should be presented through the modality that commands the driver's attention the fastest - the auditory mode. Any other information that can be considered advisory or purely informative (without being requested) can best be presented in the visual mode, which will not distract the driver from the main task of driving." (pp. 3-25)

Reference 2 used their own design tool to identify the best display modality for IVIS messages and concluded that:" (1) the visual modality should be used to display more complex information that does not require the driver's immediate response and may need to be referred to at a later time, (2) the auditory modality should be used to present simple information that is extremely urgent, or critical messages that require the driver's attention, (3) a combination of the auditory and visual modalities should be used to present information that is both complex and relatively urgent but is too complex to be presented via simple tone or verbal message." (p. 2)

5.1.3 Special Design Considerations

None

5.1.4 Cross References

Message Length

Message Structure

Driving Context Dependency

Word Format

Color

Activation Mode

5.1.5 Key References

1. Campbell, J.L., Carney, C., and Kantowitz, B.H. (1998). Human factors design guidelines for advanced traveler information systems (ATIS) and commercial vehicle operations (CVO). (Publication No. FHWA-RD-98-057). McLean, VA: Federal Highway Administration.

2. Lee, J.D., Carney, C., Casey, S.M., and Campbell, J.L. (1999). In-vehicle display icons and other information elements: Preliminary assessment of visual symbols. (Publication No. FHWA-RD-99-196). McLean, VA: Federal Highway Administration.

3. Green, P., Levison, W., Paelke, G., and Serafin, C. (1994). Preliminary human factors design guidelines for driver information systems. (Publication No. FHWA-RD-94-087). McLean, VA: Federal Highway Administration.

4. SAE J2395, ITS In-Vehicle Message Priority

5.2 Message Length

5.2.1 Introduction

Message length refers to the number of words or information units appropriate for presenting information to the driver. Depending on the type of information being presented, different message lengths are acceptable (Reference 1, pp. 3-26).

"*Information unit* is used to describe the amount of information presented in terms of key nouns and adjectives contained within a message." (Reference 1, pp. 3-24) From the changeable messages sign literature, References 1 and 2 define a "*unit of information*" as a data item given in a message, which can answer one of the following questions:

"What happened?" - Event causes

"Where did something happen?" - Geography, roadway type

"What is the effect on traffic of a given event?" - Event consequences

"What driver action is advised?" - Proposed actions

"How long is the event supposed to last?" - Time, distance

DESIGN RECOMMENDATIONS
• When possible, limit messages presented while the vehicle is moving to 4 units of information, in order to minimize eyes off the road time. (References 1, pp. 3-28, 2, 3, 4) • “Minimize what the driver needs to read.” (Reference 4, p. 21) • “Messages that are not urgent or for which a response may be delayed can be a maximum of 7 units of information in the fewest number of words possible. If the information cannot be presented in a short sentence, the most important information should be presented at the beginning and/or the end of the message.” (Reference 1, pp. 3-26; Reference 2) • “Navigation instructions should be limited to 3 or 4 information units.” (Reference 1, pp. 3-26).

TABLE 5-2 - DETERMINING THE NUMBER OF INFORMATION UNITS

UNITS	EXAMPLES
2 units	Crash ahead, traffic stopped.
4 units	Road construction on Interstate 5, next 10 miles.
6 units	Interstate 380 closed for construction between Iowa City and Cedar Rapids.
8 units	Road construction next 5 miles. Take highway 6 to Lone Tree, turn left on highway 214.

(Source: Adapted from Reference 1, pp. 3-28 and Reference 2)

TABLE 5-3 - EXAMPLES OF APPROPRIATE MESSAGES

RECOMMENDED	NOT RECOMMENDED
"Crash ahead, merge right."	"Crash ahead in the left lane, merge right as soon as possible."
"Oil change needed by July 1, 2004."	"Vehicle maintenance log shows that vehicle oil change is due and should be completed by July 1, 2004."

(Source: Adapted from Reference 1)

5.2.2 Supporting Rationale

“The longer the message, the more processing time required by the driver.” (Reference 1, pp. 3-27) Similarly, the longer the message, the more eyes-off-the-road time is required to read the message (Reference 4). Reference 5 examined alphanumeric messaging paired with navigation maps and showed significant increases in the average duration of each visual fixation, the number of visual fixations, and the overall duration of visual exploration, as message length increased. “Reference 1 suggests that messages requiring the driver to make an immediate response should be as short as possible. One-word messages informing the driver of the appropriate action to take might work best in situations such as these.” (Reference 1, pp. 3-27)

Message length has also been shown to have an effect on recall performance. Reference 5 observed an inversely proportional relationship between the length of information messages and recall performance. Reference 2 looked at driver’s ability to recall messages of various lengths presented for various exposure times. Even at the longest exposure rate (1 s per word), drivers could not satisfactorily recall all the units of a 6-unit message while driving. 4 units were established as the maximum limit of information likely to be recalled (Reference 2).

