# CONTENTS

<table>
<thead>
<tr>
<th>CONTENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>4</td>
</tr>
<tr>
<td>University Involvement</td>
<td>4</td>
</tr>
<tr>
<td>Industry Involvement</td>
<td>4</td>
</tr>
<tr>
<td>Government Involvement</td>
<td>5</td>
</tr>
<tr>
<td>UMTRI Facilities</td>
<td>5</td>
</tr>
<tr>
<td>Research Divisions</td>
<td>5</td>
</tr>
<tr>
<td>2. UMTRI STRATEGIC PLAN</td>
<td>7</td>
</tr>
<tr>
<td>Strategic Intent</td>
<td>7</td>
</tr>
<tr>
<td>Mission</td>
<td>7</td>
</tr>
<tr>
<td>Objectives</td>
<td>7</td>
</tr>
<tr>
<td>2.1 SIGNIFICANT LONG-TERM INFLUENCES</td>
<td>8</td>
</tr>
<tr>
<td>2.1.1 The Increasing Magnitude of World-Wide Highway Fatalities</td>
<td>8</td>
</tr>
<tr>
<td>2.1.2 Sustainability of Highway Transportation</td>
<td>9</td>
</tr>
<tr>
<td>2.1.3 Communication Technology</td>
<td>9</td>
</tr>
<tr>
<td>2.1.4 Solutions to Satisfy Users</td>
<td>10</td>
</tr>
<tr>
<td>2.1.5 Truck and Bus Safety in a Commercial Environment</td>
<td>10</td>
</tr>
<tr>
<td>2.1.6 Researching Complex Systems</td>
<td>11</td>
</tr>
<tr>
<td>2.2 OPPORTUNITIES WITH COMMUNICATION TECHNOLOGY</td>
<td>11</td>
</tr>
<tr>
<td>2.3 DIVISIONAL RESEARCH PLANS</td>
<td>14</td>
</tr>
<tr>
<td>2.3.1 Automotive Analysis Division (AAD)</td>
<td>14</td>
</tr>
<tr>
<td>Near Term Programs</td>
<td>15</td>
</tr>
<tr>
<td>Research Technology</td>
<td>15</td>
</tr>
<tr>
<td>Measuring Progress</td>
<td>16</td>
</tr>
<tr>
<td>2.3.2 Biosciences</td>
<td>16</td>
</tr>
<tr>
<td>Research Needs</td>
<td>16</td>
</tr>
<tr>
<td>Research Leadership</td>
<td>16</td>
</tr>
<tr>
<td>Near Term Programs</td>
<td>18</td>
</tr>
<tr>
<td>Research Technology</td>
<td>18</td>
</tr>
<tr>
<td>2.3.3 Engineering Research Division (ERD)</td>
<td>19</td>
</tr>
<tr>
<td>Research Needs</td>
<td>19</td>
</tr>
<tr>
<td>Research Leadership</td>
<td>19</td>
</tr>
<tr>
<td>Near Term Programs</td>
<td>20</td>
</tr>
<tr>
<td>Research Technology</td>
<td>21</td>
</tr>
<tr>
<td>Measuring Progress</td>
<td>21</td>
</tr>
<tr>
<td>2.3.4 Human Factors</td>
<td>21</td>
</tr>
<tr>
<td>Research Needs</td>
<td>21</td>
</tr>
<tr>
<td>Research Leadership</td>
<td>22</td>
</tr>
<tr>
<td>Near Term Programs</td>
<td>22</td>
</tr>
<tr>
<td>Research Technology</td>
<td>23</td>
</tr>
<tr>
<td>Measuring Progress</td>
<td>23</td>
</tr>
<tr>
<td>2.3.5 Social and Behavioral Analysis</td>
<td>23</td>
</tr>
<tr>
<td>Major Needs and Programs</td>
<td>23</td>
</tr>
<tr>
<td>Research Technology</td>
<td>24</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

The Transportation Research Institute of the University of Michigan (UMTRI) is committed to interdisciplinary transportation-related research that will ultimately increase driving safety and further transportation-systems knowledge. Founded in 1965, UMTRI is currently operating a $17-million per-year research program, with funds received from federal and state government agencies, motor vehicle manufacturers and suppliers, and other organizations.

Under the direction of Peter Sweatman, the current staff of approximately 130 includes full-time research, technical and administrative personnel, teaching faculty affiliated with the University’s academic departments, graduate students, and other support staff. The multidisciplinary approach taken by UMTRI is reflected in the great variety of disciplines represented within the Institute, and by its involvement with other units of the University.

More than 1,000 short- and long-term research projects have been carried out in broad areas involving accident data collection and traffic safety analysis, bioengineering, human factors, mechanical engineering, psychology, economics, and public policy. In addition, numerous multidisciplinary research programs are currently being conducted with other units of the University involving specialized areas of engineering, business, medicine, and public health.

University Involvement

The varied nature of UMTRI’s research projects has made it possible for our researchers to form ongoing collaborative relationships with many different University of Michigan schools and colleges. Many important research questions can best - and in some cases only - be answered by a multidisciplinary approach seldom possible in the traditional disciplinary structuring of a University. UMTRI provides a setting where research scientists and University faculty accomplish interdisciplinary research, generating new knowledge and providing student training.

Industry Involvement

UMTRI and the University of Michigan have enjoyed a long and mutually beneficial relationship with the automotive industry, including major manufacturers, suppliers, and trade associations such as the Alliance of Automobile Manufacturers.
**Government Involvement**

UMTRI maintains a long-term professional relationship with many government agencies. Its research has influenced public-policy decisions at the state, local, and national level and has been instrumental in bringing about legislation in the areas of occupant restraints, heavy-truck safety, and graduated licensing.

**UMTRI Facilities**

Physical facilities include an extensive array of labs and equipment to support research and to test, measure, analyze, and model both vehicles (passenger cars, light and heavy trucks) and drivers. We operate a capable fixed base driving simulator, a fleet of test vehicles fitted with advanced safety and data acquisition systems and a sled lab for occupant restraint testing. In addition, UMTRI’s library houses one of the world’s most extensive collections of literature on traffic safety.

**Research Divisions**

UMTRI currently carries out its research under six operating Divisions:

- Automotive Analysis (AAD)
- Biosciences (BIO)
- Engineering Research (ERD)
- Human Factors (HF)
- Social and Behavioral Analysis (SBA)
- Transportation Safety Analysis (TSA).

A significant proportion of UMTRI’s sponsorship has been generated from large Field Operational Tests (FOTs) of advanced safety systems; many of these tests have been generated jointly by FHWA, NHTSA and FMCSA under the auspices of intelligent transportation systems development. These tests have been carried out jointly by UMTRI’s ERD and HF Divisions.
UMTRI STRATEGIC PLAN
March 14, 2006

UMTRI’s quality reputation and diverse range of disciplines have emerged as major strengths. We intend to maintain our research quality while expanding its sustainable impact and scope by:

- Expanding the collaboration of UMTRI faculty with other U-M faculty
- Further developing Intelligent Transportation Systems (ITS) research by establishing an ITS Integration Center to collect and analyze ITS systems data and provide systematic evaluation of ITS applications
- Promoting ITS research collaboration throughout the University and broadening the scope of ITS research to include traffic flow, energy and emissions as well as safety
- Broadening the range of UMTRI’s research, to include traffic systems and sustainability
- Significantly increasing the power of our data collection and analysis technologies dedicated to the study of naturalistic driving and crash risk, and to the modeling of the driving process.
2. UMTRI STRATEGIC PLAN

Strategic Intent
UMTRI will be the leader in transportation systems research integrating vehicles, people and infrastructure to achieve a highway transportation system where:
• Fatalities and injuries are eliminated
• People and goods flow efficiently
• Reliance on non-renewable energy is reduced.

Mission
Our mission is transportation research, service and education that addresses safety, driver behavior and the sustainability of transportation systems
• We provide public policy leadership through service on national and international committees and boards
• We offer information and education both inside and outside the university
• Our research is interdisciplinary and is carried out at the local, state, national and international levels
• Our research is actively disseminated in peer-reviewed scientific journals and in government and industry policy
• Our involvement in professional service is aimed at encouraging innovation, implementation, and knowledge transfer to affect industry and government policies and practice
• Our educational activities encourage collaboration with U-M faculty, supervision of graduate and undergraduate students and collaboration with other universities.

