INTELLIGENT TRANSPORTATION SYSTEMS (ITS) AND THE TRANSPORTATION SYSTEM

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Contents

Summary

Intelligent Transport System applications in different areas of transportation are reviewed. These include traffic management, mobility, safety, public transport management, energy consumption and pollution. The effectiveness of ITS is limited at present because of slow market penetration, unproved and complex systems, and rapidly changing technologies. A most difficult outcome to predict is behavior modification by road users in response to the system after introduction, negating its benefits. ITS will be implemented for all uses in increasing intensity in the high income countries and for personal benefit of rich car owners. In low and middle income countries the promising areas are optimizing public and taxi transport, truck fleet management, pollution control

and safety devices that prevent drunken driving and speed control.

1. Introduction

The invention of the internal combustion engine in the nineteenth century changed the way people travel forever. For the first time in human history it became possible for human beings to achieve travel speeds an order of magnitude greater than they had ever experienced before. Even better, they did not have to use their own energy in any significant manner to do so. This quality of the motor car has almost everyone addicted to its use if they can afford to buy and use one. From just a handful of vehicles a century ago, now there are more than 500 million cars, buses and trucks on the roads around the world, and the number continues to increase. Road transport makes it easier for us to have access to jobs, schooling, markets, and leisure time activities and helps economic growth. However, now there are serious concerns about the detrimental impact of transport on human health and the environment. The negative externalities include: accidents, air pollution, congestion, climate change, noise, and spoiling of the landscape and urban environment. More recently, concerns about global warming focused our attention on transport as it accounts for about a fifth of all greenhouse gas emissions, mainly carbon dioxide from fuel burnt on the roads by vehicles.

Of all these, three main concerns dominate the thinking of the designers of vehicles and transport systems – reductions in crash injuries, emissions and congestion on roads. Over the past decade advances in computer systems and communication technology have given us a hope that we can accelerate the process to ameliorate the negative externalities of motor vehicle transport. Intelligent Transportation Systems (ITS) encompass a very wide range of technologies to deal with issues mentioned above. It is expected that when integrated into the transportation system's infrastructure, and in vehicles themselves, these technologies will help relieve congestion, reduce pollution and increase safety.

1.3. History of ITS

Interest in ITS begins as computer systems start becoming cheaper and smaller. In the late 1960s and early 1970s Comprehensive Automobile Traffic Control System (CACS) was introduced in Japan and the Electronic Route Guidance System (ERGS) in the United States, and in Germany. These technologies attempted to integrate complex route guidance systems and in vehicle displays. However, technical snags and high costs prevented any of these systems from being accepted on a practical scale.

Starting in the mid 1980s, ITS got a major boost when communication technologies became much cheaper and reliable and computation capabilities expanded enormously. The motor vehicle industry detected an opportunity to add value to their products and government agencies possibilities of solving problems of congestion and safety. Large projects were launched with government-industry partnership. The European Union started Dedicated Road Infrastructure for Vehicle Safety in Europe (DRIVE), the auto manufacturers-sponsored Program for a European Traffic System with Higher Efficiency and Unprecedented Safety (PROMETHEUS), the Japanese worked on the Road/Automobile Communication System (RACS) project, and in the U.S. the

Intelligent Vehicle-Highway Systems (IVHS) project was funded. Funding for Advanced driver assistance systems (ADAS) increased during this period and aimed at providing information systems keeping the driver in full control over the vehicle and receiving supporting information from the system to an eventuality when a vehicle could be operated under fully automated control on a dedicated lane on a highway.

While there has been considerable progress on all these fronts, advances have not come as fast as forecasted. We are yet to see much improvement in overall safety or congestion. Successful deployment of ITS include:

- Route guidance systems that have become available commercially and in wide use.
- Computer systems in cars that control emissions, guide restraint system (including air bags) deployment, and electronic stability control systems that prevent vehicles from rolling over.
- Toll collection and traveler information systems on highways.
- Road pricing and electronic vehicle monitoring systems in cities.
- Transit management with vehicle tracking and passenger information systems.

1.4. ITS applications

There are many ways to group ITS applications, and one possible way is as follows:

(a) Traveler information
- Pre-trip information
- On-trip driver information
- On-trip public transport information
- Personal information services
- Route guidance and navigation

(b) Traffic Management
- Transportation planning support
- Traffic control
- Incident management
- Demand management
- Policing/enforcing traffic regulations
- Infrastructure maintenance management

(c) Vehicle
- Vision enhancement
- Automated vehicle operation
- Longitudinal collision avoidance
- Lateral collision avoidance
- Safety readiness
- Pre-crash restraint deployment

(d) Commercial Vehicle

- Commercial vehicle pre-clearance
- Commercial vehicle administrative processes
- Automated roadside safety inspection
- Commercial vehicle on-board safety monitoring
- Commercial vehicle fleet management
- Automated Diagnostic Systems