For longer messages, structuring the message can help drivers to obtain information more safely. Chunking the information into units that can be read in glances of 2 s or less will accommodate the driver's forward sampling pattern by not requiring them to keep their eyes off the road longer than they feel comfortable (Reference 6). Drivers can then sample the message until all information has been obtained. An unstructured free flowing message can cause drivers to continue to attend to the message beyond comfort levels in order to obtain a complete thought.

5.2.3 Special Design Considerations

Decreased visual capabilities of older drivers must be considered. Reference 3 found that older drivers required 33 to 100% longer to read maps in a simulator, and 40 to 70% longer to read maps on the road, than younger drivers. Reference 7 observed a significant decrease in the number of terms in a message recalled as compared to younger drivers. To address this issue, Reference 1 suggests "making messages shorter and simpler to help improve performance, particularly for older drivers" (pp. 3-29). Shorter and simpler messages will require more concise information, prompting greater interpretation by the driver. Providing a means for repeating the message is one method that should be considered to help older drivers use information in messages more effectively (Reference 8).

5.2.4 Cross References

Word Format

Message Structure

Presentation Rate

5.2.5 Key References

1. Campbell, J.L., Carney, C.L., and Kantowitz, B.H. (1998). *Human factors design guidelines for advanced traveler information systems (ATIS) and commercial vehicle operations (CVO)*. (Publication No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

2. Dudek, C.L. and Huchingson, R.D. (1982). *Human factors design of dynamic displays*. (Publication No. FHWA/RD-81/039). College Station, TX: Texas Transportation Institute.

3. Green, P. (2001). Variations in task performance between younger and older drivers: UMTRI research on telematics. *Presented at the Conference on Aging and Driving, February 19-20, 2001.* Southfield, MI: Association for the Advancement of Automotive Medicine.

4. Green, P., Levison, W., Paelke, G., and Serafin, C. (1994). *Preliminary human factors design guidelines for driver information systems.* (Publication No. FHWA-RD-94-087). McLean, VA: Federal Highway Administration.

5. Labiale G. (1990). In-car road information: Comparison of auditory and visual presentation. *Proceedings of the Human Factors and Ergonomics Society 34th Annual Meeting*, (pp. 623-627). Santa Monica, CA: Human Factors and Ergonomics Society.

6. Wierwille, W.W. (1993). Visual and manual demands of in-car controls and displays. In B. Peacock and W. karwowski (Eds.). *Automotive Ergonomics*, (pp. 299-320). Washington, DC: Taylor & Francis.

7. Fleming, J., Green, P., and Katz, S. (1998). *Driver performance and memory for traffic messages: Effects of the number of messages, audio quality, and relevance.* (Technical Report UMTRI-98-22). Ann Harbor, MI: The University of Michigan Transportation Research Institute (UMTRI).

8. Ross, T., Midtland, K., Fuchs, M., Pauzie, A., Engert, A., Duncan, B., Vaughan, G., Vernet, M., Peters, H., Burnett, G., and May, A. (1996). *HARDIE Design standards handbook: Human factors guidelines for information presentation by ATT systems* (DRIVE II Project V2008).

5.3 Message Style

5.3.1 Introduction

"*Message style* refers to the way in which information is given to the driver. The information can be presented in an advisory manner ("command style") or in more of a descriptive manner ("notification style")." (Reference 1, pp. 3-32)

"Command style messages inform drivers of a situation and suggest a particular action to take in response to a situation. *Notification style messages* simply inform drivers and allow them to determine the appropriate action on their own." (Reference 1, pp. 3-32)

The language style used in a message refers to the style of speech used to present information to the driver, which can vary based on the message content. Reference 2 identifies 3 possible language styles:

Staccato - Message written in brief, incomplete sentences using primarily key nouns and adjectives

- Example (from Reference 2):

  "Truck overturned ahead.

  To avoid major delay,

  Exit at Jackson-Keller.

  Turn right on Jackson-Keller,

  Left on San Pedro,

  Back to Interstate 410 East"

Short Form - Message written as short or partial sentences

- Example (from Reference 2):

  There is an overturned truck ahead.

  To avoid major delay,

  Exit at Jackson-Keller, and take the following route:

  Turn right on Jackson-Keller,

  Then left on San Pedro,

  And proceed back to Interstate 410 East.

Conversational - Message written in full sentences, including all descriptors and connecting words

- Example (from Reference 2):

    There is an overturned truck on Interstate 410 ahead.

    To avoid a major delay,

    You are advised to exit at Jackson-Keller road and take the following route:

    Turn right on Jackson-Keller road and continue to San Pedro Avenue

    Then turn left

    And Drive back to Interstate 410 to continue your eastbound trip.

