A Formal Approach for Allocation of Informational Elements: Displays and HUDs

Michael Heymann [1*], Asaf Degani [2**]

[1] Department of Computer Science, Technion, Israel Institute of Technology
*heymann@cs.technion.ac.il
[2] General Motors R&D, Hertzelia, Israel
**asaf.degani@gmail.com

Abstract: The automotive industry is undergoing a rapid change involving new and emerging technologies and many safety enhancement features such as Smartphone integration/mirroring technologies, internet applications for entertainment and social media, apps for information, as well many safety enhancement features. One outcome of this growing, in-vehicle interface usage is the need to organize and integrate this information as well as to allow drivers to handle vehicles safely and effectively with minimal distraction and inattention. This paper describes a methodological approach to designing a driver interface that maximizes utility and minimizes driver distraction and inattention: It first characterizes informational elements to achieve a priority ranking scale. We then show how this categorization can be used to evaluate the allocation of information elements to displays (cluster, centre stack, etc.) in the car. Finally, we focus our attention on the use of head-up displays that have the advantage that the information displayed on it is in the driving field of view and discuss several aspects of its organization based on the approach and methodology.

1. Introduction

In the past two decades, automobiles and the automotive industry as a whole have been undergoing a massive, rapid change involving the implementation of new and emerging technologies. These range from changes in vehicle power plants and propulsion systems, vehicle stabilization and safety control to technologies aimed at reducing the driver's workload, increasing passenger safety, comfort, entertainment and communication capabilities.

These unprecedented advances have translated into cars with a multitude of features and enhancements. These include engine control systems to achieve efficiency and performance, computer controlled braking systems, vehicle stability and traction control, speed control and track keeping technologies, to improve safety and reducing the driver's workload. They also include adaptive cruise control, active power steering and automated braking, active navigation aids and automated parking assistance to enhance the driving and handling experience. And, finally, they include advanced infotainment systems that allow access to digital content, to the internet, and to various communication systems and location services to maintain contact with the outside world [1]. All these technologies have had an immediate, profound impact on the driver's operating environment and on the design of the cockpit. In particular, they place increased demands on the driver (and to some extent also the passengers) to understand, monitor, and interact with these systems [2].

Concurrently, there has been an ongoing shift in the way drivers and especially commuters view the time spent in their cars. People tend to consider this time as an opportunity to communicate with colleagues, friends, and family [3] -- as well as to conduct work or follow up on work-related tasks, or simply to enjoy the benefits of advanced infotainment systems. However, all these activities tend to distract the driver's attention from the road and thereby jeopardizing safety.

In recent years much attention has been devoted to the problem of accident mitigation and reducing driver distraction and inattention. Various means for driver warning of potential hazards have been developed (e.g., forward collision warning [28]), as well as techniques for prioritizing messages and tasks transmitted to the driver [26], [27]. Multiple task/performance workload studies have been performed, and control-display design factors have been investigated. Human-computer interaction problems have been explored, and human performance modeling studies have been conducted. A representative state of the literature can be found in [29].

Until recently, the driver-vehicle interface has evolved incrementally, with small successive changes in interaction and display features, so as to accommodate immediate needs as they arise. However, due to the increasing in-vehicle interface complexity, it has been becoming clear that there is an imminent need for integration of the sub-systems in the car's driver interface into a coherent whole so that the driver can handle the vehicle safely and efficiently [4]. In current vehicles, increasing amounts of information must be displayed to the driver (including the vehicle's on-the-road activity and performance, the vehicle's status and health, navigation, communication, and entertainment). This means that interaction and information presentations (e.g. displays) must be designed systematically with emphasis on minimizing driver distraction from and inattention to the main task of driving the vehicle and maintaining safety.

Since display space is always limited, there is obvious competition for the prime display space, requiring a framework for prioritizing display elements and classifying the cockpit information components according to some basic principles related to tasks, urgency, timeliness, frequency and duration of use, passive or active interaction, and other operating criteria. The most crucial consideration is to make sure that the driver's attention to the road and the driving task is minimally compromised by subsidiary activities.

Current user interfaces in cars consist of the main instrument cluster that primarily includes all the vehicle and driving information, an upper and lower center stack that includes comfort control, multimedia, navigation, and communication, and sometimes even side-mirror displays that present information about vehicles on adjacent lanes. Given this massive onslaught of information components, and the fact that the driver still bears responsibility for the control of the car, effective and efficient information presentation and interaction have become an ever-increasing challenge. In response to this challenge, Head-Up Displays

(HUD) are being considered and implemented as an additional display medium that has the unique advantage of being located in the drivers' line of sight, hence enabling them to pay attention to the road without turning their head. Clearly, head-up displays have an inherent limitation as to the amount of information that can be displayed effectively without excessive cluttering of the driving field of view. Thus, the judicious utilization of this medium requires careful consideration of what is displayed, how, and when.