Objectives
1) To conduct a systematic and broad approach to transportation research with an emphasis on safety, driver behavior, the automotive industry and technologies that integrate drivers, vehicles and the infrastructure

2) To lead and influence positive changes in the domain of transportation (including government and industry) for the benefit of all transportation sectors and for society

3) To engage a broad range of U-M faculty in transportation research and to provide transportation education for undergraduate and graduate students

4) To support transportation development, technological innovation, ITS leadership and employment in the State of Michigan.
2.1 SIGNIFICANT LONG-TERM INFLUENCES

We believe that there are a number of powerful forces for change in transportation systems and rapid change may occur after decades of relative stability. Our response to these forces for change is being framed in relation to our strengths and opportunities, including our positioning in the University and Michigan, location in South Eastern Michigan and proximity to the heartland of the auto industry.

2.1.1 The Increasing Magnitude of World-Wide Highway Fatalities

Transportation safety, and especially highway safety, is increasingly part of a global approach to economic development coupled with public health and humanitarian concerns. Current projections of world-wide annual highway fatalities in excess of two million by 2020 are unacceptable. In the US, highway fatalities remain in excess of 40,000 and the game-changing influences to avoid crashes are being sought in driver behavior and technology. Disproportionately, over 4,000 fatalities occur with trucks and pressure to improve truck and bus safety will increase.

UMTRI’s research supports science-based countermeasures to highway fatalities. We research crash circumstances and risks, as well as crash severity and occupant protection. We research driver perception and attention. We research the development and benefits of vehicle-highway technology deployed in advanced safety systems. We conduct research that enhances the safety and efficiency of transportation by advancing expert and public understanding of the social and behavioral issues important to transportation.

UMTRI seeks to implement this research nationally through policy-level contributions to both government and industry. UMTRI also seeks international partnerships for highway safety leadership. Safety needs to be considered beyond traditional considerations from the perspective of developed countries. We need to take a worldwide perspective, with a balanced consideration of circumstances for developing countries, where the demand growth for road vehicles—and the possible public health consequences—are projected to be greatest.
2.1.2 Sustainability of Highway Transportation

Highway safety remains a key research focus but increasingly does not stand alone. Mobility is being challenged by increasing fuel prices, chronic highway funding shortfalls, energy supply issues, increasing traffic levels and congestion, air quality issues and climate change issues. These matters, combined with the continuing safety problem, create a need for studying the sustainability of highway transportation.

UMTRI will expand its research scope to consider sustainability issues for both private and commercial vehicles. This expansion will initially consider how future vehicle-highway technologies will affect traffic flow (as well as safety). A further important issue is the evolution and adoption by the industry and drivers of conventional and alternative powertrain technologies.

Further questions will increasingly affect UMTRI’s research program. How will automakers approach the integration of sustainability imperatives (safety, climate change and human rights) throughout their businesses? How will motorists’ and transportation engineers’ priorities change with rising fuel prices? How do land use and road design practices contribute to fuel consumption?

2.1.3 Communication Technology

Highway vehicles are becoming more connected to the infrastructure and will share a common electronic frontier. Vehicles will increasingly deploy driver assist, communication and distributed electronic control systems which require major advances in knowledge of driver behavior. Ubiquitous sensors and controls will evolve rapidly to fuel the development of these distributed electronic control systems. Highways will communicate directly with drivers and information located in the highway system will increasingly be transferred to the vehicle.

The deployment of communication technology will require evaluative research embedded within the cycle of technology, applications development and systems deployment.

UMTRI will further expand its human factors research capability across disciplines, develop models for assessing driver assistance and vehicle control technologies and develop facilities capable of collecting and analyzing complex driving data relating to both vehicles and highway elements. Major research questions are already being posed. Which driver assist systems will provide safety benefits and be accepted by drivers? How can researchers visualize and model the complex highway driving task? How can we bring together a variety of disciplines with sufficient rigor to create truly multi-disciplinary models of complex driving processes? The significant challenge behind these questions has already prompted UMTRI’s Science of Driving initiative.
Further important research questions need to be addressed. How can vehicle and highway communication technology contribute to occupant protection? How can vehicle and highway communication technology contribute to reducing congestion? What factors influence industry and driver acceptance of new vehicle-infrastructure technologies? How should government policy be structured over a protracted period of deployment of the technology?

2.1.4 Solutions to Satisfy Users

The users of highway transportation will have an increasing say in the development of vehicles and infrastructure. Private users will seek solutions to congestion and increased ease of driving, consistent with safety and with special consideration needed for older drivers; people’s views, preferences and behavior will become increasingly important; driving will viewed more broadly as part of the basic human needs of access and mobility.

UMTRI will expand its social research activities. What influences people’s attitudes toward safety, mobility and sustainability? What broader activities and attitudes intrude into people’s driving and affect workload and distraction during driving? How can privacy concerns be balanced against needs for safety and information in the deployment of new communication and recording technologies in vehicles and highways?

UMTRI will design and conduct research on the diverse population of drivers and users of the transportation system.

2.1.5 Truck and Bus Safety in a Commercial Environment

Commercial users will seek safety, improved productivity and better working conditions for drivers. Pressure to improve truck and bus safety will increase because federal goals to reduce fatalities in truck crashes by half have not been achieved. Interest in bus safety is also increasing. Moreover, almost for the first time, traffic safety is seen as a major factor in worker health and wellness, especially for commercial drivers. At the same time, there has been a shift to crash avoidance driven by technological interventions as the solution to increased safety. Increased safety demand and the shift to crash avoidance to satisfy the demand will require crash data systems oriented to pre-crash conditions at a much finer-grained level of detail than before.

UMTRI will expand its research into truck and bus safety to encompass industry economics, productivity and driver occupational health as well as safety issues. Our truck safety research also needs greater depth. How do truck and bus crashes occur? What are the primary risk factors in crashes and what kinds of interventions can be employed? How can safety systems, communication systems and driver assistance be deployed in a highly competitive industry? What active safety systems can reduce conflicts between trucks and private vehicles?
UMTRI STRATEGIC PLAN
March 14, 2006

UMTRI’s crash data systems must be re-oriented to collect more detailed information on pre-crash conditions and driver/vehicle actions in order to support evaluation of technical interventions. In addition, crash data systems must support linkage to available administrative data, in order to evaluate risk factors that might be remote from the immediate events of a crash. Bus issues will become increasingly salient.

2.1.6 Researching Complex Systems

The role, methodology and technology of transportation research is changing rapidly: issues are more complex, competing and urgent. Carefully-controlled studies will not always be possible. Vehicle-highway technology is being developed faster than traditional research can be carried out. We will see large projects with multiple partners, including the different perspectives of infrastructure groups, vehicle makers and road users.

UMTRI will develop more policy-level influence over the way in which federal research programs are formulated and managed. UMTRI will work with other research institutes to define new principles for carrying out transportation research under complexity, time constraints and budgetary constraints.

UMTRI will develop compelling in-house research technology which will (i) assist in developing new and effective empirical research methods, (ii) assist in convincing sponsors of the value, efficiency and timeliness of proposed research programs and (iii) provide competitive advantage.

UMTRI will exploit in-vehicle and on-line technologies to enhance the efficiency of research. Data being accumulated on vehicles, via the highway system and via consumer surveys can contribute significantly.

2.2 OPPORTUNITIES WITH COMMUNICATION TECHNOLOGY

After forty years of highway safety research at UMTRI and other institutes, we are not satisfied that fundamental problems on many fronts have been solved. Nevertheless, we recognize that fundamental change brought about by communication technology offers many opportunities and requires a strategic re-assessment of our research approach.

For the first time, drivers, vehicles and the infrastructure may be connected to form a single system. Communication technologies have the potential to not only aid crash avoidance but also to reduce traffic congestion and provide a range of efficiency, comfort and entertainment services to drivers. These technologies will also provide new service improvement and cost reduction options to highway agencies and vehicle manufacturers alike. Given the otherwise bleak prospects of continuing increases in vehicle numbers and travel on a relatively static highway infrastructure, these technologies will be pursued
vigorously. In fact, the development, testing and deployment of new technologies to assist drivers is already well underway.

We feel that our research programs will be affected in several interesting and important ways as the story of technology in transportation unfolds.

