6. Summary, Conclusions, and Recommendations

6.1 Summary

While still unfamiliar to many people in the United States, the concept of an automated highway system is not only obtainable, but obtainable in the near future. The Demonstration of Technical Feasibility alleviated any doubts about such a system, and provided a beginning for the development of a national Automated Highway System.

This research looked at the operational characteristics of a potential Automated Highway System which is based on Maglev technology. It was found that the majority of such a system, which would be tied into the existing Interstate Highway System, could actually be built within the existing right-of-way of the Interstate Highway System. It was also shown that under these geometric conditions potential speeds along the guideways would be much greater than those experienced on today’s highways, or even today’s railways.

Along with these greater speeds comes increased capacity and efficiency along the routes. This is accomplished by the automated and Maglev technologies without any adverse affects on passenger safety – automation could potentially decrease the number of accidents by upwards of ninety percent.

Weaving and merging were shown to be major factors in determining the ultimate capacity of an Automated Highway System. Another factor limiting the system’s capacity is the need for Restricted Capacity Sections, through areas such as curves. This was due to compromising geometrics and the need to provide a comfortable ride to the user. The concept of platooning was discussed, and it’s positive impact on the overall capacity of the system. The ability to bring a platoon to a stop in the event of an emergency was explored, as were the general acceleration and deceleration maneuvers needed to negotiate the guideway system, especially in
conjunction with the Restricted Capacity Sections. It was found that this could be accomplished without creating instability in the platoon environment or the system.

Through examination of the interaction between the proposed Automated Highway System and the existing Interstate Highway System some interesting things were found. The interface between the freeway and the guideway was shown to possibly be critical, as an improper design could lead to queuing which could back up onto the freeway system, thus creating congestion that the guideway was supposed to ultimately relieve. The potential exists for the same problem with vehicles leaving the guideway and entering the freeway. Only in this case overflow onto the guideway could create problems on the guideway which could render it useless.

Through modeling the split of traffic between the freeway and the guideway was found for a simple freeway-guideway network. It was found that the guideway system would have to be loaded substantially before any traffic would use the freeway system. This is especially true when the system is run under user equilibrium conditions.

### 3.2 Conclusions

While it has been agreed upon that traffic congestion is a major problem in this country, as well as others, the solutions to this problem have ranged from the simple to the exotic. The same is true with the development of the Automated Highway System. While some of the benefits which are being promoted the most are increased safety and increased capacity, and thus decreased travel time during heavy traffic periods, exactly how much of a benefit which will be realized is debatable.

A system like that which was demonstrated in San Diego in August 1997, while spectacular to the public due to its novelty, expects to see an increase in capacity of around two hundred percent. While this seems like a lot, converting one lane of existing freeway into an AHS lane amounts to the construction of two new lanes to the existing infrastructure. True, it would be at
a fraction of the cost, but experience has shown that this nominal increase in capacity will be consumed quickly, just as the added capacity of new lanes are today.

What is needed is the introduction of a completely new system to complement the existing Interstate Highway System, one like the Automated Highway System explored in this research. The addition of extremely high capacity infrastructure which would work as an added layer over the Interstate Highway System has the potential to positively affect the transportation system as a whole like nothing since the introduction of the Interstate Highway System itself.

Probably the worst side-effect to increasing the capacity on today’s roadways is the likewise increase in pollution via emissions. While more fuel-efficient vehicles are being introduced every year, the increase in the number of vehicles on the road each year not only offsets the benefit of reduced emissions per vehicle, but actually overwhelms it. Therefore any system which would be introduced must make provisions for the use of alternate energy sources, preferably electricity. The system must also account for the possibility of these vehicles having different operating characteristics from vehicles with a gasoline engine. In response to this, the introduction of Maglev technology into the Automated Highway System is an option which must be considered.

