7.0 Synthesis

The preceding chapters present imposing lists of potential research projects. Since they were written independently, coordination across white papers came from two sources: (1) each author was given the same detailed set of instructions, and (2) during the feedback phase each author received a copy of all the draft white papers. The present chapter is one author's attempt to integrate and harmonize the diverse set of recommendations. It is most certainly not intended to be the last word on these issues; indeed, the final task of the SOW calls for ratings and project evaluations from a large set of stakeholders.

It may well be that the most important legacy of this report is not the sets of particular projects that have been sketched. Instead, the formal distinction between Applied and Advanced projects and the realization that both types of projects are required for a healthy highway R&T are the vital concepts advocated in this report. While there are several valid distinctions between applied and advanced research, one very useful distinction (Kantowitz, 1982) focuses upon uncertainty as a key feature. In applied research the goal is to eliminate, or at least minimize, uncertainty. No professional engineer would wish to be responsible for a bridge or a highway that did not achieve its design goals. Of course, to engineer is human (Petrosky, 1985) and bridges can collapse, especially when pushing the limits of design scalability, as did the Tacoma Narrows bridge fail from wind-induced oscillation. Applied projects should have a high probability of achieving their goals and creating effective countermeasures to improve highway safety.

In basic or advanced research, uncertainty is sought. No professional scientist would perform an experiment with an outcome that could be perfectly predicted; this does not advance the search for knowledge. Thus, advanced research is inherently more risky than applied research: its goals are more general, more difficult to evaluate, and many outcomes are possible. So why do advanced research at all? It would be safer to limit research outlays to applied projects with their more certain outcomes.

Traditionally, FHWA has followed this conservative course and has avoided most basic research. There is often a long time lag between basic results being available versus being applied to create a measurable benefit to society. For example, a study of key outcomes in research funded by the Department of Defense (Adams, cited by Kantowitz, 1982) found it took up to twenty years before basic research results produced systems deployed in the field. This long delay obscures the importance of basic research and makes it more difficult to appreciate that applied systems have roots in advanced research. But there is a limit to the countermeasures that common sense provides. Some questions are so difficult, e.g., how to model what a driver is thinking, that only basic research can provide an answer. Although rates of highway fatalities are decreasing, the number of deaths is increasing due to increased exposure. This problem was faced and solved by the aviation industry with federal government assistance. Basic research about human capabilities and limitations was used to support the applied research needed to design modern glass-cockpit aircraft that increased transportation safety despite increased exposure (see Billings 1997 for examples of human-centered design improvements). These improvements were grounded in decades of basic research funded by DoD and NASA. Ground transportation must follow this example because sufficient improvements in transportation safety cannot be achieved by only more applied research.

Thus, FHWA faces a serious challenge in determining what portion of research resources should be allocated to advanced research and how such projects will be selected and evaluated. Because of strongly divergent views about the disadvantages/advantages of uncertainty, it is problematic for basic researchers to evaluate applied research and for applied researchers to judge basic research. The population of scientist-practitioners who are expert in both areas is quite small. This suggests that, at least initially, decisions about advanced highway safety research will be made primarily by engineers who have not been trained in basic/advanced research techniques. Suggestions for new university programs, comparable to what currently exists in aviation, to bridge this gap are beyond the scope of this report.

7.1 Advanced Projects

Table 7.1.1 lists nineteen advanced projects proposed in the preceding white papers. These projects have a mean duration of 42 months and a mean cost of $3.9 million. Advanced research requires more time than applied research. Although advanced research does not necessarily cost more per year of research than applied research, total costs tend to be higher since projects are of longer duration. The need for continuity is greater in advanced research. While applied projects can often be broken down into smaller tasks that are sometimes independent, advanced projects suffer more from interruption. It would be more effective to spend $1 million per year for ten years on a major advanced project, such as development of a driver model, than to spend $20 million over five years.

	Advanced Projects
ROR 4	Development and Application of a Roadside Inventory Database
IS 1a	Magnitude, Characteristic, & Causation of Intersection Accidents
IS 1b	Establish Root Causes of Driver Error
IS 2a-1	Safety Impacts of Alternative Intersection Controls
IS 2c	Intersection Sight Distance
HF 1a	Computational Driver Model: WE (Whole Enchilada)
HF 1b	Computational Driver Model: Light
HF 2	Processing Multiple Sources Of Information
WZ 2a	Incorporate New WZ Data Elements into CDS Crash Investigations
WZ 3a	Feasibility and Validity of Region-wide WZ Crash Risk Estimation Techniques
WZ 4a	Improving the Understanding and Measurement of Driver Behavior in High Driver Workload Environments
ADV 1a	Development of a Driver Modeling Structure
ADV 1b	Development of a Prototype Driver Model
ADV 1c	Development of a Driver Model
ADV 2a	Evaluation of Advanced Sensors and Data Mining Techniques
ADV 2b	Development of Safety Decision Aids for Planners
ADV 3	Evaluation of Nanotechnology for Safety Countermeasures

