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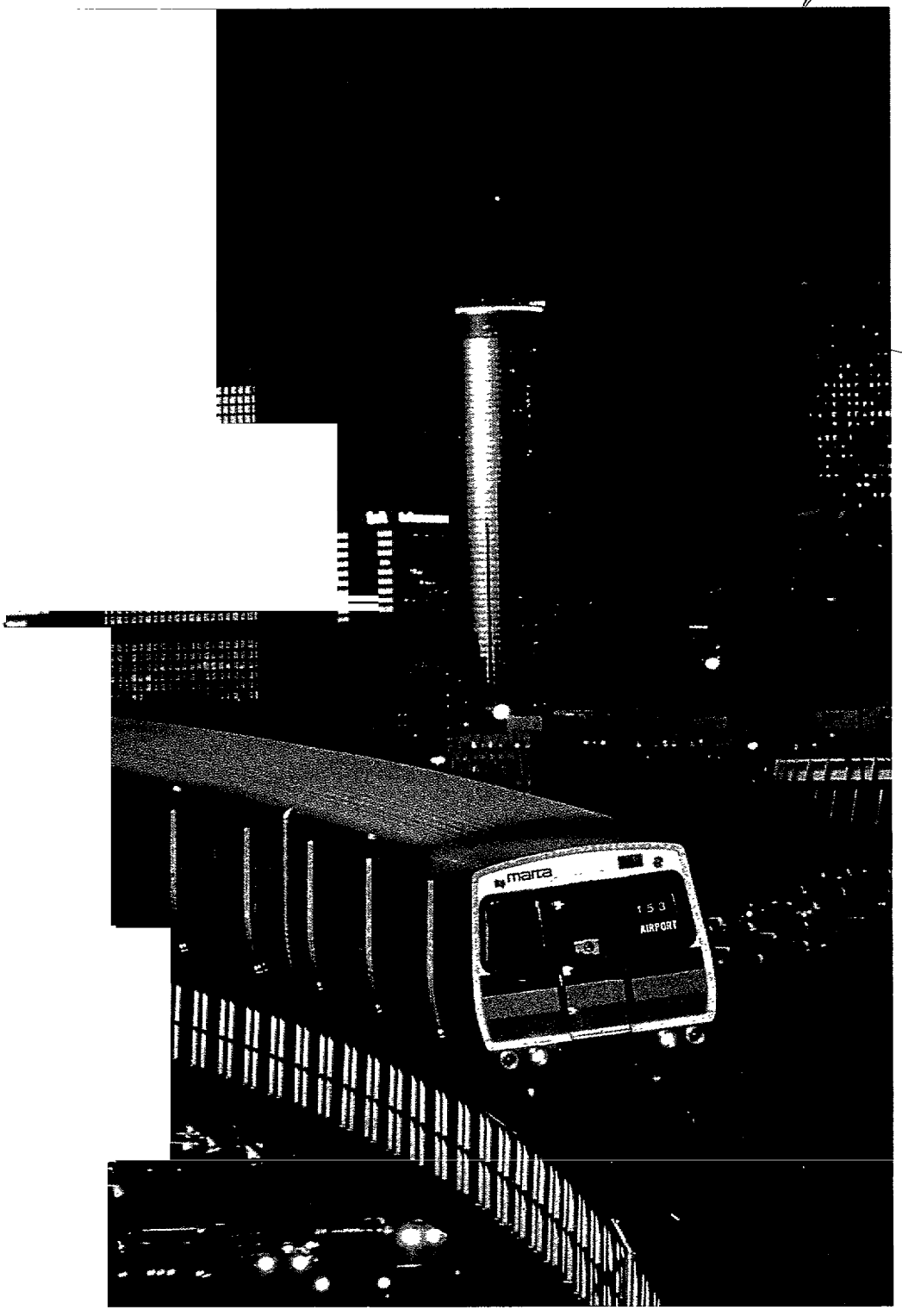

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Intelligent Vehicle Highway Systems: Going Places Fast

