4.0 Human Factors

4.1 Introduction

It is difficult to estimate the impact of human factors on driver safety because existing accident databases depend upon a police officer having sufficient time and motivation to carefully complete accident forms. Thus, certain factors may be unobserved or unrecorded. Therefore, such safety estimates are conservative and may underestimate the impact of human factors.

A recent report on highway safety (GAO, 2003 Figure 5) stated that GAO analysis of NHTSA data from 1997-2001 found about 2.5 million drivers of passenger vehicles that were towed away from crashes attributed to driver inattentiveness. Yet driver inattention is only one of several human factors issues that contribute to crashes. UMTRI conducted a univariate analysis of FARS data from 2000-2002 classified as Driver Related Factors; Codes 61-88, which refer to items beyond the driver's control such as weather and visibility were omitted from the analysis which covered the remaining codes as Factors 1, or 2, or 3 or 4. The number of cases found was 104,921 out of a total of 173,308. Thus, over the three-year period, 60.5% of coded fatal accidents involved human factors. Of course, these data considered alone, are not likely to provide effective countermeasures (see Figure 4.6.2). This requires research and building models of driver performance that are described in this white paper.

4.2 Critical Future Highway Issues

There is, of course, an element of risk in specifying critical future issues. A panel of experts given this charge 100 years ago might have determined that the most critical transportation issue of the future would be removing vast piles of horse manure from city streets. Technology can produce sudden changes that dramatically alter our perspective about the future.

Nevertheless, there are certain constants in highway safety. Vehicles will change. Roadways will change. But human drivers will be controlling vehicles for the indefinite future. Humans have not changed. In some ways, this is unfortunate, for humans did not evolve to control machines that provide greater speed and greater weight than the unaided human. People lack the muscle power and perceptual skills to directly control high-speed vehicles. By the time a bullet-train engineer sees a stop signal on the track ahead, it is too late to halt the train. Airplane pilots have even greater control issues. But these transportation systems work reliably because of equipment and procedures that take human limitations into account.

Much of these safeguards are absent in ground surface transportation. Operator training and licensing requirements are quite minimal, compared to air transportation. Fitness for duty is not evaluated a priori for car drivers, who may be fatigued or under the influence of alcohol or drugs. At first blush, the world of flight should appear to be far more dangerous than travel on the ground. Airplanes cannot pull over to the side of the road to solve a problem. Yet flying is far safer than driving. The risk of driving 18 km equals the risk of a non-stop continental flight (Sivak, 2003). Familiarity breeds contempt and the car is so familiar that most drivers are unaware of the risk they assume behind the wheel.

From a human factors perspective, the most critical future issue is automation. Cars and trucks are starting to look more and more like airplanes with new in-vehicle systems that are proliferating at an accelerating rate. These telematic and driver assistance systems are already changing the function of the driver. In the future, the ground vehicle operator will become more a monitor of vehicle systems that will have the ability to take over control of his vehicle. Automated cruise control will slow the vehicle if headway is too low. Crash avoidance systems will apply the brakes and override inappropriate driver tendencies, such as lifting the foot from the brake pedal when ABS causes pedal vibration. Radar and additional sensors will detect other vehicles and pedestrians and offer enhanced driver vision at night. All these technologies aim to overcome the limitations of the human driver who was designed to control his own locomotion at low speed. Cars will offer enhanced convenience and entertainment for drivers who can read e-mail, receive faxes, talk on cell phones, surf the internet, and place orders with their stock brokers from a moving vehicle.

Automation is not always an innate good. Indeed, the National Highway R&T Partnership has selected the human-machine interface in light-duty vehicles as a research area for emphasis within the Light-Duty Vehicle-Safety theme (Table 2, National Highway R&T Partnership, 2002). Clumsy automation, as has been studied in aviation, can decrease vehicle safety. More in-vehicle devices can equate to more driver distraction. While each individual system offers some potential for increased safety or convenience, the effects of many such systems in a single vehicle are unknown. Will the new advanced vehicles be safer or more dangerous than current vehicles?

4.3 Human Factors Research Topics

Table 4.3.1 lists the specific research topics discussed in this section and summarizes their characteristics. Projects are listed according to their potential to yield important results as evaluated by the Human Factors Working Group. Project parameters are based primarily on estimates from the Working Group. The goal of this whitepaper is to elaborate the projects specified in Table 4.3.1.

This is accomplished in three steps:

1. Review each project for technical feasibility.
2. Add new projects, if any major topics were omitted.
3. Explain briefly, within the 15-page white paper limit, how each project might be conducted.

Note that the author of this white paper does not view this chapter as an opportunity to substitute his own judgment for that of the working group. His charge is to refine the suggested topics, rather than to discard the topics and start anew.

Category	Project Title	Type of Research	Likelihood of success	Duration (Months)	Cost ($1,000,000)
Human Factors Cognitive Models	**HF 1a:** Computational Driver Model: WE (Whole Enchilada)	Advanced	3.5	144	12
	HF 1b: Computational Driver Model: Light	Advanced	4.0	60	5
Human Factors Information Overload	**HF 2:** Processing Multiple Sources Of Information	Advanced	4.0	60	10
Human Factors Speed Control	**HF 3:** Understanding Speed Selection	Applied	3.0	48	8
Human Factors Perception/Attention	**HF 4:** Look but not see	Applied	2.5	36	4
Human Factors Basis for Design Standards	**HF 5:** Design Driver	Applied	4.5	18	0.3
Human Factors Decision Rationality	**HF 6:** Risk Homeostasis	Applied	2.5	28	1
Human Factors Simulator Generalization	**HF 7:** Driving Simulator Validity	Applied Methodology	4.5	42	4.5

Table 4.3.1 Prioritized list of research projects. Likelihood of success ranges from Very Low (1) to Very High (5).

4.4 Knowledge Strongholds

Knowledge strongholds are areas where there has been substantial research yielding decreased need for future research. They arise in two ways. First, a research area may be fully mature so that additional effort yields diminishing returns. Second, a research area may be currently popular and vigorous so that the need for future research is either filled or cannot be fully

evaluated until research already in progress has been completed. In the human factors domain, the first instance is denoted by Multi-Disciplinary Accident Investigation (MDAI) while the second instance is represented by current work on the naturalistic observation of on-road traffic using instrumented vehicles.

MDAI

The landmark MDAI study was conducted over twenty-five years ago in Monroe County Indiana. This tri-level study used teams of experts to investigate accidents and suggest possible countermeasures (NHTSA DOT-HS-034-3-535, 1975). The recognition afforded this study occasionally leads to calls for a contemporary follow-up study, perhaps involving several counties geographically disbursed across the United States. However, subsequent evaluations of the methodology of this important study revealed significant limitations that arise from the subjective nature of expert opinion. Replication is the essence of science. It is impossible to suggest effective countermeasures for results that cannot be duplicated.