DESIGN RECOMMENDATIONS - COMMAND STYLE MESSAGES

- "Command style messages should be used infrequently, as they may cause drivers to over-rely on information given to them in-vehicle and to become complacent about searching the outside environment for out-of-vehicle information." (Reference 1, pp. 3-32)
- Use the short form or staccato language styles as opposed to the conversational style, particularly when retention is important (Reference 2).
- Use of a signal word at the beginning of the message can help to convey the purpose of the message (References 3 and 4).
- Messages can be formatted as follows: signal word, event, consequences, and instructions (References 3 and 6).

TABLE 5-4 - DECISION AID FOR DETERMINING WHEN TO USE EACH MESSAGE FORMAT

		Is the situation critical?	
		No	Yes
Is an immediate control action necessary?	No	Notification Format	Notification Format
	Yes	Notification Format	Command Format

(Source: Reference 1, pp. 3-32)

DESIGN RECOMMENDATIONS - NOTIFICATION STYLE MESSAGES

- "Notification style messages should be used for presenting low criticality information." (Reference 1, pp. 3-32)
- Use the short form or staccato language styles as opposed to the conversational style, particularly when retention is important. (Reference 2)
- Use of a signal word at the beginning of the message can help to convey the purpose of the message. (References 3 and 4)
- Brevity is important in messages containing more than 8 units of information.

TABLE 5-5 - EXAMPLES OF THE DIFFERENT MESSAGE FORMATS

Command Style	"Slow down" "Move into the right lane"
Notification Style	"Vehicle ahead" "Crash ahead, 1/2 mile"

(Source: Reference 1, pp. 3-32)

5.3.2 Supporting Rationale

When presenting messages, a format should be used that provides the most information in the fewest number of words possible, in order to minimize eyes-off-the-road time. According to *human factors standards for advanced traveler information systems and commercial vehicle operations: Design alternatives for in-vehicle information displays,* this is particularly important for command format messages, which serve to direct the driver to some action with minimal information processing time. "In Reference 5, message format was investigated in order to determine its effect on driver compliance with warnings and driver safety. Results of the study indicate that the importance of the message should determine the message format to be used. For highly critical messages, command style should be used in order to increase the level of compliance. For less critical messages, notification style should be used, to ensure that the driver remains actively involved in the driving task. The urgency associated with making some type of control action should also be considered when determining the message style to be used." (Reference 1, pp. 3-33)

Reference 3 describes a format for warning messages that demonstrates a combination of the command and notification formats. As stated, warning messages should contain the following elements: a *signal word*, a description of the *hazard*, a description of the *consequences*, and *instructions* on actions to be taken. Generalizing this to a message format: the *signal word* would convey the reason for the message, i.e. "weather" or "traffic"; the *hazard* would relay the event that had occurred, i.e., "crash"; the *consequences* would describe the results of the event, i.e., "road closed"; the *instructions* would direct the driver to take action, i.e., "exit 2 miles". Reference 4 also recommends the use of a signal word to support judgments of relevance on the part of the driver. A signal word can indicate the purpose of the message, helping the driver decide if the message requires attending to immediately, or if the information can be viewed at a later time.

Reference 2 looked at how people follow directions as a result of language style. When presented with route following messages of 6 and 8 units, drivers performed equally well when the message was presented in staccato, short form, and conversational styles. When 10 unit messages had routes following, drivers made significantly more errors when the conversational and staccato styles were used. However, driver preference ratings showed that drivers preferred the short form and staccato language styles over the conversational styles, and as a result, the staccato style has been included as an option.

5.3.3 Special Design Considerations

None

5.3.4 Cross References

Message Length

Word Format

5.3.5 Key References

1. Campbell, J.L., Carney, C.L., and Kantowitz, B.H. (1998). *Human factors design standards for advanced traveler information systems (ATIS) and commercial vehicle operations (CVO)*. (Publication No. FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

2. Dudek, C.L. and Huchingson, R.D. (1982). *Human factors design of dynamic displays*. (Publication No. FHWA/RD-81/039). College Station, TX: Texas Transportation Institute.

3. Sanders, M.S. and McCormick, E.J. (1993). *Human factors in engineering and design*. New York, NY: McGraw-Hill, Inc.

4. Green, P., Levison, W., Paelke, G., and Serafin, C. (1994). *Preliminary human factors design standards for driver information systems.* (Publication No. FHWA-RD-94-087). McLean, VA: Federal Highway Administration.

5. Lee, J.D., Stone, S.R., Gore, B.F., Colton, C., Macauley, J., Kinghorn, R.A., Campbell, J.L., Finch, M., and Jamieson, G. (1996). *Development of human factors standards for advanced traveler information systems and commercial vehicle operations: Design alternatives for in-vehicle information displays: Message style, modality and location.* (Publication No. FHWA-RD-96-147). Washington, DC: Federal Highway Administration.