Tom Rose
M/A-COM, Microelectronics Division
Lowell, #A

Introduction

When people think of intelligent vehicle highway systems (IVHS), which combine the powers of radar and communications systems, electronics and computer control software to improve highway safety and efficiency, they usually imagine a space-age scenario years in the future. And while it is true that the Department of Transportation is expected to spend more than $350 B (more than the Apollo project) on developing a nationwide IVHS infrastructure incorporating microwave and other technology over the next 30 years, many IVHS applications are in use right now. For example, in numerous sites across the US, drivers are breezing through toll collection booths by paying tolls electronically with the use of microwave sensors tuned to magnetic and smart card technology. Collision warning radar systems, which notify drivers of vehicles or objects in front of their vehicles, are now being installed in 2400 Greyhound buses. Over 100 vehicles in Orlando, FL, including 75 rental cars, are now equipped with a navigation system incorporating wireless communications that utilize roadside beacons to provide information on local restaurants and hotels, as well as the best routes to reach them.

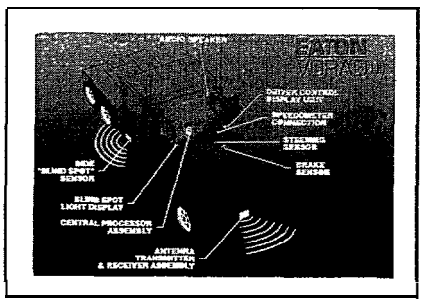

Fig. 1 The VORAD collision warning system.

A Solution to a Growing Problem

This is only the beginning for IVHS, considered by many to be the next evolution in highway transportation, which is often exemplified by the bumper-to-bumper traffic at rush hour in every major, and not so major metropolitan area in the country, if not the world. Streets are becoming more and more congested, while the ability to build new and/or bigger roads, especially in urban areas, where space is at a premium, is limited if not decreasing. Since the 1970s, total travel on American roads has more than doubled.1

A report from the General Accounting Office (GAO) states that this increasing traffic congestion and resulting delays translated to $100 B in lost productivity in 1991. Traffic congestion also results in wasted fuel (two billion gallons in 1991), more air pollution and more frequent accidents. The solution is to use the current roads more efficiently and safely through IVHS.

Different IVHS Components

There are many different elements of IVHS, and almost all will have a direct impact on the microwave marketplace. Mobility 2000, an informal group of individuals from government, industry and educational institutions whose goal is to define a national cooperative program for IVHS, has broken down IVHS technologies into four areas, including advanced vehicle control systems (AVCS), advanced traffic management systems (ATMS), advanced traveler information systems and commercial vehicle operation (CVO).

Advanced Vehicle Control Systems

AVCS uses collision warning and avoidance technology, such as radar sensors, to identify nearby vehicles and other obstacles in order to prevent collisions. A study2 found that one extra second of warning could prevent approximately 90 percent of rear-end collisions and about 60 percent of head-on collisions. Providing drivers with this additional reaction time is one of the driving forces behind these IVHS systems.

An example of collision warning is the vehicle on-board radar (VORAD) vehicle detection and alert system offered by IVHS Technologies and the EATON Corp. The VORAD system, shown in Figure 1, is a good example of conversion of defense radar technology to practical commercial application. The VORAD radar is a K-band Doppler system using a planar narrow beamwidth antenna, an integrated transmitter/receiver assembly (both supplied by M/A-

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COM), and a digital signal processor. This radar provides the performance of a complex military radar with the reliability and cost profile of a consumer product. This low cost system is capable of reliable operation in the demanding environment of heavy vehicles. The VORAD radar can track up to 20 targets at a time, and achieves this performance with an absolute minimum of radiated power. The VORAD system is a shining example of what is possible in converting military technology to a useful commercial application.

The VORAD system determines the position and speed of objects ahead. If the system senses a potential danger, a warning is sounded, giving the driver additional time to take evasive action. Other components of this system are near object detection sensors (NODS) that can be located on the sides or rear of the vehicle. These sensors indicate with a visual signal if an object has entered the vehicle's blind spots. In addition, an audible alarm is sounded if when the driver turns on a directional signal or puts the vehicle in reverse the NODS detects a potential collision with an object in the immediate vicinity.