One subsequent evaluation (Haight et al, 1976) of the tri-level study was unable to replicate findings using the same taxonomy:

> *Along this line, as part of the MDAI editing and coding efforts at HSRI, an attempt was made to apply the Indiana taxonomy to a small number of in-depth accident cases. Three experienced editors were given a copy of the taxonomy and asked to record the causative factors…it was exceedingly difficult to get consistent causation reporting by the three editors –**particularly in the human factors area** [emphasis added* p. 78*].*

This same report also criticized the tri-level study, among others, for issuing careful caveats about potential conclusions at the start of the report and then ignoring these caveats at the end of the report when offering conclusions that could not be supported by proper statistical analysis. When observational data have known faults, it is tricky to avoid the temptation to "suggest" when one cannot prove. It is quite difficult, and perhaps impossible (Kantowitz, Roediger & Elmes, 2001 chapter 2), to make inferences about causality from even objective observational data. When the data are subjective opinions, rigorous conclusions that meet established scientific standards are unlikely.

Thus, while the questions raised by the tri-level study still are vital today, the methodology used has asymptoted and little will be gained by repeating the same methodology again. Therefore, a new MDAI study is not proposed later in this document, even though this topic was recommended, albeit with the lowest ranking, in the Irvine Safety Research Agenda Planning Conference.

Naturalistic Observation From Instrumented Vehicles (NOFIV)

Fatal accidents are very low-frequency events. Therefore, one approach to aggregate data is to deploy large fleets of instrumented vehicles equipped to record objective data in hopes of capturing real-life accident numbers with NOFIV technology. While there are several NOFIV studies in progress, e.g., UMTRI Automotive Collision Avoidance System, UMTRI Road

Departure Crash Warning System, Virginia Tech Naturalistic Driving Study, a recent F-SHRP Safety Plan (Campbell et al, 2003, p. 17) noted that

> *a large, nationally representative number of crashes is not presently achievable with a fleet of instrumented vehicles. That would require a single project on the order of $500M to achieve a test fleet of 100,000 vehicle-years that would be expected to produce 6,000 police-reported crashes.*

Furthermore, our ability to collect NOFIV data vastly exceeds our ability to analyze and understand it. Techniques to parse and analyze the large data sets provided by NOFIV are being developed, but this is a complex task, especially if video data are also considered. Therefore, no new NOFIV studies are proposed in this document.

4.5 Knowledge Gaps

Six of the seven knowledge gaps listed here are based upon recommendations of the Human Factors Breakout Group at the Irvine Planning Conference. The seventh gap replaces the MDAI gap identified by this Group. The gaps are listed in the priority establish by the Breakout Group:

1. *Understanding the driver*. The driver is the major cause of accidents and fatalities. Until we understand the driver our ability to propose effective countermeasures is limited.
2. *Driver information overload*. This is a key instance of the previous gap that is so important it justifies its own listing. Drivers are overwhelmed by vast amounts of information both within and without the vehicle. New ITS developments can provide sufficient information to exceed the processing capacity of the driver while the vehicle is parked.
3. *Speed out of control.* Excessive speed is a major contributor to run-off-road and other accidents.
4. *See but not understand.* Human perception is a complex process. Looking at a stimulus does not guaranty it will be processed correctly or that an appropriate timely response will be made by the driver.
5. *Human factors basis for design driver.* As demographics and vehicle mix changes, the target of highway design must also be updated.
6. *Is theory of risk homeostasis valid?* This important theory explains why accidents rates do not improve when better technology is added to the vehicle or to the highway. Is it the best explanation?
7. *Driving simulator validation.* The driving simulator is a key tool used to investigate situations that are too dangerous for road testing or too expensive to create in the world (e.g., building a new tunnel or highway for test purposes). But until proper validation tools are built, designers will not accept simulator results.

The human factors of highway safety is best characterized as an empirical enterprise where data are collected to meet very specific needs. Relatively little effort has gone into building models of driver behavior. Our ability to collect data vastly exceeds our ability to understand these data in a systematic, coherent way. There is an urgent need to support more basic research efforts

targeted at understanding driver behavior. It is inefficient to perform an experiment to answer every question. A good model of driver behavior can answer many different questions.

There is a vital need to invest research dollars in improving methodology. The best example of this need concerns driving simulators. In the past, it has been difficult to obtain funding to validate simulators and to compare different models and characteristics of advanced simulators. Decades of research in areas such as nuclear power and aviation have shown that very expensive simulators with full physical fidelity are not required to answer many important questions.

The seven research projects discussed in the next section all seek to improve our understanding of some aspect of driver behavior related to road safety. While the Advanced projects clearly imply basic research efforts, it is important to realize that the Applied projects as well can and should be conducted so as to not only gather salient data, but to also advance basic understanding of the cognitive processes that control and modulate driver behavior.

Comment from R&T Partnership Steering Committee

The reviewers raised many questions about whether knowing the prevalence of human errors will lead to countermeasure development. It is one of the basic tenets of ergonomics that humans will make errors and the task is to make the environment of the human operator such that errors are less frequent and its consequences less harsh. Thus, if more research is needed on human factors, it needs to be well justified in terms of what the outcome is expected to be in terms of new treatments.

The paper criticizes multi-disciplinary accident investigation (MDAI) methodology. This contrasts to some extent with the recent implementation of a national MDAI-type study on truck crash causation and a proposed NHTSA large study. Should the profession be looking at better ways to do MDAI studies?

Response from White Paper authors

The reviewers pose a vital question: How are good countermeasures created? Much of the following answer is taken, almost verbatim in some parts, from Sivak (2002).

Many early safety countermeasures could be viewed as based on common sense. No fancy theories or models were required. But as vehicles and roads became more complex, common sense countermeasures have been supplemented or replaced by better countermeasures that required going beyond common sense. An example of a common sense based countermeasure is the dual-beam headlighting system with high beams for distance viewing when there is no oncoming traffic. But low beams lack sufficient illumination for safe driving at speeds above 70km/h and high beams create glare for oncoming traffic. This creates a human factors conflict between maximizing visibility and minimizing glare that has not been solved using common sense. A noncommon sense solution might involve use of polarized headlighting. This requires a theoretical knowledge of physics and human vision to be successful. Table 4.5.1 gives other examples.

Common-sense countermeasure	Science-based countermeasure
Low beam and high beam headlighting	Polarized headlighting
Getting rid of sharp fins	Pedestrian airbags
Minimum windshield transmittance	See-through A pillars
Dash-mounted displays	Head-up displays
No nearby trees and poles	Collapsible poles and channeling guardrails
Visual screening	Attentional Screening

Table 4.5.1 Examples of common-sense and science-based countermeasures (Sivak, 2002)

Another more quantitative example comes from the work of Palmer and Kantowitz (1994) on daytime running lights and turn signals. Daytime running lights offer some potential safety advantages but have the disadvantage of making it more difficult for drivers to perceive turn signals that are located adjacent to headlamps. This reduction in visibility is called visual masking. Industry standards exist for increasing turn-signal intensity as turn signals are moved closer to headlamps. What should the intensity be for turn signals adjacent to reduced intensity high-beam daytime running lights (5000cd)? How should turn-signal intensity be adjusted as a function of the separation between turn signals and headlamps?

The simplest and most direct way to answer these questions at first blush appears to be a series of experiments that varies separation, headlamp intensity, ambient illumination, and turn-signal intensity. If enough data are collected, nomographs can be constructed to be used by design engineers. If available resources do not permit collection of all the data needed, the most important combinations can be sampled and a regression equation can be used to fill in the missing points. So when NHTSA asked us to answer this question, it anticipated a series of experiments. Instead, we found a better solution (Palmer & Kantowitz, 1994) that was more cost effective – NHTSA did not have a lot of money for this project – and more useful.

