Feasibility Of The Deployment Of Intelligent Transportation Systems (ITS) In Jordan”

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FEASIBILITY OF THE DEPLOYMENT OF INTELLIGENT TRANSPORTATION SYSTEMS (ITS) IN JORDAN

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ABSTRACT: The main objectives of this paper include: 1) giving an overview of the up-to-date development and deployment of Intelligent Transportation Systems (ITS) all over the world; and 2) assessing the feasibility of the application of ITS in Jordan.

ITS use advanced electronics, communications, computers and information systems to improve productivity, operating efficiencies and safety in the transportation sector. They include various systems such as: Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS), and Advanced Vehicle Control and Safety Systems (AVCSS).

This paper presents an extensive overview of the goals of each ITS program, state-of-the-art, benefits, barriers, limitations, research and development programs, and operational testing and deployment.

A framework to integrate ITS with other systems such as Geographic Information Systems (GIS), Vision Systems, and Artificial Intelligence including Knowledge-Based Systems and Expert Systems is also presented. This integration of advanced computerized systems has the advantage of automating decision making support which will aid the drivers in their decisions.

Real-time knowledge of traffic system performance and documentation of congestion levels and responding to them during rush hours make it possible to propose the deployment of ITS on selected high volume corridors in Greater Amman area. This of course requires an extensive studies and testing, money, and convincing people to accept and understand the technology of ITS.

Keywords: Intelligent Transportation Systems, Information Systems, Geographic Information Systems, Vision Systems, Real-time, and Decision Making.

1- Introduction

Intelligent Transportation Systems (ITS), formerly Intelligent Vehicle/Highway Systems (IVHS), is considered as a hot issue in transportation engineering because this technology is anticipated to solve the current problems of urban traffic congestion through an automated system to control traffic movement. ITS include a range of technologies and ideas that can improve mobility and transportation productivity, enhance safety, maximize existing transportation facilities and energy resources, and protect the environment. It is based on modern communications, computers, and control technology (Mobility 2000 1990, and Federal Highway Administration 1991). It is often called "Smart Cars" and "Smart Highways" because it involves interaction of advanced communications technology, electronic information displays, warning systems, and vehicle/traffic control systems. ITS is, therefore, not a single, static technology, but a continually evolving group of technologies, by which each advancement will build upon previous advancements, and provide increase benefits to highway operators and users. Some research activities of ITS include: vehicle detection, incident detection, real-time measurements, routing systems, safety advisory and warning capability, pilot operational use of automated control, information technology, etc.
The United States, besides other countries such as Japan and European countries, are now moving from the enormously successful Interstate Highway construction program to programs that will set the course of highway transportation well into the 21st century. Their programs will develop, test, and deploy advanced electronics technology and systems to meet the increasingly critical operational needs of the highway transportation systems. The ITS technology trend is targeting a fully automated, computerized, and digital image-based communication information systems. Particularly, vehicle detection through image processing is considered one of the most attractive alternatives of this technology. Other traffic activities which could be quantified through computer vision technology include: congestion level, queue length, incident detection, vehicle's running speed, etc.
This paper gives a spot light and an overview about ITS, its functional systems, proposed and deployed projects, its benefits if compared with current traffic management systems, academic effort in ITS, and the feasibility of ITS application in Jordan. Further, incorporating of GIS and Vision Systems with ITS is proposed.

2- ITS Database

ITS information management system obtain information from road sensors, traffic reports, city maps and event schedules, and generates information to drivers, traffic controllers and researchers (Yang Hanocock 1991). Figure 1 shows the general database of the ITS.

3- Functional Areas of ITS

Mobility 2000 (1990) and U.S. Department of Transportation report (1996) addressed the traffic, traveler information, and public transportation advances as the critical components to form an integrated ITS. They set the infrastructure core of ITS components for ITS technology evolution. These components include: congestion reduction, freeway and incident management, transit management, traffic signal system, electronic fare payment, delivers safety, security, traveler information systems, and productivity benefits. Traditional categorization of ITS normally has the following functional areas:

3.1 Advanced Traffic Management Systems (ATMS)

ATMS permit real-time adjustment of traffic control system and variable signing for driver advice. ATMS involve detection, communication, and control. A surveillance system detects traffic conditions in a metropolitan area and transmits the information to a traffic management center to process the information. The processed information is used to advise people about current and expected traffic conditions; to recommend the best routes; to inform drivers of the location, severity, and expected duration of incident; and develop ramp metering rates and update traffic signal timing.