The VORAD system also features a black box capability that aids in reconstructing the events leading up to the collision. Data gathered by this capability can provide invaluable information to insurance adjustors, litigators and law enforcement officials trying to determine responsibility for the accident. This feature is especially discerning in collisions involving vehicles with anti-lock brakes, which do not leave skid marks at the accident site.

Unlike collision warning systems that only alert the driver to potential collisions, collision avoidance systems automatically take evasive action to prevent an accident and/or injuries. The first step of this technology currently in use is airbags, which are automatically deployed when sensors imbedded in the front of the car detect a certain force of impact. As products for this area are developed, there will be many opportunities for microwave technology, where such technology is incorporated in a closed-loop system. An example currently being evaluated is a radar system that enables an adaptive cruise control function to adjust the vehicle's speed automatically so that it remains at a specified distance behind the vehicle ahead of it.

Advanced Traffic Management Systems

Another area of potential growth for the microwave industry is in ATMS, which uses roadside scanners, microwaves and infrared technology to identify traffic problems, and alert drivers and emergency response vehicles accordingly. Initial advanced traffic management systems, such as the Euro-Scout developed by Siemens Automotive of Siemens AG, Munich, use infrared technology. However, infrared has limitations because of reliability problems in certain environmental situations.

Vehicles are equipped with infrared or microwave receivers, an interface keyboard, a small arrow indicator guidance display, a computer and a voice messaging system. The car's transmitter and receiver send and collect traffic information as the car passes roadside beacons on traffic lights. These roadside beacons are hooked up to a central control facility where information about traffic congestion and travel time are collected. This information can then by relayed back to the vehicle, with appropriate traffic advisories.

These systems can also aid in navigation by tracking the location of the vehicle in relation to the chosen route. The system uses this information to prepare the driver for a direction change or to suggest a lane change.

Advanced Traveler Information Systems

Advanced traveler information systems not only provide drivers with information about traffic delays and navigational information, but also with data about local attractions, hotels and restaurants. These systems include elements such as video screens and/or heads-up displays, microcomputers, radios for data communications and on-board antennas and receivers to interface with the global positioning satellite (GPS) system. Upon request, a menu of local attractions, such as hotels or restaurants in the vicinity, can also be called up on the video screen.

One of the best known examples of this technology is the $8 M TravTek project, a cooperative partnership of General Motors Corp., the Federal Highway Administration, the Florida Department of Transportation, the Automobile Association of America, and the city of Orlando. TravTek offers drivers information about Orlando hotels and restaurants, and route guidance instructions using simple intersection schematics and directional arrows. When drivers select destinations, TravTek determines the most efficient route.

Commercial Vehicle Operation

CVO utilizes many of the mentioned IVHS technologies to speed deliveries and enhance safety. For instance, ATMS technology is being used by truck fleets to monitor the location of their vehicles and reroute them when necessary. Commercial vehicles also benefit from AVCS. VORAD is being installed on some 2400 Greyhound buses, as well as on numerous independently operated trucks.

Many CVO technologies, especially those involving safety, have practical applications for passenger cars as well. However, commercial vehicles are using these technologies first because they have the most to gain from the lower insurance rates, reduced property damage and increased efficiency offered by IVHS systems. The experience of commercial vehicle operators is expected to provide the needed baseline of confidence before the adoption of IVHS safety features in passenger cars.

For instance, one currently used CVO technology that benefits passenger cars is electronic tolling. Electronic tolling, operating in numerous locations across the US, is a rapidly growing application of this technology. The driver pays road tolls by inserting a magnetic or smart card into a small radio frequency transponder on the car dashboard. Receivers mounted above or in the pavement communicate with the transponder, noting the driver's entry and exit points of

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the toll-zone on the road, and the driver's credit or debit status, depending on the system. The receiver then transmits the toll amount back to the transponder, where the transaction is recorded. This entire procedure takes only milliseconds, eliminating the need for the driver to stop or even slow down as he/she approaches the toll collection area.

The applications of this technology are not limited to road tolls, but can also be used for automatic vehicle identification (AVI). One European company is even working on a smart parking system that would inform an approaching driver of available parking spots in a parking garage, direct the driver to the spot, and record and charge the parking fee to a smart card when the driver exits the garage.

