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Intercity Passenger Rail

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While the state of the art of intercity passenger rail (IPR) has advanced steadily worldwide during the past quarter-century, there is immense potential for further improvements in North America given the underutilization of and limited investment in this mode to date. Europe and Japan have advanced their IPR systems well beyond those in the United States, Canada, and Mexico. If North America is to remain truly competitive in the global marketplace, it must invest in a world-class transportation system that includes IPR, an important element of which is high-speed ground transportation (HSGT).

HSGT—a family of technologies ranging from upgraded existing railroads to magnetically levitated vehicles—is the most efficient mode for moving large volumes of people between metropolitan areas lying about 100–500 miles apart. In the United States, HSGT already exists in the Northeast Corridor. There are from 6 to 12 potential HSGT corridors in North America (depending on how they are defined), where investment in HSGT is commercially feasible (*1*).

CHALLENGES AND ISSUES

At the dawn of the new millennium, IPR is reemerging in North America as not just viable, but essential to the improved mobility of the densely populated Northeast, Southeast, West Coast, and Midwest (Chicago Hub) corridors, as well as of other potential emerging corridors in the Gulf Coast states, Texas, and Eastern Canada. There are nevertheless many challenges to be overcome before the development of IPR in these corridors can be realized. Most of these challenges are not technological, but political, institutional, and financial. Yet resolution of the technological issues can aid in addressing the other issues as well.

Technology Transfer

Since HSGT system technology is being developed and improved primarily overseas, technology transfer is a key step toward the implementation of HSGT systems in North America. It is ironic that a nation as technologically advanced as the United States must rely on foreign know-how. But the fact is that the United States has not invested in HSGT system development, and it would be foolish not to take advantage of the major investments and experience of others in high-speed train and maglev systems technology.

While the United States proposed leveraging foreign maglev development through the National Maglev Initiative, there has to date been no long-term national commitment or significant financial support for such development in North America. The recent Transportation Equity Act for the 21st Century (TEA-21) does, however, contain a provision for constructing a 40-mile maglev demonstration system. Perhaps in the new millennium, maglev technology will be adopted for certain niche ground transportation applications requiring very high speed. Alternatively, very-high-speed rail technology may prove to be more economical or to have sufficiently high performance that further maglev development may be unwarranted. The jury is still out on this debate.

Similarly, investment in very-high-speed steel wheel-on-rail technology development has taken place to date primarily in Europe and Japan. Without a domestic financial commitment to system development, the United States' only near-term option is to adopt foreign technology. Such is the case in Amtrak's Northeast Corridor, where Bombardier and Alstom have developed a completely new high-speed trainset that incorporates many of the high-speed elements of the French TGV (*Train à Grande Vitesse*) train technology.

In response to a state of Florida initiative for high-speed ground service between Miami, Orlando, and Tampa, a consortium comprising Fluor Daniel, Bombardier, GEC Alsthom (now Alstom), and Odebrecht Contractors of Florida proposed building an entirely new HSGT system in Florida. However, as of this writing, political and financial issues had resulted in the cancellation of this project by Florida's new governor. Contract award and authorization had finally been accomplished by the previous state administration after a decade of hard work. The Florida Overland Express project would have utilized TGV technology operating on a completely dedicated and grade-separated right-of-way at speeds of up to 200 mph. Since this would have been the first such HSGT system in the United States, new safety standards covering all aspects of the system design and operation were being developed.

New Federal Track Safety Standards were recently promulgated to address today's railroad operating environment and provide for future high-speed train operations. Similar revisions to safety standards for signaling and train control, vehicle structure, crashworthiness, braking systems, and other systems are also being developed to permit the implementation of HSGT systems in the United States. The challenge is to take full advantage of foreign HSGT experience while ensuring that no degradation of safety or unmitigated environmental effects result from the deployment of this technology in North America.

Design and Construction Issues

The intent of all passenger system designs is to offer safe and comfortable transportation at an affordable cost. The provision of high-speed rail transportation requires attention to those design criteria that differ from the traditional, established standards and specifications for railroad construction. HSGT design and construction issues need to be addressed in the areas of technology development, infrastructure requirements, cost, system safety, and environmental effects.

Technology Development

Although the state of the art of intercity passenger rail systems is quite mature (having evolved during the last 150 years), continuing improvements in IPR technology have been realized through developments in materials technology; advances in electronics, particularly with the advent of microelectronics and computer systems; and automation of manufacturing and assembly techniques. Ongoing advances in signaling and communications systems technology, in particular, could have a dramatic beneficial effect on the future of passenger rail systems. Use of satellites, the Global Positioning System (GPS), communications-based train control, and computer control of dispatching and real-time health monitoring of vital and important nonvital systems and subsystems promise to enhance the safety, reliability, and performance—and possibly reduce the cost—of IPR systems. As in other fields, technological developments have revolutionized the industry, and there is no end in sight for further advances in the state of the art.