In this paper, we focus our attention on providing a systematic approach to the problem of information organization, with special emphasis on allocation of informational elements to display components. We begin by characterizing informational elements, to obtain a driver-centric perspective, where each informational element has associated a set of attributes. This facilitates the construction of a prioritization of the informational elements. Next, each display component is assigned a cost function that expresses driver distraction based on its deflection from the main (driving) line of sight, distance from the driver, the cognitive load associated with the interaction, etc. A cost-benefit principle can then be established to the final allocation of information elements to display components. Finally, in the last section of this paper, we discuss some of the insights we have gained in applying this particular approach and methodology to the design and evaluation of automotive head-up displays.

2. Characterization of vehicle information

To apply a systematic approach to the problem of organizing information for display presentation, we first need to consider all the elements of information at hand and characterize them by their attributes [5, p. 518]. To do this we take the driver's point of view with a special emphasis on the main activities of driving and monitoring information. This will provide us with sufficient operational data to classify the information elements according to a prioritized presentation scheme that optimizes user interaction efficiency, safety, and satisfaction. For each information element to be displayed, we specify a set of associated attributes that characterize its full range of operational and consequential features. The display designer will then need to assign a value or property to each information attribute to optimize his design objective. These nine attributes are listed below and discussed in the following subsections:

2.1. Activity

We distinguish between four main driver activities – driving, navigation, monitoring, and auxiliary [6, 7. 8]. The driving activity is further divided into operating the vehicle (speed, lane keeping, and stability control) and tactical maneuvering (passing other vehicles and obstacles). Navigation activities support the sequential and planned maneuvers such as exits from highway, lane changes, and turns. Monitoring refers to the act of observing and registering the displayed information, understanding its meaning and implications (comprehension), and finally constructing a mental model of the situation over time (projection) as well as understanding consequences [9]. Auxiliary information refers to all activities that are not associated with driving and monitoring such as setting radios, communications, and climate control systems.

2.2. *Information Type*

We make a distinction between several types of information: state, status, alerts, and warnings:

a. *System state.* The value of a continuous quantity (e.g. vehicle speed, engine RPM, ambient temperature display, time, fuel level).

b. *System status*. A discrete variable that usually has only two values (e.g. lights on/off, ACC on/off) for nominal events.

c. *Alerts*. The annunciation of unusual or unexpected events that do not necessarily require immediate response (e.g. an indication of an upcoming gas station or an incoming phone call).

d. *Warnings*. The annunciation of unwanted situations, either current or imminent, that require an immediate awareness, attention, and response.

Information type can be further categorized according to whether the information is direct (such as speedometer, tachometer, fuel level, instantaneous fuel consumption, automation aids status, navigational information) or derived (average fuel consumption, average speed, trip time).

2.3. *Urgency*

Urgency is the extent and speed with which the information element must be attended to and resolved by the driver. We define four levels of urgency (high, medium, low, none).

2.4. *Timeliness*

Timeliness reflects the fact that an information element is relevant only within a limited time window. When the time window expires, the information becomes irrelevant or invalid. These include, for example, an upcoming road service station, distance-to-manoeuver, change route suggestion. For simplicity we divide timeliness into four levels that express the urgency and importance to act (high, medium, low, none).

2.5. *Duration of interaction*

The length of time of the expected user interaction. We define four levels of interaction duration (high, medium, low, none).

2.6. Importance

We rank information importance based on its utility to the driver, with benefit weighed positively and cost weighed negatively. We distinguish four levels of importance (high, medium, low, none).

2.7. *Frequency of use*

Reflects the intensity of driver interaction with or monitoring of the information element (high, medium, low, none).

2.8. *Type of user response required*

This attribute details the response requirement, on part of the driver, concerning the displayed information:

a. No response requirement (e.g. ambient temperature, date).

b. Discretionary response (e.g. for air conditioner status, radio station, incoming phone call, SMS).

c. Obligatory response (e.g. change gear, seat belt alert, high beam, low tire pressure).

d. Imperative response (e.g. engine failure, flat tire, low oil pressure, lane deviation).

e. Imminent response (e.g. collision warning).

2.9. *Activation mode*

This attribute refers to how the information is presented. This can either be presented constantly (persistent), presented only when triggered by the system or environment (intermittent), or when selected by the driver for display (selectable).