In looking into the operational characteristics of a Maglev Automated Highway System, several characteristics of the existing highway system were found to also fit the AHS. One of these is the restriction of capacity by the entry and exit points, brought on by the weaving and merging created by two traffic streams coming together. Another is the restriction of maximum operational speed by compromising geometrics. The need to provide safe and comfortable conditions while negotiating a curve restricts the ability of vehicles to travel at unlimited maximum speeds, and therefore places a ceiling on the maximum achievable capacity. While the capacity would be controlled more by weaving and merging sections, this geometrics create the need to transition vehicles between higher speed operations and lower speed operations. A new concept which applies exclusively to the Automated Highway System is that of platooning. It has been shown that capacity can dramatically increased through proper platoon management.
In reference to the actual operational interaction between the Automated Highway System and the Interstate Highway System, several conclusions can be drawn from the simulation run on the sample network. The first of these is the impact the AHS will have on freeway operations and volumes. Due to the ability of the guideways to carry vehicles at speeds much faster than those on the freeway, the vast majority of AHS equipped vehicles would use the guideway and not the freeway until volumes reached levels in the ten thousands of vehicles per hour. Therefore if one was to take today’s traffic volumes and apply them to the proposed network, all traffic able to do so would decide to take the AHS.

While this expanded capacity seems like the commuters’ dream, one must be careful of its future effects. Recall how when the Interstate Highway System was implemented, growth developed around its interchanges to utilize the new infrastructure. This growth ultimately continued until the highway system could no longer support it. This growth has to be expected to happen around the guideway-freeway interchanges also. Only the potential increase in capacity is by far greater than what the Interstate Highway System provided, therefore it is reasonable to expect the resultant growth to be much greater also. This is where the danger comes in. Operation of the AHS must be controlled so as to allow for gradual growth over time instead of having large population centers developing overnight. In this sense some form of planned development must be implemented in conjunction with the construction of an Automated Highway System. By planning the communities which will develop around interchanges, the potential for seriously overloading arterials and other feeder roadways can be kept in check, or at least under control.

Due to the decrease in travel time of the AHS over the freeway, even for short trips, the AHS could potentially replace the Interstate Highway System completely in the eyes of travelers. To prevent this from happening, and from creating congestion on the AHS, the placement of access points should be minimal. If the distance between interchanges is large enough, short trips like the one used in Section 5.3 will be assigned to the freeway while reserving AHS use to those travelers who have larger distances to travel. Since travelers covering a longer distance will
realize greater travel time savings than those on short trips, the total system travel time should be lower.

Finally there the issue of what operational method the AHS should operate under, user equilibrium or system optimization. With the Interstate Highway System this was not an issue, since drivers naturally conform to user equilibrium while there is no way to alter their travel patterns to conform to system optimization. But with vehicles under automated control, system optimization now becomes a very real option. After running the model, it became clear that there would be a clearly different distribution of traffic between the two methods. By implementing a system optimal approach, one would be able to keep more local traffic on the freeway by regulating vehicle flow through the ramp gates at the freeway-guideway interchanges. Regulation of vehicles through certain ramps can also be used to stimulate or retard growth in areas where intervention is needed. And by implementing a system optimal operational approach the total travel time experienced through the system will be lower, thereby increasing the efficiency of the system simply by not allowing travelers to choose routes according to user equilibrium.

6.3 Recommendations for Future Research

For a Maglev Automated Highway System to be implemented, the Maglev research in this country must be increased dramatically. Currently all significant research in the area is being conducted in Germany and Japan, with both of those countries emphasizing on mass transit applications. If the United States was able to develop a personal Maglev system and put it into operation, our transportation system would again be thrust into the forefront and by being the only country with such technology, would provide numerous opportunities for this country’s industries, including former defense companies. Included in this Maglev research would have to be characteristics which would be unique to personal Maglev, such as the ability to merge and weave vehicles between two or more guideways.
Furthermore, development of a practical electric vehicle must be accomplished. While serious efforts are underway, the incorporation of Maglev technology into a hybrid-electric vehicle is not being pursued. This should be done in conjunction with the research and development of a personal Maglev system.

After the Demonstration of Technical Feasibility performed in San Diego, it appears that the AHS which will be implemented in the near future will be one which involves retrofitting the existing highway infrastructure or free agent operations. In areas of high congestion and needing increased capacity the former option appears to be the most likely. In this case, it must be considered that if a Maglev Automated Highway System is ever to be implemented, it will have to interact with such a system. The possible advantages and disadvantages of such a hybrid AHS should be researched to see how operations, such as interchange operations, would be altered and if the efficiency of a Maglev AHS could actually be increased by the inclusion of such a system into the existing highway system. The other consideration is the effect on overall capacity of the system. Of interest is whether the guideway would attract enough vehicles from the highway as to neutralize the potential increase in capacity such a retrofitted system could potentially have. It could possibly be found that while such a system would increase capacity nominally now, future improvements would render the system useless in increasing capacity.