SECURITY CONSIDERATIONS IN TRANSPORTATION PLANNING: A WHITE PAPER

By

Steven E. Polzin, P.E. Ph.D.

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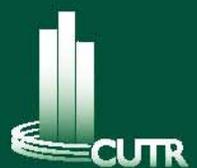
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Introduction

This paper explores the implications of enhanced security concerns on transportation planning activities. It is becoming increasingly clear that security concerns will significantly influence how transportation facilities and services are provided. Hence, via this white paper possible implications on transportation planning are explored. Over the next several years, security considerations will most probably result in a multitude of changes in how transportation is planned, designed, implemented and operated. Transportation goals, planning processes, databases, analytical tools, and organizational structures will change due to security concerns. This paper is intended to seed that discussion and facilitate that process of change.   Just as the transportation planning professional and the planning process have evolved to accommodate issues such as enhanced environmental concern, social equity, evolving technologies and multimodal considerations, the inclusion of demand management strategies, and various other new goals and considerations, so too, it will have to adapt to the need to address security considerations in the planning of transportation infrastructure and services.

Transportation and Security

A secure transportation system is critical to overall national security from terrorism. Groups or individuals motivated to terrorize or injure people or the economy may well have transportation facilities as a target or a tool. Most assuredly, they would have a transportation element in an overall plan of terrorism. Thus, securing the transportation system is a critical consideration in overall security planning.

Terrorists may be motivated to disrupt the economy. Transportation infrastructure is critical to the functioning of the economy. Transportation activities comprise 12 percent of the gross domestic economy, and virtually all of the economy is contingent on a functioning transportation system. Disruption to critical links in the transportation system provides an opportunity to cause serious economic harm. Thus, transportation facilities may be targets of terrorists intending to harm the economy.

Terrorists may be motivated to cause personal injury to concentrations of people. Transportation facilities often provide anonymous gathering places for large numbers of individuals. Planes, trains, buses, terminal facilities, and pedestrian plazas have been terrorist targets. Thus, transportation facilities as gathering places for large groups of people may be targets of terrorists seeking to kill or injure significant numbers of individuals.

Terrorists may be motivated to strike at symbolic targets in an effort to harm a group or organization of people. Thus, high profile transportation facilities may be emotionally appealing targets for terrorism. The Golden Gate Bridge, the LA Airport, and other high profile transportation facilities have been mentioned as possible targets due to the fact that damaging these facilities would have impacts beyond the personal and economic consequences. Thus, high profile transportation facilities may be targets of terrorism.

Terrorists need to deliver the people, munitions, explosives, biological agents, or other destructive elements in their initiatives to terrorize. Thus, transportation is explicitly an element of delivering terror. Be it airplanes, as in the case of September 11, 2001; trucks, as in the case of the Oklahoma federal building bombing and the 1993 World Trade Center bombing, or personal and freight vehicles that move the people and materials of terrorism around, transportation vehicles and facilities are critical elements in delivering terror.

Finally, as transportation is critical to the mobility of all people, including individuals who inflict terror and jeopardize security, transportation operating and regulatory agencies have opportunities and responsibilities to oversee various aspects of person movement and licensure. This includes involvement in securing borders, licensing vehicle operators, licensing vehicles, and enforcing various other laws regulating the safe use of vehicles and the transportation system.

Thus, collectively, the transportation sector is intimately involved in the security of our society and, in many respects, will be a front-line area of focus in enhancing security. The future of transportation will be very much influenced by security considerations.

> *Transportation requires security because it:*
> - *Is a critical element of the economy*
> - *Is a gathering place for groups of people*
> - *Has symbolic and emotional importance*
> - *Provides a delivery means for people and products of terrorism*
> - *Includes institutions with licensing and enforcement responsibilities*

Security Risk

In its simplest terms, security risk might be expressed as a mathematical function. The security risk is a product of the probability of an incident attempt times the vulnerability of the target times the damage costs of a successful breach of security:

> *Security Risk = Probability of Incident Attempt $\times$ Vulnerability $\times$ Damage*

Each of these terms suggests something about the nature of security risks to the transportation sector and the potential consequences of ongoing security concerns. Historically domestic security concerns have been modest as a result of the fact that the probability of an incident was believed to be so dramatically small that the extent of vulnerability and the size of the potential damage had been relatively unimportant. However, in the post September 11th era, the probability of an incident attempt is believed to be far greater than previously appreciated by the vast majority of the public, thus resulting in the security risk being far greater than heretofore acknowledged. Additionally, the magnitude of the potential damage from an incident is now recognized as far higher than previously perceived. The extraordinary human and monetary consequence of the September 11th incident increased by orders of magnitude the perceived size of the possible damages from an incident of terrorism. Subsequent expert and media scenarios of increasingly sophisticated and dangerous tools of terrorism, including biological and chemical agents as well as the use of ever more powerful explosives strategically placed, has resulted in the commonly held perception of security risk being far higher to virtually all public and private sector entities in the United States.

While the above calculation could be applied to individual services and facilities, it can also be applied at the systems level where it would suggest that the security risk is now far greater, and, accordingly, should receive more attention and resources to aid in more fully diagnosing and taking other steps to reduce one or more of the factors -- probability of incident attempt, vulnerability or damage. Both the freshness of the memories of September 11th and the empirical reality of this event on the cumulative calculation of security risk will result in heightened attention for a period of time, certainly several years, even in the absence of subsequent events. If significant subsequent terrorist events occur that involve transportation services or infrastructure, then the corresponding values in the above equation will continue to increase the measure of security risk and, most assuredly, the investment in enhancing the security of transportation.

What Does Increased Security Risk Mean?

Within days of the tragedy of the September 11th terrorist incidents, speculation began in the media among security and transportation experts and among the general public regarding the consequences of these incidents on America's mobility. The speculation has run the gamut, from predicting the end of skyscraper construction and the subsequent decline in urban densities, to anticipating or advocating new infrastructure investments such as high-speed rail

as alternatives to air travel. In the months since the incident, there has been a flurry of responses including military personnel policing airports, organizations and businesses pulling sensitive information off web sites that could have aided terrorists in planning attacks, and the U.S. Department of Transportation establishing a process whereby all transportation employees will go through a screening and verification process. A multitude of other activities is in various phases of planning and implementation, and a significant amount of effort is appropriately being invested in careful analysis and planning for subsequent steps in the overall plan to improve security. Old reports are being dusted off, new reports are being written, task forces are being formed, and training initiatives are being provided. Early action steps are already being identified and implemented while other actions will require considerable more evaluation before prudent actions can be determined.

The remainder of this paper explores how heightened security concerns will impact the planning, design, implementation and operation of transportation infrastructure and services and how these changes then might influence how transportation planning is carried out -- specifically, how the impacts of heightened security sensitivity may result in changes in how transportation planning is conducted. Evaluation criteria for project programming are likely to change and costs for various transportation investments may change as a result of different design standards that enable enhanced security. Intelligent Transportation System (ITS) investments may have security roles and incident response rolls that may change how we design and specify these systems. Mode choice behaviors may change influencing the overall demand for various travel options. The era of placing parking lots under elevated freeway sections may end, and the processes of issuing driver licenses and vehicle titles may change as security considerations influence the data collection and screening steps. The goal of this paper is not to identify or prescribe all the actions that will need to be taken, but rather to focus on how the changes that do occur will impact how one might go about conducting transportation planning efforts.