Table 1 shows the use of these nine attributes with respect to a partial list of information elements in a generic automobile cluster display.

	Activity	Information type	Urgency	Timeliness	Criticallity (perception of risk)	Frequency of user access	Duration of inter-action	Response type	Activation mode
Odometer	auxilary	state	none	none	low	low	low	none	persistent
Trip odometer	navigating	state	none	none	low	low	low	none	persistent
Door ajar icon	monitoring	warning	high	none	high	none	none	imperative	intermittent
High engine-temperature icon	monitoring	warning	high	low	high	none	none	imperative	intermittent
Engine-temperature gauge	monitoring	state	none	none	medium	low	low	none	intermittent
Low tire pressure icon	monitoring	warning	medium	none	high	none	none	obligatory	intermittent
Fuel level gauge	monitoring	state	none	none	high	low	low	none	intermittent
Fuel low indicator	monitoring	warning	medium	low	high	none	none	obligatory	intermittent
Fuel range	navigating	annunciation	low	low	medium	low	low	none	persistent
Turn signal	driving	alert	none	none	medium	high	low	none	intermittent
PRNDL indicator	driving	status	none	none	medium	medium	low	none	persistent
Gear shift advisory (up, down)	driving	alert	medium	none	medium	medium	low	discretionary	intermittent
Speedometer	driving	state	none	none	high	high	low	none	persistent
Speed limit (traffic sign, etc.)	driving	alert	none	none	high	high	low	discretionary	intermittent
Speed limit indicator warning	driving	warning	high	none	medium	none	none	discretionary	intermittent
ACC on/off	driving	status	none	none	low	medium	low	none	selectable
ACC set speed	driving	state	none	none	high	medium	low	none	selectable
ACC engaged call	driving	status	none	none	high	medium	low	none	selectable
ACC set gap	driving	state	none	none	medium	medium	low	none	selectable
Lane centering engaged	driving	status	none	none	high	medium	low	none	selectable
Side blind zone	driving	alert	high	none	high	none	none	obligatory	intermittent
Lane Departure Warning (LDW)	driving	alert	high	high	high	none	none	obligatory	intermittent
Traffic events (e.g. construction)	navigating	alert	low	medium	medium	none	none	discretionary	intermittent
Vehicle ahead indicator	driving	alert	low	none	medium	none	none	none	intermittent
Compass	navigating	state	none	none	low	low	low	none	persistent
Tachometer	driving	state	none	none	low	medium	low	none	persistent
Turn-by-turn indicator Expected	navigating	alert	medium	high	high	high	low	discretionary	intermittent
Time of Arrival (ETA)	navigating	state	none	none	low	low	low	none	persistent
Map and vehicle location	navigating	state	none	none	high	high	medium	none	selectable

3. Methodology for allocation of information elements

The set of nine attributes constitutes the basis on which a methodology can be developed for the organization of the displayed information. Each information element can be displayed on any one of the available display components: the main instrument cluster, the upper center stack, the lower center stack and/or the head up display. The problem, of course, is that each of the displays has a limited capacity for information content. A decision mechanism for organizing the information is outlined next.

We first consider the display component locations. Each display is located at a different viewing angle from the main (driving) line of sight and at a different distance from the driver. Hence, the interaction with each display component distracts the driver to a degree that corresponds, at least in the geometrical and anthropometrical sense, to this angle and distance. The head-up display has the advantage of a minimal distraction from the driving task since its viewing angle coincides with the driving line of sight. As opposed to the head up display, interaction with the center stack causes a significant distraction as its information is displayed far away from the main line of sight and at a significant distance from the driver. In addition to the geometrical and anthropometrical consideration, we distinguish the display components with respect to the way the driver interact with its content. Specifically, the center stack is usually designed for extensive driver interaction. The instrument cluster is designed primarily for viewing while the data panel in the instrument cluster can be accessed through the steering wheel buttons and control wheels. Finally, the head-up display is generally designed exclusively for viewing and the driver cannot interact with it at all.

We can now associate a "cost factor" with every display component that expresses its distractive effect on the driver based on the deviation from the driving line of sight and distance from the driver (the latter particularly relevant when manual interaction with the display surface is required). Additionally, each interaction with an information element takes a specific duration, cognitive effort, etc. Also, interaction with each information element has its own characteristic frequency of occurrence (or intensity). Thus, different interaction (duration and intensity) costs are associated with the various information elements.