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5.4 Driving Context Dependency

5.4.1 Introduction

Driving context dependency is an important context characteristic, along with time urgency and criticality, when evaluating IVIS messages. "*Driving context dependency* is defined as the degree to which a message is related to the primary task of driving." (Reference 1, p. 54)

Design Recommendations

- As a general principle, designers should use the priority rankings to avoid the simultaneous presentation of messages. This is particularly important with auditory messages. If two or more in-vehicle messages need to be displayed to the driver at the same time, those with larger priority rankings should be emphasized. After the message(s) has been presented to the driver, the driver should be in control of selecting, deactivating, and cancelling messages, independent of priority, except for messages regulated by law (Reference 3).

- An auditory signal concerning the safety of the driver or other people, and requiring immediate action by the driver, shall not be presented exclusively by auditory means, but shall also be presented using another sensory channel. Other modes for presenting the information may be visual, haptic and/or kinesthetic (Reference 4).

- In instances where messages that are related to driving control activities must be presented visually, they should be presented near the driver's center of attention to minimize looking away from the roadway. (Reference 1, p. 57)

- "Use caution in augmenting an auditory display with a redundant visual head-down text display." (Reference 2, p. 55)

- When the auditory modality is reserved for driving related messages, in general, use visual presentation for messages unrelated to driving. (Reference 2)

- Focus on enhancing driver's understanding and response time but be careful of not tasking drivers with too much information. (Reference 1, p .57)

TABLE 5-6 - DEFINITION AND HEURISTICS FOR ASSESSING DRIVING CONTEXT DEPENDENCY FOR IVIS MESSAGES

MESSAGE CHARACTERISTICS	DEFINITION	RANGE
Driving Context Dependency	Relationship to driving context	Related = linked to driver control Unrelated = No relation to driving context

(Source: Adapted from Reference 1, p. 20)

5.4.2 Supporting Rationale

Reference 1 considered *Driving Context Dependency* to be an important message characteristic when they evaluated a wide range of IVIS messages. The degree to which a message is dependent on the driving context varies greatly. Reference 1 defined the continuum of driving context dependency into five categories based on whether a message was directly linked to driving control activities, involved decision-making activities, or was not related to the driving task at all. Their range for *driving con*text *dependency* was: "(1) Linked to safety critical driving control activities, (2) Linked to tactical driving decisions, (3) Linked to strategic driving decisions, (4) Linked to overall purpose of trip, and (5) No relation to the driving task." For the purpose of this report, the set was reduced to two categories, as summarized in Table 5-6.

Reference 2 conducted a study using a driving simulator where participants were presented with IVIS messages that were either related or unrelated to the current driving environment. Results showed that drivers were able to keep their eyes on the road longer and better integrate driving related information with current driving tasks when information was presented in the auditory modality. In general, unrelated messages showed no significant benefit from either presentation modality. However, reserving the auditory modality for driving related messages suggests the use of visual presentation for messages unrelated to driving.

Reference 3 is ISO/TS 16951 which examines message priority.
Reference 4 is ISO/FDS 15006 which specifies in-vehicle auditory presentation

5.4.3 Special Design Considerations

None

5.4.4 Cross References

Message Priority, Urgency, and Criticality

5.4.5 Key Reference

1. Lee, J.D., Carney, C., Casey, S.M., and Campbell, J.L. (1999). *In-vehicle display icons and other information elements: Conduct preliminary assessment of visual symbols*. (Publication No. FHWA-RD-99-196). McLean, VA: Federal Highway Administration.

2. Seppelt, B.D. and Wickens, C.D. (2003). In-vehicle tasks: Effects of modality, driving relevance, and redundancy. (Technical Report AHFD-03-16/GM-03-2). Savoy, Illinois: University of Illinois Institute of Aviation.

3. ISO/TS 16951 (2004). Road vehicles - Ergonomic aspects of transport information and control systems (TICS) - Procedures for determining priority of on-board messages presented to drivers (15 March, 2004).

4. ISO/FDS 15006 (2011). Road vehicles - Ergonomic aspects of transport information and control systems - Specifications for in-vehicle auditory presentation.

WORD FORMAT

5.4.6 Introduction

Word format refers to the manner in which individual words are displayed, either in their entirety or an abbreviated form. Abbreviation strategies include (from Reference 1):

- First letter - Only the first letter of the word is retained.
- Key consonant - Vowels are eliminated and only key consonants are retained.
- First syllable - The syllable pronounced first is retained.

