1. Introduction

1.1 Today's Transportation Dilemma

One of the many characteristics we as Americans have prided ourselves on, and indeed based our government on, is our personal freedom. And no place is it so evident as in our transportation system, and specifically in America's unique fascination and attachment to the automobile.

Up through the twentieth century we relied on stage coach and then the railroad as our main means of traveling great distances. The dominance of the railroad was shown when the government helped to finance the first transcontinental rail line. Then after the turn of the century the automobile was born. This invention allowed those who had one to travel quickly and on their own, without the need for traveling according to the railroad's timetable. When Henry Ford developed his assembly line system to allow for the rapid and inexpensive construction of automobiles, suddenly this new wonder was available to most families.

With the ability to travel greater distances faster without the need for railroads or other forms of mass transit, people began moving out of the cities and away from their jobs. They could now live where ever they wanted to, no longer constrained by the need for easy access to mass transit. Now the local municipalities had to provide upgraded roadways to allow for their use by the automobile. The use of the car likewise grew as the facilities upon which to use them improved.

In 1956 Congress passed a bill granting 32.9 billion dollars for the establishment of the Interstate Highway System. The goal was to create 40,000 miles of controlled access freeways with 80 mile per hour design speeds to allow for travel from coast to coast without encountering a single signalized intersection. While this was deemed a necessity for our nation's defense, it now allowed anyone with an automobile to travel greater distances faster and safer than was

previously possible without the help of some form of mass transit. Cars had grown from being a luxury to becoming a necessity for survival in the United States.

Along with the growing use of cars came the increased reliance on trucks for freight transport. As the highway system became increasing better, the savings of truck transport over other freight carriers also increased. This led to the truck becoming the dominate mode of moving freight. It has been estimated that 76% of all freight carried is done so by trucks [1].

As the number of vehicles on these freeways and other roadways grew at a phenomenal rate, it became impossible to provide the infrastructure that was necessary to handle all of these vehicles efficiently. Congestion became part of the experience of commuting to work, especially in the central business districts (CBDs) of the cities. The phenomenon known as 'rush hour' rapidly grew into several hours and the ability of the highways and arterials in and around major population areas to move vehicles during these times resembled parking lots more so than the interstate highways originally envisioned. The cost of this congestion is thought to be about 100 billion dollars each year [1]. And the Federal Highway Administration (FHWA) has estimated that the increase in delay from 1985 to 2005 will be 360% for urban freeways and 433% in central cities [2]. While the traditional solution was to construct more lane-miles of highways to accommodate the increase in traffic, the construction could not keep up with the demand. The cost of this construction also grew as quickly as did the traffic demand, to the point where it now costs over eight million dollars to construct just one lane-mile of interstate highway.

Another traditional solution, mass transit, has had a kind of rebirth as local municipalities attempt to use improved mass transit as part of their solution to the congestion problem. This has included subsidizing and even government ownership. But Americans attachment to their automobiles and the freedom it portrays prevents these mass transit endeavors from creating the impact that they probably should. Therefore it has started to become apparent that another solution, or solutions, will have to be found.

1.2 ITS – A Potential Solution

Out of this attempt to find another solution to our transportation problem has come the national Intelligent Transportation System (ITS) Program. The ITS Program attempts to take the available advanced technologies, some of which comes from the defense sector, and apply them to the transportation network in an attempt to create a safer and more efficient system. In the past decade the amount of research done in the area of ITS has increased dramatically, mostly due to Congress' passing of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991. Some of the funding that ISTEA provides in the area of ITS is to help fulfill the requirement that an automated highway and vehicle system be developed and demonstrated. The concept behind the Automated Highway System (AHS) is to create a fully automated driver-vehicle-road interface which will provide "hands off" vehicle operation at better levels of performance than today's in terms of safety, efficiency, and comfort, while maintaining the advantage of personal mobility that Americans hold so dear.

Just as forty years ago when the Interstate Highway System was considered the "new" transportation paradigm, it is said that ITS is our new transportation paradigm which will take us into the new millennium. While with the Interstate Highway System there were established goals, or a "strategic vision", currently no such national goals exist for ITS.