Next, we consider the utility, or benefit, that the driver derives from interacting with the information when operating the vehicle. This utility can be evaluated from the table of attributes associated with the information elements discussed earlier. First, the designer can rank the attributes. One way for ranking activities is defining an ordered preference list, inspired by the concept of dynamic driving task, to include first and foremost the driving (primary), navigating as secondary, monitoring tertiary, and auxiliary-application as the quaternary. This prioritization is shown schematically as coaxial circles in Fig. 1 below.

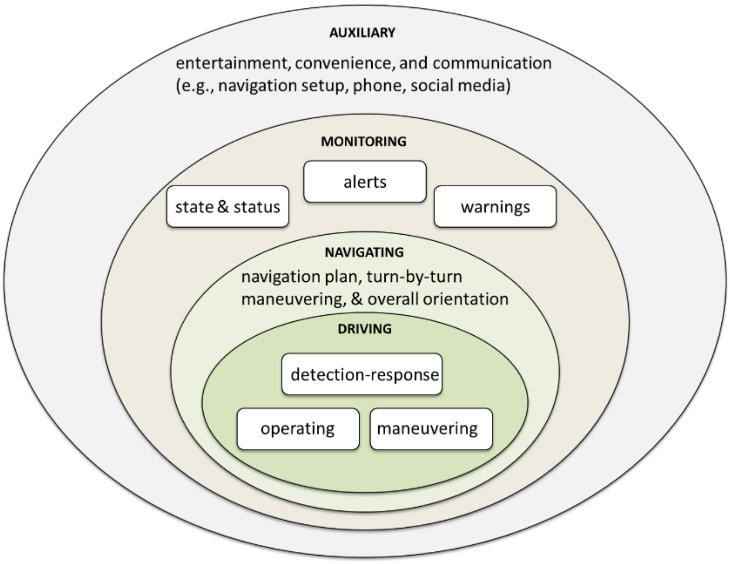

Fig. 1. *Prioritization of information types.*

The designer may also want to prioritize the list in terms of information type -- (1) warning, (2) alert, (3) state, (4) status. The prioritization can be further refined by assigning numerical weights to the components thereby enabling a formal optimization approach to solving the display organization problem.

To summarize, the interaction with each information element entails both a utility and a cost. The utility is derived from the value of the information to the driver. The cost is derived from the distraction that the interaction entails (measured by the deflection from the line of sight and length or interaction, the cognitive load associated with the interaction, interaction complexity, time to completion, etc.), such as searching for a particular radio station. The issue of allocating the information elements to display components can thus be cast as a classical resource allocation problem. Every allocation of information elements is associated with a utility value. This utility is obtained from the utilities and costs of the information attributes and the distractive cost of the display component. An allocation should thus be made such that the overall utility is optimized (i.e. the cost is minimized and utility is maximized). The optimal allocation obtained from the above analysis must undergo a further review and possible adjustment. This is because there is no a priori guarantee that the optimization alone will cause the informational elements to be clustered into coherent units. This clustering is a separate issue because the clustering of information has an independent value that cannot be computed based on the individual information elements.

For example, we may decide to leave out an element because of its prioritization but include it anyway to not stop a cluster from being coherent or complete. The clustering problem has its roots in understanding the (strong/weak) interrelationships among informational elements and the opportunity to combine elements with strong relations into a coherent unit [10, 11, 12]. As such, a second iteration devoted to clustering analysis is recommended to complete the information organization methodology. Shmueli et al. [14] investigated the problem of organizing informational elements in clusters according to importance, color-coding, symmetry and more using a Gestalt approach [13]. A formal methodology to solve this problem is provided there.

4. Head up display and its information organization

The head-up display is primarily a safety-oriented feature aimed at supporting the activities of driving, navigating and monitoring. The secondary role of this display is convenience. Current vehicle cockpit designs show a trend towards placing vehicle controls as well as the many entertainment and communication controls within easy reach of the driver (e.g., on the steering wheel). An emerging trend is to display feedback for these important interactions in the head-up display, thereby creating a composite steering-wheel-to-HUD interface system. In view of this dual role of the head up display, its design must meet the following objectives: (1) to provide the driver with easily accessible information for driving, navigating, and monitoring tasks (as well as auxiliary and convenience activities) within a single display that is collocated with the main driving line of sight, thereby minimizing the need to divert attention to other interface components; (2) to provide the driver with a concise view of the current vehicle's driving state, system configuration, and the state of the operational environment (V2I, V2V, V2X).

