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How Rapidly should Developing Countries Implement Intelligent Transportation Systems (ITS) to Solve the Growing Urban Traffic Congestion Problem?

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Many newly developing countries are growing rapidly. One example is India, currently the second most populous country in the world. According to the Indian Ministry of Urban Development, from 1981 to 2001, the population in six major Indian cities increased twofold while motor vehicles increased eightfold. Such rapid growth in vehicles without a comparable growth in transportation infrastructure leads to increasing traffic congestion. Cities in India are already considered congested today, and are going to be even more congested in the coming years since the rate of urbanization in India in 2006 was only 29% and is expected to grow to 41% by 2030 [1]. The corresponding rates for the world and Asia as a whole are projected to be 61% and 55%, respectively.

One solution to the growing congestion problem is to build more transportation infrastructure. It is cost prohibitive, however, to build new infrastructure in built-up areas. So developing countries around the world are looking for other alternatives to deal with this problem. One such alternative is a set of practices called Intelligent Transportation Systems (ITS). ITS is commonly understood to denote systems that combine recent advances in information and communication technologies to better manage the transport system. ITS comprises a wide range of tools for managing transport networks as well as for providing services to travelers. One of the basic features of ITS is the collection of data and conversion of the data into information that can be used to fulfill a user need. Through ITS, transportation authorities, operators, and individual travelers are able to make more coordinated and intelligent decisions based on timely information.

ITS has been widely implemented around the world, especially in high-income, developed countries. It has been used to reduce congestion by improving traffic flows on transportation networks, managing the demand, and diverting the demand for car travel to other modes of travel. It has been used to enhance safety through faster emergency response, better incident detection and management, enforcement of speed limits/red light violations, and anti-collision and enhanced vision systems. ITS has also been used to help protect and improve the environment through pollution monitoring, disseminating air quality information, providing real-time information that helps to manage demand, and providing access control to high pollution areas. Operating costs have been reduced and productivity improvements induced through automatic vehicle location, computer-aided dispatch, weigh-in-motion systems, and electronic toll collection. Travel experience of travelers has been enhanced and stress of travelers reduced through real time traffic information, dynamic route guidance, real time public transit information, and smart card payment systems for public transport.

With the many benefits described above, the allure of ITS for transport managers in newly developing countries is understandable. This is especially true for countries like India, which has experienced high economic growth in recent times and has placed a high priority on infrastructure development. ITS appears to promise solutions to many urgent transportation problems in the country. For example, in a study completed on 14 selected highway locations in India, the percentage of rear-end crashes on 4-lane divided highways, 2-lane roads without shoulders, 2-lane roads with 1.5 m paved shoulder, and 2-lane roads with 2.5 m paved shoulder were 19%, 31%, 16%, and 25%, respectively of all fatal crashes [2]. Vehicular anti-collision systems would be an ideal solution to the rear-end collision problem. These systems have undergone significant advancement from initial costly, camera-based systems, to current state-of-the-art inter vehicular communication that communicates position, speed, and direction data to other vehicles [3].

Another ITS technology that can prove to be beneficial is related to fatalities involving pedestrians, bicyclists, hand-cart pushers, or people in cycle-rickshaws or animal driven carts. According to the Indian Ministry of Road Transport and Highways over 18% of all fatalities in India involved people in those groups [4]. Technologies such as microwave radar; video image processing; and infrared (passive as well as active), acoustic, ultrasonic, piezoelectric, and magnetic sensors have been used with reasonable success for vehicle detection. However, they do not work similarly for pedestrian detection. A newer technology based on an IR, light-emitting diode (LED) stereo camera appears to be more promising for detecting pedestrians both during the day and at night [5]. Such technologies could help to reduce fatalities of the vulnerable group described above.

Other technologies with potential benefits to developing countries include enhanced visions systems (EVS) on vehicles, adaptive cruise control systems, and data fusion techniques. EVS on vehicles present an augmented reality of the road including any obstacles on the road to drivers through heads-up displays [6]. When visibility is low due to fog or weather conditions, a series of front-facing sensors will paint road lines on the windshield using ultraviolet lasers. The system can even read road signs to aid the driver with navigation. In-vehicle cameras are used to track the driver's head and eyes to properly place the augmented reality on the windshield. EVS systems enhance safety.