The response to terrorism is not restricted to any single level of government. Transportation planning is carried out by localities, regional authorities, Metropolitan Planning Organizations, state departments of transportation, the US Department of Transportation and various other authorities and transportation providers. Security issues permeate all levels of government and all aspects of planning and delivery of services and infrastructure. The private sector also is significantly impacted be they service providers, contractors, consumers, vehicle manufacturers and operators, or consultants and others in support roles. Security will impacts day-to-day operations, mid-term planning and programming and long-range planning activities.

The following section outlines some possibilities on how security concerns might influence transportation. The intention is to speculate on the full range of possible impacts and to subsequently sort and classify them in a manner that enables a systematic exploration of what this might mean in terms of transportation planning. Subsequent sections explore the implication on the transportation planning process.

The Impacts of Security Concerns on Transportation

The September 11th incident created a financial crisis for the airline industry; government involvement will inevitably change our perception of a mode that heretofore was generally regarded as user supported. Regardless of who pays, the long-term cost of air travel is likely to go up, due to greater security costs, higher risk costs, and perhaps fewer economies of scale. Time costs of air travel may also go up as security clearances slow boarding. And, somewhat unique to air travel, there may be an increase in those who have a mode-choice-altering fear of flying. How do these changes filter into our transportation planning activities? Should mode choice coefficients or the time and money cost estimates of various modes be altered for future planning studies? Has the steeply-sloped curve of growing air travel demand been permanently altered? Can technology and procedures ultimately provide needed security without significant time penalties? Does the willingness of the federal government to make a significant financial contribution to the airline industry render subsequent subsidies to Amtrak or high-speed rail more palatable?

After a decade of preaching multimodalism and modal integration, do we need to rethink those plans for remote airline check-in counters at downtown rail transit stations? Is the convenience of intermodal transfer offset by the security risk of larger concentrations of passengers and the complications of security screening to the highest prevailing standard of the associated modes? Are all modes of public travel inherently more attractive to terrorist attention and hence subject to higher security costs? Some have argued that investment in alternatives such as rail provides a necessary contingency -- do we now justify investments in these alternatives by highly valuing this contingency potential in our resource programming decisions?

Many have noted that transportation's importance to the economy was underscored by the terrorists' actions, and hence, the public may be more willing to increase the investment in our transportation system. Yet, security concerns and subsequent initiatives are competition for funds in the near term and may significantly impact the cost of transportation infrastructure and services over time.

Will there be more subtle impacts in personal activity schedules and behaviors that will impact transportation? Some suggest that there is a renewed focus on the family and a tendency to stay closer to home. Others have speculated on a fear of traveling to high profile locations. Within an hour of the first terrorists' actions on September 11th, traveler behavior in response to security threats changed remarkably from passive to active roles in responding to security incidents.

Intelligent transportation system investments are now seen as an important tool in responding to terrorist incidents and their design is taking into consideration the possible role in disaster evacuation. Physical locations of transportation infrastructure are receiving more attention, with parking locations being scrutinized from the perspective of the opportunity parking provides for staging an attack on adjacent facilities. A host of responses to various security threats can be hypothesized. Table 1 outlines the types of security threats that have been contemplated as possibly impacting transportation facilities and services.

Table 1: Scenarios Considered in the U.S. DOT Vulnerability Assessment

Physical Attacks	
• Car bomb at bridge approach • Series of small explosives on highway bridge • Single small explosive on highway bridge • Single small explosive in highway tunnel • Car bomb in highway tunnel • Series of car bombs on adjacent bridges or tunnels • Bomb(s) detonated at pipeline compressor stations • Bomb detonated at pipeline storage facility • Bomb detonated on pipeline segment • Simultaneous attacks on ports • Terrorist bombing of waterfront pavilion • Container vessel fire at marine terminal • Ramming of railroad bridge by maritime vessel	• Attack on passenger vessel in port • Shooting in rail station • Vehicle bomb adjacent to rail station • Bombing of airport transit station • Bombing of underwater transit tunnel • Bus bombing • Deliberate blocking of highway-rail grade crossing • Terrorist bombing of rail tunnel • Bomb detonated on train in rail station • Vandalism of track structure and signal system • Terrorist bombing of rail bridge • Explosives attack on multiple rail bridges • Explosive in cargo of passenger aircraft
Biological Attacks	
• Biological release in multiple subway stations • Anthrax release from freight ship	• Anthrax release in transit station • Anthrax release on passenger train
Chemical Attacks	
• Sarin release in multiple subway stations	• Physical attack on railcar carrying toxics
Cyber and C3 Attacks	
• Cyber attack on highway traffic control system • Cyber attack on pipeline control system • Attack on port power/telecommunications	• Sabotage of train control system • Tampering with rail signals • Cyber attack on train control center

Source: National Research Council, *Improving Surface Transportation Security, A Research and Development Strategy*, Washington D.C: National Academy Press, 1999.

It may be useful to explore the implications of security threats on transportation planning by reflecting on a simplistic model. Figure 1 outlines such a model, where security concerns influence land use, travel behavior, public investment priorities, and transportation system performance. In each category, impacts can be long or short range. These changes may create a need to change transportation planning activities. Changes in our planning subsequently feed back to influence these four factors and thus, the level of security risk may be impacted as changes influence the probability of an incident attempt, the vulnerability, or the damage.

Figure 1 Conceptual Model of Impacts of Security Risks on Transportation Planning
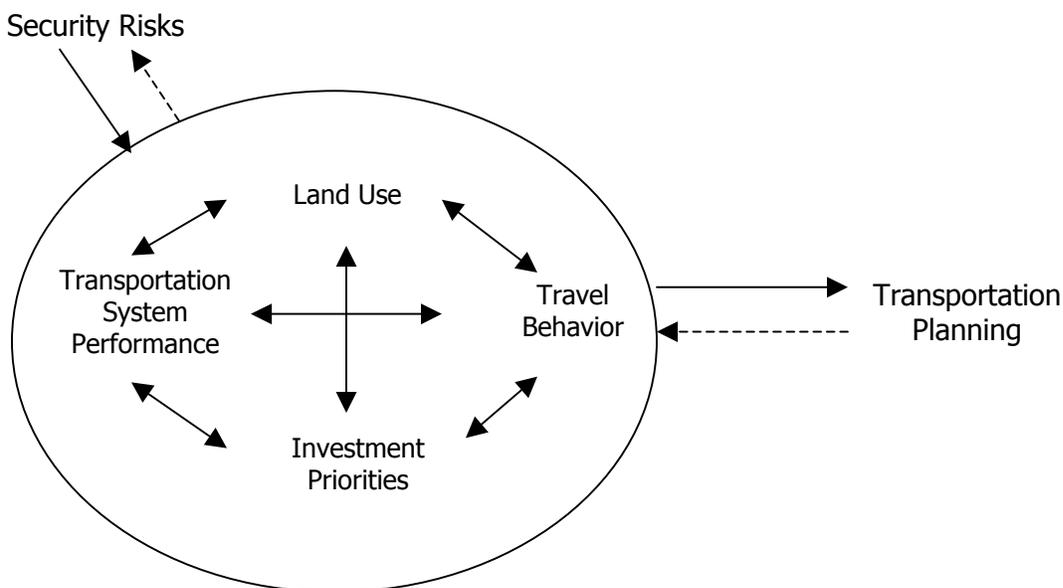
Each of the four factors is discussed below with examples of how they may change as a result of security risks.

