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CENTENNIAL PAPERS

Standing Committee on Congestion Pricing (ABE25)
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Congestion Pricing: Driving Efficiency Through Innovation, Research, and Deployment

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INTRODUCTION

Congestion pricing and related market-oriented strategies have the potential to create far-reaching improvements in the planning, funding, and operation of transportation systems. Transportation facilities and services are known to produce the greatest benefits for society when prices, access and other perceived user costs reflect the marginal cost of travel, thereby balancing supply and demand. Carefully crafted pricing innovations that rely on market principles are needed to achieve more efficient infrastructure and resource use, better resource allocation decisions for investments, strengthened links between travel demand and revenue generation, improved reliability of transportation infrastructure, and increased consumer choice in satisfying diverse existing and future transport needs. The increased benefits from innovative transportation pricing can be achieved in ways consistent with environmental values, social equity, protection of personal privacy, and expanded freedom of choice. Despite the benefits, and similar principles applied in power, water, and other utilities, the use of congestion pricing for transportation purposes has been limited and its acceptance continues to be a challenge.

PAST: THE LEGACY OF CONGESTION PRICING RESEARCH WITH TRB

Since the 1990s, the Transportation Research Board (TRB) has invested its time, resources, and attention to researching, growing, and connecting state, local, and industry practitioners with researchers in congestion pricing concepts worldwide. Initially formed as a joint subcommittee between Revenue and Finance (ABE10) and Transportation Economics (ABE20) in 1994 under the leadership of Ralph Erickson, the Congestion Pricing Committee (ABE25) received full standing committee status, chaired by Lee Munnich of the University of Minnesota, in September 2005, reflecting the broad and growing interest in research, education and outreach in congestion pricing and related market-based transportation issues.

The committee has engaged many hundreds of active members and friends, along with extensive interactions with other TRB committees, most notably its original two parent committees, the Transportation Demand Management Committee (ABE50), and the Managed Lanes Committee (AHB35), which constitutes the primary form of governmental-based congestion pricing deployed in North America.

Despite the continuing advances in applied research, ABE25 has maintained its original focus on theoretical applications of pricing and transportation economics through its first joint subcommittee with ABE 20, the Economics of Pricing joint subcommittee. This joint subcommittee has continued the founding goals and objectives of ABE25 while the parent committee has expanded its research reach with other committees. In collaborating with ABE10, the Congestion Pricing Committee has hosted research exchanges to evaluate the potential

impact of congestion pricing systems upon transportation revenue, sustainability, and long-term transition away from fuel-based taxation systems. Partnership mechanisms have included joint sessions at annual meetings, co-sponsorship of mid-year and international conferences, and the formation of a joint subcommittee (Mileage Based User Fees). The joint subcommittee served a vital, unmet need in the industry, as it was the first organized entity to encourage research and dissemination for this up and coming topical area. Additional partnerships, focusing more on the applied nature of research in physical project development, the Congestion Pricing Committee has partnered with ABE50 for the Parking Management joint subcommittee, which constitutes an examination of how congestion pricing principles can be infused with other demand and system management strategies aimed at parking solutions. Finally, ABE25 has partnered with AHB35 for the Multimodal Pricing Implementation joint subcommittee. In addition to researching congestion pricing's effects on priced managed lanes, this joint subcommittee has also expanded its role as a clearinghouse to address research needs and changes to NCHRP Report 835. Altogether, through these mechanisms, the Congestion Pricing Committee has maintained its role of conveying innovative research to implementation.

The Congestion Pricing Committee's membership and friends network reflects a diverse array of people and entities actively engaged in exploring and expanding the concept. Practitioners are garnered from not only the U.S. and Canada, but also Germany, Israel, Australia, Sweden, the Netherlands, the United Kingdom, Hong Kong, and China. Agencies represented have included federal and state departments of transportation (Washington, Minnesota, Colorado, Virginia, Florida, Oregon, Georgia, and Texas, who have had representation on the board for almost every year since the committee's formation), regional public agencies (such as metropolitan planning organizations, transit, and toll agencies), academic institutions, and consultancies.