We started by building a theoretical model of masking. The model was designed to predict the intensity of a turn signal that yields a fixed level of performance as a function of other relevant variables such as separation. For example, the model can be used to estimate the intensity that makes a turn signal recognizable 90% of the time as a function of separation. The heart of the model is an analysis of glare whereby light scattered from the headlamp reduces the contrast for nearby lights. Of course, the model must also include other factors of practical interest such as viewing distance, ambient illumination, and the size and shape of the lights. To make sure that we picked reasonable separation values, we did a quick survey of vehicle lights and found that the Ford Explorer was a good worst case for proximity of turn signals and headlamps.

Figure 4.5.1 shows part of the model predictions that can be used to answer questions of the following form: take a square daytime running light 10 cm on a side abutted by a turn signal 5 cm wide and 10 cm high. This gives a separation (measured from the lamp edge to the center of the turn signal) of 2.5 cm. How much would the detectability of the signal be improved if separation was increased from 5 to 10 cm? Figure 4.5.1 gives an answer of 75% decrease in masking for nighttime (lower curve).

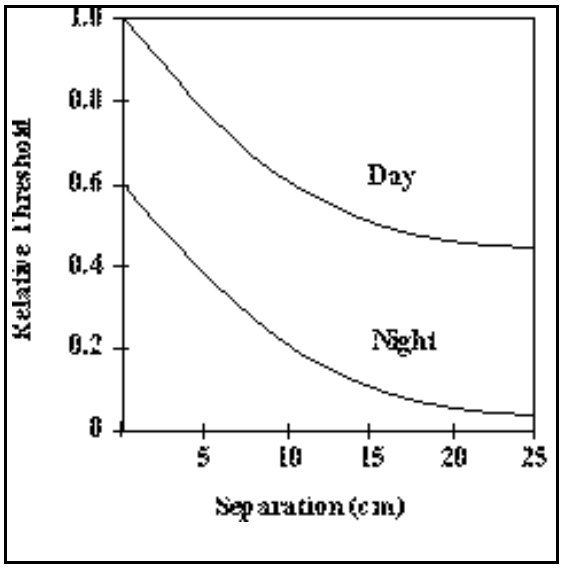

Figure 4.5.1 Model predictions for relative threshold. The upper curve is daylight (10,000 lx), and the lower curve is for no ambient illumination. (From Palmer and Kantowitz, 1994)

This countermeasure goes well beyond common sense. Indeed, common sense might not even realize that daytime running lights can make it more difficult to perceive turn signals. The theoretical model provides a set of equations to the headlamp designer that elegantly presents the trade-offs between separation and visibility. It allows the countermeasure of spacing headlamps and turn signals to avoid excessive visual masking.

A final example used by Sivak (2002) to demonstrate that common sense countermeasure can decrease safety is based upon a theory of vision applied to driving by Leibowitz and Owens (1977). The theory states that focal (central) vision is used to detect objects, like pedestrians, while ambient (peripheral) vision is used for lane keeping. Common sense implies that better reflective lane markers would improve night driving. But the theory predicts that improvement in lane keeping would not be accompanied by a similar improvement in focal vision. Drivers confidently relying on ambient vision to remain in their lane could now drive faster, making it more likely to strike objects in the road not detected in time by focal vision.

It is not random that the examples above are all drawn from vision. Basic research on vision is well developed and many theories and models of vision have been formulated and tested. Thus, it is easier to relate countermeasures to driver vision than to other aspects of the driver-roadway interaction. Trying to specify what new treatments might be developed from new theories and models presents a chicken and egg conundrum. Absent the theories, it is almost impossible to specify what new countermeasures might emerge. Thus, what is a standard operating procedure for many human factors researchers (using models), might require an act of faith from practicing highway engineers who do not normally invoke theories of human behavior. The best arguments for human factors models producing effective new countermeasures are inductive, based upon

examples such as were presented above. There are entire handbooks of human factors presenting hundreds of such examples in many different content areas. If aviation, nuclear power, and human-computer interaction can create better countermeasures through models, so can driving.

The criticisms of MDAI are of the same form as the examples given previously: common sense versus science. MDAI studies represent common sense. They are not replicable and do not meet the most basic of scientific criteria. Their time has passed. While there may be strong political reasons for funding future MDAI studies, there is no scientific justification for such work.

4.6 Research Topics

HF 1: Computational Driver Model - Category: Human Factors Cognitive Models

Comment from R&T Partnership Steering Committee

The proposed research is very high risk. It needs careful consideration and justification. The authors mention two different approaches (large and semi-large). More details are needed on how the "best model" will be chosen in the "large model shoot-off", and second, how do we decide if the large project will be twice as good as the smaller one? With respect to the former, even though there is some mention of the use of test scenarios for model evaluation, there is not enough detail to convince certain reviewers this is a valid methodology. Has it been used before? What is the nature of the alternative scenarios – are they individual-driver oriented or traffic-flow oriented? Will any be based on crash outcomes? More importantly, questions were raised by the reviewers concerning whether model of individual driver can be done or is sufficient since: 1) the profession has no accepted theory of "driver adaptation" to changes, and if adaptation occurs, developing a model that can "adapt" seems very difficult, and 2) doesn't "group behavior" matter in traffic (as opposed to "individual behavior")? The way we behave on the road as drivers or pedestrians is clearly a reflection not only of individual capabilities and inclinations but also of a norm of behavior that evolves through emulation and imitation and may be characteristic of a city, a region and a country. Were it not so, people in New York and in Minneapolis would behave in the same way as people in Naples or Hamburg do. Indeed, the aim of important countermeasures is to affect something like 'the culture of driving' or the 'distribution of speeds'.

Basic conclusion -- This proposed research needs further assessment by international Human Factors experts who have attempted this and who have no stake in the United States program.

Response from White Paper authors

Further review by international experts, especially from Scandinavia where the FHWA-AASHTO scan tour will be spending substantial amounts of time, is an excellent idea.

The main difference between the large and semi-large versions of model development is the scope of the model. Existing human factors driver models have very limited scope. Computational models that might be borrowed and extended have medium scope. If the desired

scope is large, then the large version might be worth more than twice the cost of the semi-large model. For example, if it is important to include something like the 'culture of driving' then a large new model would be required. Existing models tend to focus upon the behavior of single individuals. While there may be some existing computational models of group behavior (which would require some research to uncover), they most likely have not been combined with the kinds of human performance models most applicable to 'plain old driving'.

The kinds of experimental details requested by the Steering Committee go beyond the scope of this effort (see chapter 1) which is aimed at selecting specific topics and not aimed at generating a detailed statement of work (SOW) for each possibility. The cooperation of several stakeholders in defining key issues for the SOW would be essential. For a long-term basic research project such as this, there should be a panel of external experts to review and help guide the work on a continuing basis. These details would need to be elaborated in a full SOW. However, here are some possible ways to approach the issues raised.

The best model in a shoot-off is one that most accurately predicts and explains driver behavior for a set of specific tasks, such as run-off road, gap acceptance in passing, etc. Each model would receive a score for each task. Models would have to score above a threshold for each task: a model cannot make up for inaccuracy in a key task by high accuracy in a different task. Extra points would be given for models that accurately explained driver behavior for tasks not used to generate the model initially.

