Guest Editor's Introduction

An Electronic Copilot in Your Car?

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Electronics in the car continues to be a much debated issue. Fascination about its potential on the one hand and concerns about its invisible inner workings on the other hand, together with the impact on individual safety and freedom of action, provide a challenge probably unparalleled in any other field of applied microelectronics. With over 500 million cars on the world's roads, we certainly stretch our imagination if we think that all these units one day may have airplanelike cockpits in them. Moreover, with this or just because of this comparison, everyone of us can instantly quote many good reasons why electronic road traffic will be much more complex than electronic flying.

Appropriately, in the area of cooperative civil technology research and development, no more complex projects have ever been conceived than Prometheus in Europe and IVHS in the United States. Prometheus stands for Program of European Traffic with Highest Efficiency and Unprecedented Safety, while IVHS is short for the Intelligent Vehicle-Highway System. The public sector at state, national, and international levels as well as industry, academia, and consumer groups continue to advance these programs, which present unprecedented challenges for cooperation in very complex networks of communication and coordination.

The strategic plan for IVHS in the US gives us an impression of this unique scenario. Although IVHS as a consolidated program is only two years old, already more than 50 operational test sites are in place, and the projected expenditures for IVHS deployment in the US run beyond $200 billion over a 20-year period.

Prometheus was conceived in 1986 as a joint precompetitive research and development program by the European automotive industry in five countries: France, Germany, Great Britain, Italy, and Sweden. It now involves 18 car companies, many electronics and supplier companies, over 100 research institutes and universities as well as numerous consulting companies and public authorities such as those for transportation and telecommunications. In spite of its significance, the annual Prometheus budgets of about $100 million have been lean, with more than two thirds provided by the industry and one third by national ministries of research and technology. Road transport-related programs of the European Community like DRIVE (Dedicated Road Infrastructure for Vehicle Safety in Europe) supplement the effort, and, recently, numerous test sites have been established in Europe with partial regional, national, and European Community support.

In Japan, several major projects are under way: RACS (Road/Automobile Communication System), AMTICS (Advanced Mobile Traffic Information and Communication System), and recently VICS (Vehicle Information and Communication System).

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Individual travelers</th>
<th>Fleet operators</th>
<th>Businesses</th>
<th>Government agencies</th>
<th>Society at large</th>
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<tr>
<td>Safety</td>
<td>40</td>
<td>20</td>
<td>—</td>
<td>—</td>
<td>40</td>
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<tr>
<td>Congestion</td>
<td>30</td>
<td>20</td>
<td>—</td>
<td>20</td>
<td>30</td>
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<tr>
<td>Environmental benefits</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>100</td>
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<tr>
<td>Energy conservation</td>
<td>30</td>
<td>10</td>
<td>—</td>
<td>—</td>
<td>60</td>
</tr>
<tr>
<td>Universal mobility and accessibility</td>
<td>70</td>
<td>10</td>
<td>—</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Public transportation</td>
<td>60</td>
<td>—</td>
<td>—</td>
<td>20</td>
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<tr>
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<td>40</td>
<td>—</td>
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<tr>
<td>Law enforcement</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>30</td>
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Source: Sigmund Silber

The scope and the progress of these programs are so multifaceted that I've had to deliberately select a certain topical area to give a somewhat concise view in this magazine of the present state of goals and results.

What are the expected benefits of intelligent vehicle-highway systems? A matrix, reproduced in Table 1, addresses the major issues of safety, congestion, environmental benefits, energy conservation, universal mobility and accessibility, public transportation, and economic activity. Prometheus displays a similar ranking when one considers its major European demonstration projects.

- **Safe driving**
  - Vision enhancement
  - Proper vehicle operation
  - Collision avoidance

- **Traffic flow harmonization**
  - Cooperative driving
  - Autonomous intelligent cruise control
  - Emergency systems

- **Travel and transport management**
  - Commercial fleet management
  - Dual-mode route guidance
  - Travel information services

Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CVO), and Advanced Public Transportation Systems (APTS).

