

IVI Human Factors Strategy

U.S. Department of Transportation

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Human Factors in the Intelligent Vehicle Research Agenda

In the following three sections, Mitretek first briefly introduces the *Compendium of Human Factors Research Projects Supporting the Intelligent Vehicle Initiative (IVI)*. Section Two presents status of the problem areas of the 1999 IVI Business Plan within categories often used by the human factors (HF) community to organize HF processes. Section Three presents the same material within emphases of the IVI program. As a result of discussing the compendium and the IVI HF research agenda, three recommendations are suggested to intensify the established processes.

1. Compendium of Human Factors Research Projects Supporting the IVI

Mitretek prepared a *Compendium of Human Factors Research Projects Supporting the Intelligent Vehicle Initiative (IVI)*. This document was developed to better illustrate how human factors studies have been intertwined with the system approach undertaken for vehicle-embedded safety improvements. Seven top-level categories were developed to show evolutionary support for the current IVI research plan and how the related studies have contributed throughout the systems engineering life cycle. These categories are assessed in terms of the problem areas that have been defined for the IVI program.

The IVI research program is envisioned as addressing vehicle-related safety in terms of seven problem areas:

Specific Types of Crashes (five problem areas)

Rear-End Collision Avoidance

Lane Change and Merge Collision Avoidance

Road Departure Collision Avoidance

Intersection Collision Avoidance

Vehicle Stability

Driver Performance Enhancement (two problem areas)

Vision Enhancement (augment driver's vision under conditions of reduce visibility)

Driver Condition Warning (a driver monitoring and warning capability to alert driver to problems such as drowsiness)

In addition to these seven research problem areas, assessments are conducted on Safety-Related Systems. That is, as new technologies are introduced any possible degradation of

safety is addressed. The driver's task allocation and workload will change as safety impacting services are added to the vehicle. Currently these services are envisioned as route guidance and navigation (G&N), adaptive cruise control (ACC), automatic collision notification (ACN), cellular phones (CP), and in-vehicle computing (IVC).

The compendium categories of classification are listed below:

Advanced Travel Information System (ATIS) - includes in vehicle navigation and guidance systems

Automated Highway System (AHS)

Collision Avoidance System (CAS) - includes rear-end, lane change, road departure, and intersection subcategories

Vision Enhancement (VE) – includes augmented views of the forward scene

Drowsy Driver (DD) - detection methods and countermeasures for fatigue management

Related Driver Behavior (RDB) - includes crash causation studies, baseline data collection of driver behavior, and impact of vehicle technologies on driver performance. Baseline data collection defines the capabilities and limitations of the drivers, serving as a foundation for functional requirements definition for IVI.

Driver Vehicle Interface (DVI) - other human centered design issues including signs as related to the goals of IVI but not covered by the above categories.

Both AHS and CAS have provided the direct foundations for the collision avoidance technologies while ATIS and studies on driver behavior and DVI have provided a wealth of data about driver performance and how to design human-centered displays in-vehicle. Studies on the drowsy driver have led to the recent validation of a practical technology for detecting driver fatigue, eyelid closure measures. Vision enhancement appears to have received the least human factors emphasis, but it should be noted that the accompanying technologies (e.g., head up displays) are difficult to design for both effective use and acceptability by the very diverse range of drivers with significant variance in visual abilities. Driver age and related differences in visual acuity, contrast sensitivity, and the efficiency of attentional and other cognitive processes are important in the definition of critical parameters for product design, development, and testing (VE-2).

The data collection for the compendium focused upon the internal reports of projects that have been funded either partially or totally by Federal Highway Administration (FHWA) or the National Highway Traffic Safety Administration (NHTSA). The internal reports