Infrastructure Requirements

An objective of the design, construction, and subsequent maintenance of IPR systems is to achieve a fully integrated vehicle–track system. The track structure must be durable, stable, and able to withstand repetitive dynamic loading without excessive deformation in the track, its foundation, or adjacent structures. This is achieved by designing track to close geometric tolerances, maintaining a consistent track modulus, designing and maintaining the wheel tread and rail head profiles to stay within close tolerances, and ensuring that the vehicle–track system as a whole performs as intended. Achieving a consistent track modulus can be extremely costly on existing rail lines. Research into ways of making existing infrastructure appear uniform to the vehicle may yield large dividends. Continued advances in the modeling and simulation of vehicle–track interaction should lead to better understanding of the system requirements and foster further improvements in the state of the practice.

Advances in materials, construction techniques, inspection methods, and maintenance practices have elevated the performance level, ride-comfort, and safety of IPR systems over the years and will continue to contribute to better infrastructure performance in years to come. The widespread use of continuous welded rail, concrete ties with resilient fastening systems, track geometry cars, and ultrasonic rail flaw detection techniques have all contributed to higher-quality and safer track. Nevertheless, interpretation of rail flaw detection tests remains difficult and inconsistent, and there is still no test for the base of the rail, where many of the failures in field welds occur.

Cost

One of the principal stumbling blocks in developing HSGT systems from a technological standpoint is cost. The U.S. government made a deliberate decision in 1975 not to invest any further significant public monies in HSGT technology research, development, or demonstration. The new Pueblo Test Center was converted from a test site for advanced high-speed technologies to a laboratory for freight-rail accelerated testing through the Facility for Accelerated Service Testing (FAST) program. While the high-speed Railroad Test Track loop at Pueblo has recently been rehabilitated for testing Amtrak's new high-speed trainsets, destined for service in the Northeast Corridor, the facility has not been deployed for its original purpose (to develop HSGT technology), primarily because of the lack of funding.

HSGT is very expensive to deploy, as has been documented in several recent studies (e.g., *2*). Unfortunately, this is a fact of life, and while advances in the state of the art may lower the cost of future deployment, recent history indicates that infrastructure and vehicle system costs will continue to rise despite improved methods of construction and enhanced design and manufacturing techniques. This is true overseas as well. The good news is that other competing transportation systems face similar, if not greater, cost pressures, and IPR is increasingly becoming the most cost-effective means of meeting the rising demand for intercity passenger transportation. Thus while cost is certainly an important issue, and ways of economizing are always being sought, cost should not be a long-term impediment to greater deployment of HSGT systems.

System Safety

Historically, HSGT has been the safest mode of transportation. The Japanese Shinkansen system has an unblemished safety record, carrying 275 million passengers per year without a major accident in its 35-year history. Until the InterCityExpress (ICE) train crash in Eschede, Germany, in 1998, the European high-speed rail network had a similar remarkable safety record, with no deaths or serious injury after many years of service. The German accident occurred on conventional intercity trackage, not high-speed infrastructure, a fact that raises concern that higher risks may be posed by operating on track not built specifically for high speed. In this particular case, however, a faulty wheel design was determined to be the primary cause of the accident.

Even with the tragic German accident, the overall safety record for high-speed rail is much better than that for any other mode. Nonetheless, safety can never be taken for granted, and ensuring the integrity of impending high-speed rail systems in the United States will take a concerted effort throughout the planning, design, construction, and operation of these systems. The following are some areas requiring further investigation:

- Development of more information on the true cost of safety, quantifying risk and the value of accident avoidance;
- Identification of safety-critical systems, human factors, training requirements, and automation issues;
- Improved methods of risk analysis for determining the cost-effectiveness of safety measures;
- Establishment of credible component and system failure rates for input to risk analysis studies and for the determination of safe and cost-effective inspection intervals for safety-critical components; and
- Identification and evaluation of new approaches to sharing rights-of-way safely and improving grade-crossing safety.

The recent ICE train accident raises several issues. First is the need for an on-board, on-line detector of derailment or excess noise and vibration. The passengers in the train knew something was wrong; thus the impending disaster could have been sensed. A second issue is the location of turnouts and crossovers and their potential for contributing to derailments. If operationally acceptable, consideration should be given to locating turnouts and crossovers away from large fixed structures, such as bridges and underpasses. Finally, the ICE accident raises a concern about the longitudinal and lateral crashworthiness of lightweight, large-windowed carbodies. In the United States, considerable research on crashworthiness and crash energy management has gone into the design of the new Amtrak Acela high-speed trainsets being constructed for the Northeast Corridor rail service.