Land Use -- Individuals have speculated on a variety of land use implications, ranging from an increase in employment dispersion and sprawl to a renewed focus on the importance of the city. While signature high rises may not be a growth market, there is little reason to anticipate meaningful land use changes in the short term. The fixed nature of land use and capital intensive supporting infrastructure dampens any rapid land use changes even if there were strong pressures to make changes. According to participants in the recent Urban Land Institute's Global Mayors Forum, the September 11th terrorist attacks have sharpened the focus of municipal officials, both nationally and abroad, on the need to sustain urban revitalization efforts and enhance community livability. The participants concurred that

while the possibility exists that the attacks could drive some people out of urban areas, the reaction of urban residents so far has resulted in an "overwhelming celebration" of cities. Other planners have postulated that the economic impacts will slow retirement-driven migration patterns as well as growth in tourism intensive economies. Subsequent reports from New York real estate analysts suggest that there will be some dispersion from Lower Manhattan to other locations in the near term. This appears to reflect a variety of factors including security concerns but other factors as well. There does seem to be some reinforcement of the concept of a given firm having multiple locations to enable it to have redundancy in case of disasters.

The complex set of factors that govern location choice will make it difficult to determine the significance of security risks in location decisions and subsequent land use patterns. Discerning security considerations from factors such as the ongoing shift to service and information industries and the influence of improved communications on location choice may favor dispersion of activities regardless of security concerns. If there were to be multiple future terrorist incidents concentrated in highly urban areas or other specific locations, this could result in land use responses becoming more significant over time.

One would not currently anticipate security concerns to induce changes in land use patterns that would influence transportation planning initiatives. While one might speculate that heightened security concerns may reinforce demographic shifts to lower density smaller areas, there is currently no empirical basis for this expectation. There is no reason to expect that security concerns will impact migration to or from various regions of the country.

Travel Behavior -- One can speculate on how security risks may impact each of the traditional four elements of travel behavior that transportation planners typically consider: trip generation, trip distribution, mode choice, and route assignment. As in the case of land use location choices, travel behavior is complex behavior influenced by a host of factors. The cumulative

> *Travel Behavior:*
> - *Trip Generation*
> - *Trip distribution*
> - *Mode Choice*
> - *Route Assignment*

experiences and perceptions of travelers will influence travel behavior; thus, the perception of security risk as influenced by security incidents and perceptions of security levels for various travel options will influence individuals' travel decisions.

  Trip Generation -- After September 11th, trip making declined as people chose to forgo certain trips. This behavior was particularly apparent for long distance business and personal trips. There is speculation that a proportion of the general public will remain unwilling to fly. Some may substitute auto or rail travel, but some others will simply forgo

the activity. On the business side, there is likely to be some mode shift but also some occasion for other forms of communication to substitute for travel. The September 11th tragedy is likely to enhance the use of evolving telecommunications capabilities and result in some activities being carried out by phone and other electronic communications means. The information we have on changing trip generation is based on the single extraordinary September 11th event and is complicated by the economic consequences of that event and the underlying slowing of the economy. Certain travel demand may be postponed in time while other travel may be a net loss. The empirical data that is currently being gathered suggests that the travel industry is recovering from the consequence of September 11th. It is premature to predict how security risks will impact long-term long-distance trip generation directly. Indirectly, changes in travel costs and other factors as a result of security considerations could also impact trip generation levels. As shown in Figure 2, the share of total person travel that is classified as urban (less than 100 miles from home) is the vast majority of all travel nationwide, approximately 82 percent. Arguably, the fear of security risks has had very modest, if

**Figure 2
Annual Person Travel
(Miles)**

3,129

14,115

- Local, Annual
- Long-Distance, Annual

any, direct impacts on overall local trip making beyond the immediate physical area of an incident and the immediate aftermath of an incident. Only with sustained security incidents is it likely that local trip making rates would be measurably impacted.
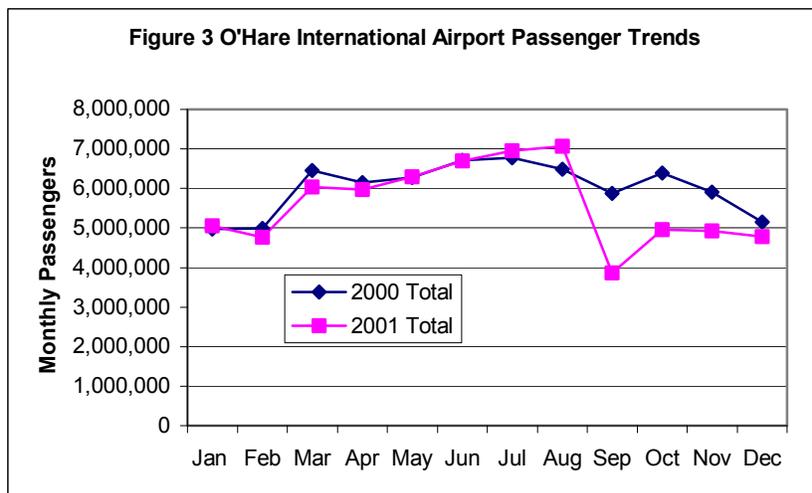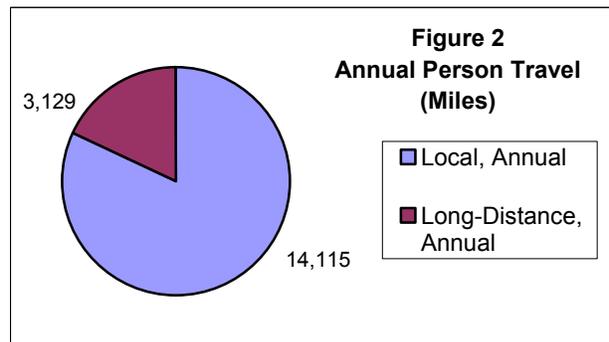

Figure 3 indicates travel activity at O'Hare International Airport. As this graphic indicates, air travel levels have recovered from the immediate post September 11th levels[1]. The remaining discrepancy in travel levels from pre-September levels is most probably attributable to a number of factors from

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[1] http://ohare.com/doa/about/statistics.shtm

security related fears to economic conditions to declining air service frequency to longer travel times through airports as a result of security precautions.