A multi-partner approach will be needed. The Federal government will take an enabling and evaluative role and look to the auto industry and academia to develop the systems, or applications, which will improve safety and improve highway throughput. UMTRI will be called upon to assist the auto industry in understanding driver reactions to communication applications and in understanding the presentation of infrastructure information. UMTRI will be called upon for evaluation of outcomes for the Federal government. UMTRI will also be called upon to work with highway agencies and other research organizations to assist in developing and evaluating highway-based communication applications.

UMTRI will work closely with MDoT and will need to develop research capabilities in ITS applications and traffic flow.

UMTRI’s research technology, including vehicle-based and site-based systems, will be critical to our effectiveness with the required range of partners.

The deployment of communication technology in vehicles and in the highway system will be a gradual process, with technology-enabled drivers and vehicles increasingly mixing with conventional vehicles and gradual penetration through the highway system. Evaluative research will need to encompass not only safety but also traffic flow, energy, emissions and travel behavior. Drivers’ attitudes to both vehicle-based and infrastructure-based technologies will need to be researched and monitored.

Trucks and buses are early adopters of communication technologies because they have business advantages. Early adoption by trucks will assist with the current disproportionate role of trucks in high-severity crashes and could impact adverse reactions of other road users to increasing numbers of trucks on the highways. UMTRI will be called on to evaluate safety technologies in trucks and to monitor the effects of technologies on the safety of the truck and its driver as well as other road users. This will require enhanced crash databases and would be strengthened with research into the economic benefits of the communication technologies.
The increased use of technology inside the vehicle, outside the vehicle, and between vehicles will require evaluation of the following effects of technology on drivers:

- Driver assistance/support systems (e.g., ATIS, Navigation, On-Star, Night Vision, and AFS Systems)
- Collision avoidance systems (warning delivery systems): (e.g., lane departure, forward collision, other violation/error detection systems—intersection errors; speed errors)
- Consumer-products (e.g., cellular telephones, satellite radios, information/internet accessibility, entertainment systems)
- Intelligent roadway signing and signaling (e.g., roadside warnings, traffic management, dynamic traffic configuration – changeable speed limits, changeable lanes, pedestrian alerts)
- Cooperative vehicle communication – for example, traffic flow characteristics may be regulated by negotiation between vehicles to permit higher roadway throughput.

As technology develops and proliferates, an increasing amount of assistance will be needed with traffic safety policy and legislative actions concerning technology use while driving. Assistance will be needed with issues such as regulating the use of cell phones in vehicles, and with research into the mitigation of specific accident types such as those at intersections and involving departure from the roadway.

There may also be an increasing use of technology for law enforcement. This will be controversial and could conflict with the promotion of technology deployment.

As the penetration of technology in vehicles on the road increases, it will be necessary to monitor effects on the severity of crashes and injury patterns for vehicle occupants. UMTRI will evaluate the effects on injury types and severity and to assist in developing intelligent means of reducing injuries and improving occupant protection. This will require advanced simulation capabilities.

The proliferation of technology in vehicles will occur at the same time as the aging of the population and research will be needed in transportation alternatives, lifelong mobility, and accessibility. Special consideration will also be needed for young drivers, with the increasing recognition that brain and cognitive development occurs into young adulthood.

Even with improvements in crash avoidance, for which predictions could be overestimated, we are at least decades from a crash-free society. There is therefore a need to continue to improve occupant protection systems, which, with the increasing complexity and sophistication of restraint technologies, requires the development of better injury assessment tools.
Federal safety standards, and consumer testing, will continue to require assessment of vehicle and restraint system performance in a wide range of crash scenarios. For the results of these tests to be credible and valid, the injury assessment tools must be increasingly sophisticated and the performance measures must be shown to correlate with real-world experience.

2.3 DIVISIONAL RESEARCH PLANS

Research plans with a three-to-five-year time frame have been developed by UMTRI research divisions, comprising:

- Automotive analysis
- Biosciences
- Engineering research
- Human factors
- Social and behavioral analysis
- Transportation safety analysis.

New programs have been considered in:

- The science of driving
- Sustainability
- Vehicle and highway user attitudes
- Truck safety in a commercial environment
- Research technology.

The following aspects of research programs have been identified:

- Research needs on the part of sponsors (current and possible future)
- Researchers’ perspectives of transportation domain problems and issues
- Major projects on the horizon
- Required developments in research technology and methodology
- Means of measuring progress against overall UMTRI aims and directions.

2.3.1 Automotive Analysis Division (AAD)

AAD (formerly OSAT) is UMTRI’s portal into the automotive industry. AAD supports UMTRI by maintaining an understanding of how industry, economic, and demographic trends are changing the world’s vehicles, roads, drivers, and driving. AAD brings this understanding to UMTRI through informal discussions, seminars, and joint research projects.
AAD carries out its mission through sponsored automotive industry research and analysis in the following areas:

- Industry Structure and Globalization
- Product Design and Development
- Manufacturing Systems Technology
- Information Technology & e-business
- Technology Forecasts.

**Near Term Programs**

The near term research programs conducted by AAD cover manufacturing systems, industry structure, and economics. AAD is focused on understanding how the global automotive industry operates and on how technological, social, and economic trends influence the industry.

Research in manufacturing systems is directed at understanding and improving how the industry operates. AAD supports manufacturers and suppliers in their efforts to deliver competitive, high-quality products to consumers through an ongoing research program in world-class design-for-quality practices. AAD aids in the implementation of procedures and practices that increase manufacturing competitiveness through a research program in automotive body product development strategies.

Research in industry structure is directed at understanding and improving how the industry responds to changing market pressures. AAD supports manufacturers and policy makers understand and respond to the increasingly interconnected and global nature of industry competition through a research program in workforce planning in a global industry. The Chinese automotive industry as a consumer market and as a production base is the subject of another ongoing research program. Information technology advances are transforming the ways that manufacturers and suppliers collaborate, and is the subject of another AAD research program in industry structure.

Research in economics is directed at understanding and improving industry responses to technology, demographics, and regulatory trends. The role of greater scrutiny by securities market regulators is being examined in a research program in financial information and corporate governance for suppliers. The adoption by manufacturers and consumers of new technologies intended to enhance the sustainability of mobility is the subject of another research program in economics. Another AAD research program aims to understand the influence of global demographic changes on mobility, safety, and sustainability.

**Research Technology**

AAD’s manufacturing systems group will maintain its lead in the development and implementation of three-dimensional, non-contact white light measurement technology for quality research. AAD’s industry structure group relies on labor-intensive interviewing methods and will maintain high-level industry contacts in order for the interviews to yield credible results. AAD’s economics group is implementing traditional
and innovative consumer research methods including surveys, online behavior tracking, and real-world observation of driving.

AAD’s researchers serve as honest brokers in the research and analysis of controversial public policy issues. We have a record of balanced research programs and a reputation as neutral, facts-based analysts. AAD uses its role as an honest broker to help its clients to initiate organizational change, implement new technology, and address controversial issues.

Measuring Progress
AAD’s progress is measured by the size and influence of its Affiliate program. AAD will use the Affiliate program to serve a core group of OEMs, suppliers, dealers, and automotive service companies through leading edge research and training.

2.3.2 Biosciences

Research Needs
In general, the auto industry and suppliers have reduced and limited capability to conduct occupant protection and ergonomic/accommodation research. They are therefore dependent on outside contractors, such as UMTRI, to conduct this research, which includes crash investigations.

With regard to ergonomic/anthropometric research, the potential and current sponsors for this research include NHTSA and auto manufacturers, truck manufacturers, off-road equipment manufacturers, and their suppliers of seats, restraint systems, and other vehicle components. We develop models of body shape, posture, and position of vehicle occupants in normal riding/driving and while performing particular tasks, such as looking in mirrors (drivers) or sleeping (passengers). The applications of these models include the layout of vehicle interiors and seats for comfort and accommodation, restraint system design, assessment of physical factors relating to driver-assistance systems, and crash testing methods, including dummy positioning.

Research Leadership
While it is important to pursue research in active safety aimed at crash avoidance, this cannot be done at the expense of passive safety research and development. Even with improvements in crash avoidance, for which predictions are likely overestimated, we are at least decades from a crash-free society. There is therefore a need to continue to improve occupant protection systems, which, with the increasing complexity and sophistication of restraint technologies, requires the development of better injury assessment tools.

There is also an increasing need for timely and accurate data from real-world crashes to assess the performance, both positive and negative, of new and more sophisticated restraint technologies, such as side-curtain airbags, belt pretensioners and load limiters,
and advanced frontal-impact airbags with a wide range of occupant sensing technologies and deployment characteristics.