Tremendous Market Potential

The potential scope of the IVHS market is staggering. One study3 predicts that by the year 2002, a mere nine years away, five percent of all cars will have collision warning systems. Since 32 million vehicles are produced worldwide each year, the opportunity for the microwave marketplace is tremendous. Another report4 predicts that revenues from automotive sensors alone will experience a compound annual growth rate of 13.2 percent in the immediate future, growing from about $1 B in 1988 to almost **$2.6** B by 1998.

Heavy Vehicle Market Potential

Currently, the greatest short-term potential growth is in the heavy vehicle market. There are now three million heavy vehicles in the **US,** and 200,000 new heavy vehicles are produced in this country each year. Heavy vehicle drivers have a professional interest in IVHS efficiency and safety. Finally, the economic payback for heavy vehicle operators is greater. It is estimated that a collision warning system installed on a typical truck fleet will pay for itself if it prevents just one accident.

This potential was the impetus for the Heavy Vehicle Market Consortium, of which M/A-COM is a member. The consortium was founded in February of 1993. In addition to M/A-COM, the consortium is comprised of IVHS Technologies Inc., Allstate Insurance Co., EATON Corp. and AIL Systems Inc. The mission of the consortium, the first such alliance in this field in the US, is to bring real technology and product applications to the IVHS market quickly. The consortium is dedicated to using microwave technology because it is more reliable than infrared technology, which can be severely impacted by adverse weather conditions.

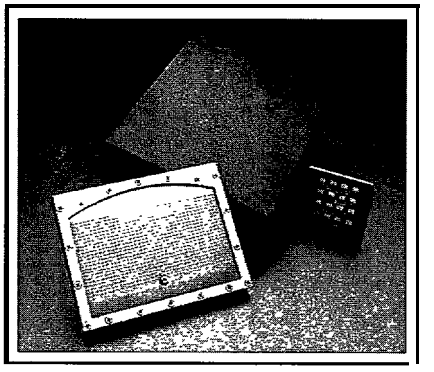

Fig. 2 Automotive mm-wave radar front-ends used in the VORAD vehicle detection and driver alert system.

In the consortium, M/A-COM, Allstate and EATON have taken equity positions in IVHS Technologies Inc., the parent company of VORAD Safety Systems. In addition, M/A-COM, along with AIL Systems, an EATON subsidiary with a long history of radar development, will provide technology. M/A-COM's broad range of RF, microwave and mm-wave radar sensor products are already used in various IVHS applications. Figure 2 shows automotive mm-wave radar front-ends used in the VORAD vehicle detection and driver alert system.

International Opportunities

The trend to IVHS is by no means limited to the US. In Europe, the need is addressed by the Dedicated Road Infrastructure for Vehicle Safety in Europe (DRIVE) and the Program for European Traffic of the Highest Efficiency (Prometheus) projects.The Prometheus project, the better known of the two, is a $700 M research project started in 1987 by 18 European car manufacturers. It includes vehicle-oriented research supplied by 40 research institutions, the European electronics industry, traffic engineering agencies and telecommunications industries. In Japan, the two major projects in the works are Advanced Mobile Traffic Information and Communication Systems (Amtics) and the Road/Automobile Communication System (RACS). RACS is now in the process of being merged with a project called Vehicle Information Communication System (VICS).

Conclusion

IVHS is rapidly becoming a reality, and the market potential for IVHS technology is tremendous. Companies and alliances, such as the Heavy Vehicle Consortium that are poised to take advantage of these opportunities can help the US and the world address the problem of congested roads by offering technology solutions that make ground transportation safer and more efficient than ever before. ■

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Thomas A. Rose *received his BS degree in physics from Fairfield Universitv and his MSEE anb MBA degrees from Northeastern University. Rose is the director of commercial marketing and business development at M/A-COM's Microelectronics Division, where he has focused on the wireless and IVHS/automotive markets. Also, he has served in various management positions at M/A-COM in operations, sales, marketing and business development. Rose's career* **in** *microwave engineering includes Rockwell Co//ins, Lockheed Sanders and Raytheon. He is a member of IEEE.*