DESIGN RECOMMENDATIONS
• In general, words of 5 to 8 letters should be abbreviated using the key consonant strategy. (Reference 1) • In general, words of 9 letters or more should be abbreviated using the first syllable strategy. (Reference 1) • Impose standard rules for abbreviating words. (Reference 2) • Cardinal directions can be abbreviated using the first letter strategy. (Reference 1) • When the best understood abbreviation is longer than two-thirds of the word itself, abbreviating is discouraged. (Reference 1) • For expressions difficult to abbreviate, consider simpler expressions, i.e., “Fog” for “Reduced Visibility”. (Reference 1) • Prompt words can improve recognition of abbreviated words, but must be tested prior to implementation. (Reference 1) • Street names should not be abbreviated. (Reference 2) • Specifics on display characteristics should examine ISO 15008. (Reference 3)

5.4.7 Supporting Rationale

While abbreviating words are not necessarily preferred, abbreviating words can potentially allow more information to be presented within the same amount of space. In order to determine which abbreviations or types of abbreviations would be appropriate, Reference 1 presented participants with a set of 80 traffic-related words prepared by the Texas Transportation Institute and other traffic agencies (see Appendix A). The participants were instructed to write the shortest abbreviation that would be understood by drivers. These abbreviations were presented to a different group of participants who were instructed to identify the abbreviated word. The abbreviations were also presented to a group of participants with a commonly-used word either before or after the abbreviation to determine if the prompt word increased identification. Those abbreviations correctly identified by 85% or more of the participants were considered to be appropriate for use. When presented alone, 21 abbreviations met this criterion. When presented with a prompt word, the initial 21 abbreviations again met this criterion, as well as 26 other abbreviations.

Reference 2 suggests using full street names, rather than abbreviations. This prevents drivers from confusing streets with regions, and streets with each other. Reference 2 argues for the use of consistent rules for abbreviating which, when understood by users, can also be used in reverse order to reconstruct the original term from the abbreviation. Deviating from these abbreviation rules can greatly increase the recognition demand of the user, and the effects on understandability resulting from this deviation must be examined. (Reference 2)

Reference 3 is the ISO 15008 (2009). Road vehicles - Ergonomic aspects of transport information and control systems - Specifications and test procedures for in-vehicle visual presentation. The visual characteristics of display systems are only one set of factors influencing this process. They therefore need to be considered, along with human capabilities, in connection with the other elements of the driving environment. Visual specifications fall within a wide range of environmental conditions and constitute only one necessary condition for adequate performance, comfort and workload. They refer to the relevant range of illumination conditions and to the location of the display with respect to the driver.

5.4.8 Special Design Considerations

The abbreviations examined by Reference 1 were intended for use on a roadside changeable message sign (CMS), and pertain mainly to traffic-related terms. Vehicle systems terminology, such as those terms already implemented on some OEM displays, can be considered validated through extensive application.

5.4.9 Cross References

Message Length

5.4.10 Key References

1. Dudek, C.L. and Huchingson, R.D. (1982). *Human factors design of dynamic displays*. (FHWA/RD-81/039). College Station, TX: Texas Transportation Institute.

2. Green, P., Levison, W., Paelke, G., and Serafin, C. (1994). Preliminary human factors design guidelines for driver information systems. (FHWA-RD-94-087). Washington, CD: Federal Highway Administration.

3. ISO 15008 (2009). Road vehicles - Ergonomic aspects of transport information and control systems - Specifications and test procedures for in-vehicle visual presentation (15 February, 2009).

5.5 Font

5.5.1 Introduction

"*Font* refers to the geometrical characteristics or style of symbology (References 1 and 2). The design goal for symbol font is to avoid extensive flourishes and embellishments of the symbols." (Reference 2, pp. 3-8)

DESIGN RECOMMENDATIONS
• Definition and measurement of character dimensions should use ISO 15008 (Reference 9, Annex A) • Examples include Geneva, Helvetica, Tahoma, Hazeltine, Leroy, Lincoln-mitre, Huddleston, and many Modern Gothic fonts, among others." (Reference 2, pp. 3-8; 3; 4) • Titles and other key elements in a message should span a minimum visual angle of 0.50 degrees. (References 2 and 3) • Dynamic or critical elements should span a minimum visual angle of 0.33 degrees. (Reference 2) • Static or noncritical elements should span a minimum visual angle of 0.266 degrees. (Reference 2) • Uppercase letters should be used for 5x7 matrix displays. A 7x9 matrix display is necessary to produce reasonable lower case fonts (Reference 5). • On displays other than 5x7 matrix, use mix • ed case instead of all capital letters for messages in excess of two to three words. (Reference 3) • "All lines and gaps between lines should be at least 0.05 degrees wide." (Adapted from Reference 3, p. 24)