Alternative scenarios would be created based on input from the expert panel. For example, the $6 million FHWA ATIS/CVO project had to create a set of scenarios for use of in-vehicle telematic devices. These scenarios were reviewed by an industry panel to ensure that vital aspects of telematics were properly considered.

Another name for adaptation is learning. Psychology, as a discipline, has over a hundred years of experience in creating valid models of learning that have been successfully applied in military, commercial and educational settings. Developing an adaptive learning model does not pose unusual technical difficulties. However, it does require a sustained long-term basic research effort that has not yet been attempted by the U.S. Department of Transportation.

Narrative Description
This is the highest priority project considered by the Human Factors Working Group. It is a high-risk project with a huge potential payoff.

Theory is the best practical human factors tool. It offers several advantages to the user who must solve an immediate pragmatic problem (Kantowitz, 2000):

- It fills in where data are lacking. No handbook or guideline has all the necessary data.
- Computational theories provide quantitative predictions needed by engineers.
- It prevents us from reinventing the wheel by allowing us to recognize similarities among problems, such as the tendency for drivers to adopt inappropriate decision criteria in many situations.

- It is reusable. Once the investment has been made to build a mode for a particular domain, the theory can be recycled inexpensively to answer many system-design questions.

Theory is a powerful lens that connects user needs to sets of data (Figure 4.6.1). It does this by illuminating both the need and the data. When faced with a specific user need, e.g., why do drivers look but not see important external cues?, theory allows us to refine the question in a more detailed way that improves the odds of an effective answer. A question that may at first seem unanswerable or illogical, may through the lens of theory become tractable. Theory also illuminates data. When faced with a large set of data, e.g., from a naturalistic observation study, theory helps us to determine which aspects of the data may be most useful in solving a problem.

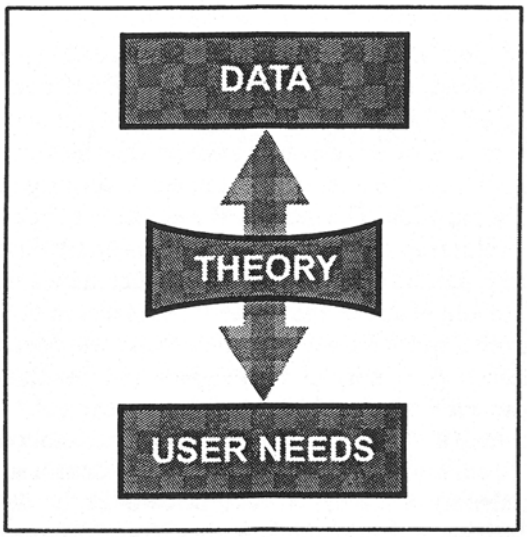

Figure 4.6.1 Theory links data to user needs. (From Kantowitz, 2000)

Computational models produce a quantitative output. This is accomplished through mathematical equations and computer algorithms. Traffic engineers are accustomed to using computational models both at the aggregate level, where for example principles of fluid dynamics are used to predict macro-level traffic flow, and at the micro-level to describe behavior patterns of individual drivers. Since these models are usually written by civil engineers, the components of the model that explain mental and physical driver processes are often rudimentary. While human factors experts tend to produce qualitative models, if models are used at all, there are emerging process models of driver performance that are computational (Lee, in press). This is a relatively new emphasis in human factors, although continuous control-theory models have been applied to operator control for many years. Thus, the tools and techniques to build computational driver models already exist.

Problem Statement

A pile of bricks is not a house. A blueprint is needed to transform the pile into a dwelling. Similarly, a pile of data will not by itself lead to effective countermeasures. A theory is needed to transform the data into, first information (selective representations of data) and second, understanding (a set of organized principles to explain the data). While it is often necessary to

proceed from information (or even worse from raw data) to countermeasures, as shown in the dotted lines of Figure 4.6.2, this shortcut relies upon crude extrapolation, often based upon the idiosyncratic opinions of the expert collecting the data, rather than a systematic formalization of theory. In other words, many "theories" about traffic safety are implicit and latent in the minds of their creators. Science progresses when theories are made explicit and formal to be scrutinized and improved by the research and practice community at large. Thus, the goal of this project is to produce an explicit formal model of driving behavior that can generate and evaluate potential safety and human factors countermeasures.

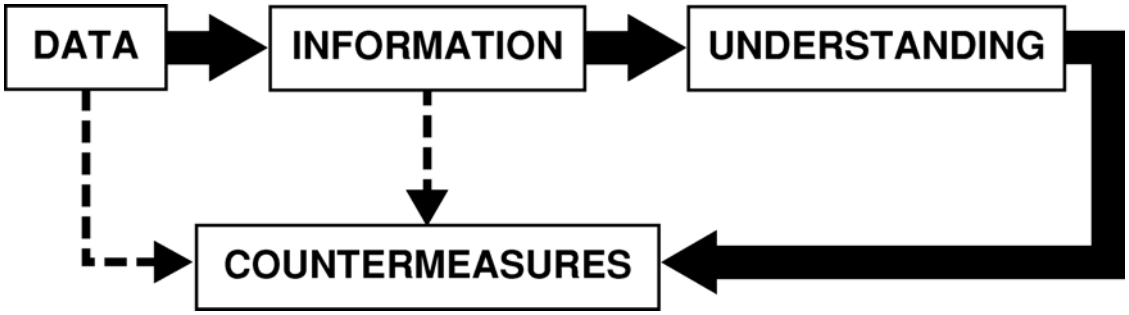

Figure 4.6.2 Precursors of Countermeasures

HF 1a: This is a large-scale long-duration effort to build a computational driver model from scratch. While several useful computational models of human behavior exist, almost none have been constructed primarily to explain driving. They cover relevant activities such as attention and decision making but a model, for example of chess playing, may not focus on the most salient cognitive activities required for driving. In particular, models of driving require fast real-time dynamic calculations; this has been called inner-loop processing in vehicle control theory plus a more strategic goal structure that governs slower high-level cognition such as the reason for the trip. These two levels of control often interact: driving a pregnant woman to a hospital as a strategic goal might impose stronger constraints on inner-loop control than a Sunday drive through the park. Drivers can succeed or fail at each level. Failure of inner-loop processing means the vehicle may crash or depart from the roadway. Failure of strategic control imposes additional trip demands: for example, most of us have had the experience of intending to drive to some recreational setting on a weekend but winding up in the parking lot at work instead.

This project would entail three successive four-year phases. Phase I would accomplish specification of overall system architecture by a detailed evaluation of alternatives. Phase 2 would be an analytic build and extension of the most successful Phase I architecture. Phase II would stress empirical validation of the full model and generation of countermeasures.

HF 1b: This is a light, less expensive, version of 1a. Instead of building a new general model of driving, we would try to extend one or more existing computational models to also cover driving. Therefore Phase I and part of Phase II could be minimized. The final model would be less broad than model 1a and it would be important to understand what aspects of driving behavior would not be covered.