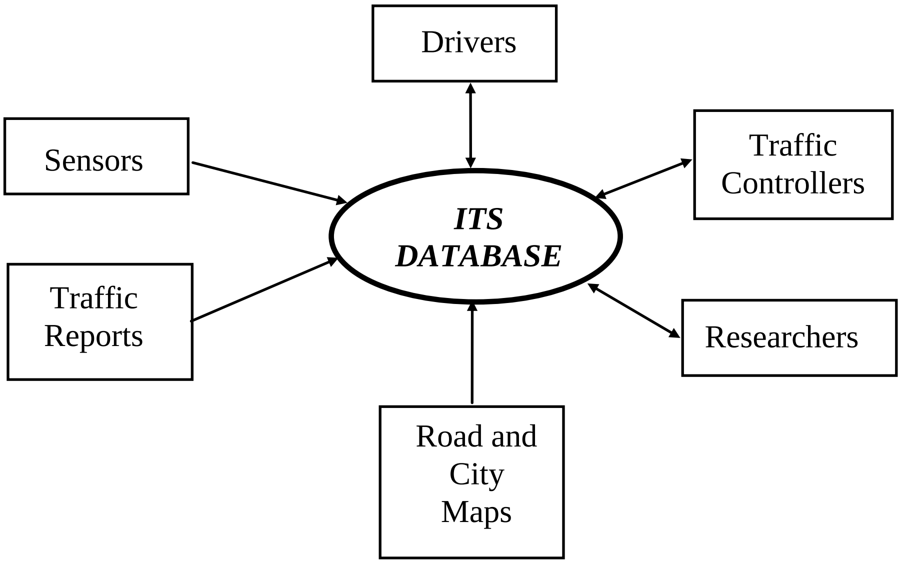

Figure 1: Structure of ITS Database.

The following examples demonstrate the benefits of ATMS in the U.S by reducing accidents, reducing congestion (by improving traffic flow), and reducing emissions (Stehr 1991): a) in Minneapolis/St. Paul freeway, speeds increased 35%, and accidents declined 27%; b) in Seattle, ramp metering reduced travel time from 22 to 11.5 minutes, while volume rose and accidents decreased; and c) in Long Island, travel time decreased 13% to 20%, fuel consumption fell 6.7%, and hydrocarbon and carbon monoxide fell to 15.2%.

Efficiency and capabilities in traffic management have been expanded toward a fully-integrated network-wide including advanced sensors, analysis, and software which allow metropolitan areas to manage arterial and freeway roadways within real-time control capability.

3.2 Advanced Traveler (Driver) Information System (ATIS)

These systems let drivers know their locations and how to find desired services through alternate routes, and safety issues in real-time guidance (Heywood 1991). The main features of ATIS include: map-match navigation system, information from traffic management centers on congestion, incidents, electronic vehicle identification for toll debiting, vehicle location, route-planning of minimum distance of travel, information receiver, assistance for age drivers, color video display for streets maps, complete database with detailed maps, traffic information and route guidance, highway-advisory radio, and safety advisory systems. In the U.S. public/private sector partnership was the key of ATIS marketing.

3.3 Advanced Public Transportation Systems (APTS)

This ITS category deals with public transit. Technologies related to this system include: fleet management, mobility management, traveler information, and electronic fare payment (smart cards using credit cards). Transit fleet management uses Global Positioning System (GPS) data to automate the location of vehicles within real-time.

There have been a significant number of full deployments of ITS in the U.S. besides other operational tests.

3.4 Commercial Vehicle Operations (CVO)

CVO select from ATIS those features critical to commercial and emergency vehicles. ITS technologies of use to commercial vehicles include: weigh-in-motion, on-board computer, automatic vehicle identification, automatic vehicle classification, electronic placarding/bill of loading, two-way real time communication, and automatic clearance sensing.

3.5 Advanced Vehicle Control System (AVCS)

AVCS applies additional technology to vehicles to identify obstacles and adjacent vehicles. Thus, it will assist in the prevention of collisions and in safer operation at high speed. By interaction with other systems such as ATMS, AVCS can provide automatic vehicle operations. Three levels of enhancements are foreseen: a) early AVCS technology: this uses a radar-type technology and other on-board systems to provide additional warning time (especially for rear-end collision, and intersection accidents), observe presence of vehicles or obstacles in blind spots, and warn drivers of loss of alertness; b) intermediate AVCS: here vehicles would enter the lane voluntarily under manual control, but once in the lane, it would be under full or partial control. The advantages of this include: increased speed and safety, reduced collisions, platooning, and private vehicles communication of travel paths; and c) completely automated AVCS: this will be effective in automatic chauffeuring of vehicles from on-ramp arrival to off-ramp departure, and realizing a new level of safety and mobility through high-speed.