5.5.2 Supporting Rationale

“Drivers must be able to read displays quickly in order to minimize eyes-off-the-road time.” (Reference 3, p. 22) Selection of font size and type is critical to supporting this ability, as together they determine how much information can be presented, how much information can be read in a glance, and correspondingly, how long it will take to read the information (Reference 3). Font sizes that are too small will be below legibility thresholds for drivers. Font types that include embellishments and flourishes may create confusion between letters, increasing the demand on drivers when identifying words. Therefore, Reference 2 identifies 3 categories which text may fall into, titles and other key elements, dynamic or critical elements, and static or noncritical elements, with minimum visual angle suggestions for each. These recommendations are based on standard human factors reference sources and empirical evidence (see Reference 2, pp.3-5 for detailed description). Reference 6 conducted a study displaying single and multi-line alphanumeric messages using font with a visual angle of 0.33 degrees, in order to represent a worst case scenario of displaying text in-vehicles. Consistently high comprehension was observed across a variety of display manipulations, suggesting the font size used was appropriate for the display of alphanumeric information. This size is suggested as a lower boundary, as decreasing the font size can present difficulties for older drivers (Reference 2).

The use of lower case letters in highway signs has resulted in better word recognition performance and equal word legibility performance when individual letter reading is required, as compared to upper case words (Reference 7). This result seems plausible considering most reading includes recognition of words composed of lower case letters. Reference 3, therefore, suggests that messages beyond two or three words employ the use of lowercase letter. However, this suggestion reflects the point that short messages often parallel information displayed on signs in uppercase, and exceptions may have to be made to maintain consistency with information from outside the vehicle. (Reference 3)

5.5.3 Special Design Considerations

Display characteristics must be considered when choosing an appropriate font size and type. For example, Reference 4 found that the superior visual performance characteristics of electroluminescent (EL) displays (increased brightness and contrast) permits the use of a smaller font size than most in-vehicle displays, with no degradation in reading performance. A range of font sizes and types should be tested on non-traditional and innovative in-vehicle displays and compared against conventional displays to determine if current standards are applicable.

5.5.4 Cross References

None

5.5.5 Key References

1. Decker, J.J., Pigion, R.D., and Snyder, H.L. (1987). A literature review and experimental plan for research on the display of information on matrix-addressable displays. Blacksburg, VA: Human Engineering Laboratory, VPI & SU.

2. Campbell, J.L., Carney, C.L., and Kantowitz, B.H. (1998). Human factors design guidelines for advanced traveler information systems (ATIS) and commercial vehicle operations (CVO). (FHWA-RD-98-057). Washington, DC: Federal Highway Administration.

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5. Dudek, C.L. and Huchingson, R.D. (1982). Human factors design of dynamic displays. (FHWA/RD-81/039). College Station, TX: Texas Transportation Institute.

6. Hoffman, J.D., Lee, J.D., McGehee, D.V., and Gellatly, A.W. (2005). Visual sampling of in-vehicle text messages: The effects of number of lines, page presentation and message control. *Transportation Research Record,* 1937, 22-31.

7. Garvey, P.M., Pietrucha, M.T., and Meeker, D. (1997). Effects of font and capitalization on legibility of guide signs. Transportation Research Record, No. 1605, pp. 73-79. Washington, DC: National Acad. Press.

8. Garvey, P.M. Synthesis on the legibility of variable message signing (VMS) for readers with vision loss. Retrieved 8/18/2003 from: http://www.access-board.gov/research&training/VMS/finalreport.htm

9. ISO 15008 (2009). Road vehicles – Ergonomic aspects of transport information and control systems – Specifications and test procedures for in-vehicle visual presentation (15 February, 2009).

5.6 Color and Accentuation

5.6.1 Introduction

Message color and accentuation refers to the color combinations used to present messages and the methods used to draw the driver's attention to particular content within a message.

DESIGN RECOMMENDATIONS
• "In general, use light characters on a dark background." (Reference 1, pp. 25, 2, 3)
• Important information should be displayed on the first line of the message. Natural reading habits direct driver's attention to this line. (Reference 2)
• Color accentuation is the most effective method for drawing a reader's attention to a particular line of text. (Reference 2)
• For specific definition of color, use ISO 15008. (Reference 6, Annex B)
• Double-stroke characters can also be used to accentuate text.
• Flashing text should not be used as a method to draw the driver's attention to particular text for urgent alerts. (Reference 3)

5.6.2 Supporting Rationale

Reducing the amount of glare produced by a vehicle display is achieved by placing light colored text on dark backgrounds, a technique referred to as negative contrast. (References 1 and 2) Placing a bright, light colored text on a dark background can greatly increase the contrast, and consequently the legibility of a display (References 1 and 3). Given appropriate brightness and luminance, green or yellow text on a dark background provides good contrast and accommodates drivers with vision impairments, particularly those with reduced sensitivity to red. (Reference 2)

Reading top-to-bottom is an established reading habit; line accentuation cannot be expected to alter this habit appreciably (Reference 4). The study conducted in Reference 2 used red letters, a message flashed on and off at 0.2 s intervals, and double-stroke characters to cue readers to the accentuated line first. Red letters were found to be more effective than double-stroke characters or flashing, with no increase in performance from a combination of these techniques. Reference 5 found also found that flashing all or parts of the message had no effect on attenuation and that it actually increased reading time as a result of decreased exposure time.