(e) Public Transport
- Public transport management
- Demand responsive transport management
- Shared transport management

(f) Emergency
- Emergency notification and personal security
- Emergency vehicle management
- Hazardous materials and incident notification

(g) Electronic Payment
- Electronic financial transactions

(h) Safety
- Public travel security
- Safety enhancement for vulnerable road users
- Intelligent junctions

Most of the above applications can be grouped into the following goals:
(a) Safety
(b) Mobility
(c) Management and revenue collection
(d) Energy and Environment

2. ITS and Behavior Adaptation

The use of ITS has elevated the expectations of society and the individual traveler, based on the promise of the technologies involved. In addition, the producers and marketers of these technologies have at times introduced unnecessary hype in what is possible in the future. The results have been mixed.

The less than expected performance in the real world for some promised solutions is partly because human beings change behavior when the system around them changes. In other words, people adapt to what other people and technologies require of them to function according to their own expectations. Such adaptations produce unintended or unexpected results. Some examples are given below:

- If an ITS feature increases perception of safety in a road user then the road user may start behaving in riskier ways. Perceived safety usually increases if there is feedback, convincing the driver there is increased safety. For example, drivers of vehicles equipped with Antilock Braking Systems (ABS) have shown an adaptation to this feature by taking on more risk including hard brake maneuvers since they do not expect their vehicles to skid. Drivers with vehicles equipped with ABS therefore have changed the patterns of crashes they are involved in and overall crash reductions are much less than expected. ITS systems that improve the handling characteristics of vehicles may lead to increased use of those vehicles under adverse weather conditions like heavy rain, snow or ice. This is not to say that all safety devices produce such adaptations. Use of helmets, seat belts and airbag equipped cars do not seem to have the same result because the driver has no instant feed back that the system has become safer. These latter devices only provide protection once you have a crash and most of the motorists never have this experience.

- Onboard driver assist systems can produce a task overload when several tasks compete for attention of the driver. The addition of visual or auditory attention by ITS can distract the driver from the main driving task and result in errors or slowed reactions. Both can increase the risk of a collision and also divert the driver's attention to tasks that are not related to driving. These tasks, for instance the operation of route guidance systems, can distract the driver to take away time from the driving task.
- Route guidance and traffic information systems can help drivers chose roads and streets that they normally do not use, are unfamiliar with and do not know their way around. This can result in a redistribution of traffic through areas where high traffic densities are not desired and end up increasing traffic on all roads. This redistribution of traffic may not correspond with what is desirable from a societal point of view. Short cuts through residential areas may increase probability of crashes, pollution and noise. In such a situation local residents could find ways to prevent these negative impacts by physical road blocks or traffic calming measures, thus negating the original benefits of the ITS system.
- If the effect of ITS is to reduce the drivers' role in active control of the vehicle then they may adapt to it and over time depend completely on these systems. Then they are likely to be less sensitive and incapable of taking active control in complex situations. Overdependence on ITS systems can also produce task under load and make the driving task very monotonous resulting in attention deficit. The knowledge about these effects is still in its primitive stage and it is very difficult to predict how human beings adapt to such changes over a long period of time.
- Experts concerned with pollution, energy consumption and global warming issues have also cautioned us about the effect of technologies that making driving much more pleasurable and less difficult. Creation of new trips because drivers feel comfortable going to unknown destinations with less uncertainty will lead to an undesired increase in the use of motor vehicles.

The above concerns give us an idea of the complexity of man-machine interaction outcomes and remind us that sophisticated technology alone will not determine the successful deployment of ITS. Bearing in mind these safety considerations and challenges, the sections below, outline some of the benefits of ITS.

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Biographical Sketch

Dinesh Mohan is Professor for Biomechanics and Transportation Safety and Coordinator of the Transportation Research and Injury Prevention Programme at the Indian Institute of Technology, Delhi. He obtained his BTech in Mechanical Engineering from the Indian Institute of Technology Bombay, followed by a Masters degree in Mechanical and Aerospace Engineering from the University of Delaware and then a PhD in Biomechanics from the University of Michigan, Ann Arbor. He started his research career working on vibrations of anisotropic plates and moved on to mechanical properties of human tissues. This was followed by work on head, chest and femur injury tolerance, injuries in human free falls, effectiveness of helmets, child seats and the first evaluation of airbags in real world crashes. Concerned with mobility and safety of people outside the car he is trying to integrate these issues within a broader framework of sustainable transport policies, urban transport options and people's right to access and safety as a fundamental human right. He has co-authored and edited five books on safety. He is the recipient of: Distinguished Alumnus Award of Indian Institute of Technology Bombay, the American Public Health Association International Distinguished Career Award, the Bertil Aldman Award of the International Council on Biomechanics of Impacts, the Association for Advancement of Automotive Medicine's Award of Merit and the International Association for Accident & Traffic Medicine's International Award and Medal for outstanding achievement in traffic safety.