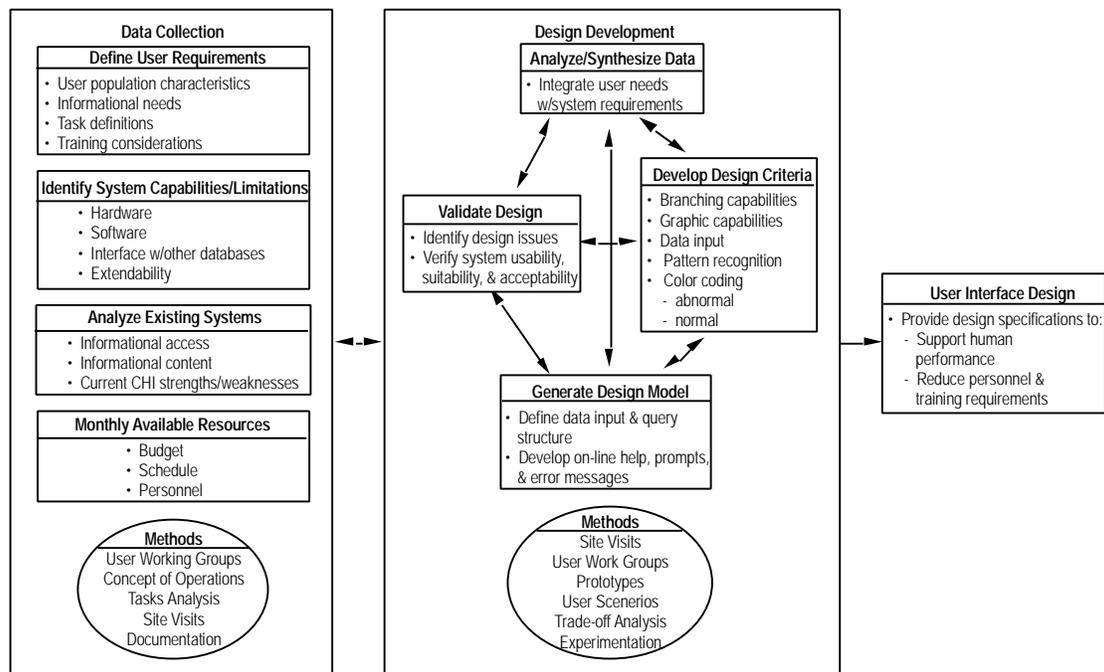
comprise approximately 62% of the total of 208 entries. The remainder are open literature reports. These are frequently derived from the internal reports.

The compendium represents the first attempt to document the extensive human factors activities of FHWA and NHTSA over a period of nearly a decade of research. Mitretek recommends that the document be treated as a living document, placed online as part of the ITS Electronic Document Library, and updated yearly.

2. Problem Areas of the Intelligent Vehicle Research Agenda

In an earlier preliminary review of human factors in the IVI, Mitretek referred to a classic figure, reproduced as Figure 1, that illustrates the generic human factors processes imbedded in the typical systems engineering process. Taking the key human factors processes from Figure 1 and casting them into tabular form in Table 1, the various problem areas in IVI can be portrayed from a human factors perspective, using the compendium.

Figure 1. Human Factors Engineering Processes in the Engineering Life Cycle



The activities presented in Table 1 represent the results of examining multiyear reports from the human factors compendium relative to the current and projected problem areas in IVI. The lack of a “check” in a box does not mean the activity is not planned or will not be inserted at the appropriate engineering cycle time. The summary information was simply derived from the available publications that were cited in the compendium. It is

Table 1. Human Factors Processes by Problem Area

Human Factors Processes	Crash Type/Safety Systems					Driver Performance Enhancement		Safety-Related Systems* ¹			
	Rear End	Lane Change and Merge	Road Departure	Intersection	Vehicle Stability	Vision Enhancement	Driver Condition Warning	G&N	ACC	CP	IVC
Data Collection											
Baseline driver data collection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Define driver requirements: operational, functional, and performance (particularly for the older driver)	✓	✓	✓	✓			✓	✓	✓		
Identify system capabilities/limitations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Analyze existing systems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Design Development											
Analyze/Synthesize driver needs with system requirements	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Develop design criteria	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Validate design – usability, suitability, and acceptability.	✓	✓					✓	✓	✓	✓	
Develop online help/training								N/A* ²			
Driver Interface Design											
Design specifications to support human performance	✓	✓			✓		✓	✓		✓	
Integration of complex displays and controls											

*¹ G&N - Route Guidance and Navigation
 ACC - Adaptive Cruise Control
 CP - Cellular Telephone
 IVC - In-Vehicle Computing

*² Design objective is to develop such that driver does not need help while driving

clear that most human factors processes have occurred, or are occurring, particularly for the more mature projects of ATIS (G&N under Safety-Related Systems), CAS (collection of problems under Safety Systems), and Driver Condition Warning (under Driver Performance Enhancement). Vision Enhancement (under Driver Performance Enhancement), on the other hand has been addressed relatively recently but is proceeding through the processes.

The progress within a human factors process has varied across problem areas, and the processes have not necessarily proceeded in sequence. For example, ATIS appears to have the most complete set of design specifications (under Driver Interface Design) as shown in ATIS-59. This project accounts for 59 citations, representing a significant amount of human factors research activities. Driver Condition Warning, 32 citations, is a subset of the large amount of work that has been devoted to fatigue detection and countermeasure development. This subset represents the technological activities that have culminated in the validation of the in-vehicle eye closure measurement technique (see DD-30).