Some current and future issues in occupant protection include:

- Side-impact protection
- Vehicle incompatibility and aggressivity
- Disabling lower extremities injuries in frontal crashes
- Performance of advanced restraint systems in frontal and side impacts
- Protection for the special populations, including elderly, pregnant, short, and disabled occupants
- Head/brain injuries
- Child injuries, especially four to eight years
- Child crash dummies and injury criteria
- Thoracic injuries, especially aortic injuries in side impacts

It is also expected that computational models will continue to be more important for safety system development. However, almost all occupant models used in crash simulations today are models of the crash dummies. Simulating hardware with poor biofidelity is insufficient for optimizing restraint systems, so research that leads to improved and validated human models is needed.

The bottom line is that federal safety standards, and consumer testing, will continue to require assessment of vehicle and restraint system performance in a wide range of crash scenarios. For the results of these tests to be credible and valid, the injury assessment tools must be increasingly sophisticated and the performance measures must be shown to correlated with real-world experience.

With regard to research in vehicle ergonomics, industry and government trends are positive for increased support in this area. In particular:

- Increased diversity in target vehicle occupant populations (both "world" car designs and niche marketing) necessitates more flexible models to predict occupant requirements.

- The expansion of government safety priorities to address more completely the needs of a diverse occupant population, including the addition of many new crash dummies (small female, child occupants) to Federal standards, has increased the need for accurate information on the postures and positions of all vehicle occupants.

- The design of restraint systems that will function well for all vehicle occupants requires more information on the occupants.
• The reduction in the number of physical prototypes of vehicles that are constructed during the development cycle means a greater emphasis on accurate prediction of human responses in computer simulation.

• There is an increasing sophistication of design methods in commercial vehicles, which until recently lagged substantially behind the design methods used for passenger cars and light trucks.

Near Term Programs
In the area of passive safety, we are in the first year of a five-year program on injury biomechanics and dummy development funded by NHTSA. The scope of this research program is wide and includes 1) completion of the knee, thigh, hip injury criteria with implementation in current and future crash dummies, 2) development of improved child crash dummies, 3) response and injury to the abdomen with an emphasis on side impact loading, and 4) improved occupant protection for elderly occupants.

In addition, the aging US population and the increasing numbers of people with significant physical disabilities who are using motor vehicle transportation will cause growth in our wheelchair transportation safety research programs.

A third area of growing interest is that of improved protection for pedestrians and the development of standards for vehicle performance testing relative to reducing pedestrian head and lower-extremity injuries.

With regard to vehicle ergonomics, the conceptual design of several major studies has been completed, including:

• A large-scale laboratory study of passenger-car and light-truck driver posture and position, including large ranges of adjustment in all components. A new buck needs to be fabricated and a study conducted with 60 to 100 drivers.

• An in-vehicle study of perhaps 100 drivers in ten vehicles to validate the results of the lab study.

• On-road data collection of driver postures and motions in heavy trucks.

Biosciences’ crash investigation program with the Alliance for Automobile Manufacturers, as well as the NHTSA (CIREN), both appear to be continuing for the foreseeable future.

Research Technology
We will enhance our capability and facilities for computation modeling of vehicle crashes and occupant kinematics and kinetics in different crash and vehicle environments.

We will also develop technologies that will enhance our ability to quantify and track driver positions and postures dynamically in vehicles driven on-road.
2.3.3 Engineering Research Division (ERD)

Research Needs
Over the past 40 years, the automotive industry and USDOT have placed great emphasis on the engineering needs for safety (as well as performance, comfort and reliability) at the level of the individual vehicle. In terms of passive safety, areas such as restraint systems, crashworthy structures, air bags, side-impact protection and fuel system integrity have been predominant – making sure things don’t go wrong after a crash, or perhaps more commonly, bringing forward design changes and legislation to reduce the effects of those individual factors that cause death and serious injury in crashes.

To deliver active safety, the emphasis has been to ensure the driver can maintain essential vehicle control under the widest possible conditions. Design and safety standards again address much of the vehicle technology, at the component level (e.g. tire and brake system specifications) and the vehicle system level (e.g. split hydraulic brake systems, ABS, traction control). However these “common safety practices” lose momentum when the factors of concern are no longer limited to the individual vehicle as a mechanical device.

In the next 40 years of UMTRI’s research, issues wider than the individual vehicle are certain to be much more significant. These include
- The vehicle as a complex electronic and software based product
- The vehicle having increasing scope for competence and decision authority to supersede that of the driver – for example in pre-crash sensing and avoidance
- The vehicle as part of a more organized vehicle-highway system, involving active management and control of interactions and communications.

Understanding the issues associated with safe and predictable operation of the whole system, vehicle + driver + external vehicles + infrastructure, becomes the major new challenge for the industry (how to optimize design) and government (how to develop standards). This will be the increasing focus of Engineering Research at UMTRI.

This does not imply that the “old” vehicle/mechanical issues are all solved or irrelevant, but they will become part of the bigger picture. Technological change driven by innovation, resources and environmental concerns remain a challenge for UMTRI’s sponsors, and will continue to challenge Engineering Research at UMTRI.

Research Leadership
Successful future engineering-based research at UMTRI needs to transcend a number of common boundaries – of discipline, of research division and of individual projects. Many future issues are simply too broad and challenging to be limited in traditional ways. So the Engineering Research Division will play a leading role in building appropriate collaborations, within UMTRI, within the University of Michigan, more broadly across US transportation research institutes and academic institutions, and internationally.

Key areas of technical research leadership are:
UMTRI STRATEGIC PLAN
March 14, 2006

- To become established as the leading institute for collecting, fusing, manipulating, understanding, and performing intelligent processing of high quality driving data, using vehicle and infrastructure sources.
- To lead the development of “Next Generation” Field Operational Test (FOT) methodologies – providing means for smarter use of data, more rapid gathering of critical data, and adapting experimental designs to suit specific research questions – hence reducing the time to conclusion
- To retain its leading position in defining metrics for road surface characteristics relevant to ride, handling and (in the future) noise generation
- To help establish UMTRI as the de facto center for research into the Science of Driving

Working collaboratively to achieve these aims means being open to increasing the scope and depth of cross-divisional collaborations, and also moving further to codify engineering-based resources to assist collaborations – for example in terms of existing and future driving databases.

Near Term Programs
The Engineering Research Division will participate in a number of major national programs that are consistent with its core interests and leadership aspirations, some of which are mentioned here:

- CICAS - Cooperative Intersection Collision Avoidance System(s): in collaboration with Human Factors, CAMP, three other universities and four state DOT’s, including MDOT. This FHWA/MDOT funded project is to help develop and evaluate systems within vehicles and the infrastructure that provided communications based countermeasures to avoid intersection crashes.
- VII – Vehicle Infrastructure Integration: we intend to work closely with MDOT to help establish Michigan as the leading player in communications based vehicle-highway systems, based on pilot installations of DSRC and other wireless network technologies. ERD/HF’s expertise in conducting FOT’s is a major component of this strategy.
- IVBSS - Integrated Vehicle Based Safety Systems: this current (2005-08) NHTSA-funded $25 M project is a natural successor to earlier UMTRI FOT’s with fleets of vehicles fitted with technologically advanced driver assistance systems. The increased scale and scope of IVBSS compared to earlier projects is motivating further development of ERD’s technology for FOT conduct.
- SHRP II – the Strategic Highway Research Program II offers major opportunities in furthering our fundamental understanding of how naturalistic driving behavior can itself create crash risk, to move away from the simplistic attribution of cause to vague notions of “driver error”.

20
Research Technology

ERD has for a long time been the technology leader at UMTRI for developing and implementing novel systems, and experimental methods, in laboratories, in vehicles and at the roadside. ERD’s innovation and creative research thinking will continue to grow and continue to be made available to collaborative groups. Key areas of growth are listed below:

- Systems incorporating distributed computation, sensing and communication, for example to increase the flow of searchable data into driving databases
- Increased use of data fusion from existing resources to synthesize new knowledge – in particular, context-sensitive extraction of motion data from multiple imaging sources (vehicle motions, occupant posture and kinematics)
- New techniques for automated extraction of data from large FOT databases
- Increasing the turnkey availability of instrumented research vehicle fleet, as a resource for ERD and collaborating groups
- Further specialist facilities for data visualization and data capture from an instrumented roadway test-bed
- Increased use of GIS and high fidelity digital mapping capabilities.

