International Technology Scanning Program

EXECUTIVE SUMMARY

Freeway Geometric Design for Active Traffic Management in Europe

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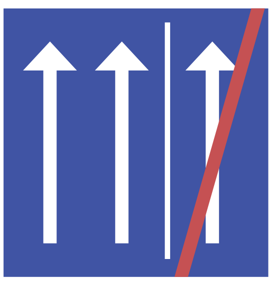

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Introduction

Continued growth in travel on congested freeway corridors exceeds agencies' abilities to provide sufficient solutions and alternatives based on traditional roadway expansion and improvement projects. High construction costs, constrained right-of-way, statutory restrictions, and environmental factors are pushing agencies to explore solutions such as active traffic management and managed lanes, which improve safety by reducing collisions and nonrecurring congestion and maximize throughput under congested conditions. Finding cost-effective options to mitigate recurrent and nonrecurrent congestion on freeway facilities is one of the most significant challenges State and regional transportation organizations face.

Several countries are implementing managed motorway concepts to move higher traffic volumes on their freeways more efficiently without acquiring more land and constructing large-scale infrastructure projects. Managed motorway concepts introduce new and revised operational activities that place greater reliance on technology than traditional roadway projects. Managed motorways combine actively or dynamically managed operational regimes, specific infrastructure designs, and technology solutions. They use a range of traffic management measures to actively monitor the motorway based on real-time conditions:

- Dynamically control speeds (see figure 1).
- Add capacity (figure 2).
- Inform road users of conditions on the network (figure 3, see next page).

The objective of implementing this range of measures is to optimize traffic and safety performance. Examples of these measures include shoulder running, variable speed limits, lane control signals, dynamic rerouting, and the provision of driver information using variable message signs. Managed motorway concepts applied in Europe have been proven to reduce collisions, improve journey time reliability, and increase vehicular throughput.

Figure 1. *England: example of variable speed limit in Birmingham (vehicles enter the roadway from the left, opposing traffic is on the right, and speeds shown are in miles per hour).*

Figure 2. *Netherlands: example of shoulder running.*

Figure 3. *England: examples of variable message signs in Birmingham (vehicles enter the roadway from the left, opposing traffic is on the right, and speeds shown are in miles per hour).*

Background

In 2006 a scan team observed that transportation agencies in Denmark, England, Germany, and the Netherlands, through the deployment of congestion management strategies, were able to optimize the investment in infrastructure to meet drivers' needs. Strategies included speed harmonization, temporary shoulder use, and dynamic signing and rerouting. The team's recommendations for U.S. implementation included promoting active traffic management to optimize existing infrastructure during recurrent and nonrecurrent congestion, emphasizing customer orientation, focusing on trip reliability, providing consistent messages to roadway users, and making operations a priority in planning, programming, and funding processes. Since the 2006 scanning study, active traffic management concepts have been implemented in Washington and Minnesota and are being considered in Virginia. During these implementations, several geometric design-related questions were voiced. A scanning study was proposed to obtain a better appreciation for how geometric design is handled with active traffic management programs. The desk scan revealed that several European counties have implemented innovative geometric design solutions in their active traffic management programs. In June 2010 a team of 10 U.S. transportation professionals with expertise in planning, design, and operations of freeways visited four countries in Europe: England, Germany, the Netherlands, and Spain. The purpose of the scanning study was to examine active traffic management design practices used in other countries to improve the operational performance of congested freeway facilities without compromising safety. This 2010 scan built on other scans that focused on congestion management and managed lane programs.

Key Findings

Key findings from the 2010 scan include the following:

- Much like the United States, many European nations face growing traffic and congestion levels on their freeway networks. Several European highway agencies are responding to growing congestion by implementing active traffic management systems that better use the existing roadway footprint. In Europe, "managed motorways" is the term used to describe the traffic management measures implemented to improve traffic flow, enhance safety, and inform road users of conditions on the freeway network. Managed motorway concepts have had great success in the countries the scan team visited, and these strategies and techniques are likely to provide great benefit if applied in the United States.