This concise view serves to enhance the driver's situation awareness about the vehicle, its driving conditions, and its road scene – thus enabling a *one-shot* understanding of what is going on. The role and objectives of the head up display in supporting driving and auxiliary activities are thus well understood. However, what remains unclear is which information elements should be presented and how to organize and display this information, given the head-up display's limited display space. Furthermore, since the head up display is constantly present in the viewing field of the driver, the information must be selected and displayed in a concise and nonintrusive manner so as to minimize interference with the driving scene. The use of a head-up display nevertheless has several additional (implicit) design challenges. The first is that the information must be *complete* in the sense that driver's dependency on other display components for routine activities is minimized (or even eliminated). Second, the information must be confined to driving and interaction-related activities. These challenges place a major burden on the design in view of its limited display space and requirement of minimal clutter. Third, the information displayed on the head-up display has a significant bearing on the design of other display components if a rational human-machine system is to be achieved. For example, it may be desirable to display alerts and warning only by category – thereby requiring the driver to obtain additional detailed information about their specific nature elsewhere on the interface. This suggests that other display components need to be augmented with information resources and details (e.g. vehicle diagnostics).

Thus, we need to address two main design issues: (1) deciding which information needs to be extracted to design a complete, concise head up display; and (2) deciding how to organize the information to maximize situation awareness, minimize clutter and facilitate easy interaction.

4.1. *Standardized structure of HUD information*

Based on our viewpoint that the head-up display is primarily a safety-oriented display, we suggest a standardized structure for presenting information, which includes the four levels discussed earlier (Fig. 1): driving, navigation, monitoring, and auxiliary activities. This conceptual structure of information works well to define the objectives of the head up display; namely safety and driver convenience, minimizing distraction and supporting situation-awareness/understanding.

The ***driving*** level has three components: The *operating* component includes all the information related to speed, safe distance, lane control, etc. (presumably, this information must always be present while the vehicle is being driven). The second component is the *maneuvering* that displays information concerning current, upcoming, and perhaps even future maneuver(s) such as turns, lane changes, and highway exists, etc., along with the corresponding parameters such as distance and/or time to maneuver. The set of maneuvers displayed on the head-up display is related to both tactical maneuvers (dealing with road hazards and passing another vehicle, e.g.) as well as navigation-related maneuvers. The operating and maneuvering components, in addition to *object and event detection and response*, can be linked visually to generate a functional unit for driving.

The ***navigation*** level of the head up display provides the driver with information about navigation maneuvers (which are part of the overall navigation plan), parameters associated with these maneuvers (distance to, time to, etc.). Another important function of the navigation presentation is to provide the driver with *orientation* information. The key questions when making design decisions have to do with the role of safety in the navigation information provided on the display and whether it contributes to driver convenience.

The ***monitoring*** level of the head up display consists of state and status information that need to be monitored by the driver on the head-up display as well as information that the driver interacts with (such as headway gap settings and adaptive cruise control modes). This is also where *alerts* and *warning* – some related to the vehicle and other related to the operating environment – can be provided.

The ***auxiliary*** unit of the head up display contains activities relating to configurations of comfort, convenience, and communication features (climate control setting, infotainment, and phone, social media, etc.). Generally speaking, these activities are dealt with one at a time and are interchangeable. The standardized structure can support designers in making sure that informational elements that have been selected for the head up display are not placed in disarray. The designer's challenge is to abstract, integrate, and then configure these structures into a coherent whole [12]. Fig. 2 shows a hierarchical structure to support the designer in this task. Additional clues as to the details of this process can be obtained from the human factors literature on configural displays [15, 16] and some traditions in art (to be discussed later). Shmueli-Friedland et al. [14] provide some directions toward a methodological approach to suggest opportunities for integration and then quantify the amount of abstraction and integration in a display feature (see p.171-176).