Like other TRB committees, ABE25 has found that bringing practitioners together in regular forums is an effective way to advance the state-of-the-practice through knowledge sharing and technology transfer. Since the Committee's formation, the Congestion Pricing Committee has fostered relevant industry-wide collaboration and knowledge sharing initiatives through the conduct of conferences and symposia in partnership with the International Bridge, Tunnel, and Turnpike Association, the Mileage Based User Fee Alliance, the Association for Commuter Transportation, and its close TRB Committee partners (ABE10, ABE20, ABE50, and AHB35). As an example, ABE25 not only co-endorsed the *Managed Lanes Implementation Guidance* research with AHB35 (later completed as NCHRP Report 835), but it has also directed its joint subcommittee with AHB35 towards serving as clearinghouse and maintainer of research needs and necessary changes to the NCHRP report as developments occur over time.

Congestion Pricing Definition

Congestion pricing is an economics-based and market-oriented approach to managing traffic congestion on transportation infrastructure. Whereas the concept is typically associated with limited access highways or urbanized surface streets, the principles can be equally applied to transit, shared mobility, parking, and aviation. From a roadway perspective, while congestion is caused by a myriad of factors, it is typically highest in urban areas during morning and evening commute times. At these times, demand for vehicular travel along the roadways exceeds the available capacity, leading to decreased travel speeds, increased emissions, and significantly reduced vehicular and person throughput. Congestion pricing levies a fee for access to facilities (or lanes on a facility) that reflects current demand. As such, the price for access to the roadways

increases when there are more vehicles. In this sense, congestion pricing is like pricing structures found in utility services, sporting events, and airline tickets, where the price fluctuates concurrent with changes in demand.

Congestion pricing works to maintain designed traffic speeds while allowing optimal vehicular throughput along the defined facilities to maximize utilization of limited capacity. However, moving vehicles is only part of the story. When properly designed and implemented, another beneficial outcome of congestion pricing is to elicit change in travel behavior or decisions towards other transportation modes, to less congested periods of the day, or to other adjacent roadways with available capacity – thereby optimizing the comprehensive "carrying capacity" of all modes, routes, and times. This behavioral ability of congestion pricing to influence people to either choose to pay a higher fee, change to transit or other modes, and/or to not take the trip at all is a powerful and effective tool to support the efficient use of limited transportation infrastructure and resources.

Those paying a fee are moved as efficiently as possible by maintaining high travel speeds with a rate set to manage demand in one of two ways:

- **Time of Day pricing** involves varying rates based on a pre-determined schedule. Rates are highest when traffic volumes are expected to be highest.
- **Dynamic pricing** involves varying rates in response to real-time traffic conditions. Such applications require the continual collection and monitoring of traffic data and technology to convey price-related information to travelers.

Since toll rates must vary in response to congestion levels it becomes increasingly important to convey accurate rate information to travelers. Congestion priced roads therefore typically use traffic information systems to provide real-time rate information for fee paying vehicles. Drivers often receive information on price levels and travel conditions from different media sources, including variable message signs, web sites, and app-based devices, all of which allows them to make the decision whether to use the priced roads.

Congestion Pricing Committee Accomplishments

The Congestion Pricing Committee is charged with encouraging fundamental research into congestion pricing along with supporting practitioners and furthering applied research. The TRB Committee serves as the central hub for bringing different operators together, fostering communication and sharing of practices and innovative ideas. Besides informal exchanges, the Committee has publicized and advanced research and projects related to not only congestion pricing, but also tolling, managed lanes, parking management, and road usage charging.

The Committee's most important accomplishments include advocating and advancing congestion pricing research with NCHRP, notably:

- NCHRP Report 686, Road Pricing Public Perceptions and Program Development
- NCHRP Report 694, Evaluation and Performance Measurement of Congestion Pricing Projects
- NCHRP Report 722, Assessing Highway Tolling and Pricing Options and Impacts
- NCHRP Synthesis 377, Compilation of Public Opinion Data on Tolls and Road Pricing
- NCHRP Synthesis 487, Public Perception of Mileage Based User Fees

Additionally, ABE25 has partnered with AHB35 through the Multimodal Pricing Implementation joint subcommittee to serve as the current practices clearinghouse for NCHRP

Report 835, Guidelines for Implementing Managed Lanes (originally sponsored by the Managed Lanes Committee, but with the support and advocacy by the Congestion Pricing Committee).

These accomplishments include research coordination with the Federal Highway Administration (FHWA) Value Pricing Pilot Program and HOV/Managed Use Lanes Pooled Fund Study, and, regular partnering with the four primary TRB committee partners (ABE10, ABE20, ABE50, and AHB35) on many initiatives including annual workshops, joint poster sessions, and technical sessions.