3.6 Advanced Rural Transportation Systems (ARTS)

Rural areas account for a high percentage of the total road mileage. Thus, if compared with urban areas, they have a unique set of characteristics such as rural environment of long distances, low traffic volumes, rare traffic congestion, and most travelers are unfamiliar with the surroundings.

4- Benefits of ITS

ITS is anticipated to have several advantages including the improvement of national mobility, traffic safety, environmental benefits, and energy efficiency (Mobility 2000 1990, U.S. Department of Transportation 1990, and Federal Highway Administration 1991-a and 1991-b).

4.1 National Mobility

Measured quantified improvements to mobility include: reduced congestion (normally more than 70% of all peak hour travel occurs under congested condition), augmented and enhanced driver capabilities, reduced motorists confusion and aggravation, accommodation of increased travel and higher speeds, and reduced driver fatigue and frustration. Preliminary studies including 39 major cities in the United States showed that $41 billion dollars per year lost due to congestion. Whereas, the following enhancements are anticipated from the application of IVHS:

1. Advanced Traffic Management System (ATMS) have been shown to reduce stop-and-go traffic up to 30%, and to reduce travel time from 13% to 45%.
2. Advanced Driver Information System (ADIS) are expected to contribute another 10% to 15% in travel time reduction which will improve air quality.
3. Commercial Vehicle Operation Systems (CVO) will contribute significantly to the efficient utilization of trucks.
4. As a sequence of sensors and controls, Advanced Vehicle Highway System (AVCS) will reduce accidents and increase traffic flow.
5. Worker attitude and productivity will be additional benefits.

4.2 Traffic Safety

ITS will significantly improve safety on the highways and streets, especially when it includes obstacle detection, collision warning, and collision avoidance features to help drivers to avoid serious accidents.

The safety benefits include reduced fatalities, injuries and property damage. Thus, the economic by-products of reduced accidents will benefit all society, not just transportation systems users. For example, the expected dollars saved of ITS in the United States due to safety in the year 2010 is $22.2 billions.

Accident types are those seen as most amenable to prevention with the use of ITS technology include: off-road accidents, angle collisions, head-on collisions, rear-end collisions, side-swipe collisions, and aggravating environments.

According to ITS report (Federal Highway Administration 1991-a), the system will save 1000 lives, 35000 injuries, and 1.8 billion dollars by the year 2000, while by the year 2010, over 11000 lives, 440000 injuries, and 22 billion dollars will be saved in the U.S. alone.

4.3 Energy and Environment

Since ITS application will reduce congestion, the energy efficiency will be improved. Travel planning and routing will also be improved. ITS has environmental benefits through fuel saving, reduced vehicle emission, and reduced noise levels (in the U.S. by the year 2000, 2.2 billion gallons of fuel per year will be saved and 6.5 billion gallons by the year 2010).

5- Research and Development in ITS

According to Mobility 2000 report (1990), Table 1 demonstrates the expected development of ITS for the years 1990 to 2020. In U.S. 35 billion dollars is recommended for the total stages of the implementation of ITS; i.e. research, development, and field testing. While ATMS, ATIS, and CVO systems are now being deployed, AVCS will require substantial research before it can become operational.

5.1 Academic Research Effort

The academic research effort in ITS is done through the *Guidestar* project at the University of Minnesota (Johns 1991). The following research activities represent the seven major components of the academic research effort:

1. Real-time traffic surveillance/detection using image processing for wide area multiple detection and automatic traffic surveillance through the Autoscope system.
2. Real-time origin-destination estimation and demand prediction.
3. Modeling and simulation of traffic flow through parallel processing.
4. Decision-making and control such as incident management and guidance/ information systems.
5. Database design and information system management in order to develop information systems for traffic management, drivers, and transit drivers.
6. In-vehicle collision avoidance.
7. In-vehicle navigation and its effect on driver's behavior.

6- Other ITS programs

Besides the U.S. ITS programs there are two other research programs in Europe and Japan (U.S. Department of Transportation 1990, and Katakura and Saito 1991).