Method / Approach

HF1a: Phase I would be a shoot-off between different system architectures designed by competing groups of researchers. Typical architectures to be considered would be queuing theory models (Liu 1996), control theory models (Levison et al, 1998), ACT-RPM models (Byrne & Anderson, 2001; Salvucci, 2002), and central controller models (Meyer & Kieras, 1997) among others. This list could easily be expanded as part of Phase I. An independent set of researchers would generate a set of test scenarios for model evaluation. Models usually do well on an initial test scenario. Therefore, an important part of the shoot-off would require additional evaluation on new scenarios that were unknown initially to the research groups building the competing architectures.

In Phase II the winning architecture would be expanded by adding new modules designed to increase the domains of applicability. Sets of experts from different areas (e.g., road geometry, traffic safety, driver workload and distraction, etc) would decide which domains are most important. Phase III would collect new data, as well as using existing data sets, to evaluate and improve the final model.

HF1b: Phase I would be limited to a one-year evaluation of only two competing existing models by researchers on a team selected by open competition. Phase II would have a smaller set of test scenarios. Phase III would emphasize using existing data sets rather than collecting new data.

Project Duration

HF1a: A twelve-year duration is currently unheard of in DOT research projects. This goes a long way to explaining why there are no basic research models in driving. Basic research takes a long time and a consistent long duration is far more important than adding large sums of funding to decrease project time. Spending $1 million per year for 12 years will create a better outcome than, for example, spending $24 million over 6 years. Nine women cannot produce a baby in one month. A basic research model of this complexity cannot be produced in the normal five-year research cycle. Advanced projects require advanced thinking. The long-term research plan should allow the government to terminate the project at the end of each Phase if progress does not warrant continuation but the intention should be for supporting a 12-year project.

HF1b: The five-year proposed duration is consistent with past large DOT projects such as FHWAATIS/CVO. This is enough time to borrow an existing computational model that can be extended into the driving domain.

Payoff Potential

Both proposed projects have a large potential payoff. At present, there is no complete computational model of the driver. Thus, countermeasures are proposed based upon instinct, general expertise, and luck. There are some highly gifted engineers whose years of experience have produced worthwhile counter-measures, just as centuries ago some highly gifted Italian violin makers produced extraordinary instruments. But many of their secrets died with those Italian artisans. If the human factors of driving is to advance as a discipline, it must seek and find the formal models used by other branches of science.

HF 2. Processing Multiple Sources of Information - Category: Human Factors Information Overload

Comment from R&T Partnership Steering Committee

The reviewers generally couldn't form a clear opinion on the merits of this program. In terms of specific questions/comments, does "workload" include only "divided attention" or also "inattention" due to fatigue, boredom, etc? Since the analytical and validation parts include instrumented vehicles, this should be coordinated with the F-SHRP safety project. How will the model help engineers make better decisions about how much information is too much in a given situation?

This proposed research is better classified as Fundamental Research. Again, this proposed research needs further assessment by international Human Factors experts who have attempted this and who have no stake in the United States program.

Response from White Paper authors

Figure 4.6.3 shows driver performance as a function of workload. The curve has three important regions. When workload is too low, performance is limited by inattention and boredom. Performance is optimal at moderate levels of workload. When workload is too high, problems of driver capacity and divided attention decrease driving performance. As driver fatigue increases, the entire curve shifts downward. Thus, workload is a broad concept that can be applied to a wide range of issues related to driving performance. The model should be able to identify transition levels across the three regions, helping engineers make better decisions about driver underload and overload.

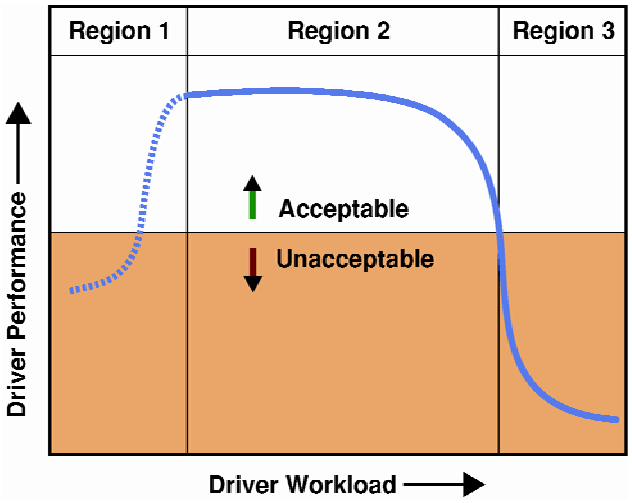

Figure 4.6.3 Three driver workload regions.

The empirical phase could certainly be coordinated with an F-SHRP project since it is easy for instrumented vehicles to acquire vast quantities of data.

Narrative Description

People have a limited ability to process information (Kantowitz & Campbell, 1996). When the rate of incoming information exceeds this ability, errors are made. Fortunately, such errors are not random. Instead, they follow from the human cognitive system architecture and so can be predicted. For example, people raise their decision criterion (beta in signal detection theory) to minimize the need to respond to stimuli, thereby increasing the risk that a crucial signal will not lead to an appropriate response.

It is convenient in driving to divide information into two main classifications: in-vehicle information and out-of-vehicle information. It is common sense that a driver who is not looking out through the windshield cannot observe potential dangers, although the common statement that vision accounts for 90% of driving information is premature (Sivak, 1996). The rising presence of new in-vehicle information systems offers considerable potential to distract both the driver's vision and attention to events inside the vehicle, leading to a concurrent decrease in ability to monitor the out-of-vehicle environment. Furthermore, increasing scientific awareness of the distraction associated with devices such as cell phones has made researchers, and perhaps the general driving public, note that even "eyes on the road" do not ensure "mind on the road." How can we measure the complexity of an intersection with many traffic control devices and intricate road geometry in terms of information processing demands placed on the driver? Although it is clear that rate of external information flow is proportional to vehicle speed, can we find a quantitative relationship between speed and information that would be useful to a highway engineer? How can we measure the workload and distraction of in-vehicle information? And, perhaps most importantly, how can we add up these measures to determine total demands on the driver? Finally, how can total demand be related to driving safety and potential countermeasures?

While DOT is currently funding research on driver workload and distraction, with an emphasis upon in-vehicle information and workload managers (e.g., SAVE-IT, CAMP), there would be substantial safety benefits to an integrated approach that tries to answer the sorts of questions raised in the preceding paragraph as part of a systems approach to driving safety. It would be especially valuable to consider and to calibrate in- and out-of-vehicle information flow in a single project.

Problem Statement

A plethora of secondary tasks has been used to measure driver workload, but without additional theoretical understanding, it is unclear how such measures can be combined because many are redundant (Young & Angell, 2003). So the first part of the problem is to create a driver attention model to illuminate the large set of potential measures of driver workload and distraction. Such a model must explain in- and out-of-vehicle information load as well as the switching costs associated with transfers of attention from in-vehicle to out-of-vehicle events.

Once a model is formulated it will be tested against empirical data for solving Applied problems such as:

- Create a metric for out-of-vehicle information load based upon vehicle speed and environment

- Create a metric for in-vehicle information load, including load imposed by non-visual events
- Estimate total driver workload
- Create red-line limits for excessive rates of information load
- Validate model predictions
- Write engineering design guidelines for avoiding information overload

Finally, once the above is accomplished, suggestions should be made for appropriate countermeasures.