Much of the above addresses data needs in experimentation, and this will be synchronized to the use of computational modeling of complex scenarios and systems. One major challenge this will address is the need smarter data evaluation, to help bridge the gap between FOT data collection and the evaluation of safety consequences of new technologies.

Measuring Progress

Progress and performance is focused on projects run, research dollars and indirect funding earned, journal publications, PhD students graduated, presence on committees, international profile.

There are important additional, though less tangible, metrics of progress, particularly in terms of the amount of long-term research funding to improve fundamental knowledge of the driving process, and in terms of the level of collaborations, especially with the state of Michigan, with UM academic departments (interaction with faculty and students), with other units of UMTRI, and with other national and international research groups.

2.3.4 Human Factors

Research Needs

The importance of human factors in transportation systems has never been greater than it is today as advanced technologies are rapidly integrated into both vehicles and the roadway infrastructure. These changes promise to provide drivers with enhanced vehicle control (including shared/collaborative control), heightened detection capacity, and more timely and detailed information about the roadway environment, presumably leading to a
safer and more efficient transportation system. However, it is often unclear whether many of these new enhancements in fact produce such benefits because causal mechanisms linking the enhancement to an outcome are poorly understood—drivers compensate for risk, adopt new driving strategies, and redirect their attention in ways that are difficult to predict. Research is needed to understand where in the driving process an intervention would be most effective, and in predicting how the driver would respond when such an intervention is introduced.

Likewise, advanced wireless technologies have also made a wide variety of non-driving activities available in mobile environments, thereby increasing competition for a driver’s attention. Whether such non-driving related activities present a substantial distraction to driving—and hence a safety problem—has become an important concern among the public, manufacturers, and law-makers.

Another significant role for human factors research concerns the development of transportation capacity in emerging nations and the substantial health and safety problem posed by this development. The World Health Organization predicts that by 2020, road traffic injuries will become the third leading contributor to the global burden of disease and injury. Most of these injuries are predicted to involve pedestrians, bicyclists, and moped users, implicating visibility and thus underscoring the continued importance of a key research area for this division.

**Research Leadership**

Over the last 40 years, the Human Factors Division at UMTRI has played a significant role in developing key research on driver and vehicle visibility, and human factors related to the use of in-vehicle telematics. The former has included active participation in the SAE Lighting Committee, the development of a headlamp ratings system for NHTSA’s rulemaking division, and the formation of the Industry Affiliation Program for Human Factors in Transportation Safety (currently comprised of 46 industry affiliates); the latter includes active participation in the SAE Safety and Human Factors committee and development of the current SAE telematics safety standard.

The division has participated in the Transportation Research Board’s bi-annual Visibility Symposia, as organizers for annual TRB Workshops, and as members of the international steering boards for PAL and VISION. In collaboration with the Biosciences and Engineering Research Divisions, Human Factors has also provided NHTSA with systematic assessments of how emerging automotive technologies are likely to affect the existing Federal Motor Vehicle Safety Standards. More recently, the focus of this effort has included comparisons of international safety standards as well.

**Near Term Programs**

In the immediate near term, the Human Factors Division will likely be engaged in a study of driver distraction in police vehicles, evaluation of the US Army’s HMMVW vehicle, and continued research on vision-in-vehicles supported by the Industry Affiliation Program. On the horizon, the division looks forward to a collaboration with Wayne
State, Henry Ford Hospital, and General Motors on a neuroimaging study of driver distraction.

The division is currently collaborating with ERD in carrying out the major NHTSA-funded $25 M IVBSS project (2005-08), and anticipates a collaborative role with ERD in CICAS-related research.

Finally, the division is spearheading a new research initiative – Strategic Worldwide Transportation 2020 - that focuses on long-term reductions in road fatalities worldwide.

**Research Technology**

Although laboratory and simulator studies are likely to continue to play a significant role in our research program, the division sees strong future in the collection and analysis of naturalistic driving data. Thus, low-cost and flexible vehicle instrumentation, analysis tools, and support staff will be needed to collect and manage this data. In particular, we anticipate a need for driver-centered data channels (e.g., eye movement, video capture, glance analysis) to complement the vehicle-centered data, along with corresponding analysis capability.

**Measuring Progress**

The Human Factors Division measures its growth and success both through traditionally academic accomplishments (e.g., refereed publications, conference presentations, and technical reports) as well as by the successful maintenance and expansion of research sponsors. Moreover, our influence on the transportation community can be measured by our involvement in standard-setting activities and by membership on steering boards of international conferences.

**2.3.5 Social and Behavioral Analysis**

The mission of the Social and Behavioral Analysis (SBA) Division is to conduct research that enhances the safety and efficiency of transportation by advancing expert and public understanding of the social and behavioral issues important to transportation. Planning for the next three to five years will be driven by the following issues.

**Major Needs and Programs**

There are several external factors that are likely to impact our business in the next three to five years including: the aging of the population; the proliferation of crash avoidance/driver assistance technology; the continuing evolution of traffic safety policy, particularly in the area of technology use while driving; an increasing focus on valid driver licensing practices due to homeland security; an increasing need for traffic safety expertise in developing countries; an increasing emphasis on transportation alternatives, lifelong mobility, and accessibility; an increased use of technology for law enforcement; greater constraints in conducting survey research due to the substitution of cellular phones for land-line phones; and the increasing recognition that brain and cognitive development occurs into young adulthood. The latter point reflects current biological and
psychological finding that show continued development of the brain up to about age 25. These findings suggest new approaches for the development of traffic safety messages and programs.

Our expectations of current and potential sponsors that are likely to drive funding decisions in the next three to five years include: multi-agency partnering at the sponsor level; multi-organization collaboration; focus on “translational” research; increasing need to show “value” for the research dollars spent; and multilevel interventions.

SBA remains interested in all aspects of the transportation system that are impacted by social and behavioral factors. Plans to increase our influence and leadership include: increasing our leadership role in core research areas recognizing that many sponsors and competitors are in transition; disseminating research findings in peer reviewed publications and conferences; participating in sponsor policy meetings; serving as experts for our sponsors, the government, the university, and the public; participating in editorial and grant review activity; and participation in professional organizations.

SBA plans to pursue strategic opportunities that involve multi-divisional participation in the next three to five years while maintaining sponsorship in our core research areas. One major opportunity is to utilize the powerful abilities of an instrumented vehicle in collaboration with ERD to gather objective data about driving behavior and the social factors within the vehicle that influence behavior.

**Research Technology**

SBA’s research could be enhanced with: unfettered access to a research-quality test track; greater and easier access to instrumented vehicles; expanded use of PDAs in research.

**Measuring Progress**

SBA measures its growth and success through our: number of peer-reviewed publications; number of peer-reviewed conference presentations; our expenditures; growth in research personnel; the proportion of collaborative projects in our portfolio; the proportion of multi-year research projects in portfolio; and the number of months of projected salary coverage. We aim to include students in our research projects.

**2.3.6 Transportation Safety Analysis**

The Transportation Safety Analysis Division (TSA) mission is to generate new knowledge that will ultimately lead to a reduction of traffic accidents and their associated fatalities and injuries. Collection of detailed information on the trucks and buses involved in fatal accidents (TIFA,BIFA) allows for more in-depth analysis of such crashes. These databases are produced annually and made available to industry, government agencies as well as other researchers. Detailed statistics from the data files are published in truck and bus factbooks, which are made available through the website.

The Transportation Data Center (TDC), part of the Transportation Safety Analysis Division, has maintained and continually expanded a crash data library that is made
available to all UMTRI and other U-M researchers as well as many outside researchers. This resource makes it possible for any division to include crash data analysis in a project without the need to acquire crash data and expertise in its analysis. Beyond UMTRI, TDC aids U-M researchers and their students in understanding and accessing crash data. The data are used extensively by the international automotive industry. TDC supports the Michigan State Police (MSP) offices that process and house the Michigan crash data. Members of TDC participate in State committees and planning groups with the purpose of improving the Michigan data.

In addition, our research staff conduct targeted research projects sponsored by industry, government agencies and other sponsor entities. Studies on SUV rollover, truck brakes, truck mirrors, vocational trucks, emergency vehicle lighting systems, hazardous materials transport, bus accidents, rear-end crashes and many others provide new knowledge that contributes to industry advancement, government regulations, and public policy.