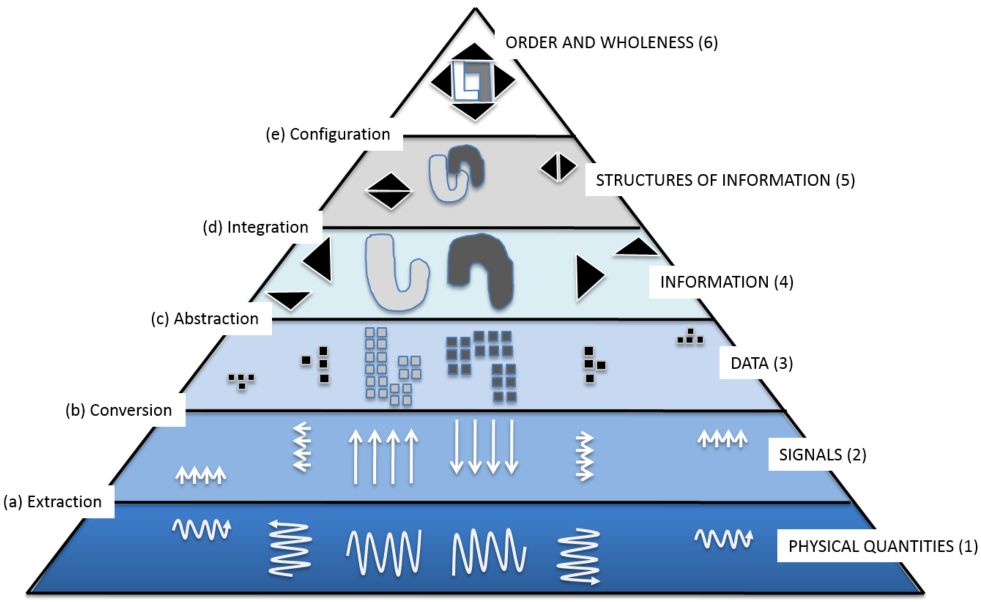

Fig. 2. *Organization of information (*adopted from [19], with permission).

4.2. *Design guidelines and example*

In this Section, we provide some general principles for the head-up display organization. Some of these principles are based on the above discussion while others are based on information organization principles observed in and deduced from existing aviation head up displays where this technology has reached a certain level of maturation [17,18].

1. The head-up display should be partitioned into functional units whose placement is generally fixed. The display should be partitioned in a consistent manner such that relative feature locations are preserved (e.g. driving information is always below warnings, auxiliary features are always located at the bottom of the display).

2. Information should be presented in a manner that does not compete or interfere with the visual scene. As such, the information presentation should have minimal cluttering. Images and features need to be thin-lined, sharp and terse.

3. Due to the limited real-estate of head up display arrangements of information elements should be integrated into a coherent structure of information. These structures (e.g., the functional units discussed in guideline 1) should then be configured into a whole [19].

4. The head-up display presentation structure should be somewhat consistent with the display structure and content on the cluster and center stack (e.g. head down displays).

5. The informational content on the display is selected to minimize the dependency of the driver on monitoring other sources of information.

6. The representation of the head-up display should be aligned with the line of sight (and direction of driving).

7. Graphics should be featured only to the extent that they convey concrete information and not for aesthetics purpose.

8. Color-coding is important for head-up display presentation and a consistent scheme is advised.

9. Head-up displays have different display modes (user selected or automatically triggered) and may change dynamically given a new situation, task, or driver state. The transitions and display transformation necessary for switching between these modes can be supported by the application of guidelines 1, 2, 3, and 4.