With the lack of a strategic vision in mind, it is the purpose of this research to develop a conceptualization of a guideway-based AHS which utilizes the existing right-of-way of the Interstate Highway System. The emphasis will be placed on the operational characteristics of such a system rather than on the technological development and implementation of the system.

1.3 ITS Categories

The goal of ITS is to use advanced technologies to improve the operating efficiency of a transportation network. Efforts and concepts in ITS can be classified as being in one of six ITS program categories, all of which were included under the ISTEA legislation. These categories are

ATMS – Advanced Traffic Management Systems
ATIS – Advanced Traffic Information Systems
APTS – Advanced Public Transportation Systems
CVO – Commercial Vehicle Operations
ARTS – Advanced Rural Transportation Systems
AVCS – Advanced Vehicle Control Systems

ATMS concerns itself with managing traffic in a network to ultimately reduce congestion to a minimum level and to increase the efficiency of the network. This is accomplished through collecting real-time data of the status of traffic flows and use this data in an attempt to optimize the system. An example of this would be ramp metering – where a vehicle would not be allowed to attempt to enter the traffic stream unless there is space available. The heavier the traffic is the fewer the number of vehicles which are allowed to enter. Another important role of ATMS is incident management. In this case when an incident occurs, whether an accident, severe congestion, or construction, the system will route drivers around the incident, while making adjustments, such as to signal timings, to expedite the movement of traffic along the new route or routes. The system would also notify the proper authorities to allow them to respond to the incident quickly, with the hope of resolving it as quickly as possible and thereby returning the traffic flow to normal. ATMS would form the backbone of a successful ITS system and work in unison with the other categories, especially ATIS.

ATIS regards the distribution of pertinent information to the transportation system user with the intent being that a better informed traveler is a smarter traveler, one who takes alternate routes to arrive at his or her destination quicker. Most of the information being distributed comes directly from a Traffic Management Center (TMC), which is the core of an ATMS. The modes through which the information can be distributed are numerous. They include variable message signs (VMS), highway advisory radio (HAR), in-vehicle navigation systems such as Travtek, kiosks, and the Internet. With ATMS, ATIS is where much of the congestion management strategy today comes from.

The goal of APTS is to use technology to increase the efficiency of a public transportation system, thereby increasing its attractiveness and ultimately its ridership. Using such concepts as advanced vehicle location (AVL) to predict the arrival of vehicles to a destination or to reroute a vehicle to optimize its efficiency, APTS would limit the time spent waiting at a stop. With vehicle pre-emption technologies and exclusive lanes it would even be possible to reduce travel time, possibly to less than that obtainable with a personal vehicle. By attracting more commuters to mass transit, it is the hope of APTS to ultimately have the impact of reducing congestion.

CVO, like APTS, is an attempt to optimize the operations of a fleet of vehicles. AVL would be used to be able to easily locate the company's vehicles and therefore allow a controller to "vector" vehicles to their destination via the most efficient and productive route. It is in this category that the "Traveling Salesman Problem" would be addressed. Also included in CVO is such concepts as vehicle monitoring. In this case the vehicles in the fleet would be tracked as to ensure that operators are following all the safety requirements, like the limit on hours of driving without rest. CVO, through the optimization of vehicle operations and increased safety, ultimately should increase the safety on the roadway and reduce congestion through route guidance.

ARTS apply advance technologies and communications systems to improve safety and travel on rural roads. Part of this is accomplished through ATIS, providing drivers with information on

the road conditions ahead. Another part of ARTS is emergency notification. In the event of an accident or other mishap, it is the goal to have the ability to summon help automatically and to be able to provide location information to aid in having a timely response by the appropriate emergency services.

AVCS concerns itself with adding new technologies to the actual vehicle to improve its actual operation. Cruise control is an example which is already commonplace in today's vehicles. These systems will assist the driver in collision avoidance through obstacle detection, and ultimately automated braking and steering control. Lateral control systems will help with lane-keeping maneuvers by first notifying the driver of the vehicle's drift and ultimately by maneuvering the vehicle back into its lane. The culmination of AVCS could be the total automation of the vehicle's control systems. This would mean taking the driver completely out of the loop. When coupled with other ITS concepts as ATMS and ATIS, the ultimate result becomes an automated highway system.