Environmental Effects

While passenger rail is one of the most environmentally benign transportation modes, the development of HSGT systems must address a number of environmental concerns, such as the following:

- Noise and vibration;
- Electromagnetic interference/electromagnetic field (EMF) effects;
- Aerodynamic (wind) effects;
- Aesthetics; and
- Energy utilization.

One impediment to implementing very-high-speed rail systems in the United States is the regulatory environment with regard to noise. Current federal regulations are written to address rail freight operations and are not appropriate for very-high-speed rail systems. It will be necessary to either modify current standards or issue new standards specific to very-high-speed rail systems on the basis of research in this area.

Recent studies of noise and vibration, funded by the Federal Railroad Administration, have contributed greatly to the general understanding of these effects. Further research is needed, however, in methods of reducing or mitigating the noise and vibration of high-speed trains and in disseminating this information to system developers and regulatory agencies.

Similarly, a series of studies recently undertaken by the Volpe Center in Cambridge, Massachusetts, led to documentation of the EMF levels of HSGT systems and how they compare with the levels from other EMF generators. While there does not appear to be a sound basis for public concern in this area, the issue is one often voiced by those not informed of the facts. Therefore, there is a need for better communication of information on this subject to the public at large.

With the implementation of high-speed rail trains operating at speeds of up to 150 mph in the Northeast Corridor, concern has been raised about the aerodynamic (wind) effects on people and property in close proximity to trains passing station platforms at high speed. The results of initial studies on this subject have identified no significant safety concerns, but this is another area in which environmental or safety issues need to be addressed.

With regard to energy utilization, since most HSGT is electrified and is relatively energy-efficient, further research to improve this aspect of the technology is not urgently needed. Nevertheless, as with all modes of transportation, energy consumption is a major cost of operation, and it has an environmental effect as well that must be considered in evaluating modal alternatives and planning, designing, constructing, and operating HSGT systems. Advances in technology will undoubtedly continue to contribute to improvements in energy utilization to the further advantage of this mode.

A final, overall concern is that as time passes and less land is available for HSGT systems, more environmental issues are raised, making consideration of this future transportation option increasingly difficult. Unlike the advanced planning that is conducted by municipalities and states for future highway rights-of-way, there is very little, if any, planning for HSGT systems. Unless serious long-term planning for HSGT systems is undertaken by all levels of government, future implementation will become increasingly problematic.

Operation and Maintenance Issues

Beyond the design and construction issues discussed above, it is worthwhile to look ahead to HSGT operation and maintenance (O&M) issues as well. As in all other areas, accumulated experience is the best teacher, and lessons learned are the best way of improving the existing state of practice. Of course, since the vast majority of high-speed rail experience has been overseas, North America has a great deal to learn in this regard. While a substantial body of experience has been accumulated through the years in operating and maintaining conventional intercity passenger rail services in North America, it is still worthwhile to adopt best practices from the vast experience of Europe and Japan. Doing so may require the abandonment of certain long-term and historical practices developed for conventional North American rail operations. Areas of needed research and development in this area include the following:

- Identifying and establishing education and training needs, preparing training courses, and developing programs for certifying job applicants in certain safety-critical skill areas. An exchange program would be beneficial and should include people at all levels, since those not at the highest levels are sometimes more candid about problems.
- Advancing the state of the art in vehicle system and track and guideway inspection, maintenance techniques, and failure prediction.
- Identifying means of reducing O&M costs while improving the operational safety and performance of HSGT systems. (Lowering O&M costs depends ultimately on preventing failure.)

CONCLUSIONS

Steady progress has been made throughout the past quarter-century in developing and deploying improved intercity passenger rail systems, particularly with the advent of very-high-speed rail systems in Europe and Japan that have revolutionized and redefined this mode of transportation. The challenge facing the United States is how to take advantage of these foreign advances in the state of the art of ground transportation systems. Recent history has demonstrated the difficulties, the long lead times, the costs, and the institutional impediments to system deployment in the United States. With the advent of the new millennium, HSGT has a bright future. Given the need for improved passenger system performance and significantly higher capacity in high-density intercity corridors throughout North America, HSGT will undoubtedly be the mode of choice for many regional applications through the next century and beyond.

HSGT can be viewed as a critical link in seamless transportation, with connections to major airports and the urban rail systems of large regional cities. HSGT can free the airports, runways, and airspace of short-haul flights. State- or regionwide HSGT or IPR systems, as proposed in California and in the Midwest, have the potential to generate high levels of ridership and revenue and to recover at a minimum their operating costs. While the focus here has been on steel wheel technology, maglev offers great potential for the 21st century as well.

REFERENCES

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