6.1 European Program

Beginning 1986, 19 countries were participated in this program which was designed to stimulate cooperative research and development between industries and governments in Europe. A major goal of the program was to improve European industrial competitiveness. The program is called EUREKA. Its two main ITS programs are: Program for European Traffic with High Efficiency and Unprecedented Safety (PROMETHEUS), and Dedicated Road Infrastructure for Vehicle Safety in Europe

(DRIVE). PROMETHEUS objectives are to improve traffic safety, enhance vehicle operations efficiency, and reduce the adverse environmental effects of automobile travel. DRIVES goal is to improve road safety, promote transport efficiency, and reduce environmental pollution.

Table 1: Field Operation Tests of ITS in the U.S.

1990-1995
• Corridor systems that integrate freeways and arterials. • Route guidance. • Real-time travel information. • Automatic vehicle identification and classification, weight-in-motion, and on-board computers.
1996-2000
• In-car enhanced images of roadway signs and hazards. • Vehicle-to-vehicle hazard warning. • Real-time two-way communications. • Modeling techniques manage congestion. • Roadway powered electric vehicles. • Automated parking facilities. • Adaptive cruise control, automatic braking, and automatic lane keeping. • Platooning.
2000-2010
• High-speed inter-city and rural travel. • Electric vehicles for commercial delivery and public transit fleets. • Network of fully automated freeways, traffic information and management systems, and arterials.

Source: Mobility 2000 (1990)

6.2 Japanese Program

Japanese ITS development focuses on information dissemination. Japan digital map database was completed in 1989. Since 1973, technologies on vehicle/road communication and information processing technologies have been advanced by both the electronic and automobile industries. Japan has two major ITS research programs: a) Advanced Mobile Traffic Information and Communication System (AMTICS); and b) Road Automobile Communication System (RACS). AMTICS was proposed in 1987 to collect traffic information by the computerized Automatic Traffic Control (ATC) center located in the police terminals. The tele-terminal system is a radio communication system which communicates digital data between the tele-terminal corporation service center and individual mobile communications units. AMTICS main functions are in-vehicle navigation and dynamic route guidance. RACS started in 1984. Its objectives include offering advanced information environment to the motorist by the installation of roadside facilities and in-vehicle devices. The system comprises three functions:

navigation, information service, and individual communication. Nowadays, the two systems have been combined in one system.

7- ITS Deployment in Jordan

ITS deployment in Jordan or any other country in the middle east (even in the western countries) faces many technical and non-technical barriers. Some of these barriers are specific for Jordan while the others are common with other countries.

7.1 Technical Barriers

ITS technical barriers include investigation of the following particular areas:

1. System architecture: this system needs to adapt to the advent of new technologies and requirements without requiring the replacement of basic system elements such as communication equipment.
2. System liability: it is not unreasonable to postulate that a driver who accepted alternate route guidance and subsequently was involved in an accident would sue all parties connected with the system. Because of that a fair compromise between limitations of liability and incentives for system designers, builders, and operator to act responsibly will have to be worked out.
3. Evaluation and standards: ITS program must have criteria for the evaluation based on performance, by which fair technical competition will be accomplished.
4. Understand the potential for a shift in liability for automobile accidents from primarily vehicle-driver negligence toward the equipment and vehicle manufacturers and the organizations operating the systems (Pattern and Mason 1991).

7.2 Non-technical Barriers

These barriers include the following:

1. Human factors: all of the ITS subsystems need extensive human factors screening even before being funded for field experimentation.
2. Public agency: Rowe (1991) supported the public agencies role to maintain and operate ITS equipment. Local agencies should also be informed that the improvement of freeway travel will be done at the expense of added congestion on local surface streets.
3. Protocols and standards must be developed for both hardware and software to ensure compatibility and safe operations, and try to minimize duplication of effort.
4. Financial and social support to understand and convince people to adapt the technology transfer of ITS.
5. Infrastructure of control devices should have the potential to adapt the ITS integrated technology.

6. Cost of navigation and communication systems which will be equipped in every vehicle participating in the system.
7. Educational programs to understand ITS.
8. Privacy of individuals who use ITS systems.

The time must be taken to create the organizational, educational, and funding mechanisms necessary for the implementation and deployment of ITS in Jordan. Testing and operations might start at selected junctions of Amman intersections and congested arterials.