- The European countries visited comprehensively integrate a suite of complementary techniques to dynamically manage traffic flow in response to changing volumes, speeds, and incidents. The result is demonstrably improved safety, travel time reliability, and congestion relief on urban motorway sections. Techniques that integrate roadway design with operational strategies include the following:

- Variable speed limits, line control, and speed harmonization (see figures 1, 4, and 5)
- Shoulder running (figures 2 and 4) with emergency refuge areas (figure 6)
- Queue warning and variable messaging (figure 3)
- 24/7 monitoring of traffic with cameras and/or in-pavement sensors (both to detect incidents and identify when to reduce speed limits) (figure 7)
- Incident management (figure 8, see next page)
- Automated enforcement (see figure 9 on next page for examples of signs)
- Specialized algorithms for temporary shoulder running, variable speed limits, and/or incident detection and management
- Ramp metering (coordinated or independent function)

SOURCE: STAUFREIES HESSEN 2015

Figure 4. *Germany: example of shoulder use and variable speed limit from Hessen Web site (speeds are in kilometers per hour).*[1]

Figure 5. *Netherlands: example of variable speed limit (speeds are in kilometers per hour).*

Figure 6. *England: example of emergency refuge area in Birmingham (traffic travels on the left side on England's roadways).*

Camera

Loop detectors

Figure 7. *Netherlands: examples of surveillance camera and loop detectors.*

Figure 8. *England: examples of incident management in Birmingham.*

- Managed motorway strategies are synergistic and are most effective when applied in an integrated and dynamic system.

- Many managed motorway concepts are applicable to all U.S. metro areas and rural high-volume freeway corridors. The management strategies appropriate for a freeway corridor evolve as the needs and demands of the area change. In other words, transportation officials should recognize that freeways need a continuum of operational and management strategies that change as traffic needs and demands change.

- European countries faced safety concerns similar to those in the United States and successfully addressed those concerns in managed motorway deployments. Managed motorways have contributed to substantial safety improvements in Europe.

- Many European countries went through a paradigm shift in their design policies and practices by adopting risk- and performance-based approaches to making design choices on actively managed freeway facilities. An example of changed design philosophy is considering the dynamic operating regimes of a managed freeway rather than selecting design criteria based on a static operating condition. Successful active traffic management deployments require a well-planned, interdisciplinary collaboration of design with operations and enforcement. Successful implementation also requires the following:

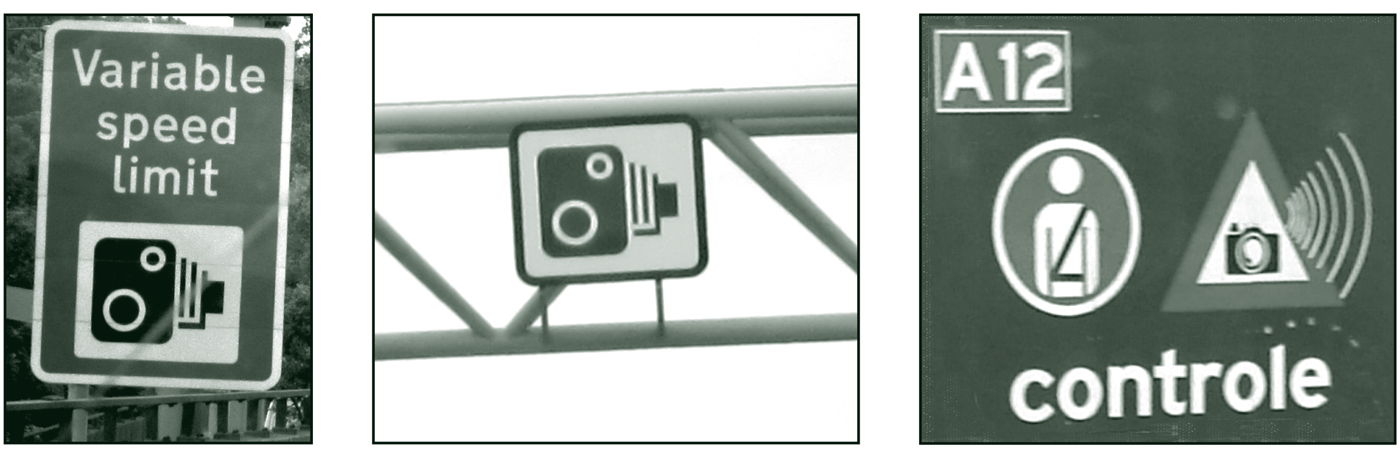

Figure 9. *Examples of automated enforcement signs.*

- High-level champions who lead a culture change in an agency and institutionalize the agency's commitment to prioritizing traffic management
- Overcoming the "we never did this before" attitude
- Funding commitments for adequate long-term operational maintenance

■ Advancing active traffic management in the United States will require evolution of long-standing design practices, collaboration of design and operations disciplines, and advances in real-time communication to motorists.

Findings for Design

■ **Functionality of shoulders.** Representatives of the host highway agencies shared their evolving perspectives on the functionality of freeway shoulders. In both England and the Netherlands, it was noted that the utility of the outside shoulder to serve as a disabled vehicle area has diminished because of improvements in vehicle mechanical reliability. Therefore, the level of risk for not providing full shoulder widths may have diminished compared to when fundamental freeway design criteria were established. These types of considerations weigh into the host highway agencies' assessment of the tradeoffs for continual or dynamic shoulder running. Each of the countries visited had a general practice of reducing the speed limits within freeway sections where shoulder width was reduced (both permanently and part time) to allow shoulder running.

■ **Shoulder running (or plus lanes) with variable speed limits.** On some motorway segments in England, Germany, and the Netherlands, the shoulder is used dynamically to create an additional travel lane when conditions are appropriate. When the travel lane is added on the outside edge (e.g., right side for Germany and the Netherlands, left side for England), "hard shoulder running" is the term generally used. When the additional lane is on the inside edge, "plus lane" is the term used. Gantries that include speed and lane control signs are provided in these sections and can show a green arrow when the lane is available for use and a red cross when it is closed. The signs can also show the appropriate speed limit when shoulder running is allowed or the plus lane can be used. In Germany, when a paved shoulder is converted to a travel lane, a reduced speed limit of 120 kilometers per hour (km/h) (75 miles per hour (mi/h)) is considered (from a normal speed limit of 130 to 150 km/h (81 to 93 mi/h)). If reallocation of the roadway for hard shoulder running reduces lane widths to less than 3.5 meters (m) (11.5 feet (ft), a speed limit of 100 km/h (62 mi/h) is instituted. During shoulder running, the speed limit of the hard shoulder and the general travel lanes varies based on data from surveillance systems (loop detectors and/or cameras).

■ **Lane width.** When an existing roadway cross section is reallocated to add a lane, existing lane widths may be narrowed to accommodate the new lane. In several locations, lane widths varied within the cross section, with narrower lanes typically on the inside (or the lane nearest the median). In some instances, no-passing restrictions were instituted for trucks to restrict them from the narrow inside lanes, harmonize speeds, and maintain lane control.

■ **Shoulder running and ramp junctions.** Different approaches are considered for shoulder running through ramp junctions. In England, initial operations of shoulder running used only shoulder segments between ramps (i.e., the shoulder functioned as a lane gain or lane drop at each interchange). In 2009 England implemented a pilot using through-junction running on the M42 motorway at certain locations to increase capacity at key bottlenecks.

■ **Lighting needs with shoulder running.** Lighting for shoulder running sections has been a discussion topic in England, and over time the Highways Agency has found that continuous lighting treatments are not highly essential. In Germany and the Netherlands, continuous lighting is considered beneficial.

■ **Variable speed limits, line control, and speed harmonization.** Speed harmonization is introduced through the use of variable speed limits to improve traffic flow on freeway sections that experience recurrent congestion and protect vehicles at the back of congestion- or incident-related queues.