Trip Distribution -- Another possible significant change resulting from September 11th may be altered trip destinations. Individual travel location choices might be modestly altered. As people refocus their priorities, some may value time with family more highly and choose to minimize lengthy commutes to distant job sites. Conversely, others have argued that the push toward decentralized urban areas may result in greater sprawl, meaning longer commute trips for many. Independent of the effects of the slowing economy, work commitments and local urban travel activities are likely to remain unaffected. There may be situations where a high profile location and presumed attractive terrorist target may be avoided by some travelers. For example, following September 11th, there were warnings that the Golden Gate Bridge may be a target of terrorists. This type of attention may result in altered trip destinations with people substituting alternative destinations to avoid certain routes, or trip paths. Other travelers may be more reluctant to use various facilities that are perceived to be at risk or susceptible to significant damage if attacked. For example, some travelers may avoid tunnels and bridges. An example of changes in trip distribution includes dramatic falloff in retail sales at downtown Chicago buildings, such as the Sears Tower, when security measures made it more difficult to access interior businesses, such as restaurants and service outlets.
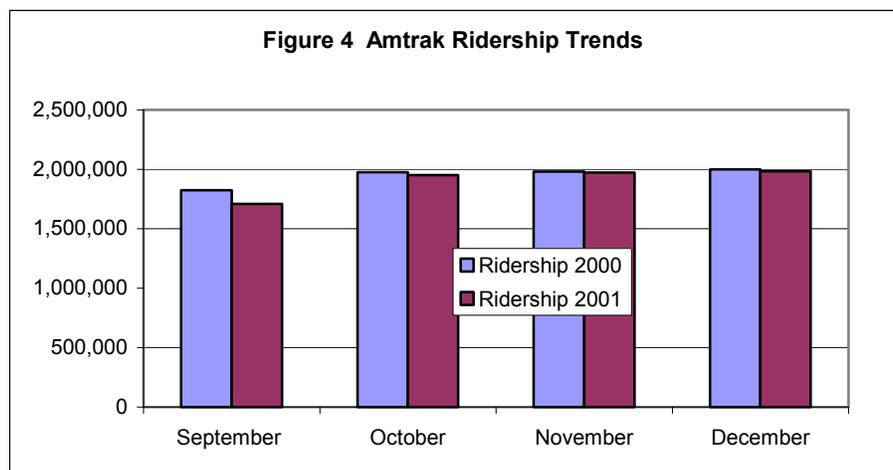
The largest prospect for change in trip distribution again involves those longer distance trips - specifically, trips that might involve air travel. In this regard, both personal and business trips are likely to be affected. Some individuals will choose vacation locations that do not require air travel, and other locations that are perceived as unsafe or prone to security bottlenecks, may be avoided. Travelers have long avoided international hot spots, and, if sustained terrorist activities result in concentrations of incidents in certain locations, then those locations are likely to be avoided. In a more general sense, travelers may seek to avoid crowded or high profile locations or events in fear that these could be targets for terrorists. Only with a sustained significantly higher frequency of incidents are travelers likely to meaningfully alter trip destinations as a result of the fear of terrorist incidents. One may see more significant impacts for discretionary travel purposes. Various airports were impacted differently by September 11th, partially as a result of the nature of the travel market served and partially as a result of the target market and financial health of the particularly airlines that have high activity levels at that airport.

Mode Choice -- Mode choice changes as a result of security concerns are possible due to fears that arise from terrorist incidents or the prospects of them and as an indirect result

of changes in the performance of modes due to security induced changes. The most obvious example is the impact on airline travel. Initially fears of flying altered long-distance trip-making mode choices for some people and, over time, change in the time or money cost of air travel may continue to impact air travel choice. To the extent that there is a fear that vehicles such as planes or buses could be hijacked and used in a terrorist incident or that mass mode vehicles or station locations are perceived as attractive targets with crowds of people, these modes may be avoided by some travelers. It would appear that public modes offer the opportunity for terrorists to both remain anonymous and to impact groups of people; thus, one might expect individual vehicles are less likely to be targets of terrorism. Currently there is no empirical or anecdotal evidence to indicate the extent to which mode choice behavior will be altered. There is no evidence to indicate the extent to which travelers removed in time and space would react to a terrorist incident. Would travelers in a west coast city be less likely to use the bus if there had been a bus bombing in New York three days ago, or three months ago, or three years ago? What if the incident were in an adjacent city or in your city? At this point in time, planners do not know what types of incidents or frequency of incidents would be necessary to change the travel behaviors that are reflected in transportation modeling.

As shown in Figure 3, air travel has been disproportionally impacted by the September 11th attack -- however, one can only speculate with limited data regarding how much of this decline in air travel was accommodated by travel on other modes. Amtrak, as shown in Figure 4, was less seriously impacted, but there is little evidence that much air travel shifted to intercity rail. Some speculate that there was a shift to auto travel. Again, mode choice changes appear to be more apparent for long distance trips. Local travel is predominantly auto travel, and the terrorist incident did nothing to discourage the individual auto mode choice.

Indirect impacts to mode choice are also likely as a result of security risks. Significant and highly visible changes to air travel security and perhaps less visible changes in security precautions for other modes of collective travel could result in

Figure 4 Amtrak Ridership Trends

Legend: Ridership 2000, Ridership 2001. Categories: September, October, November, December. Y-axis 0 to 2,500,000.

mode choice differences. The most obvious impact will be the time and dollar cost of providing the security for travel by public carriers. Currently airport arrival time increases are variously perceived to be in the vicinity of an hour (more than previously required). Intercity bus and rail security also has increased, but service times are not perceived to have been impacted. Air travel security changes are continuing and are expected to evolve over the next several years as strategies and technologies are put in place. A $2.50 per flight-segment passenger security surcharge had been proposed in federal legislation for heightened airport security. Other estimates and strategies could result in a significantly higher per trip increase in the cost of delivering air travel. The magnitude of that cost and how it is passed on to travelers and non-travelers will impact the extent to which security costs influence mode choice for air travel. Time penalties for security enforcement also can influence mode choice as they may impact the comparative attractiveness of air travel versus alternatives. In many locations, an additional hour per air trip for check–in could be enough to encourage the traveler to choose an alternative such as driving or perhaps rail travel in corridors where it is available.

Security incidents such as evacuations of terminals and cancellations of flights as a result of suspicious circumstances can, over time, result in poorer reliability of air travel and hence a greater reluctance of travelers to use it. However, air travel nationally carries approximately 100 times as many passenger miles as Amtrak; thus, the absence of competitive alternatives will dampen the impact of security concerns on air travel mode share.[2]

Beyond long-distance travel, security considerations may impact local travel as well. Factors that may affect more localized urban travel include changes in security procedures that affect public transit and parking facilities. In several areas of the country, parking facilities have been closed or security enhanced in order to restrict access. The fear that vehicles loaded with explosives could damage adjacent facilities or gatherings have resulted in changes in parking policy and locations in numerous areas. The 1993 World Trade Center bombing and the 1995 Oklahoma Federal Building bombing both involved trucks parked in locations that enabled their explosive contents to cause tremendous damage to the respective facilities.[3] To the extent that security concerns impede access by car or truck to various locations or result in search delays for entering vehicles, travel behavior could be

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[2] Bureau of Transportation Statistics, *Pocket Guide to Transportation*, Table 9, Page 13.