Geo-locating the sites of all fatal truck crashes using geographic information systems (GIS) will deepen understanding of roadway risk factors. This new information can help reduce risk by developing alternative routes for hazardous vehicles. Efforts such as the Motor Carrier Management Information System (MCMIS) evaluations for Federal Motor Carrier Safety Administration (FMCSA) supports national policy to create national databases that are used to evaluate and compare the safety status of carriers.

**Research Needs**

TSA’s research program is being influenced by a changing environment for accident data collection and analysis, particularly with regard to:

- Increasing focus on crash avoidance - driver behavior/characteristics, vehicle safety devices, vehicle violations, driver/vehicle interaction and accident characteristics
- Updating databases with (i) more precise data elements and more comprehensive sets of variables and (ii) additional and more fine-grained variables on pre-crash conditions to support the emerging focus on crash avoidance
- More efficient information transfer with TIFA and BIFA databases and documentation in formats more useable by outside researchers and pre-preparation of files ready to share, rather than doing the work on an ad hoc basis
- Higher statistical content with increased our use of statistical models and more sophisticated statistical techniques.

FMCSA, a current major sponsor, is becoming more focused on crash reduction and is more interested in driving down crash frequencies. This provides an opportunity for us to support this effort, by providing data and analysis.
Areas of interest for a potential wider group of sponsors include:

- Support for collision avoidance strategies (countermeasures for rear end collisions, lane change collision avoidance, drowsy driver collision avoidance, older driver collision avoidance)
- Support for collision avoidance technologies (human factor considerations for in-vehicle crash avoidance and driver assistance systems, vehicle feedback cues and driver performance)
- Support for regulatory interventions, such as the implications of cell phone use in vehicles, and other forms of driver distraction

Areas of interest in relation to TSA’s core truck and bus activity include:

- Issues related to bus crashes
- Crash risk of small and informal bus for-hire carriers
- Driver behavior and characteristics related to crashes
- Truck and bus vehicle condition
- CMV driver hours of service
- Vehicle safety devices

**Researchers’ Perspectives and Leadership**

The Division currently provides truck and bus accident data at a greater level of detail and completeness than any other source in the U.S. Even though the TIFA and BIFA databases are more accurate than the FARS database, they appear to be underutilized, probably due to their complex nature and time delay in production.

The Division will be more proactive by improving awareness of the potential user community and finding ways to make the data more accessible. It will also strive to increase the number of research projects based on the TIFA and BIFA files.

TSA will expand by applying the crash data experience we have developed with trucks to other vehicle types, i.e., passenger cars and other light vehicles. TSA will strengthen its capability in risk assessment and encourage projects demanding rigorous safety analysis.

We also need to expand the depth of our analytical work by more fully exploiting the data sets we compile and contribute to: primarily the TIFA and BIFA data sets, and then FMCSA’s Large Truck Crash Causation Study (LTCCS) data set, which we have contributed to substantially.

We plan to restructure our data collection efforts to be able to respond to emerging issues. Our truck survey was designed twenty years ago to satisfy the data requirements of that time. There is a need for modifications to the truck (bus) data items we collect to more fully address the issues of today.

The Division is committed to creating more research opportunities by using Affiliates funds to help cover the costs involved with writing additional peer-reviewed articles for publication.
Near Term Programs
We will support FMCSA’s efforts to improve the quality of motor carrier safety ratings administered by the states. TIFA provides a valuable resource for assessing the accuracy of state data and UMTRI provides a trusted independent resource for this quality assessment research.

Analysis of LTCCS data for FMCSA will provide support for a major sponsor in an area important to that sponsor as well as increase our involvement in this area. The approach we have taken on crash avoidance analysis has been adopted not only by FMCSA, but also by NHTSA in its National Motor Vehicle Crash Causation Study.

Our increasing competency in bus research will allow us to establish a research capability in mass transit safety.

Research Technology
We will reduce the time lag involved in producing TIFA/BIFA. The recent initiation of the 2004 TIFA survey marked the shortest time lag between the close of a data year and the initiation of the survey.

In the longer term, we will develop improved and more fine-grain exposure measures and a means of scaling our relative risk methodology to an absolute risk metric.

2.4 NEW RESEARCH THEMES
Our review of influences for change in transportation systems and of research plans within UMTRI’s disciplines (divisions) has highlighted key areas of opportunity where UMTRI should develop research programs. These cross-disciplinary initiatives are important for ensuring a vibrant level of basic research in UMTRI and for providing long-term growth potential in sponsored research.

We believe that the crash avoidance challenge, coupled with the rapid development of driver assist and system connection technology, requires a deeper understanding of precursors and risks prior to accidents and a predictive capability for the design of new technologies – the Science of Driving. This is a natural for UMTRI given our existing databases of naturalistic driving and future involvement in field operational tests of vehicle and infrastructure technologies.

A broadening of UMTRI’s research program beyond current safety disciplines is also needed so that we continue to address societal concerns with transportation, and vehicles operating with a high degree of mobility on highways in particular. The new focus of societal concern will be sustainability, encompassing safety, mobility (in terms of both congestion and maintaining mobility once driving is no longer possible), public health, economics, energy sources, climate change, and human rights. While safety remains a key element of sustainability, we must be able to address at least some of the broader issues, particularly as they connect with the safety issue.
While representing a minority of highway vehicles, trucks deserve special attention because they play a disproportionate role in highway safety and will also play an increasing role in climate change over the coming decades. Truck safety is also highly involved with economics, productivity and growth in the national economy. Truck and bus safety in a commercial environment is an important research theme, and one which builds on existing UMTRI strengths in stability and control, field operational tests and accident databases and analyses.

2.4.1 The Science of Driving (SciD)

At present there is no comprehensive and accepted scientific understanding of how people drive cars. There is a lot of relevant data, statistical information, knowledge and even computational models scattered across a range of disciplines, and in this context the driving process is understood and predictable in a number of aspects. But perhaps because of its disparate nature, the overall understanding is neither deep nor general, and predictive capability is not readily available to a high level of resolution or generality.

How would a particular driver interact with a future design of collision avoidance system under specified conditions of low, medium or high risk at a busy intersection? What would be the effect on statistical crash risk of such a system? How would specific errors in driver anticipation influence the outcome of a potential traffic conflict? Detailed questions of this type relating to future or hypothetical scenarios are not currently amenable to scientific or computational analysis.

To answer such questions, the current approach is to experiment with surrogates or prototypes in the laboratory, the test track or under limited conditions of real-world exposure. The sad fact however is that such an approach delivers slow progress and has limited power; extensive reliance on physical testing of complex systems involving driver performance is inefficient, costly and frustrating to the expectations of policy makers, product designers and service providers. The current lack of a true predictive capability for driving is a clear weak point in delivering safety and efficiency benefits in the future.

UMTRI recognizes the Science of Driving (SciD) as a strategic “must” for the future of research in highway transportation.

The following outlines some of our aspirations in the area, but first it is worth posing the question of why such a Science of Driving has not been invented or developed already. There are a number of possibilities, for example:

- The goal is ultimately elusive – there is no underlying scientific understanding to be gained; people mostly drive randomly, and significant patterns only emerge in the large-scale; the microscopic second-by-second process of driving cannot be understood and is not amenable to scientific analysis
- The relevant scientific knowledge is specific to particular situations, and cannot be generalized
UMTRI STRATEGIC PLAN
March 14, 2006

- The process is actually well understood – one just needs to access the relevant parts of the literature
- The goal is difficult – knowledge is needed from different disciplines, and even there the knowledge is not mature; so new and coordinated research is required to fill in the significant gaps in previous research.

UMTRI researchers believe that only the last point is valid. Researchers have not so far unified existing knowledge, nor developed new integrated theories and models, largely because the prior research needs have been overwhelmingly directed towards “firefighting” urgent problems – improving vehicle structural and dynamic performance, testing the performance of driver assistance systems in the field, assessing the safety effects of cell-phone use, measuring the impact of standards, policy and legislation on driving behavior, etc. Such problems tend to bias researchers away from the wider and long-term issues that SciD seeks to address. Of course it remains important to continue problem-specific research activities; developing a Science of Driving is intended to provide new concepts, theories and toolsets for researchers that can increasingly be applied in parallel to more traditional methods, ultimately increasing the effectiveness of such research, as well as reducing the time and costs involved.