Adaptive cruise control systems provide longitudinal and lateral vehicle control assistance. The most common sensors used for longitudinal control are radars and laser devices. These devices measure the distance from the vehicle ahead and detect obstacles on the way. To detect people and objects behind the vehicle, sonic and ultrasonic sensors can be used. The most basic need of lateral vehicle control is lane-keeping which could be easily achieved through video image processing of the white edge of the road. This can also be done through the use of Global Positioning System (GPS) and digital maps.

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These approaches to lane keeping do not require modifications of the existing road infrastructure. Another approach that has been used is guide wires along the lane pavement carrying electrical signals and installation of magnetic nails buried in the pavement. Magnetometers placed under the vehicle detect these signals and help to keep the vehicle in its lane.

Data processing is a key element in ITS and it involves acquiring data from various traffic management centers, checking the data for accuracy, making it compatible, and incorporating the information from other agencies such as police departments and highway management organizations. Since it involves the processing of raw data from multiple sources, such processing is usually called "data fusion". Since data are obtained from multiple inputs, data fusion techniques allow for tracking of changing conditions more reliably than that possible from a single data source, however reliable. Since data collection sources have proliferated in ITS, the means to process data from these multiple sources have become essential. Data fusion techniques fulfill such needs [7-10].

Thus the benefits from ITS are varied and multiple, and developing countries like India stand to gain a lot by implementing one or more ITS components. ITS can help to mitigate the effects of some of the many gaps in the infrastructure, but ITS will not "solve" all urban infrastructure problems of rapidly growing cities of the developing world. Missing links in the arterial street network will need to be built, sub-standard segments will need to be upgraded, new roadways will need to be built, intersections will need to be improved, facilities for slow-moving and non-motorized vehicles will need to provided, sidewalks on streets with heavy pedestrian demand will need to be built, and facilities for pedestrians to cross streets should be provided. Only when these gaps in the infrastructure are filled will the full benefits from ITS be realized.

It is understandable that rapidly growing economies with large urban areas with massively congested streets are impatient to implement ITS with its promising, advanced technical solutions to many of the ills faced by them. Various ITS components have been implemented at various locations in many of these countries with the help of consultants and vendors from different countries. Such piece meal development of ITS is not advisable. This is especially true in the case of complex systems that have many interrelated parts that work together to fulfil a common objective; ITS is an example of such a complex system. The U.S. Department of Transportation recommends the use of Systems Engineering for deployment of ITS projects [11]. The Systems Engineering principle recommends the use of system architecture for complex systems. A system architecture is a framework that depicts how different sub-systems of ITS interrelate with each other and work collectively to deliver the required services to users of the system. The architecture defines the components as well as the interrelationships and information exchange among the components. Due to the complexity of integration of information systems in the field of transport, it is desirable to define and develop an ITS architecture at the national level, which will function as an overarching framework within which individual components or groups of components of ITS can be built. Such an approach will ensure that systems developed and implemented at different places and times are interoperable and compatible with each other. The range of the transport sector spans from an area level to city level, from city level to regional level, from regional level to state level, and finally from state level to the national level. To benefit fully from ITS, a nation needs to develop the ITS architecture at various levels: local, city, region, state, and national. The various methods through which architecture can add value to transport can be enumerated as shown below.

- Foster consensus in transport policy and implementation
- Fulfil user needs
- Promote ITS standards
- Manage risk
- Link ITS to transport planning process
- Provide a basis for software development
- Prepare for future expansion

Isolated development managed by disparate parties from around the world without any indigenous master framework to guide the work can lead to incompatible and non-interoperable systems that will hinder further development and expansion of ITS in any country [12]. So countries like India, which have not defined a National or Regional ITS Architecture yet, should not embark on full scale ITS deployment. Small, localized projects such as synchronization of traffic signals along a corridor, installation of some video cameras for monitoring traffic at selected locations, and the installation of a few changeable message signs can be undertaken. So the answer to the question posed in the title is that ITS development in developing countries should proceed gradually until a national or regional architecture is in place and the bulk of the resources until then should be devoted to non-ITS infrastructure improvements.

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