5.6.3 Special Considerations

If information requires accentuation within a message due to priority, it is better to include the information at the beginning or end of the message, or separate it into an individual message. The natural tendency of reading from top-to-bottom implies that the driver will receive the warning provided it is placed at the beginning of the warning (Reference 4).

5.6.4 Cross References

None

5.6.5 Key References

1. Green, P., Levison, W., Paelke, G., and Serafin, C. (1994). Preliminary human factors design standards for driver information systems. (FHWA-RD-94-087). Washington, CD: Federal Highway Administration.

2. Garvey, P.M. Synthesis on the legibility of variable message signing (VMS) for readers with vision loss. Retrieved 8/18/2003 from: http://www.access-board.gov/research&training/VMS/finalreport.htm

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4. Dudek, C.L. and Huchingson, R.D. (1982). Human factors design of dynamic displays. (FHWA/RD-81/039). College Station, TX: Texas Transportation Institute.

5. Dudek, C.L., Trout, N.D., Durkop, B., Booth, S., and Ullman, G.L. (2001). Improving dynamic message sign operations. (Report 1882-S). College Station, TX: Texas Transportation Institute.

6. ISO 15008 (2009). Road vehicles - Ergonomic aspects of transport information and control systems - Specifications and test procedures for in-vehicle visual presentation (15 February, 2009).

5.7 Display Length

5.7.1 Introduction

Display length refers to the amount of information presented on the display during a single scrolling. In this context, display length refers to the number of lines displayed at a time, with a line consisting of a maximum of 22 characters.

DESIGN RECOMMENDATIONS
• For short messages, displaying one line of text is adequate for reading and comprehension. (References 1 and 2). • As the length of messages increases, limit the display of messages to 2 lines of text so as not to intrude on visual sampling performance or driving performance. (References 1 and 3).

5.7.2 Supporting Rationale

Reference 1 conducted a study that included an examination of the influence of the number of lines displayed on visual sampling behavior. Drivers were presented with one, two, or four lines of an 8 to 9 line message, which they were required to read while operating a driving simulator. Results showed that as the number of lines displayed increased, the number of glances to the display decreased, while the duration of those glances increased primarily within ranges previously identified as acceptable by References 4, 5, 6, and 7, among others. One line displays required the most glances and had the greatest number of short glances (<=1 s), which may prove to be ineffective in obtaining information over large amounts of information. Messages presented on one line displays also required the longest time to read, increasing the amount of time the driver's eyes were off the forward roadway. As more information was presented to the driver, the more they attempted to sample in a single glance. For four line displays, the number of long (>2 s) and potentially dangerous glances (Reference 3) increased. Two line displays appear to be most appropriate for presenting information.

5.7.3 Special Design Considerations

For presenting extremely short messages, such as single word warnings or instructions, longer line displays may be unnecessary, occupying valuable space on displays that are already limited in area.

5.7.4 Cross References

Message Length

Scrolling Strategy

Presentation Rate

5.7.5 Key References

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6. RECOMMENDATIONS FOR MESSAGE PRESENTATION AND FLOW PARAMETERS

Message Scrolling, Paging, and Repetition:

- State Change Indication & Message initiation
- Message Entry and Presentation Rate
- Message Scrolling, Paging, and Repetition
    - Multi-line, multi-message
    - Paging
    - Marquise
- Scroll Control (Driver- versus System-activated)