The SciD initiative is based on three simple aims:

- To discover an enduring set of fundamental scientific principles, concepts, and theories of the driving process
- To develop a body of applied knowledge for understanding and predicting the driving process
- To address challenging research problems with first-order quantitative descriptions of “what’s important?” and “what happens?”

The third point recognizes that general theories cannot provide detailed answers to all questions, but again the issue is to promote sound conceptual principles to accelerate progress in new areas applied research for which the dynamics of the driving process is a key factor. Relevant application areas include: integrated vehicle controls, driver assistance systems, communication systems in vehicles, road geometry design, vision enhancement, designing systems to address driver impairment and reduce distraction. More practically, any aspect of system design related to driving would see great benefit, with SciD reducing the search space for new and effective designs.

If also appears necessary to “reduce the search space” for the Science of Driving itself. Clearly the theories and tools should transcend immediate problems, and be as relevant to driving in 20 years time as they are today. To this end, SciD is focused on four themes that provide a sharper focus for its development:

1. **How should we share driving control with smart technologies?**
   There is a large gap between the ‘simple’ driving modes of purely manual and purely automated driving. New technologies are starting to move driving into that gap, with systems like Adaptive Cruise Control. What is needed to make this trend safe, predictable and effective?
2. **Understanding conflicts and measuring crash risk**
Crashes often occur for complex reasons, involving the precise timing of decisions and control actions between two or more drivers. Detailed predictions of driver intent and actions can be simulated to predict outcome probabilities over time periods in the region of one-to-ten seconds. The relevant traffic interactions are closed-loop and involve driver perception and anticipation as much as they involve physical vehicle trajectories. Though existing traffic simulation models do predict certain types of traffic interactions, *there are no such models available today to perform simulations* relevant to emergent crash risk.

3. **Estimation of driver information processing**
The driver is essentially a “black box” for transportation researchers. Although some attempts are now being made to use brain imaging technology to look inside that box, other techniques are needed. In particular it is crucial to be able to estimate the time sequence of perception, anticipation and control states of the driver, just using available information relating to eye glance, external scene and driver control actions. A model-based approach becomes feasible once suitably detailed and comprehensive driver models are available to SciD.

4. **How do people learn to drive?**
Learning to drive is a fundamental aspect of driving behavior, and is more than simply the acquisition of skill - it also includes a significant experiential component for making tactical and strategic decisions. A model-based approach should form part of the SciD model development, and output should explain known facts, such as the rapid decrease in crash rates during the first six months of driving.

Ultimately, UMTRI sees these efforts taking place on an international scale, and some steps have already been undertaken to initiate a strategic approach to developing the core driver models. In addition to existing driver modeling efforts – within UMTRI, and in collaboration with U-M faculty – a key credential for Michigan is the naturalistic driving data already available within UMTRI databases.

### 2.4.2 Sustainability

With increasing concern about oil prices and security of energy supplies consumers are rapidly becoming more interested in vehicles with significantly improved fuel efficiency. The acceptance of hybrid powertrain vehicles, and increased interest in commercializing fuel cells and hydrogen powered vehicles, shows a developing commitment to technologies which will not only reduce dependence on oil but will also reduce greenhouse gas emissions.

Automakers are increasingly examining their business plans from the viewpoint of long-term business sustainability. Global citizenship, in relation to the impact of companies’ activities on safety, climate change and human rights, is being examined and reported on a regular basis. Investors are increasingly demanding sustainability reporting by publicly listed corporations.
Highway agencies are increasingly interested in the environmental impacts of the construction and maintenance of highway systems, and in responding to the needs of highway users. Traffic congestion is a major issue, along with the reliability of travel times. Non-recurring congestion is of particular concern because it reduces the reliability of travel time, making it more difficult for users to plan trips in a predictable manner.

Safety remains a pivotal consideration in the sustainability of transportation systems. Changes in the usage of various modes will change exposure to accidents and therefore safety will change. In terms of annual mileages traveled, usage of cars is expected to continue to increase, but at a lesser rate; usage of trucks will increase at a faster rate. Increased mobility has increased mileages while accident risks per mile have reduced. As users become more concerned with accessibility than mobility per se, how will this affect safety? Will exposure reduce and risk per mile continue to reduce? Or will accessibility pose new types of accident risks related to changed automobile travel patterns?

User choice needs to be examined through a whole range of transportation decisions. Why do we make the choices we make, and what are the unintended consequences? Survey data combined with econometric modeling has the potential to unlock some of these issues.

Unintended consequences cover a very broad field, including effects on health.

Heavy truck transport is an important and often overlooked sustainability issue. Globalization of economies has significantly increased the demand for transportation. Truck size and weight rules, and the issue of larger combination vehicles, have a major effect on the sustainability of road freight transport. Freight vehicles are doubly important because they have a disproportionate effect on safety, fuel use, air quality and climate change. Biodiesel-fueled trucks could be trialed in the state of Michigan.

UMTRI has existing strengths in truck safety, productivity and policy plus expertise in surveys, economics and automobile consumer choice.

The development of ITS solutions such as vehicle-vehicle and vehicle-highway communication is intended to dramatically improve safety through the avoidance of crashes and to reduce congestion and to increase the throughput of our highway system. While the delivery of safety benefits will require research, the delivery of benefits for traffic flow will require fundamental research and the impact on fuel use and emissions will need to get on the research agenda.
2.4.3 Truck and Bus Safety in a Commercial Environment

The national public perception of commercial trucks is generally negative, influenced by safety concerns and increasing numbers of large trucks on our roads. Low gross vehicle weight and dimension limits enacted by Congress in 1982 (the lowest in developed world) created commercial fleet underperformance of approximately 20 percent by mass and approximately 40 percent by volume (based on long combination vehicle performance) compared with competitor nations.

The US Department of Transportation is forecasting truck transport to increase 80 percent by the year 2020 which will be a major challenge to highway capacity. This emerging condition will force a more pragmatic approach to road system use and elevate road transport efficiency to the highest priority level. There are also developing national concerns about freight bottlenecks and significant projected shortfalls in freight capacity.

Road safety is an essential part of the efficiency equation and the anticipated increase in commercial vehicle traffic will require advanced application of real time risk based policy, crash avoidance technology and advanced communication and routing systems to improve safety.

The commercial transport sector could be significant beneficiaries of Vehicle Infrastructure Interaction (VII) technology which, among other things, may allow for a degree of electronic separation of the commercial vehicle fleet from the private vehicle traffic stream. We will promote the important role of trucks and buses in VII and other major ITS initiatives.

UMTRI has a long standing reputation of excellence in heavy truck research and is seen as the national center of objective analysis. Given the sociopolitical climate that has affected systematic evolution of truck transport policy, UMTRI is well positioned to take a leadership role focused on in improving road transport efficiency and safety by developing, implementing and evaluating new technology and providing the scientific foundation on which more rational national transport policy can flourish. There is a need for policy level research as well as safety research.

**Heavy Truck Research Capabilities**

UMTRI’s heavy truck research capabilities have a very broad scope and can be summarized as follows:

1. Engineering Research- vehicle stability and control simulation and testing, physical parameter measurement including comprehensive suspension parameter measurement for computer modeling and suspension evaluation, ride quality and dynamic road loading.

2. Biosciences – commercial driver safety, cab ergonomics, driver task and motion optimization.
4. Human Factors – evaluation of driver assistance technology, visibility, work load
5. Safety Analysis – crash data analysis identifies traffic safety problems and measures the impact on crashes of the problems studied in the other divisions. UMTRI also maintains the most comprehensive and detailed database of truck and bus fatal crashes available

**Major Opportunities and Goals**

There are several major federally funded ITS research opportunities that will have influence on commercial vehicle research:

1. Integrated Vehicle Based Safety Systems (IVBSS) – a major program funded by NHTSA which includes heavy trucks as well as cars
2. Strategic Highway Research Program II (SHRP II) – this program is soon to be initiated and does not appear to include heavy trucks, although this would be desirable
3. Vehicle Infrastructure Integration (VII)
4. Co-operative Intersection Collision Avoidance System (CICAS)

Efforts should focus on preventing collisions between trucks and lighter vehicles and to better protect the occupants of both vehicle classes (and all vehicle-type mismatches) Advances are required in driver task optimization; particularly with the anticipated use of system-based technological aids (driver assistant systems) in an effort to integrate the vehicle with the road system (traffic management, adaptive cruise control, lane keeping assistance).