Method / Approach
This project contains analytic, empirical, and validation phases. Analytic efforts include reviews of existing attention models and DOT research in progress and building a driver attention model. Empirical aspects will require data collection in both driving simulators and instrumented vehicles. Simulators are needed to vary in-vehicle and out-of-vehicle complexity. Vehicles are needed to validate simulator results. Finally, revised model predictions must be tested against on-road data so that design guidelines can be established.

Project Duration
Year 1 will be entirely analytic. Year 2 continues analytic efforts and the design of empirical data collection experiments. Years 3 and 4 perform experiments and compare results to model predictions, revising the attention model as required. Year 5 validates the final revised model against on-road data and provides design guidelines for safe information loads for in- and out-of-vehicle information.

Payoff Potential
The potential payoff is quite high because several products will be delivered. The most important product is a driver attention model that informs research and generates useful answers for highway engineers and vehicle designers. Several data sets will be collected in a standardized format that can be used in other projects. Finally, design guidelines will make application of these results straightforward for highway engineers and vehicle designers. There is also potential to coordinate this project with other Federal research efforts in progress as well as with projects discussed in this chapter.

HF 3. Understanding Speed Selection - Category: Human Factors Speed Control

Comment from R&T Partnership Steering Committee

This is an important project to undertake. However, there is concern about the stated hypotheses and details. It may not be just view of road ahead, but what the road behind has been like, past experience on the road, and how other drivers are behaving. The proposed method/approach is vague. Also, simulator and road experiments to measure psychological parameters related to speed are indicated which jump immediately to implementing countermeasures – time and energy to develop and test countermeasures is necessary. A clear statement of the question and a sound detailed approach is needed. Again, this work should be coordinated with F-SHRP and NHTSA's current research on speed choice.

Response from White Paper authors

The comments are all reasonable and appropriate. It would be prudent to add another year and additional funds to test and develop countermeasures.

Narrative Description
Excessive speed is a major cause of accidents for both light passenger vehicles and heavy vehicles, contributing to run-off-road accidents and other crashes. A recent accident at the intersection of I-94 and I-75 in Michigan illustrates the serious economic impact of even a single accident. A gasoline tanker truck overturned and caught fire. The heat generated by the fire melted the steel in the overpass and has closed the intersection for several months while it is being rebuilt. It is likely that the cost of this one accident, including increased congestion and construction, may exceed the proposed cost of this research project.

While a rational driver would select speed according to warning signs and road conditions, many drivers fail to do this. What are some of the other factors that influence driver speed selection and what implications might they have for effective countermeasures?

One reasonable hypothesis is that perception of the roadway controls speed. For example, how might a driver select a speed to enter a curve (assuming the curve warning sign is ignored)? While radius of curvature, an important design parameter for road geometry, has a strong effect other factors, such a length of the curve, may also control driver speed selection. A shorter curve may be perceived as less difficult (holding radius constant), leading to a higher speed selection.

Feedback may also control speed selection. However, just looking at the speedometer may not be sufficient since drivers adapt and may not give proper weight to this display. Preliminary data on in-vehicle devices suggest that additional auditory feedback when the speed limit is exceeded may remind drivers to slow down.

Problem Statement
Review the psychological parameters that may affect driver selection of speed for light passenger and heavy vehicles. Parameters may vary according to the kind of driver (professional or not), hours of service, driver fatigue, driver age, and driver skill and experience. What elements of road geometry are most salient in speed decisions? Does vehicle technology, e.g., ABS brakes, studded tires, encourage a higher speed selection? How does driver perception of traffic density within varying levels of service affect speed selection? Determine empirically which parameters exert the greatest control on speed selection. Suggest and test appropriate countermeasures.

Method / Approach
Start by performing a statistical analysis of national accident data to define the set of accidents associated with excessive speed. Although coding limitations will probably prevent any detailed assessment of psychological parameters, this step is useful to set the stage. Design simulator and road experiments to measure driver speed selection as a function of estimated psychological parameters. Implement countermeasures and collect new data to determine their effectiveness.

Project Duration
The first year will be spent doing statistical analyses, reviewing literature, including research in progress in Europe on Intelligent Speed Adaptation, and designing experiments. Data collection and analysis will occur in years two and three. Note that if substantial relevant data are already available from existing field operational tests, this time period (and associated costs) could be reduced substantially. Countermeasures will be determined in year three. Year four tests a small set of potential countermeasures.

Payoff Potential
Studying psychological factors of individual drivers is risky but there are models of perception than can be applied. This problem is so important, that it is worth the risk. Speed selection is a problem that has been around for many years, but a solution will not be attained until a better understanding of relevant driver perception and decision processes is achieved.

HF 4. Look But Did Not See - Category: Human Factors Driver Perception

Comment from R&T Partnership Steering Committee

The topic seems to have merit but the proposed study needs refinement. Specific questions include: 1) Will eye trackers really define what is "seen?" 2) If we learn whether the problem is (a) peripheral vision, vs. (b) visual scanning habits, what will that tell us in terms of treatments? The authors need to make it clear how the increase in understanding might translate into countermeasures. More justification is needed. 3) Shouldn't the study look at overrepresentation in crashes rather than just lab studies (i.e., do people with poor peripheral vision or poor scanning habits get in more look-but-did-not-see crashes?) It would seem that unless one can show a relationship between the competing explanations and crashes, there is not much urgency to finding out which explanation is more likely. Would one not have to show that people who scan inefficiently are over-represented in the look-but-did-not-see accidents? For, if not, efficient scanning may not be of importance.

Response from White Paper authors

Eye trackers do not define what is perceived; they only resolve where the eye is looking. This is sufficient to determine which visual system, foveal or peripheral vision, is controlling perception.

There already are existing devices to test peripheral versus central vision. Indeed, during my last eye exam the optometrist used such a machine because poor peripheral vision is a predictor of glaucoma. Testing drivers for peripheral vision is a good idea. I am not sure how difficult it would be to obtain a sample of drivers involved in look-but-did-not-see accidents who are willing to have their vision tested. Perhaps people would do this if the project paid for the testing. The ultimate countermeasure would have drivers tested for peripheral vision in addition to central vision as is currently done. Drivers with unacceptable peripheral vision would have limitations placed on their driving but this might be a politically difficult decision to implement.

Other less drastic countermeasures might involve special training for drivers with poor peripheral vision to alter visual scanning patterns.

Narrative Description
It is an amazing fact that drivers can be looking directly at on object yet fail to perceive it. For example, drivers entering a roundabout collide with bicyclists who must have been clearly visible, yet the drivers report consistently that they did not see the bicycle rider (Herslund & Jorgensen, 2003). A similar effect, called change blindness or change inattention, has been well documented in experimental psychology research where even gross changes in a scene, e.g., a person walking by in a gorilla suit, have gone unnoticed (Mack, 2003).

Two explanations of these phenomena have received some support from data. The first explanation is the distinction between foveal and peripheral vision. Drivers are less likely to perceive objects in peripheral vision than objects in foveal (central) vision. Time to detect peripheral stimuli is increased when workload increases. The second explanation is the strategy associated with visual scanning learned from experience. For example, experienced drivers know where to look for vehicles when entering a roundabout and may not scan other areas where a bicycle is more likely to appear than a vehicle (Herslund & Jorgensen, 2003). This hypothesis is consistent with the paradoxical finding that bicyclists are safer when in the proximity of vehicles than when alone.