The speed harmonization system detects changes in traffic speeds and volumes along a corridor, and an algorithm automatically reduces speeds based on real-time traffic conditions. To ensure respect for the variable speed limits, communicating the reason for the lower speed and enforcement are essential. Representatives of the European agencies used the phrase "trust equals compliance" on several occasions to indicate that the speed limit needs to be reasonable and the reason for lower speed needs to be clear.

- **Gantry and detector spacing.** The spacing between gantries that contain variable speed limit and line control signs and detectors that collect traffic data varies among countries. In Germany the national standard is 2.5 kilometers (km) (1.6 miles (mi)), but Hessen spaces its detectors at 1 km (0.6 mi) and gantries at 1 to 1.5 km (0.6 to 0.9 mi). It justifies the shorter spacing to collect better traffic flow data, provide better alternate route information, and improve system management. Other countries use 600-m (0.37-mi) to 1,000-m (0.62-mi) spacing of gantries. For gantry spacing, both the English and the Germans stressed the importance of having a continuum of information with intervisibility of signs on successive gantries for the driver.

- **Emergency refuge areas.** When the shoulder was used as a travel lane—either part time or permanently—emergency refuge areas were added. The spacing of the refuge areas varied by facility and country.

- **Signs.** There is an ongoing debate on the best balance between static and variable message signs. One thought is that variable message signs provide better opportunity to communicate with the driver, such as the reason for speed limit changes or the presence of a queue or anticipated delay downstream. Some suggest that all signs should be dynamic signs, whether electronic or mechanical. However, variable message signs are more costly and require backup power systems to maintain continuous operation during a power failure.

- **Evolution in design philosophy: transition to a performance- or risk-based design approach.** Representatives from England, Germany, and the Netherlands all emphasized the need to use performance- and risk-based methods for making design choices. Historically, highway design criteria have been developed with a static roadway in mind. With a dynamically operated roadway, the needs and solutions may be different from those of a static design. Performance-based design is an outcome-based, operationally focused design approach that considers the desired goals and objectives of the transportation facility and establishes project design criteria accordingly. England has developed a risk-based approach to innovative design practices, providing additional flexibility to design for safe operations.

- **Evolution of design criteria.** Countries continuously evaluate cost-saving approaches, including the tradeoffs of increasing the spacing between gantries, detectors, and emergency refuge areas. In England earlier implementations are now considered conservative and current experience indicates that greater spacing may be appropriate.

Findings for Performance Measures

- **Key performance measures: travel time reliability and safety.** The key performance measures used in some European countries are improved travel time reliability while enhancing or maintaining safety. The active traffic management strategies being implemented allow a wide range of options to improve or maintain safety while providing substantive mobility benefits.

- **Other performance measures: travel speed and congestion.** Average travel speeds for a roadway section have been used to quantify successful implementation of traffic management strategies, in addition to recognized and documented improvement in congestion. In Germany the Congestion-Free Hessen 2015 initiative was started with the intent to ensure continual improvement of traffic flow. The vision of the initiative is that "mobility is one of the greatest issues for the future in Hessen. Both in economic and ecological terms, as well as with reference to social and cultural aspects, this task demands our full attention. Because for a transit state like Hessen at the heart of Germany and Europe, mobility and logistics are not only sustainable economic factors but also synonyms for a modern and progressive society."[2] Hessen has experienced a reduction in congestion of 80 percent,[3] but the initial large reduction in congestion duration was because of the completion of major road projects.

- **Public relations.** Education of drivers and stakeholders on managed motorway features is important for successful operations. Projects are driven by desired outcome; therefore, understanding the overall goal and clearly and successfully communicating the goal to the public are critical. Experiences in Europe have identified radio and Web-based approaches as the best methods to reach the public. In some cases, the driver culture of the area may influence how treatments are implemented and communicated to drivers.