PRESENT: THE LOOK OF TODAY'S CONGESTION PRICING

When the Congestion Pricing Committee was formed in 2006, the world had already witnessed many successes. Singapore had a robust cordon pricing scheme in place for over 20 years. The states of California, Texas, Minnesota, Utah, and Colorado had opened priced lane facilities that were reducing travel delays and offering new multimodal transit options. Finally, the U.S. Department of Transportation was on the verge of launching an ambitious competition, with congestion pricing as its featured component. All of these successes have led to today's state of the practice.

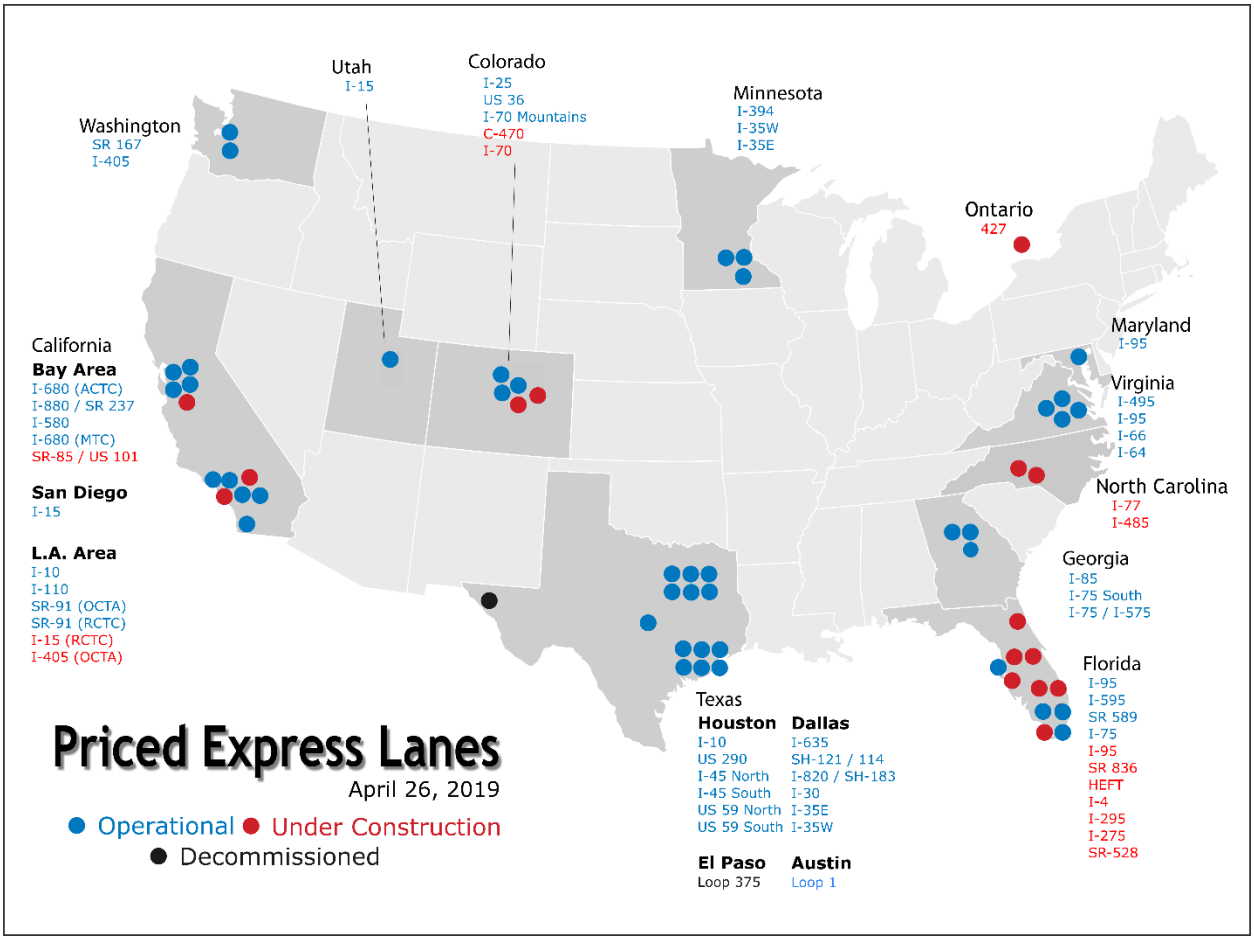
Current State of the Practice

Congestion pricing comes in many forms, yet all centering around the use of variable pricing to actively manage demand. Congestion pricing applications include:

- **Priced roadways**, where all lanes of travel are assessed a price for access. Although toll roads are considered priced roadways, and are very common throughout the world, toll rates rarely are set in relation to prevailing demand. Limited applications of *congestion* priced roadways exist on I-66 in Virginia and when coupled with spot pricing on bridges, as discussed below.
- **Priced lanes**, where congestion pricing is applied to specific lanes within a roadway (often known as managed lanes, a key association with AHB35). The facilities are the most common forms of congestion pricing in the U.S., with over 40 facilities in operation as of the end of 2018 (figure 1). Priced lanes vary greatly in design and operational rules, even within a metropolitan area. Much of ABE25's activities since inception have involved research regarding priced lanes.
- **Cordon pricing**, which establishes a boundary around a geographic area and charges a fee for entering or exiting the area. Cordon pricing actively manages congestion in London, Stockholm, Gothenburg, and Singapore, with many other cities in North America, Europe, and Asia considering deployment.
- **Parking pricing** applies the congestion pricing concept to parking by raising and lowering parking fees in response to demand. There are only limited applications of governmental-based parking pricing, with the most recent being the SFPark program in San Francisco, California. Privately provisioned parking often incorporates a demand component, especially those found in multi-use and special-event concentrated areas.
- **Spot pricing** involves the application of a toll at a single location for accessing a facility. Rates are commonly flat but, in a value pricing application, may vary based on the time of day or downstream and/or local traffic conditions. Contemporary examples include the Bay Bridge in the San Francisco / Oakland area and the SR 520 bridge in Seattle / Bellevue.

- **Distance-based charging** involves levying a fee on every mile travelled in a designated area. While there are many ways this might be accomplished, in general the concept relies on in-vehicle equipment that collects travel information and transmits it to a back office for processing and issuing of an invoice. Only limited application of distance based fees are active in Oregon, New Zealand, and Germany, and none apply a variable fee based upon congestion.

Figure 1. Priced Lane Facilities in the United States, 2019, Source: WSP USA.



Current Issues / Needs / Research Gaps

The Congestion Pricing committee works with practitioners within all agencies involved in research project development, operation and monitoring to address issues and needs of the profession. Issues that have been identified by the Committee in relation to research needs and gaps include:

- **Connected and automated vehicle impact to pricing signals**. Clear trends indicate that transportation agencies must plan for road use by connected and automated vehicles. Congestion pricing provides demand management through behavioral economics; however, there is no identification or prediction for the evaluation of price by automated vehicles.

- **Articulating the value proposition of congestion pricing**. System benefits are clearly identified; individual user benefits remain more elusive. As congestion pricing becomes more established, research is needed to evaluate individual responses to pricing, and the net effect upon mobility and economy.
- **Equity impacts from congestion pricing**. Many notable research efforts, including those conducted by the Government Accountability Office in 2013 and NCHRP in 2018, have indicated that concerns regarding income equity and environmental justice remain with broad implementation of congestion pricing.
- **Price as an indicator of trip time and value**. Implementers of congestion pricing articulate the current price, and that is driven by the current level of demand for roadway space. However, individuals make travel choices based upon not only the prevailing price, but also perceived values of time, reliability, overall trip time, and modal convenience. Without concurrent information on these choice vectors, what is the role of pricing as a proxy for such information?
- **Short-term vs. long-term reliability of congestion pricing for traffic management**. Individual response to price signals tempers over time, with large changes primarily driven by exogenous factors (such as fuel prices, economic trends, etc.). Practitioners have highlighted a need for a longitudinal study to evaluate the long term effects of pricing in regards to price elasticity, which in turn affects the long term reliability of facilities with congestion pricing.
- **Using congestion pricing for revenue generation**. Increasingly, state agencies are looking to congestion pricing as a means of regulating demand but also generating revenue to replace or supplement existing funding mechanisms. However, as congestion pricing proves effective in reducing congestion, what is the long-term impact upon sustainable, bankable revenue generation?
- **Impacts of congestion pricing on other modes of travel**. Congestion pricing can be effective at encouraging the use of other modes of travel (transit, carpools, etc.) or trip alternatives (shopping at home, telework, etc.). To date, little research has been done looking at individual travel behavior across modes to better understand the linkages and synergies between these concepts and concurrent effects.
- **Ability for congestion pricing to help mitigate climate change**. Congestion pricing can improve the quality of life by providing the public with a reliable travel time. When maintenance and operations are considered a primary recipient of revenue, then net revenue can be purposed towards actions to mitigate the effects of climate change without detriment to the transportation system. Furthermore, congestion pricing rates and allocations could be set to control the total amount of vehicular trips made, which can result in changes to travel behavior and vehicular use.
- **Enforcement of congestion pricing systems**. To date, most congestion pricing systems have relied upon vehicle-based transponders and license plate recognition. However, little attention is paid towards the adequate enforcement of fees. Additionally, when incentives are provided for multi-occupant vehicles, having reliable systems for detecting and enforcing violators of the occupancy policy would greatly improve the system's effectiveness.