An emphasis should be placed on crash avoidance using emerging technology. This could include truck perception at intersections; truck/car interaction at intersections (from the perspective of the small vehicle); and trucks as non-typical vehicles. Crash protection systems such as seating and restraint systems, cab /door latching integrity, cab interior surfaces (injury sources), fire resistance and vehicle crush zones in trucks to reduce truck aggressivity are examples of important complementary protection strategies.

**Challenges Facing Truck Research**

Truck manufacturers are surprisingly lean operations focused on final assembly of supplier parts and sub assemblies. There are very few funding opportunities directly available from the industry. However by partnering with the truck manufacturing industry it is possible to leverage research funds from the federal government.

**Bus Research**

Annually, between 300 and 350 buses are involved in fatal crashes, resulting in 400 fatalities and over 1,000 injuries. Bus operations on U.S. roads are, if anything, even more diverse than trucks and truck operators. School buses account for about a third of
bus fatal involvements, transit buses account for another third, charter and intercity operations make up about 15 percent, with the remainder consisting of irregular operators, shuttle buses, church (and other private organization) buses, and buses used by private companies.

There is an increased interest in bus traffic safety, driven by the tragic nature of recurrent high-profile crashes involving a large loss of life, as well as crashes involving vulnerable bus users such as children. There is also a growing trend of small informal operators who operate outside of the regulatory framework but who increasingly transport migrant workers and others in small vans. These “carriers,” often just an owner of a single passenger van, are thought to account for a disproportionate share of the bus traffic safety problem.

Research is needed to better characterize the scope and nature of the bus crash problem in a way that accounts for the diversity of bus operations in the U.S. UMTRI’s BIFA program produces the only crash data that can reliably identify bus type and identify the full range of bus operators in this country. Previous research has shown that the nature of the crash problem varies by bus operator type. Research is needed to characterize the nature of the crash problem for different operations types so that appropriate interventions may be tailored to specific bus operations.

For example, research is needed on driver vision around the bus for transit and school buses, which have a high proportion of crashes with non-motorists. Research into driver issues, in terms of training, licensing, and condition, is needed for over-the-road buses and particularly the irregular operators. Finally, bus “aggressivity,” characterized by the large mass and geometric mismatch with other road users, will be a fruitful area of future research. In all these areas, UMTRI is well-positioned to respond to future research needs.
UMTRI STRATEGIC PLAN  
March 14, 2006

2.5 Research Facilities

UMTRI needs compelling in-house research technology which can effectively and rapidly research complex environments and which leverages the technological developments occurring in the transportation system itself.

We currently have highly effective assets in the form of instrumented vehicles (with data acquisition systems suitable for naturalistic driving), driving databases with analytical tools, biosciences impact laboratory, accident databases and driving simulator.

We see the need for a dramatic improvement in measuring what drivers are doing while they are driving as well as measuring drivers’ values, attitudes and behaviors to safety and a wide range of sustainability issues.

2.5.1 Research Technology for Measuring Drivers

A number of technological developments are leading to much improved availability of driving data. Vehicle-vehicle and vehicle-infrastructure communication will provide a platform for increased data scope and depth. Driver monitoring systems incorporating video of the driver offer information on pre-crash driver actions and potentially occupant positioning and injury information in crashes. Software is being developed for image analysis which will convert video images into data. Fusion is occurring between sensor technologies in vehicles, to remove duplication and improve quality and reliability.

We intend to exploit all of these technologies and capabilities in our data collection systems.

Federal DoT sponsorship is the major enabler in naturalistic driving studies. A significant series of field operational tests (FOTs) has already been carried out and there is some evolution apparent in the FOT methodology. There is a need to accommodate larger numbers of private vehicles in FOTs and to reduce the cost of data collection. There is also an increasing need to measure the trajectories of other vehicles relative to the subject vehicle. Data collection will be required not only in vehicles but also at road sites such as intersections, and it will be necessary to combine vehicle-based and site-based data into a single unified database.

UMTRI’s efforts are being devoted to research technology which can measure the driver while he/she is driving, create relational databases and enable teams of researchers to deal concurrently with parallel data streams. This means that data visualization is a major requirement for the future.

As a flagship UMTRI facility, we will develop an ITS integration laboratory which will incorporate a moving-base driving simulator and provide data visualization with a high
degree of realism for multiple vehicles, allow a real time interdisciplinary team to operate with the data, handle multi-dimensional data and permit interaction with the data.

### 2.5.2 Vehicle and Highway User Perceptions and Behaviors

UMTRI is taking a strategic initiative to develop and implement a research platform to survey the users of the transportation system, to bring an understanding of people’s values, attitudes, and behaviors about safety, mobility and sustainability in transportation. We will conduct research on the diverse population of drivers and users of the transportation system. Our definition of transportation user should be broad enough to include drivers of passenger cars and light trucks, drivers of heavy-duty trucks, emergency first responders, and users of public modes.

This initiative will support manufacturers and suppliers in their efforts to deliver competitive, high-quality products to consumers. The research will also aid in the implementation of procedures and practices that increase manufacturing competitiveness.

We define “transportation system users” to include drivers of passenger cars and light trucks, drivers of commercial trucks, and first-responders (law enforcement, fire, medical). We will explore the inclusion of the following groups: (1) passengers on municipal or commercial buses or other multi-passenger vehicles, (2) commercial and public organizations that directly serve the transportation system (service and refueling stations, rest stops, adjacent food and lodging, etc.). We will expand our research into truck safety to encompass industry economics and driver occupational health and safety issues.

We should maintain a list of issues that the UMTRI transportation system user survey research program should address. The first draft of this list of issues should include:

- How do users think about driving as it fits into their overall lifestyle?
- What influences attitudes toward safety, mobility, and sustainability?
- What activities and attitudes influence people while driving and affect workload and attention?
- What user concerns need to be addressed in the deployment of new communication and recording technologies in vehicles and highways?
- Data on vehicle use have the potential to help improve the transportation system. What concerns do users have about their personal use data being accessible to government or private organizations? What policies are needed to facilitate reasonable access to vehicle use data and provide privacy safeguards?
- How can UMTRI assist automakers and infrastructure developers with information on user attitudes and issues?
- How can systems for safety, communication, and driver assistance be deployed in a highly competitive industry?
- What safety systems can reduce conflicts between trucks and passenger vehicles?
2.6 EDUCATIONAL MISSION

Along with its research and service roles, UMTRI aims to make a comprehensive contribution to the educational mission of the University. We propose to do far more than simply contribute. New and exciting initiatives will be undertaken that build on UMTRI’s unique strengths, and will result in training and educating essential future generations of transportation thinkers and leaders.

Among UMTRI’s strengths are its awareness of transportation issues, challenges, and opportunities; its superb databases and projects; its excellent relationships with sponsors and strong history of external funding; and its stimulating faculty with unique expertise. As an interdisciplinary research unit at the University of Michigan, UMTRI is extremely well-positioned to collaborate on projects and in training with faculty from a full range of the U-M’s rich array of academic departments and research centers.

Long-term trends that stimulate and inform our educational initiatives are: safety is only a part of much broader transportation trends and challenges; there is increased emphasis on human/behavioral factors in transportation; there is more complex technology, connected vehicles and infrastructure; and there is a need for research to respond to transportation challenges more quickly. UMTRI can meet these new challenges by helping to prepare new, well-trained transportation researchers to address the technology advances and to replace those retiring from the field. UMTRI’s interdisciplinary research approach is most appropriate to address these complex transportation issues, and to prepare future researchers.

We envision several educational initiatives to be launched in the coming years. Our Doctoral Studies Program (DSP) will ensure that more Ph.D. students complete their dissertation work at UMTRI (OVPR faculty involvement funds and various training grants can support this activity). There need to be more joint appointments for UMTRI faculty in academic units and academic faculty in UMTRI, as well as joint recruitments for such appointments.

A major transportation training conference, or summer institute for credit should be hosted by UMTRI. An UMTRI transportation research certificate should be awarded to U-M students who wish to focus on transportation within their academic area. There should be an increased effort toward scholarship fundraising and scholarship program activity. UMTRI faculty should be more involved in Centers of Excellence that attract students. UMTRI faculty should offer more guest lectures, and full courses covering the range of topics addressed by UMTRI research. There should be increased international training (UMTRI faculty at other institutions and visiting scholars at UMTRI).