Table 7.1.1

The most important advanced project is development of a computational driver model. It is reassuring that the authors of the papers recommending this project (HF 1 and ADV 1), one from academia and one from private industry, independently reached similar conclusions about the need for this work, the requirement for a computational rather than a verbal model, its scope and its cost. Two additional white papers also included advanced topics that would benefit from, and support development of, a driver model (IS 1b, WZ 4a). The modal objection raised to this project, stated bluntly, is that it would be impossible to achieve. Some engineers believe it is impossible to fathom the workings of the human mind. It is probably true that the standard tools of civil engineering are not readily adopted to the study of human behavior. However, other engineering domains, such as aviation, have benefited greatly from the tools of human factors, which can fathom and model human cognition and behavior. Indeed, the Human Factors and Ergonomics Society has recently started a new special interest group devoted to modeling human behavior in applied systems. What has been accomplished in other domains can also be accomplished for highway safety and operations.

FHWA has made some initial attempts to model driver behavior in very simple ways as components of microsimulation traffic models. A more serious effort was undertaken to improve the driver model in IHSDM. But even this model is relatively simple in its goals; the author of this chapter was the initial Principal Investigator for the project developing this model and so is intimately acquainted with its limitations. For example, the IHSDM driver model is for a two-lane rural road with no other traffic and assumes a fully-functioning driver who is not distracted or fatigued. While the IHSDM modelers built in place holders for other cognitive functions, such as attention, these have not yet been exploited.

The approaches taken toward building a driver model are similar in both white papers. First, a review is needed to establish preferred system architecture. There are competing computational tools for this task, and the best approach cannot be specified a priori. The next decision point concerns whether to build a full-blown model from scratch or to try to save money by borrowing from existing, primarily non-driver, computational models. Finally, specific scenarios must be generated: should the model be applied to intersections, rural roads, or to workzones? Ongoing oversight by an independent committee of stakeholders would be helpful in making these decisions. This research should be coordinated with other planned research, such as specified in F-SHRP. However, coordination will not be successful if all that happens is that the F-SHRP data get thrown over the fence to the model builders. There must be a contractual mechanism that allows the contractors doing the model to create some data specifications for the F-SHRP contractors responsible for data collection.

The feedback on the draft white papers indicated that the following advanced projects were considered to be important:

- ROR-4
- IS2a-1
- IS2c

However, further evaluation by a larger group of stakeholders is needed.

7.2 Applied Projects

Table 7.2.1 lists sixteen applied projects proposed in the preceding white papers. These projects have a mean duration of 35 months and a mean cost of $1.7 million. They are a good sample of the kinds of important bread-and-butter issues FHWA has been researching for years in order to improve highway safety. Hence, it does not seem appropriate to single out only one project as being of greatest consequence.

	Applied Projects
ROR 1	Use of Rumble Strips on Non-Freeways
ROR 2	Development of a System of TCDs to Reduce ROR Crashes at Curves
ROR 3	Optimizing the Net Benefits of Delineation
IS 2a-2	Safety Effects of Alternative Left Turn Phasing
IS 2b	Safety effects of alternative signal layouts
IS 3	Effectiveness of various countermeasures for reducing accidents
IS 4	Effectiveness of & Driver Response to Automatic All-red Signal Extension System
HF 3	Understanding Speed Selection
HF 4	Look but not see
HF 5	Design Driver
HF 6	Risk Homeostasis
HF 7	Driving Simulator Validity
WZ 1a	Estimate WZ Exposure Characteristics from FMIS
WZ 1b	Develop VMT Temporal Distributions to Estimate WZ Exposure
WZ 2b	Investigate Likelihood of Work Zone Crash Reporting
WZ 3b	Project-Level Crash Consequences of Work Zone Design Features
WZ 4b	Evaluate Dynamic Queue End Warning Systems for WZ
WZ 5a	Analyze State WZ Monitoring and Management Programs and Procedures

Table 7.2.1

The feedback on the draft white papers indicated several projects to be worthwhile:

- ROR-1 [median barriers]
- ROR-3
- IS 2a-2
- HF-3
- HF-4
- HF-7

However, further evaluation by a larger group of stakeholders is needed.