Mission Alignment with Other Committees
As noted, the Congestion Pricing Committee has partnered with other TRB committees in research and events including conferences, annual meeting sessions and workshops since its inception. The committee seeks to partner on the larger list of committees based on mutual interest, including identification of research needs and development of research proposals, and joint sponsorship of events with common interest. Committees which align with ABE25 are shown below.

Table 1. Committees with Common Interests to ABE25

Number	Name	Common Interests
ABE10	Revenue and Finance	Revenue and financing of transportation systems with congestion pricing applications. *Current joint subcommittee: Mileage Based User Fees*
ABE20	Transportation Economics	The economics of travel behavior, response, and system are core to congestion pricing applications. *Current joint subcommittee: Economics of Pricing*
ABE50	Transportation Demand Management	Managing demand through congestion pricing is a core, complementary TDM strategy. *Current joint subcommittee: Parking Management*
AHB35	Managed Lanes Committee	Congestion pricing, as applied on priced lanes. *Current joint subcommittee: Multimodal Pricing Implementation*
AHB20	Freeway Operations	Freeway operations and traffic management are necessary, complementary strategies for enacting effective congestion relief through pricing
ABC30	Performance Measurement	Performance monitoring on congestion priced facilities
ADA60	Public Involvement in Transportation	Market research, understanding, engagement, and education for advancing congestion pricing strategies
ADB10	Traveler Behavior and Values	Modal, temporal, and spatial shifts caused by changes in travel behavior by price signals
AHB15	Intelligent Transportation Systems	ITS features on congestion priced roadways, including fee collection and information technologies

As mentioned above, joint subcommittees are co-sponsored by the Congestion Pricing Committee with other committees where there are common interests. They currently include:

- **Joint Subcommittee on Multimodal Pricing Implementation.** The Multimodal Pricing Implementation Subcommittee is a joint subcommittee with the Managed Lanes

Committee (AHB35). It has a mission to serve as a forum for review, discussion and development and dissemination of a research agenda for planning, development, implementation and evaluation of congestion pricing projects, with emphasis on those projects with multimodal components or potential.

- **Joint Subcommittee on the Economics of Pricing.** The Joint Subcommittee on the Economics of Pricing is cosponsored by the Congestion Pricing Committee and the Transportation Economics Committee (ABE20) and focuses its agenda and activities on research and policy analysis of pricing issues from a foundation of economics. Research related to behavioral economics is of particular interest.
- **Joint Subcommittee on Parking Management and Pricing.** The Joint Subcommittee on Parking Management and Pricing is cosponsored with the Transportation Economics Committee (ABE20) and the Transportation Demand Management Committee (ABE50). Its mission is to promote, facilitate and disseminate research on all aspects of parking management, but especially parking behavior and demand management.
- **Joint Subcommittee on Mileage-based User Fees**. The Joint Subcommittee on Mileage-based User Fees is cosponsored with the Revenue and Finance Committee (ABE10). Its mission is to promote, facilitate and disseminate research on all aspects of mileage-based user fees, with a particular focus on relationship of these fees to congestion pricing.

FUTURE: LOOKING AHEAD TO NEW CHALLENGES AND OPPORTUNITIES

Evolutions in technology help create an environment for new concepts and interactions to thrive. For example, "video calling" was a common feature of pop culture – from TV series like *the Jetsons* and *Star Trek*, to blockbuster movies like *2001, Back to the Future 2*, and *Total Recall* – video based interactions were considered a predicted and accepted means of communication, well before the technology actually made it viable. It was not until mobile telecommunications networks coupled with highly advanced mobile ("smart") phone technologies were available that video calling became an actual communication mechanism. Today, whether one is using an Apple, Microsoft, or Google based platform, video calling is omnipresent, reliable, and accepted.