[3] 1993, Feb. 26, New York City: bomb exploded in basement garage of World Trade Center; killing six and injuring at least 1,040 others. Six Middle Eastern men were later convicted. They claimed to be retaliating against U.S. support for the Israeli government. 1995, April 19, Oklahoma City: car bomb exploded outside federal office building, collapsing walls and floors. 168 persons were killed. Over 220 buildings sustained damage. Timothy McVeigh and Terry Nichols later convicted in the antigovernment plot to avenge the Branch Davidian standoff in Waco, TX.

impacted. Greater walk access from parking to the ultimate destination, higher-priced parking as accessible supplies dwindle, or other changes imposed as a result of security concerns could dampen the relative appeal of personal auto travel.

Finally, to the extent that subsequent terrorist activities create a fear of group travel, there is the prospect that public modes of group travel could be impacted. In Israel, repeated terrorist incidents on public buses have reportedly altered the willingness of some individuals to use public transportation. While the prospects of such a perceptions developing in the U.S. are not imminent at this time, they could impact mode choice.

Trip Assignment – Trip assignment refers to the actual decisions on the trip route once the location and mode have been determined. Security concerns may result in some changes in trip assignment behavior. Individuals may choose to avoid routes/facilities that they feel are higher security risks. Certain stations may be perceived as less secure due to crowds or other factors. Similarly some routes may be perceived as less safe if they traverse areas that may be perceived as more likely to have security risks. For years international travel has been impacted by security concerns where persons would avoid certain airports or locations in their travel due to security concerns. For example, large hub airports may be avoided in favor of secondary hubs or direct flights. Certain bridges or tunnels may be avoided as in the case of individuals choosing to avoid using the Golden Gate Bridge.

Transportation System Performance -- Perhaps the most obvious area of impact to transportation emanating from security concerns is the prospect that the performance of the transportation system will be altered as a result of the responses to security risks. These changes in transportation system performance will then impact travel behavior. The nature of the changes in performance covers the range of performance attributes.

For example, near-term impacts of September 11th include the suspension of many airline services, long delays for airport security, security enhancements for rail travel, and minor changes in auto parking. Other changes, all intended to

> *How Can Security Impact Transportation System Performance?*
>
> - *Cost to User*   - *Safety/Security*
> - *Speed*   - *Convenience*
> - *Accessibility*   - *Connectivity*
> - *Reliability*

enhance security, may impact the transportation of various products. Of most interest to transportation planning efforts are the longer-term impacts.

Security provisions will most probably result in higher user costs for some modes. Air travel costs are likely to increase as a result of airport security costs. The prospects that various modes will have to devote resources to security precautions may divert resources or in essence increase the cost of delivering services. Parking cost may increase if security initiatives and location constraints impact the available space for parking. Additional manpower will be required to provide the enhanced security, and the implementation of various technologies to inspect baggage and screen passengers will increase costs. To the extent that these costs are passed on to travelers, the comparative cost of air travel will increase and travel behavior may change. Other modes may also have higher costs as a result of security. This could include public modes and freight transport modes.

Travel speeds for various modes could also be impacted by security concerns. Specifically, security screening for public modes may impact the total trip time for those modes. In the case of air travel, there has been a significant increase in airport passenger servicing time in the near-term, and there is some prospect that some share of that extra time will be required even when the system fully adapts to new security standards. The high value of travel time for many air travelers will inevitably result in technology and staffing level adjustments to minimize the extra total trip time, however, that may be years in coming. Other travel time delays could be incurred for travel that involves structure parking with security, border crossings, and traveling to sensitive locations that have security restrictions.

Various modes could have changes in accessibility. For example, some parking facilities have closed sections in close proximity to buildings. Truck traffic has been restricted from certain locations and bridge, tunnel, and dam crossing travel may be eliminated or restricted. Access to and by sensitive facilities such as nuclear power plants may be more restricted, and no-fly zones for such events as the Olympics and the Super Bowl are temporally impacting accessibility for some air travel. Modal reliability could also be impacted in situations where security incidents impact the on-time reliability of travel on various modes. Numerous incidents at airports have resulted in multi-hour shutdowns that have stopped air travel. Inspection delays for other modes may similarly impact travel time reliability. Over time, repeated occurrences will influence public perceptions about reliability and hence the attractiveness of the respective modes.

Safety and security is of concern to travelers, and, to the extent that the public perceives a change in relative security, they may change their travel behavior. This may include such actions as avoiding air travel, avoiding particular stations and terminals that are feared to be targets, avoiding routes with critical links that might be targets (bridges, tunnels etc.), and avoiding group travel. Convenience may be impacted in a number of ways. Enhanced

security is certainly an inconvenience, as are luggage limitations and ticketing changes that, for example, require e-ticket receipts to access airport gate areas. Additional inconveniences may be caused by requirements for enhanced personal information sharing as a condition of receiving tickets for some modes. Parking location changes, restrictions on certain vehicles such as vans, and other changes may also inconvenience some travelers. Lack of vehicle access to certain locations or parking will inconvenience some travelers and licensure and vehicle registration requirements may become more burdensome. Security and convenience perceptions may alter some travel behaviors, particularly if they fall differentially across modes.

Finally, system connectivity could be impeded by security risk concerns. Over the past decade, a significant effort within the transportation planning community has focused on intermodalism for both personal and freight travel. The intention of intermodal connections is to enable easy transfer between modes and vehicles to facilitate the most convenient and cost effective use of various technologies for transport of people or freight to various locations. The focus of such planning has been to enable convenient unencumbered transfers. To the extent that security concerns require additional scrutiny of people or freight for various modes, then intermodal initiatives may be impeded by security concerns. For example, several states are considering high-speed rail networks that are being designed to have direct convenient access to airports. To the extent that direct connections require that all rail passenger undergo the same level of security review as airline passengers, then the concept of an integrated system requires the air travel security precautions to be applied to all rail travelers that would have access to the rail-air transfer station. Similarly, precautions for baggage handling would be required to meet the perhaps higher standards of airline baggage scrutiny. Airport security requirements could also impede the convenience envisioned with off-site airport baggage and passenger check-in planned for some intermodal terminals. Similar issues could arise on the freight side where convenient intermodal transferring might require the security precautions of the most restrictive mode or product to be more broadly applied to insure security for intermodal connections.

Investment Priorities -- Speculation has centered on whether security risks will have an influence on public attitudes toward transportation investments. Some have suggested that the economic value of transportation is being recognized, and this will aid efforts to increase investment in transportation. Others anticipate a renewed interest in having transportation choices; specifically enhanced funding for rail modes. Still others worry that diversions of dollars to enhance security will detract from capacity improvements. The Bush administration proposal for the 2003 budget suggest at the aggregate level, overall national priorities for enhanced security may put pressure on available transportation resources in the

short term. Transportation investment priority changes could result from a number of considerations.