Problem Statement
Both these explanations may be illuminated by studies of eye tracking. Although eye trackers have been used for many years, they can be finicky devices that can be difficult to use, especially in bright daylight and when drivers are wearing corrective lenses. But there have been new developments in eye tracking hardware that claim to solve many of these difficulties. If eye trackers are used in dim light, where the iris is open wider, they often work better.

Being able to monitor exact gaze patterns much more precisely than from video data offers an opportunity to examine both explanations. First, it is easy to determine if an object falls into foveal or peripheral vision. Second, distributions of gaze patterns over time may help to clarify visual scanning strategies used by drivers.

Method / Approach
Conduct literature reviews of (1) eye tracking equipment, (2) effects of foveal versus peripheral vision, and (3) change blindness. Select and purchase the best two available eye trackers and compare their effectiveness in different light levels with different drivers. Conduct driving simulator and instrumented vehicle studies to investigate detection of external objects under a variety of driving conditions, monitoring gaze patterns for precise location and duration. Conduct appropriate statistical analyses, including time series analysis and pattern analysis, of gaze patterns to infer driver scanning strategies. Suggest possible countermeasures.

Project Duration
The first year will be spent doing reviews, designing experiments, and hardware evaluation and calibration. The next two years will be spent collecting and analyzing visual driving data.

Payoff Potential
This research offers the potential to solve an important class of driver error by taking advantage of new instrumentation and theories of attention.

HF 5. Design Driver - Category: Human Factors Design Standards

Comment from R&T Partnership Steering Committee

There are a number of questions surrounding this proposed study. More clarity is needed on the true effect of the definition of "design driver" on actual design standards. Also, the study should go beyond just defining the 85th, 90th, and 95th percentile of each critical parameter to some concept of what combinations of critical parameters and percentiles that might lead to a defined risk level or failure probability. Is it feasible and appropriate to incorporate "consistent" risk of failure probability in highway designs?

Response from White Paper authors

These are helpful comments. There are statistical techniques for determining how groups of variables form clusters and this could be applied to evaluating combinations of critical parameters. The workshops could seek agreement on the best ways to utilize driver characteristics for actual design standards. Evaluating "consistent" risk might not be feasible within the proposed workshops, but this could be a topic for future research if the workshops were successful enough to promote renewed interest on the design driver.

Narrative Description
Transportation engineers have implicit standards for user characteristics when they select particular parameters, such as the 85th percentile speed, for design specifications (Dewar, 1992). Unfortunately, as has been noted by a past president of the Institute of Transportation Engineers (Pline, 1991), there is no universal acceptance of driver characteristics. Changes in the demography of drivers and the mixture of on-road vehicles also argue for better specification and study of driver characteristics and the relationships between the three components of a transportation system: the facility, the vehicle, and the driver.

Problem Statement
The design driver is a statistical artifact, much like the average taxpayer with 2.3 children and 0.7 pet dogs. Using the 85th percentile value characterizes a population or a sample, not an individual. It is well –known in engineering anthropometry, the science of body measurements, that the 50th percentile male is not composed of body measurements that are the 50th percentile for each dimension. In other words, if we started with a sample and then successively eliminated people by filtering on specific dimensions (e.g., 50th percentile height, weight, arm length, etc), in short order the entire sample would be eliminated. The design driver suffers from the same

difficulty. While selecting a design driver on a single dimension is useful, great care is required to specify an ideal design driver composed of several dimensions.

Thus, the first step would be to identify which design driver dimensions would assist transportation engineers. Should the ideal design driver be based upon an average, a minimum or a maximum? For example, it does not make sense to design a ladder to hold the average weight of a population. Ladders should be designed for a maximum weight, such as the 95th (or higher) percentile. When all transportation components are considered (facility, vehicle, driver) is there a common denominator? For example, would the basis for a design driver change given the target (vehicle versus facility)?

Method Approach
Convene a panel of transportation engineers, vehicle engineers, and human factors engineers and hold a workshop on these issues after white papers have been distributed. Then have experts write position papers about the best dimensions for a design driver. Hold a final workshop to obtain agreement on these issues. Present findings at a national meeting.

Project Duration
The author of this paper has taken the liberty of decreasing the Human Factors Workshop suggested duration of 36 months to 18 months. This should offer ample time to schedule and hold two workshops with associated white papers.

Payoff Potential
It has been 20 years since a TRB sub-committee chaired by Dr. Vivek Bhise considered the Design Driver and so it is time to update this topic.

HF 6. Risk Homeostasis - Category: Human Factors Decision Rationality

Comment from R&T Partnership Steering Committee

This topic should be in the fundamental research category but there's no clear support for this project. More justification and explanation is needed. The methodology is vague. The reviewers believe it's important to find out "how" drivers will react or adapt to changes but not so sure on "why" they change is critical to know to develop effective countermeasures as the authors have stated. Also, the reviewers are not convinced that knowing if there is a difference between assessed vs. objective (true) risk will tell us anything (particularly since true risk may have little or no influence on behavior).

Response from White Paper authors

The author agrees with the comments and does not consider Risk Homeostasis to be a high-priority research project. (As explained earlier, these projects were proposed by the Working Committee, not the white paper author.)

Narrative Description
The theory of risk homeostasis states that drivers attempt to maintain a constant level of risk. Thus, when technology improves safety, for example by adding ABS brakes, drivers compensate by driving faster, thus negating safety benefits of new technology. In general, data do not support this theory (Evans, 1991 p.299). Statistical analyses that purport to show no benefit of safety standards (e.g., Peltzman, 1975) have been severely criticized for containing biased and spurious correlations (e.g., Joksch, 1976). It is remarkable how this theory has survived falsifying data, but theories tend to persist until replaced by better theories (Kantowitz, et al, 2004 chapter 1).

A better theory would be the construct of bounded rationality in which only highly salient cues control the driver's decision processes (Sivak, 2002). Drivers tend to satisfice rather than to compute an optimal rational decision. According to this view, drivers with ABS maintain shorter headways than those without ABS (Sagberg, Fosser & Saetermo, 1997) because of behavioral adaptation, a form of bounded rationality.

Problem Statement
For safety countermeasures to be effective, they need to address what drivers actually do as opposed to what they are capable of doing. There is great need to better understand the extent to which bounded rationality is involved in driver risk assessment, and how the contribution of bounded rationality is influenced by driver aspects (e.g., age and sex), vehicular factors (e.g., passenger vs. commercial vehicle), and environmental variables (e.g., weather, geometric design of the roadway, type of conflict situation). Furthermore, given differences in fatality and accident rates in other countries, it is important to identify cultural and social factors that influence driver risk assessment.

Method / Approach
This study would evaluate the extent of the mismatch between objective risk and subjective assessment of risk for the same traffic situations. The objective risk would be based on accident data. The subjective risk would be obtained by rating the risk in representations of traffic scenes (e.g., Sivak, Soler, Tränkle, and Spaghnol, 1989). A variety of traffic situations would be considered. Consequently, it would be possible to identify factors for which objective and subjective risks are similar, as well as factors for which there is a major mismatch. It would be highly desirable to compare data sets from several countries and this topic is well-suited for international collaboration for which special funding is occasionally available.