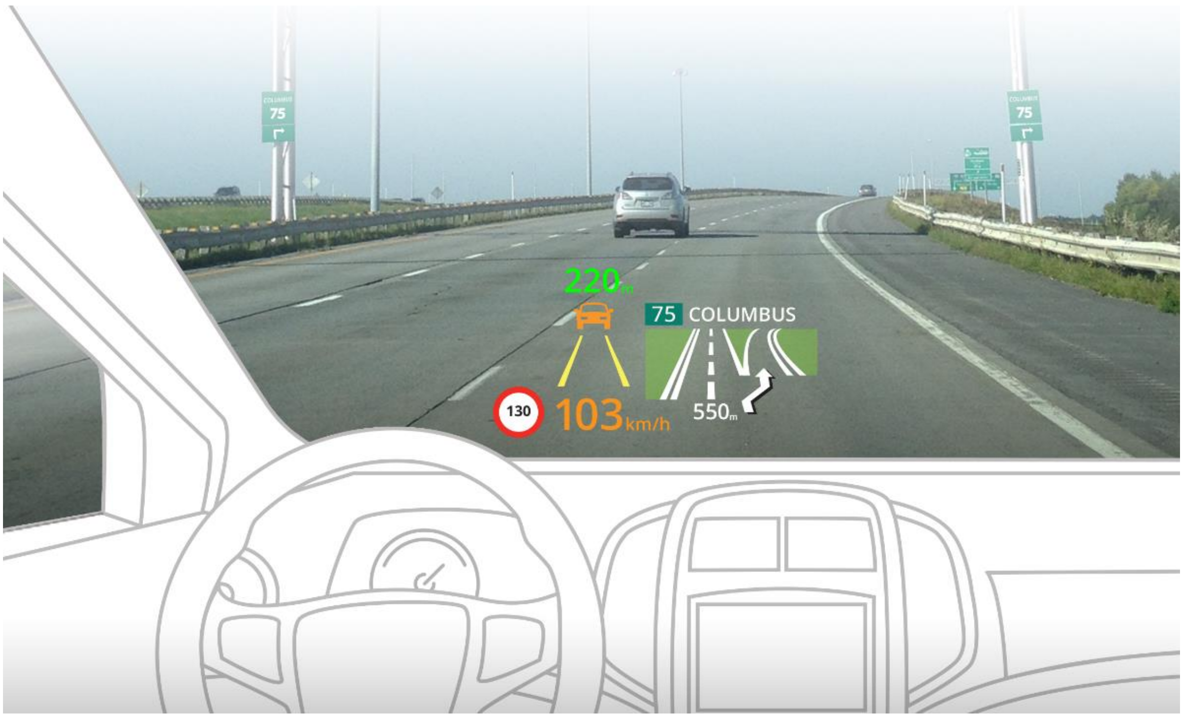

***Fig.* 3.** *Automotive head-up display (generic)*

Fig. 3 is a generic head up display presentation. It has a very intense presentation format and a graphic-rich presentation of the upcoming maneuver superimposed on the road. To the left, there is the usual vehicle speed and adaptive cruise control and lane-keeping assist presentation in a pyramid style. Fig. 3 include six informational elements: Speed limit (icon), Vehicle speed (digital), Lane keeping assist (icon), Vehicle ahead (icon), Distance to maneuver (alphanumeric), Maneuver ahead (pictorial)

This display is partitioned into functional units with preservation of relative feature location. The head-up display information. The overall organization of the display is side-by-side. Most critical is the little effort placed on the problem of how to integrate informational elements. The driving component, which is schematic, is accompanied by a navigation component that attempts to be realistic, thereby simulating augmented reality. The richness, however, of the projected information competes dramatically with the road scene and may lead to confusion. There is the aggressive use of graphics and colors but little information is conveyed. Using the methodology provided in this paper and some of the techniques for information integration provided in [14] it is possible to formally evaluate the design of head-up displays in accordance with the guidelines provided earlier [see 20 for several examples].

5. Conclusions

The increased pace of growth in vehicle cockpit complexity and the plethora of information content competing for the driver's attention calls for a methodological, systematic, and rigorous approach to the design of information presentation (see [20] for an inspirational call). This is true for all cockpit displays but is even more acute for head-up displays that have limited available "real estate" if the cost of occlusion of the road scene is to be kept at bay. Although head-up displays are being offered in an increasing number of vehicles by almost all major manufacturers, there is no common standard for their organization and no consensual principles for display content. This suggests that in the future, a multitude of information elements may migrate into head-up displays; creating clutter, occlusion, and distraction (see Fig. 4, which is an artistic "spoof" on the topic).

Designing interfaces for human interaction with machines, computers, and mobile devices also focuses on the problem of how to best organize the information so that the (interaction) space is well integrated, accessible, and coherent [21, 22] – but with a slight twist: In informational devices the interaction space is abstract and is constructed so to allows for simplicity and relevancy of information – two concepts that are critical for devices that superimpose information on the line-of-sight such as head-up displays and wearables (e.g. Google glass and augmented reality device).

The problem of how to organize information in an integrated and coherent way is not new [23]. The problem has its roots in art, where artists throughout the centuries of human development [24], have explored

Fig. 4. *The "Future" of head up displays and augmented reality displays (Photo and art: Erik Pawassar, with permission).*

the organization of the visual space as a way to reflect an internal psychological space. When builders and later architects began to worry about floor- and space layouts to create a living space that is well integrated with other spaces and is functionally workable, they employed similar principles of organization [10] – which commonly are concerned with interrelationships between elements (rooms, entrances, kitchen, and even groups of buildings and layout of piazzas and town squares) and the creation of attractive spatial patterns [25].

6. References

[1] Leen, G. & Hefferman, I. (2002). Expanding Automotive Electronic Systems. *IEEE Computer, 35*(1), pp. 88-93.

[2] Broy, M., Krüger, I., Pretschner, A., & Salzmann, C. (2007). Engineering Automotive Software. *Proceedings of the IEEE, 95*(2), pp. 356-373.

[3] Richtel, M. (2011). U.S. Safety Board Urges Cellphone Ban for Drivers. *New York Times*. December 13.

[4] Dingus, T. A., & Hulse, M. C. (1993). Some human factors design issues and recommendations for automobile navigation information systems. *Transportation Research, Part C, IC,* pp. 119–131.