Note that many of the human factors processes are often iterative processes. Thus for example, the definition of driver requirements (under Data Collection) is frequently refined at sometime later in development after prototype tests, and not necessarily in the ideal and most efficient way of baseline data, task analysis, and then requirements definition and conceptual designs. Sometimes market forces and commercial interests, particularly for the Safety-Related Systems have accelerated the processes and not permitted a systematic and methodological approach to development of a technology before fielding (e.g., CP and IVC). Some of the baseline data for these technologies have appeared in comparative studies (AHS-24 for IVC) or general driver interface studies (DVI-13 for CP).

The bottom row of Table I, integration of complex displays and controls, is blank for all problems areas. The reason being that the IVI has evolved to the point that now the first integration study is being undertaken Oak Ridge National Laboratory (ORNL). This "pathfinder" study will examine the benefit of integrated multiple in-vehicle information systems compared to non-integrated ones. In this case, a G&N, a CP, an IVC (e-mail capability) and a CAS (as a location-specific warning) will be presented to the driver a non-integrated fashion and an integrated fashion. Positive results for this study will most likely lead to other integration research activities. Studies that follow the "pathfinder" results will need to address integration issues across and within other vehicle platforms. This initial study is being conducted on the light vehicle platform. This appears appropriate since the bulk of the driver population uses this platform.

Mitretek recommends that as more safety systems and safety-related systems development progresses, the potential for increased complexity of the resulting tasks for the driver will demand a continual enhancement of the framework that has been established for development of an integrated and holistic approach to the design of driver interfaces.

3. Emphases of the Intelligent Vehicle Research Agenda

Three emphases of the IVI are related to three of the major columns in Table 1, Crash/Type/Safety Systems, Safety-Related Systems, and Driver Performance Enhancement. Although the primary emphasis is the prevention of crashes, three discrete emphases have evolved. The first concerns systems that amplify safety directly, the CASs. The research areas in the second column of Table 1 support this emphasis. The second emphasis is to develop an improved understanding of systems that can increase or decrease the probability of a crash indirectly or enhance safety. This underscores the need to understand how driver behavior with the safety-related systems can impact crash prevention. The enhancement of driver behaviors, such as alertness or visual ability, also relates to this emphasis. The research areas in the third and fourth columns of Table 1 support this emphasis. The third emphasis logically focuses on how more than one system affects drivers and their safety-related performance, an overlap or blending of the first two highlighted elements. This integration emphasis will take on more attention as safety solutions are developed in an incremental approach via generations 0 through 2.

This central (crosscutting) human factors effort to enhance the performance of the driver and shape driving behaviors when confronted with both new safety systems and safety-related systems has been established over several antecedent project research efforts that have been undertaken during nearly a decade as evidenced in the human factors compendium. The apparent compartmentalized emphases while covering the integration plans for the future actually set the stage for resolving the issues such as those related to conducting the necessary integration after significant development versus conducting integration efforts in a parallel after the early design phase.

While it can be argued that one cannot integrate displays until the design stabilizes after sufficient prototype testing in a given platform, potential information overload, particularly from multisensory stimuli for differing devices, and the loss of situation awareness can be addressed at even the concept stage of functional allocation and task analysis (for any platform).

Related to the issues concerning integration of controls and displays, a dynamic allocation of functions between driver and systems may offer a way of shaping the positive safety behaviors of the driver (Starter and Woods, 1995). While this approach may be indicative of complex systems in other domains, it could be introduced initially with the sophisticated heavy vehicle driver. For example, system operations could shift automatically to accommodate varying road conditions or weather situations unless the driver made an effort to override manually. These cases are not meant as solutions, but only serve to articulate that an adaptive automation approach could be considered for the future, sophisticated, automated, and safe vehicle.

This set of integration issues can be resolved within the framework established for managing the 1999 IVI Business Plan.

4. Conclusions

The brief review of the human factors plans in the 1999 IVI Business Plan leads Mitretek to make the following recommendations:

- The human factors compendium should be treated as a living document, placed online as part of the ITS Electronic Document Library, and updated yearly.
- As more safety systems and safety-related systems reach the deployment stage, the increased complexity of the resulting tasks for the driver will demand a continual enhancement of the existing research framework that has been established for development of an integrated and holistic approach to the design of driver interfaces.

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