The potential benefits from the view of the individual driver most likely focus on safety and mobility. The program areas of safe driving and traffic flow harmonization in Prometheus as well as Advanced Vehicle Control Systems in IVHS address these topics most closely. I've selected the articles in this issue of *IEEE Micro* accordingly.

A look at the causes of road traffic accidents and congestion (Figure 1) immediately shows the need and potential for significant improvements through the realization of what we colloquially call the electronic copilot in the car. Over 90 percent...
of all accidents in road traffic still result from human error.

Although the human brain's capacity for learning, association, memory, and processing far surpasses any computer conceivable at present, it is decidedly slow. The human reaction and decision cycle takes about 2 seconds, which is equivalent to traveling 50 meters in high-speed road traffic. Delays and errors in braking, passing, negotiating obstacles or curves, or recognizing signs and signals result in a presently unavoidable toll of accidents. Advancing the reaction time by just 1 second would eliminate 80 percent of these accidents.

Fatigue, misjudgment of safety margins, and incomplete knowledge of the status of our own vehicle and of other participants and objects in our relevant road traffic zone are the other major reasons for accidents and congestion. These causes indicate that significant benefits can and will only be possible if the electronic copilot in our car can communicate with other traffic partners, with the roadside, and with the travel management system.

Clearly, this scenario of road traffic differs considerably from what we have today, and it will take the cooperation of all constituencies to move into this new era. However, two major forces may bring about change:

- congestion and pollution approach total deadlock faster than present relief programs can affect, and
- big opportunities exist for the world's advanced economies to serve their citizens in the need and desire for safe individual mobility.

In the first article, "Research and Development Needs for Advanced Vehicle Control Systems," Steven Shladover of the University of California, Berkeley, who is also chair of the IVHS Advanced Vehicle Control Systems committee, identifies what must be accomplished in the new control systems. The second article presents an exemplary realization of an integrated system: the Arena public road test site in West Sweden. Its author, Ulf Palmquist of AB Volvo, is a deputy member of the Prometheus Steering Committee and chair of the Technical Board of the Swedish Road Traffic Informatics Program.

Given this scope of road traffic electronics, it is evident that mainstream microelectronics will not directly qualify for the car control functions, which are all safety-relevant. Car control electronics must have:

- avionics reliability,
- no box protecting it from the environment,
- small volume and weight like a pocket computer, and
- lower cost than individual consumer electronics.

Among all these design and manufacturing challenges, microelectronics reliability is most important. Accordingly, reliability research has been a common thread in the Prometheus PRO-CHIP (Prometheus Custom Hardware for Intelligent Processing) subprogram, a basic research program in which over 40 institutes in France, Germany, Italy, and Sweden participated. Enrico Zanoni of the University of Padua, Italy, who has been the European lead researcher on reliability in PRO-CHIP and who has also been instrumental in establishing the reliability laboratory at the national institute CSATA, Bari, Italy, summarizes these activities in his article, "Improving Reliability and Safety of Automotive Electronics."

Advanced vehicle control systems will benefit from any imaginable development of new hardware and software with a special quest for robustness and cost. I've chosen two examples to indicate feasible solutions. Vision enhancement in fast-changing traffic scenes is possible with a high dynamic-range, random-access silicon camera. This is a prerequisite in a system for longitudinal and lateral car control. Given that support, it is still an intricate task to mimic the steering behavior of an alert driver. The concluding article describes a trained digital neurocontroller that serves as the steering assistant in a Mercedes car, which is under continuous test in normal road traffic.

Any view of car control systems presently under development or test should conclude with the comment that the deployment of these systems will be characterized by three stages to be accomplished over the next 20 years:

- advice and warning systems,
- support systems, and
- control systems.

IN THE SPIRIT OF THE UNIQUE COOPERATION in electronic road traffic as a significant civil technology research and development program, I must thank the many experts for their support. Special thanks go to the authors and the reviewers of the articles in this issue. I gratefully acknowledge the members of the European Steering Committee of PRO-CHIP and their contributions. They represent the many helpful scientists in Prometheus: Gianni Conte, Parma, Italy; Daniel Estève, Toulouse, France; and Peter Weissglas, Stockholm, Sweden.

References

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