Such technology milestones have a profound impact upon the world. For congestion relief, the availability of electronic toll collection technologies in the early 1990s provided an opportunity to have a similar such milestone for surface transportation. Prior to 1996, when the SR-91 Express Lanes opened in Orange County, California, congestion pricing was seen as a possible strategy to reduce demand. The SR-91 express lanes, though, demonstrated that the technology was available and concept sound, ushering in an era where pricing could be used in addition to access and vehicle eligibility as a means of demand management. Today, congestion pricing applications abound throughout North America, Europe, and Asia, with many more on the way.

Today's congestion pricing experiences yield general predictions for the future. First and foremost is addressing the political realities regarding pricing implementation. In particular, we know from projects deployed to date that public acceptance is likely to be low before introduction of a pricing system, but typically increases after introduction and the benefits of congestion relief are realized. Yet, in between, as congestion pricing concepts progress towards implementation, the increased definition and specifications around policy and design may make people worried about negative personal consequences and trigger the fear of loss, leading to

lower acceptance levels. After deployment, public acceptance will typically increase, which can be attributed to a number of factors:

- Travel times improve more than motorists expected;
- Overall congestion throughout the corridor improves;
- Negative consequences such as fees paid prove less problematic than was anticipated; and
- People adapt and accept a new status quo, no longer evaluating it as a "change".

As public opinion changes regarding pricing, so too will the nature of vehicles themselves. This will have a profound impact upon not only the use of pricing, but also the entirety of the transportation system.

In addition to SR-91, 1996 was a milestone year for electric vehicles. In that year, the General Motors EV-1 (the first broadly commercial electric vehicle) began production. Since then, electric vehicles have become commonplace. Although electric vehicles only comprise less than one percent of the U.S. passenger vehicle fleet, their sales are doubling every two years. In short turn, electric vehicles will have a meaningful impact upon surface transportation, as they do not currently contribute to roadway taxation which will have a detrimental impact upon the ability of traditional fuel taxes to fund roadway infrastructure through traditional means. As state agencies look to replace this lost revenue, congestion pricing will become increasingly attractive because of its ability to generate much needed transportation revenue side by side with the congestion reduction and operational benefits that congestion pricing offers. As such, congestion pricing portends a future where transportation revenue and demand management are considered one and the same. In economic terms, if the pricing of other externalities were included, the operators would approach marginal cost pricing – the "gold standard" for congestion pricing effectiveness.

Often mentioned with electric vehicles are connected and automated vehicles (CAV). CAVs will have broad ranging impact upon surface transportation, and have particular concerns for urbanized areas. In some business models, CAVs will be subscription-based, where the vehicles remain in vicinity to arrive and take passengers, much as shared mobility providers currently do. In this business model, the CAV is consuming roadway capacity while in "waiting" mode, and this can have a detrimental effect upon congestion. If congestion pricing were used to try and balance demand, it must also account for how the fees would be perceived by business operators who need to reserve a minimum fleet for subscribers.

Trip behavior, vehicle ownership, cost of travel, type of vehicle, and mode are all going to change in tandem with limited rights of way in dense urbanized areas, funding constraints, climate change, and increased cost of living. This is one of many possible concerns and outcomes for the integration of congestion pricing and CAVs. Suffice it to say that adapting transportation policies, including demand managing strategies such as congestion pricing, to an uncertain CAV future will remain a key concern of the Congestion Pricing Committee for the foreseeable future.

Over time, a key challenge for the Congestion Pricing Committee will be working with other TRB committees to better understand how pricing influences travel behavior, how to future proof as well as to harness changes in future technology such as electric vehicles and CAVs, and how to plan for and strategize the convergence of distance-based fees, priced managed lanes, and other congestion pricing variants. Already, priced networks are emerging from priced managed lanes and corridors. Priced networks mean more than simply the network of roads upon which

pricing is applied; rather, it indicates the unification of payment systems across multiple modes, the convergence of multi-modalism, and the overall system of complete trip management. Altogether, this network approach to pricing provides new opportunities to re-evaluate and introduce expanded visions of congestion pricing at much more rapid pace than ever before. To that end, the Congestion Pricing Committee will remain a vital partner to industry in continuing to share knowledge and technology transfer.