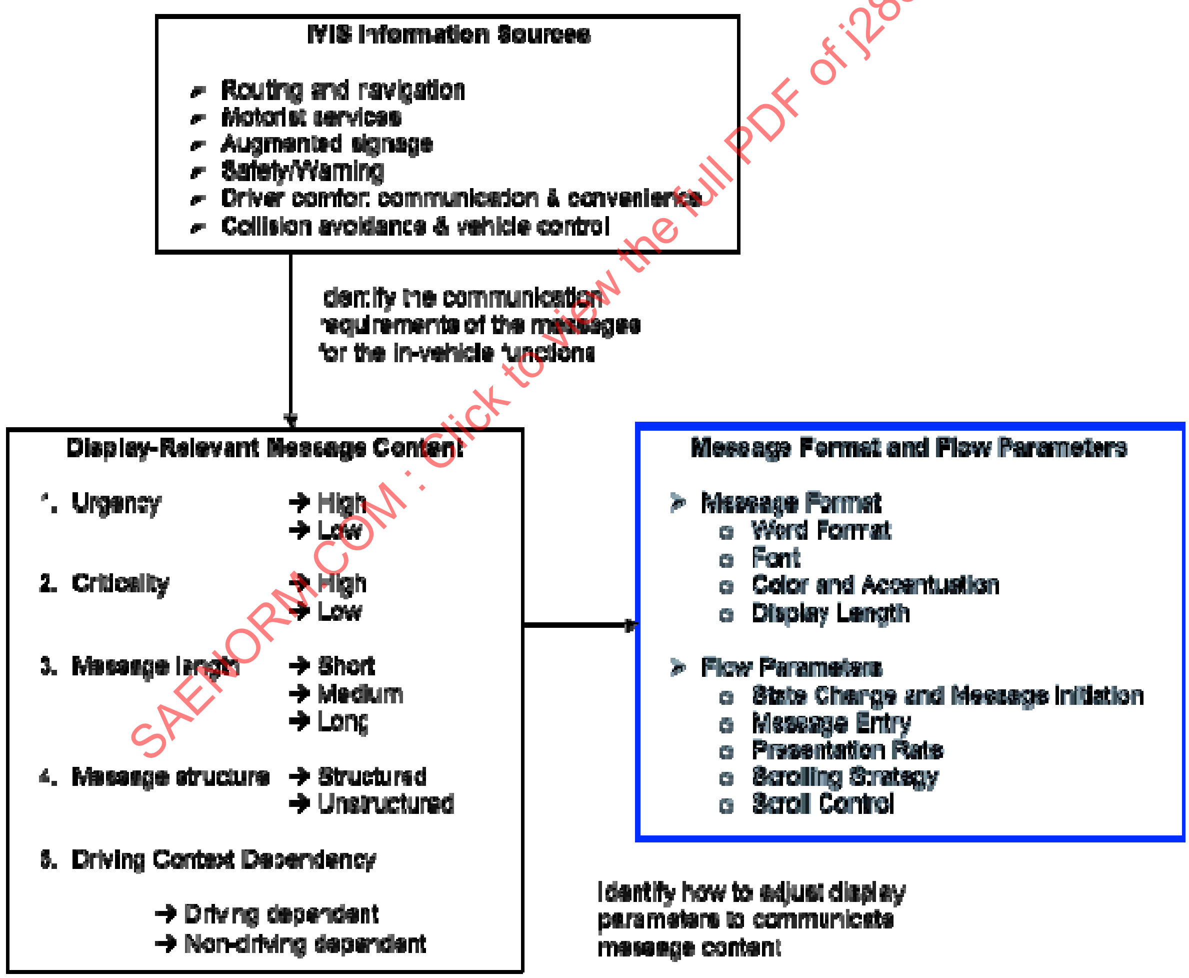

FIGURE 6-1 - FRAMEWORK GUIDING THE DESIGN RECOMMENDATIONS (ADAPTED FROM LEE ET AL., 1999)

6.1 State Change Indication and Message Initiation

6.1.1 Introduction

Intra-message state change refers to the method used to alert drivers that additional information is available within a message.

Inter-message state change refers to the method used to alert drivers that new information is available. In this context, a chime or earcon would be the appropriate 'alert.'

INTER-MESSAGE DESIGN RECOMMENDATIONS
• Inter-message state changes should use a different method than intra-message state changes, such as a flashing icon or auditory alert, to indicate to the driver that the information transition is between messages, not within a message. • Inter-message state changes can use three stars or similar symbology, such as asterisks, to indicate transition between messages. • Use auditory alert when a previously static visual display changes. (Reference 2) • Auditory state change alert should be different from all other warning alerts within the vehicle so as not to create annoyance or confusion for the driver. • "Limit the number of state change alerts to three or four." (Reference 3) • The auditory frequency of alerts should not be so high as to startle drivers, particularly older drivers. (Reference 4) • Flash coding is appropriate for identifying inter-message state changes and new information, especially for messages requiring immediate attention. (Reference 3)

6.1.2 Supporting Rationale

State change methods are used to tell the driver that new information is available. Within a message (*intra-*), visual state changes between lines are assumed to be most effective as the driver is already attenuated to the display. When interacting with the display manually, up and down arrows can be used to inform the driver that additional lines of the message exist. When messages are being displayed automatically, Reference 1 reports that the blanking times between lines within a message must be almost zero in order to prevent drivers from concluding that the current message has ended and a new message is being presented. This can force the driver to continue to focus on a message for longer glance durations than are comfortable in order to read all lines of a message.

State changes are useful in informing the driver that new information is available, particularly when the information is of high urgency or criticality. Reference 5 advises that the most critical information should be presented in a salient manner as it can influence the safe operation of the vehicle. A salient display should include some auditory prompt or signal that orients the driver to the visual display containing the information (References 2, 3, 5, 6). An auditory prompt that conveys less urgency can be appropriate for alerting drivers of new information that is not highly critical or urgent, particularly when the display has been static for a period of time (Reference 2). "Providing information in this redundant fashion will lessen the need for a driver to scan the visual display and allow him or her to review the information if it is not fully understood or remembered" (Reference 2).