7.3 Potential Deployment of ITS in Jordan

An extensive research and development work, and collaboration between different academic institutes and decision makers should be done before thinking to deploy ITS in Jordan. The establishment of transportation centers to attract and administer research funds, and manage transportation programs, is considered as one of the keys to introduce the importance of ITS. These centers have to give emphases on: traffic safety, traffic flow, transportation and environment, transportation and economy, and transportation infrastructure. Then, prototype projects with known frameworks could be selected to start with. Deployment of ITS might be started at heavy traffic volume intersections and corridors in Jordanian major cities such as selected arterials in Amman, Irbid, Zarqa, and Aqaba. After that, the deployment might be extended to other corridors in these cities and other cities. Thus, ITS deployment in Jordan is anticipated to have a great potential if the barriers mentioned before are resolved and a serious effort is made by all partners including: government, academic institutes, and road-users.

8- Integration of ITS, Vision Systems, GIS, and Artificial Intelligence

Figure 2 shows a proposed integration of other technologies such as GIS, Vision Systems, Image Processing, Artificial Intelligence, Knowledge-based and Expert Systems with ITS. These systems could assist ITS toward more flexibility, automation and accuracy of control, real-time, low-cost, and trusting road users.

8.1 Vision Systems and Image Processing

Computer vision techniques are widely used to extract three-dimensional measurements from stereo images or normal-based cameras. In fact, accurate measurements can be made from cameras mounted on the trunk or a front of vehicles. Accuracy of geometric measurements extracted from video images using charge-coupled-devices (CCD) cameras reached one picture element (pixel; i.e. about 0.02 μm). Thus, these cameras could be used as sensors mounted on the vehicles at selected configurations. Their excellent geometric fidelity, coupled with low costs (which drivers could afford) make them an ideal tool for the use in ITS, especially for AVCS.
The basic technology might be used for other ITS activities such as: a) ATMS: vehicle classification, traffic parameters measurements including queue length, delay, incident detection, congestion level, and level of service; b) ATIS: detection of vehicle location, digital map-matching navigation system, route-planning to allocate critical path of travel,

as-built drawings for road geometry, and color video display for maps; c) CVO: automatic clearance sensing, distance measurements, and assist and predict technology to weigh vehicles in motion; and d) AVCS: accident detection especially the rear-end collisions, lane position monitoring system, and assisting vehicles to avoid road-off or keep road-shoulder clearance, and enhance lane changing process using efficient computer algorithms. For example, Obaidat and Abdullah (1996) used a digital PC-based vision system to produce vehicle speed profile in different motion cases. An absolute error of about 2 km/hr was obtained for speed measurements. Queue length measurements were also accurate to within one meter.

On the other hand, image processing technique detect objects by processing digital images in two-dimensions. The basic technology could be used for purpose of detection of incidents and vehicles, congestion levels, and queue length measurement.

By integrating stereo vision with image processing techniques, ITS real-time capabilities will be enhanced since the key of successful deployment of ITS is the real-time measurement capabilities.

8.2 Geographic Information Systems (GIS)

As an information system, GIS is working with geographical or spatial coordinate referenced data which has the capability of linkage between knowledge data-base and digital drawings. It is also having the potential of displaying colored digital maps with their symbols. For example, all attributes related to certain geographic location of road segment, drivers information, road name and type, historical traffic information, etc. could be reported within real-time. Thus, GIS goal is to produce colored digital maps that have the capabilities of time saving, ease-of-use system, effort, money, and resources. Consequently, digital maps for the road network could be displayed on the computer screen by clicking a key board button on the navigation screen next to the driver.

Stereo vision might be used to collect the geometric characteristics for all road level hierarchy (for example in Jordan: primary, secondary, and village). The digital maps might also be updated according to any changes or new roads construction through stereo vision inventory system. Thus, a flexible navigation system will be available.