Transportation Resource Pressures Resulting from Security Concerns
- *Diversion of resources to security needs outside of transportation programs*
- *Diversion of funds to operating security enforcement/policing/planning/training*
- *Diversion of funds to capital investments in security (barriers, fencing, inspection, etc.)*
- *Use of funds to support network redundancy/connectivity*
- *Use of funds to support modal choice/redundancy*
- *Diversion of funds to design changes/enhancements to increase security*

Post September 11th, actions suggest a variety of possible investment needs as a result of increased sensitivity to security risks. These needs range from near-term initiatives to conduct strategic planning and assessments to supporting enhanced enforcement levels such as those found at airports, to longer-term needs to alter the physical characteristics of individual transportation investments and the system or network of investments. Changes could range from rerouting roadway alignments from sensitive sites to removing trash containers from rail station platforms. Enhancements to ITS technology as a tool to utilize in incident prevention and incident response have been contemplated, and simple design changes to enable additional vehicle inspection queues at border crossings or luggage and passenger scanning capacity at airports may be necessary. Revisiting the capability of our transportation network to handle special vehicles or military equipment in response to incidents or the exploration of modifications in our roadway network to more easily enable mass exodus from an urban area in response to a crisis are among the more complex and expensive strategies that might be pursued. Other major financial obligations could occur if decisions to change the connectivity or range of modal options in our transportation system were to move forward. Several interests, for example, have proposed major investments in high-speed rail in order to provide an alternative to dependency on air travel for longer distance trips. Additionally, certain travel behavior changes could result in different demands for transportation by various modes than are currently anticipated. This could result in changes in modal priorities, shifting geographic priorities, changes in project costs due to design or other security related changes, or other shifts in long-range transportation facility and service plans.

Having speculated on the possible repercussions of security risks to transportation and having attempted to organize those thoughts in something of a logical structure, the remainder of this paper focuses on more explicit consideration of how transportation planning might change to accommodate explicit consideration of security risks.

The Role of Security Risks in Transportation Planning

Prior to September 11th, state DOTs thought of security issues as being operational, not planning, issues. Principal responsibility usually rested with law enforcement agencies. State DOT involvement was mostly in a support role in development of emergency response plans. Security issues were not an issue in most state and MPO surface transportation planning processes. Transportation Improvement Programs (TIPs) at the state and MPO levels did not contain allocations for security related issues. Agencies are now faced with determining how security concerns should be integrated into how we plan, design, implement and operate transportation facilities and services. Is security simply another goal for our transportation system that can be integrated into our planning similarly to how we accommodate safety concerns today, or does addressing security require more radical changes including such actions as redefining organizational structures, modifying basic planning processes and developing or refining planning methods, models and tools?

The goal of transportation planning is generally to lay out a vision of the transportation system and its role in the overall economy and quality of life, specifically identifying priorities and goals that will drive subsequent decisions on investments. The plan also often lays out the processes by which these visions are turned into specific implementable projects. Exactly how the transportation planning process might be altered in light of security risks is explored in the context of the security risk definition noted previously.

Table 2 outlines examples of how security risks might be interpreted in terms of the role of a transportation agency and the implications on transportation planning. As noted in the table, the role of transportation agencies in reducing the probability of an incident attempt is relatively modest. Prudent sensitive actions of the agency can reduce the prospects of internal and customer incidents motivated by actions of the agency. There is very limited history of these types of incidents and no basis for assuming significant changes in the future. Prudent administration and appropriate training of employees to deal with potential problems is the best action and this is an operational issue whose impact on planning will be non-existent or at most a modest shift in resources to administration from capital or operating categories.

The second area where transportation agencies may influence the presence of individuals who may be motivated to carryout terrorist actions is in their role as a regulator. Prudent controls on the licensing of individuals and in selected other regulatory areas may also limit the prospect that individuals who may cause terrorist attacks are around or able to do so. This regulatory responsibility could preclude individuals from entering the country or from having

the mobility afforded by vehicle licenses. Again, prudent administration and appropriate training of employees to deal with potential problems is the best action. The impact on planning will be non-existent or at most a modest shift in resources to administration from capital or operating categories.

Transportation agencies can play a larger role in influencing the vulnerability of transportation facilities to attack. Strategies can include limiting the information that can help in planning a successful and damaging attack, reducing the prospect for an internal attack, limiting the geographic access to sensitive locations/facilities, or providing security to reduce the prospect that someone could do something harmful in sensitive locations. Only certain aspects of these strategies would have implications on planning efforts. There could be implications to facility location, facility design, and operations of facilities and services.

The final category of potential involvement of transportation agencies is in the area of reducing the damage associated with an incident. There are two major areas of damage reduction that merit consideration. The first is limiting the personal and physical damage of the incident by limiting the severity of the impact. This might, for instance, include structural design changes to limit the prospect of an explosion causing serious damage. Other responses could include physical and locational design considerations that minimize the amount and nature of incidents. The second general area of damage mitigation refers to minimizing the subsequent personal and economic impact by having evacuation and service restoration strategies in place that can limit losses and restore functioning. Among the most expensive strategies that are being considered as actions to respond to terrorism are actions to increase the redundancy of the transportation system. Thus, alternative modes or network connectivity strategies are primarily a tactic for post-incident restoration of system functioning. These strategies may reduce the impacts from an incident, particularly the economic impacts, however they do not impact the probability of such incidents.

Integrating Security Concerns into Long-Range Planning

The discussions above address relationships among security risks and transportation agencies and transportation planning. They suggest how security concerns might be interjected into how transportation planning could be adapted to respond to security concerns but do not take the next step of specifically exploring how transportation planning professionals might go about changing what they do and how they do it in order to be more sensitive to security concerns. Are existing planning tools and models altered? Is the process amended to incorporate security? Is security another goal to add to the list along with subsequent objectives and performance measures? Can one simply screen all the jargon in plans and

replace the term "safety" with "safety/security", or is there a distinct difference? Do security concerns merit changes in organizational charts, and how do the security responsibilities get spread across the federal, state, regional and local agencies involved in delivering transportation planning? Is security something that gets addressed in the public participation part of planning? How do the financial commitments to security initiatives get evaluated and how are tradeoffs made to reflect security concerns? And, is it premature to draw conclusions about how security impacts transportation planning?

One can speculate on how security issues might be reflected in the planning process. For purposes of discussion, the planning process is generalized into five specific steps that are common to most planning processes. Each of these steps is discussed in terms of how security issues might be accommodated.

1. Goal Development – Clearly the reemphasized interest in security merits its incorporation as a goal of the transportation system. Security will be a prominent goal for all types of transportation planning and operations just as safety is the single most noted goal for transportation today. Thus, with the incorporation of the security goal

Simplified Planning Process Steps
1. Goal Development
2. Conditions Assessment
3. Needs Assessment
4. Project Identification
5. Project Programming

    will come the need to develop specific objectives, criteria and performance measures that reflect security concerns. It may be logical to structure these goals along the lines of the security risk calculation by focusing on minimizing each factor: incident attempts, vulnerability of system, and damage resistance of infrastructure and services. Various other approaches for defining security objectives and performance measures may also be logical in the context of the overall strategy for objective development.