Project Duration
The first four months will be spent developing data protocols that are consistent across different countries and cultures. The remaining two years are for data collection.

Payoff Potential
This research is a first step towards understanding why drivers in different countries perceive driving risk differently.

HF 7. Driving Simulator Validity - Category: Human Factors Simulator Generalization

Comment from R&T Partnership Steering Committee

This proposed project seems to be useful. The project should consider using instrumented vehicle drivers in NHTSA's current work and in F-SHRP as subjects, since "real world" data on driving will be collected in those projects. Alternatives to the proposed full-block experimental design should be explored that will permit strong enough statistical analyses to achieve validation.

Response from White Paper authors

The author agrees with the comments. It would be more cost effective if drivers from current and F-SHRP studies were used but this will require drivers to navigate a fixed course so that the same routes can be created in the simulator.

Narrative Description
While driving simulators are widely used, becoming more capable and less expensive as computer prices decrease, many highway engineers view them as research tools and not necessarily as highway design tools. However, in Europe driving simulators are used by highway engineers as a way to visualize and compare different designs for road geometry, tunnel design, and locations of traffic control units; indeed, an AASHTO-FHWA scanning tour of Europe scheduled for June 2004 will investigate this use of simulators. Similar work in the U.S. has been proposed (Rosenthal et al, 2004).

Since people drive real vehicles on real roads, it is important to compare simulator driving with roadway driving using the same drivers. The few experiments that have done this generally conclude that simulators have high relative validity (results on roads and simulators are qualitatively alike) but little absolute validity (results being identical). However, what is of key importance is the ability to predict on-road performance from simulator data. This can be accomplished without absolute validity if a transformation equation can be developed. For example, drivers in a simulator typically drive faster than on the road, probably because the optical flow in a simulator is less than the real world. Thus, there is no absolute validity for speed. But as long as there is some mathematical, and hopefully linear, equation that relates simulator speed to road speed, it is easy to use simulator data to predict road behavior. Since it is less expensive to build new roads in a simulator, different geometries can be efficiently compared in a simulator. Finally, no one has ever died in a simulator crash so research that might be high risk on a road can still be conducted in a simulator.

We are just beginning to compare the various characteristics of different models of driving simulators (Boer et al, 2003). Simulators differ on many dimensions such as field of view, contrast, refresh rate, brightness, update time, etc. Until this is studied more carefully, it will remain difficult to compare experimental results obtained from different simulators. Furthermore, such research will help us understand how to build better simulators less expensively by learning which simulator parameters are more important, and so worth capital investment, and which are less crucial.

Problem Statement
It has been difficult in the past to obtain FHWA funds for simulator validation, since most simulator studies have been conducted to answer very specific questions where validation is but a small part of the project. In order to develop simulator methodology, making simulators a more effective tool for highway research, a project is required that is aimed at improving the methodology in general. The problem has two parts.

First, empirical data must be collected that compare performance of the same driver in the simulator and on the road. Sufficient data must be collected to allow calculation of road and simulator reliability coefficients using repeated testing in both environments. Simulator roadways need be built, to official highway standards which researchers have not always accomplished in the past due to resource limitations, that match nearby road systems. Instrumented vehicles will collect the same data as the simulator. Appropriate statistical techniques will be used to compare simulator and road data, testing to what degree it is possible to estimate road performance from simulator data.

Second, since the research world uses several models of simulators of varying expense and complexity, additional work is needed to compare parameters across simulators. The ideal test would have one location with several simulators so that the same drivers could be used in all simulator tests. This could also be accomplished, but perhaps less efficiently, if different simulators were located nearby so that the same drivers could be tested. Experimental designs would have to take into account possible negative transfer effects across simulators. The goal is to determine the most important simulator parameters that effect driver behavior. The most expensive simulators with very high physical identity to vehicles may not be required for many research problems.

Method / Approach
Using the same drivers, collect sufficient data in a simulator and an instrumented vehicle to permit appropriate statistical analyses that validate the simulator as a predictor of on-road behavior. Extend the methodology of Boer et al (2003) to further compare varieties of driving simulator and identify critical simulator parameters so that performance on simulator X can be predicted from simulator Y.

Project Duration
While simulator data collection is relative fast once scenarios have been programmed, on-road data collection is relatively slow. The first 6 months will be spent building scenarios, matching simulator roadways to local roadways, and designing experiments. The next 3 years will be for data acquisition and analysis.

Payoff Potential
Driving simulators are a key tool that cannot be fully exploited until their methodological characteristics have been systematically studied. There is great potential to use simulators for solving many problems safely and efficiently.

4.7 Relationship Between These Proposal Projects and the F-SHRP Research Plan

Table 4.7.1 lists the current set of projects and the closest related F-SHRP project (Campbell, et al, 2003). It is likely that data from some F-SHRP projects can be used to support the present proposed research projects. Project HF1 has the greatest overlap, which is hardly surprising since its goal is a complete model of the driver. Other smaller projects have much less overlap. One important caveat, indicated for projects HF2 and HF7 is that F-SHRP data will be useful only if the same drivers are tested in the field and in the driving simulator. Although it will be quite useful to coordinate F-SHRP work on countermeasures to the current projects, it is premature to attempt this now. F-SHRP project 2-3.2, Retrospective Countermeasures Evaluation Projects, is described as a "placeholder" in the F-SHRP document. Future comparisons must wait until the places are filled in.

Project Title	**F-SHRP Project**
HF 1a: Computational Driver Model: WE (Whole Enchilada) **HF 1b:** Computational Driver Model: Light	2-1.2 Development of analysis Methods for Site-Based Risk Studies Using Recent Data 2-1.3 Development of analysis Methods for Vehicle-Based Risk Studies Using Recent Data 2-2.3 Vehicle-Based Risk Study – Phase I: Study Design 2-2.7 Site-Based Risk Study – Phase II: Field Study
HF 2: Processing Multiple Sources Of Information	2-2.3* Vehicle-Based Risk Study – Phase I: Study Design
HF 3: Understanding Speed Selection	2-2.5 Vehicle-Based Risk Study – Phase IV: Road Departure Analysis and Countermeasure Implications
HF 4: Look but not see	2-2.7 Site-Based Risk Study – Phase II: Field Study
HF 5: Design Driver	None
HF 6: Risk Homeostasis	?
HF 7: Driving Simulator Validity	2-2.3* Vehicle-Based Risk Study – Phase I: Study Design

*Same drivers would need to be tested in a simulator and on the road

Table 4.7.1 Relationship of proposed projects to F-SHRP Safety Projects

4.8 Summary

The most important Advanced project is Computational Models (HF 1). While this has greater risk than some of the other projects, the risk level is still reasonable and appropriate for an Advanced project with such a large potential payoff if successful. If funds permit, the complete (HF 1a) version of this project is preferred, but that will be expensive. If less funding is available, then the condensed version (HF 1b) should be supported.

The most important Applied project is not clear because simulator validity (HF 7) was not carefully considered at the Irvine Workshop. The author of this chapter believes that this project will yield the best return for research dollars. However, there are also several other worthwhile Applied projects in the list.