Findings for Planning

- **Safety concerns.** Politicians, citizens, designers, and implementers in England, Germany, and the Netherlands had concerns similar to those expressed in the United States about potential or perceived reductions or changes in safety because of the application of some management strategies. The Highways Agency in England developed a hazard index to systematically evaluate the potential driver safety risks and aid in its decision to implement strategies and design choices on managed motorways. The agency uses a risk-based approach for transitioning the shoulder from an emergency lane space to a travel lane. Its research has indicated that the risk of eliminating shoulders (at least for part-time use) is minimal.

- **Evaluation of feasibility.** Before managed motorway treatments were implemented, extensive studies were conducted to determine a technique or strategy appropriate to the problem and the roadway geometry.

- **Stakeholders.** It is important to bring all stakeholders (enforcement, trucking, traveling public, agency, and government leadership) in at the early stages of the planning and design process. Emergency management was a key stakeholder group to educate and strategize in several European countries.

- **Legislation and policy.** In England, Germany, and the Netherlands, national or state policy was a driving factor in implementation of managed motorway concepts. In 2003 the German state of Hessen initiated "Congestion-Free Hessen 2015," which specifically identified future technologies, traffic management, and mobility services as tools to optimize traffic flow and increase safety. In England, longstanding public concern about the environmental cost of highway expansion drove the development of various reports and policy initiatives that emphasized sustainability in seeking solutions to roadway congestion.

Findings for Lessons Learned

- **Corridors in progression.** There is an evolutionary path in the appropriate design and operational strategies of individual freeway corridors. As traffic and congestion levels increase in the corridor, different approaches and management strategies should be considered to accommodate changing needs, risks, and appropriate tradeoffs.

- **Effective use of space.** Several European countries dynamically manage the freeway space available. For example, they may use the paved shoulder space for traffic movement during peak travel periods and as a typical shoulder during offpeak travel times.

- **Importance of collaborative design process.** Actively and effectively managing roadways requires coordination across disciplines, and collaboration among planning, operations, and design is imperative. In England the Highways Agency uses the operational regimes to determine design criteria rather than adhere strictly to design standards.

- **Operating costs.** Stable, consistent, and ongoing funding for operations and maintenance is a critical component of the managed motorways concept.

- **Capital costs.** The M42 in England was designed conservatively on spacing of gantries, emergency refuge areas, and ancillary equipment. After monitoring operations and results, the English have made incremental changes based on data that demonstrate they can maintain or improve traffic flow and safety while increasing the spacing between gantries and refuge areas and reducing lighting to lower costs.

- **Complementary treatments.** Many applications are complementary. For example, line control (or variable speed limits) and shoulder running installations result in complementary and synergistic operations and benefits.

- **Benefits.** The countries visited report that managed motorways result in improved safety, reliability, and air quality and can be provided at less cost than traditional capacity expansion.

- **Public perception.** The countries recognize that the proposed operational scheme will be successful only if the public perceives it to be successful (despite what data may say).

- **Procurement.** Construction methods are evolving as a result of the high degree of technology required for managed motorway concepts. England has used innovative construction methods and offsite locations to assemble managed motorway gantries, signs, and ancillary equipment and realized efficiencies in buying equipment.

- **Sign messages.** England, Germany, and the Netherlands have found that it is important to test new sign messages with users before implementation.

Next Steps

As evidenced in this report, the scan team believes that much can be gained in the United States by implementing several concepts and strategies observed during the scanning study. The next critical step is the implementation phase. Scan team members are communicating key findings, promoting implementation ideas, and advancing the adoption of key approaches and practices described in this report. The scan team is also seeking champions from transportation agencies and organizations to implement policies and practices using flexibility and innovation in designing freeways for improved safety and operational performance.

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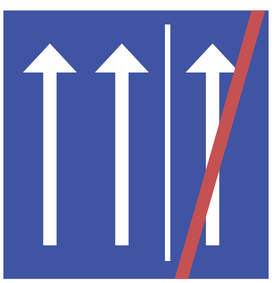

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