2. Conditions Assessment - Just as planning benefits from a rich understanding of current conditions, so too it will be important to have a data base that can identify the current conditions as it relates to security. This might include enrichments to various databases that would specifically address relevant considerations such as vulnerability. Many of the system inventory data items may have traits appended that address security considerations. Items may include such things as share of facilities that are secured, proximity to sensitive sites, critical links or susceptible structures (tunnels, bridges, etc.). Information on volumes/units of hazardous materials by route may be compiled and the roles of various facilities in evacuation may be compiled. The status

Table 2 Responsibilities of Transportation Agencies in Influencing Security Risks

Security Risk Component	Possible Role of Transportation Agency	Implications for Transportation Planning
Probability of Incident Attempt Presence of individuals who have the motivation to plan and carryout acts of terrorism.	• Utilize regulatory and oversight capabilities to help identify/capture or exclude entry of possible terrorists (via licensing, border crossing enforcement, routine traffic enforcement, etc.). • Carry out responsibilities in a manner that will minimize the prospect that employees, or affected parties (land owners, contractors, system users etc.) will be motivated to seek revenge through terrorism.	• Enhance transportation agency capabilities in the areas of regulation and enforcement. • Enhance customer interface capabilities of transportation workforce.
Vulnerability Prospect that a transportation target could be successfully terrorized	• Limit the information availability that might influence the choice of transportation as a terrorist target. • Ensure the transportation workforce is screened and monitored to reduce likelihood of internal terrorism. • Limit the access to sensitive targets. • Secure critical elements in transportation system.	• Evaluate Knowledge sharing/dissemination strategies. • Upgrade employee and contractor screening and control capabilities. • Explore physical and operational controls on access to sensitive locations. • Reconsider alignment and service location criteria to include security concerns.
Damage The direct and indirect magnitude of the consequences in personal and economic terms	• Design systems and facilities so as to be resistant to attack. • Have incident response capability to minimize loss of life and restore functioning of transportation system. • Provide redundancies to enable system robustness after an incident.	• Evaluate/modify system and facility design standards. • Consider network robustness in project design and selection. • Support investments to enable rapid incident response.

of employee and contractor security efforts may be itemized and initiatives to secure transportation information may be itemized. Other summaries of security relative to established security performance standards might also be itemized in the conditions assessment.

3. Needs Assessment - The needs assessment process determines how current trends and forecasts influence the performance of the transportation system for the design year of the plan. In this step of the process the planner would have to forecast future travel behavior and as such would need to incorporate evidence or forecasts of changes in travel behavior as a result of security concerns. Thus, if there were evidence of changes in trip generation, mode choice, trip distribution or trip assignment as a result of security concerns, these changes could result in different needs assessment findings than might otherwise be the case. These changes could be direct, for example fears of flying resulting in lower airline travel, or indirect, for example slower and more expensive air travel and thus greater use of alternatives. The needs assessment process requires forecasts of conditions twenty years in the future and hence it is difficult to extrapolate or deduce the impacts from security based on the relatively modest level of information available to date. Obviously, the magnitude of the impacts is very dependent on the prospect of future incidents and the pubic response. Even the consequence of security initiatives is difficult to determine at this point in time as technology and procedure changes will be refined and their consequences in terms of time and cost for various types of travel remain to be seen. Close monitoring of the consequences of security initiatives is certainly appropriate in order to develop a database on changes in system performance and traveler response. This response is not limited to individual travelers. As or more important is its influence on freight and commercial traffic.

4. Project Identification - The project identification step is the essence of planning in that it uses the knowledge of needs and the knowledge of possible solutions to come up with specific proposed solutions to particular needs. This step involves the creative energies of planners in conceiving specific plans. The design and location of transportation solutions may be affected by security concerns. For example, alignments may be altered to avoid sensitive locations and aspects of the design may be modified to reduce the prospect of or damage from an incident. In the case of statewide planning the actual plan development may be occurring at the local or regional levels and are assembled into statewide plans at the state level. Other

projects may be developed specifically to respond to security concerns. These may be initiatives to secure existing facilities, modify designs to minimize damage, or enhance incident response.

5. Project Selection - The final element in traditional planning is the selection of projects to be part of an overall program of actions. In this step, the projects that best respond to the collective goal set are chosen for implementation. The decision-makers will have to find ways to evaluate the relative merits of various project proposals in light of the set of goals. Thus, the importance of security in the context of other priorities such as safety and capacity will need to be determined. This resource programming activity forces tradeoffs and implicitly requires judgments or quantification of the value of security investments. Priorities can be dramatically influenced by federal mandates or requirements. Local public and political pressures may also influence project selections. In the case of security initiatives federal mandates may significantly influence decision-making. It remains to be seen how the general public rates security investments in the context of real tradeoffs between other projects or new revenues.

As the discussion above indicates, security concerns will influence how each of the five traditional steps in long-range planning is carried out. Similarly, security considerations will impact short- and mid-range planning, operations and maintenance activities, research agendas, and regulatory and administrative aspects of the operations of transportation agencies. A significant share of the influence will be determined by federal guidance and input by enforcement agencies; thus, the magnitude of the response to security concerns is only partially in the hands of state transportation officials.

General Observations on Security Planning

The response of transportation agencies to security concerns will encompass all aspects of agency operations from day to day operations and administration to midterm planning to long-range planning. Security assessments and enhancements for operating facilities will impact current operations the greatest. Beyond the near term the largest influence on planning is likely to be the impact on resource availability. The available resources influence the program of transportation investment and diversions of funds to support near-term security initiatives may have a significant impact on long-range planning initiatives.

The State of Knowledge and Uncertainty

The memories of the incidents of September 11th are very fresh, yet the country has a very limited history of terrorism incidents that can form a meaningful knowledge base. This knowledge base is being supplemented with international experience and scenario development such as explored in Table 1. Nonetheless, there is far from a consensus on the various tactics and priorities for reducing security risks. While it is important that energies be invested in understanding the security risks in our transportation systems and responding with prevention and response capabilities where evident, there are other aspects of security preparedness or prevention that have huge implications in terms of resource commitments that may not be prudent based on current knowledge levels. For example, some of the transportation initiatives being proposed are actions intended to provide a contingency transportation capability in response to a transportation terrorism attack. Network redundancy or alternative modes can help do that but these are very high cost options that don't reduce the prospects of an incident or minimize the probability of loss of life, only facilitate a return to normality after an incident. It may be premature to program these extremely expensive responses as other, not yet detailed or identified responses may be more effective and efficient. While terminology like "the war on terrorism" and the freshness of the memories of September 11th encourage a tendency to do everything possible to reduce security risks, resource constraints, both financial and other, will quickly require a more selective strategy.

In the immediate aftermath of a tragedy there is also a temptation to do things that one is knowledgeable about or able to do. Thus, the transportation industry with knowledge in areas such as disaster response and network design, are tempted to apply existing solutions to these new problems. While these tools and tactics will have a place in a comprehensive response to terrorism, developing a rich understanding of the role of transportation in terrorism and careful and systematic evaluation of various responses is likely to offer the most rational long-term response. The emotions inherent in dealing with a subject of this type are understandable; however, just as the transportation community has developed measured and data based responses to transportation safety problems, so too is it necessary to develop the information and expertise base that will enable a response to terrorism in appropriate and effective ways. Clearly, this speaks to a need to invest in learning, research, and information collection at this point in time while simultaneously increasing security in areas where it is obviously necessary and possible.