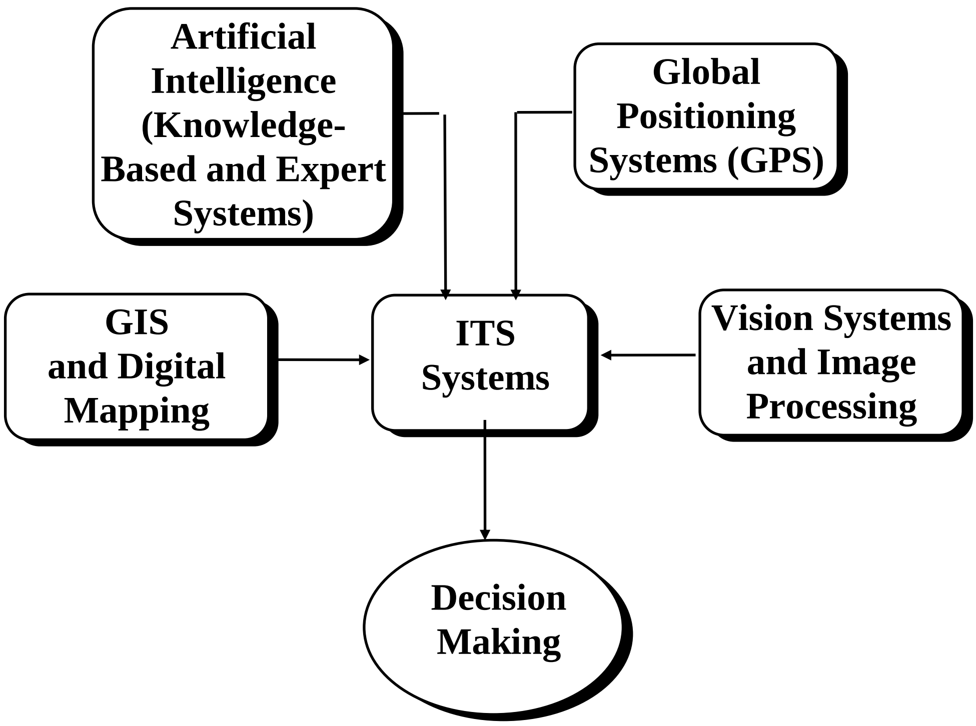

Figure 2: Integration of ITS with other technologies.

8.3 Global Positioning Systems (GPS)

GPS technology uses satellites signals and ground receivers to locate three-dimensional point positioning in real-time. It requires three antennas to compute orientation using the phase difference concept. GPS is able to precisely determine a vehicle's position and orientation. This in turn is useful for the navigation system to help drivers avoid collisions, and select the suitable routes. The key of such navigation system is its low-cost for the users, robustness, and high-precision technology. In fact, differential carrier GPS measurements have the potential accuracy of about 10 cm after correction for earth-curvature and atmospheric refraction (Asher and Dougherty 1995). GPS has potential applications to rail grade crossings and train separation issues for safety requirements. GPS technology is useful for ATIS and AVCS of ITS.

8.4 Artificial Intelligence (AI)

Complex problems require decision making from administrators and users of ITS could be solved by incorporating the central computer systems with AI (knowledge-based and expert systems). There are a number of method used for presentation of knowledge such as facts, rules, and hypotheses. Some of them are semantic nets, frames, and logic. Thus, knowing the traffic history trend and traffic regulations leads to predict future trends and control. This is useful in both ATIS and ATMS in which decision will be automated within real-time capability. Without using AI (as its name indicated), ITS will never bridge the gap of time required for application between the available conventional transportation systems and the fully automated transportation systems.

Integration of these systems with ITS is anticipated to produce an innovative and real Intelligent Transportation Systems.

9- Conclusions and Summary

Intelligent Transportation Systems (ITS) are new technological systems for traffic monitoring and control. ITS use the advanced electronics, communications, and information systems to improve productivity in transportation sector. They have several advantages such as: increasing safety and mobility, reducing the energy consumption, and global effect in terms of environment protection. ITS include an integration of various systems such as: ATMS, ATIS, CVO, APTS, ARTS, and AVCSS of which each system has its own goals, operation procedures, type of control, etc. Some of these systems are still under development, others are under research, testing, or deployment, while the rest are fully operated.

The key of ITS deployment and operation is the awareness of end-users and the public. ITS still face some technical and non-technical barriers which make them hard to be operated unless these problems will be solved. In Jordan, decision makers have to be aware of these systems and start encouraging researcher to make an effort in this domain; i.e. to be a technology developer for traffic monitoring systems rather than being as technology transferor and end-users. A good start would be studying the effect of traffic monitoring systems at high volume corridors in Greater Amman region. Hoping this will control traffic jams and high rate of accidents.

A framework to integrate ITS with other technological systems such as Geographic Information Systems (GIS), Vision Systems, Image Processing Techniques, and Artificial Intelligence including Knowledge-Based Systems and Expert Systems is also presented. Integration of these systems with ITS is anticipated to automate decision making for both administration and users (drivers) levels. Thus, data acquisition must occur in real-time. Looking forward to seeing a real application of ITS rather than virtual reality systems.

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