[5] Jacobs, E. (2004). Classification and categorization: A difference that makes a difference. *Library Trends, 52*(3), pp. 515–540.
[6] Ablaßmeier, M, Poitschke, T, Wallho, F, Bengler, K & Rigoll, G. (2007), Eye gaze studies comparing head-up and head-down displays in vehicles', *2007 IEEE International Conference on Multimedia and Expo*, pp. 2250–2252.
[7] Bendy, G. Z. & Meister, D. (1997). *The Russian Theory of Activity: Current Applications to Design and Learning*. NJ: Lawrence Erlbaum Associates.
[8] Norman, D. (2007). *The Design of Future Things*. New York: Basic Books.
[9] Solomon, R.C. (1993). *The passions: Emotions and the meaning of life*, Indianapolis, IA.
[10] Alexander, C. (2002a). *The Phenomenon of Life*. Berkeley, CA: The Center for Environmental Structure.
[11] Alexander, C. (2002b). *The Process of Creating Life*. Berkeley, CA: The Center for Environmental
[12] Degani, A. (2013). A tale of two maps: The story of the London underground diagram. *Ergonomics in Design, 21*(3).
[13] Wertheimer, M. (1923). *Laws of organization in perceptual forms*. Published in "A source book of Gestalt psychology" (pp. 71-88). London: Routledge & Kegan Paul.
[14] Shmueli-Friedland, Y., Zelman, I., Degani, A., & Asherov, R. (2016). Toward objective method in display design. In N. Shaked & U. Winter. *Design of Multimodal Mobile Interfaces*. pp. 169-194. Berlin, Germany: De Gruyter.
[15] Bennet, K.B. & Flach, J.M. (2011). *Display and interface design: Subtle science, exact art*, CRC Press, Boca Raton, FL.
[16] Vicente K.J. (2002). Ecological interface design: progress and challenges. *Human Factors*, 44, pp. 62–78.
[17] Weintraub, DJ & Ensing, MJ 1992, *Human factors issues in head-up display design: The book of HUD*, Crew System Ergonomics Information Analysis Center, Wright-Patterson AFB, Ohio.
[18] Wood, RB & Howells, PJ 2001, 'Head up displays', *in The Avionics Handbook*, R.C. Spitzer, ed., CRC Press, Boca Raton, FL, Chapter 4.
[19] Degani, A., Barshi, I., & Shafto, M. (2013). Information organization in the airline cockpit: Lessons from flight 236. *Journal of Cognitive Engineering and Decision Making, 7*, pp. 330-352.
[20] Heymann, M. & Degani, A. (2016). Classification and organization of Information: The case of the head up display. In N. Shaked & U. Winter. *Design of Multimodal Mobile Interfaces*. pp. 195-217. Berlin, Germany: De Gruyter.
[20] Card, S. K., Mackinlay, J. D., & Shneiderman, B. (1999). *Information Visualization: Using Vision to Think*. San Francisco: Morgan-Kaufmann.
[21] Barshi, I, Degani, A., Iverson, D, & Lu, P.J. (2012). Using medieval architecture as inspiration for display design: Parameter interrelationships and organizational structure. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 56, pp. 1799-1803.
[22] Monmonier, M. *How to Lie with Maps*. (1996). Chicago: University of Chicago Press.
[23] Degani, A., Jorgensen, C., Shafto, M. & Olson, L. (2009). *On Organization of Information: Approach and early work*. NASA Technical Memorandum No. 215368, Moffett Field, CA: NASA Ames Research Center.
[24] Jung, C.G. *Mandala Symbolism* (1955/1972). Princeton, N.J.: Princeton University Press.
[25] Necipoglu, G. (1995). *The Topkapi Scroll – Geometry and Ornament in Islamic Architecture*. The Getty Center for the History of Art
[26] Sohn, H., Lee, J.D., Bricker, D.L., & Hoffman, J.D. (2008). A Dynamic Programming Algorithm for Scheduling In-Vehicle Messages, *IEEE Transactions on Intelligent Transportation Systems*, 9, pp. 226-234.
[27] Richard M., Richard P., & Cottet F. (2001). Task and Message Priority Assignment in Automotive Systems, *Proceedings 4th FeT IFAC Conference on Fieldbus Systems and Their Applications*, Nancy, France, 15-16 November.
[28] Dagan E., Mano O., Stein G.P., & Shashua A. (2004). Forward collision warning with a single camera, *IEEE Intelligent Vehicle Symposium*, pp.37-42, 14-17 June.
[29] Lee, J.D., Regan, M.A., & T. W. Victor, Eds. (2013). Driver Distraction and Inattention. CRC Press, Boca Raton, FL.