Defining Roles

Perhaps the best parallel to security planning for transportation agencies is the experience in planning for emergency preparedness and incident management. Terrorists' threats and incidents are an example of an emergency of the type that transportation agencies in concert with law enforcement, the private sector, and other agencies have experienced. These types of initiatives require coordination across functional and jurisdictional lines and as such are communications and process intensive activities. The agencies have very different cultures and perspectives and, thus, resource, turf and ego issues will inevitably evolve. Reiterating the critical shared mission and utilizing the lessons learned in prior collaboration intensive initiatives will be necessary. The diversity of involvement is well exemplified by looking at

the diversity of ownership of transportation infrastructure. The roadway system has broad-based ownership and this is compounded by the private sector ownership of vehicles and terminal facilities.

September 11th reiterated the importance of coordination and communication among the many different operating agencies in a region and across the nation in response to an incident. Such coordination is needed to allow

Roadway Ownership
(Center Lane Miles, 1995)

Under Federal Control	*171,967*
Under State Control	*802,733*
Under Local Control:	
Counties	*1,744,514*
Other Jurisdictions	*1,193,012*

Excludes federal park, forest and reservations mileage.
Source: Highway Statistics, 1995, Table HM-10

enforcement/security/safety responses to occur in an expeditious manner, while at the same time still permitting the transportation system to handle the possibly overwhelming public response to the incident. While coordination and communication are critical to facilitate responses in a crisis mode, coordination and communication in planning for security is important to insure effective and efficient security risk investments. Security responses are also challenging some state officials who are being asked to make major short-term investment commitments that challenge TIP and NEPA approval processes. Cross-agency coordination and communications also will be necessary to insure rule modifications and expedited approvals where necessary.

Priority Setting and Tradeoffs

The security risk equation provides a helpful way to think about how security risk can be minimized. Transportation planners have opportunities to influence each of the factors that contribute to the overall security risk. Careful analysis of how each possible action might influence the overall security risk will be a helpful strategy in insuring that resources are

$$Security\ Risk\ =\ Probability\ of\ Incident\ Attempt\ \times\ Vulnerability\ \times\ Damage$$

directed in the most appropriate direction. Transportation agencies regularly make these types of rather complex and somewhat subjective tradeoffs for safety investments where options include near-term operating costs for enforcement, mid-term opportunities for education initiatives and maintenance activities, as well as longer-term investments in facility and vehicle design. Similar multifaceted tradeoffs will be required to prioritize security resources both among competing security investments and between security goals and other transportation goals such as safety.

As immediate and near-term efforts focus on operational spending to reduce vulnerability, the most immediate planning challenge will be determining which, if any, significant longer-term capital investments to make to enhance security. Defining how various investments contribute to security such that their contribution can be evaluated and tradeoff decisions made will be the most challenging aspect of post September 11th planning. Expert judgment and multiagency collaboration will be required as agencies throughout the country work to develop experience in security investment evaluation.

While many issues involving security are common across agencies and geography, each state and locality will also have unique conditions that will influence both the security risks that they face and the institutional context in which they do security planning and adapt transportation planning to incorporate security concerns. One element of uniqueness can be the nature of unique or specific threats that an area may face. Some of these items are addressed below.

Critical Network Segments and High Profile Targets

One element of transportation security involves identifying areas that would be probable targets based on the prospect that an incident in that location could have a significant impact. Thus, locations where the damage to people or property would be greatest may be high profile target locations that merit consideration for precautions or other initiatives to minimize the impacts of an incident. Several traits might be considered in identifying critical segments. Specific roadway links that are vulnerable or, if damaged, could cause expensive and prolonged disruptions in accessibility are examples of critical network segments. Bridges, tunnels or other critical links might be deemed critical links. The circuitry introduced if such a facility were out of service might be a consideration as might cost to repair or replace.

Other critical network segments might be defined based on the presence of alternative mode or path access to specific locations. For example, access to military facilities, nuclear facilities and other critical locations might increase the motivation for redundancy in access opportunities. Finally, critical links might be defined based on the nature of the traffic flow and the opportunities this presents for terrorist opportunities. Routes with hazardous materials, routes with significant commercial traffic or military materials movements might be such routes.

Conclusions

Over the next several years, security considerations will result in changes in how transportation is planned, designed, implemented and operated. Transportation goals, planning processes, databases, analytical tools, decision-making considerations, and organizational structures will change due to security concerns. Transportation will be on the front line in responding to security risks. The response to security concerns will cross-jurisdictional and functional lines and be among the most complex and important challenges to transportation professionals. While it may be too early to begin changing our long-range infrastructure network plans in response to security risks, there will be changes in spending priorities in the near term and most probably over a longer period of time.

It will be important for transportation planners to monitor closely changes in travel behavior and try to fully understand their underlying causes. This will help planners assess the potential for longer-term shifts in behavior as a result of security-induced changes. Similarly, planners should closely monitor the performance of our transportation systems with regard to time and cost factors as well as security, so as to be able to make informed extrapolations of how these system and service changes might be impacting travel behavior. It will be important to take steps to ensure that the September 11th tragedy does not slow our progress toward a true multimodal transportation system. Nor should these events serve to further polarize modal prejudices or be used as an emotional springboard to advocate investments whose merits should be scrutinized with clear thinking. Initiatives should be put in place to monitor how September 11th and subsequent security concerns actually change U.S. travel behavior and transportation needs.

As transportation planners have struggled to find adequate resources to fully fund capacity and safety goals, a major challenge of security concerns will be ensuring that the immediate emergency diversion of time and resources does not hinder the long-term capabilities of transportation planners to respond to transportation needs. Public recognition of the cost of providing enhanced security and public support for additional funding if transportation

resources are diverted to security investments may be required to ensure that the price of security is not a rapid decline in the condition and performance of our existing transportation system.

In the meantime, transportation operating agencies will be busy providing near-term responses to security concerns. The transportation planning profession has a significant knowledge base and capability in various areas such as incident response, hazardous materials transportation, and disaster response and recovery that provide a strong springboard for providing enhanced security and incident response. Transportation planning has grown over the past several decades to encompass far more than providing cost-effective, safe transportation capacity. Transportation has embraced a broader goal set including social and environmental factors. Thus, transportation planners are knowledgeable in integrating additional considerations into the goal set for planning transportation facilities and services. As experts in dealing with travel safety concerns, transportation professionals have an understanding of how complex tradeoffs between short- and long-term and capital and operating/enforcement decisions can be made. The new challenge will be applying the lessons learned in developing these capabilities to incorporating security considerations into the transportation planning process.

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**CENTER for
URBAN
TRANSPORTATION
RESEARCH**

College of Engineering
University of South Florida
4202 East Fowler Avenue
CUT100
Tampa, FL 33620-5375

813·974·3120
813·974·5168
www.cutr.usf.edu