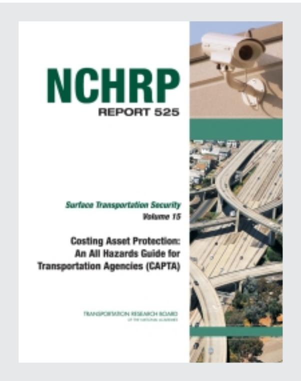

Costing Asset Protection: An All-Hazards Guide for Transportation Agencies (CAPTA)

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Transportation Research Board

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 525

Surface Transportation Security

Volume 15

Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA)

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
McLean, VA

PB CONSULT
Washington, DC

Subject Areas
Planning and Administration • Operations and Safety • Aviation • Public Transit • Rail
Freight Transportation • Marine Transportation • Security

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in cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2009
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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Dr. Michael C. Smith, Senior Scientist in SAIC's Transportation Research Division, was the principal investigator for the project. Mr. Stephen Lockwood, Senior Vice President at PB Consult, served as the subcontractor's principal investigator. Mr. Kevin Duffy served as SAIC's program manager and Ms. Jocelyn Bauer, Research Associate in SAIC's Transportation Research Division, programmed the CAPTA methodology into a spreadsheet model to facilitate its application.

Representatives from a transit authority and several state departments of transportation provided opportunities to apply the methodology in realistic settings using representative data so the study team could tailor the methodology and the spreadsheet tool to the users' needs.

FOREWORD

By S. A. Parker
Staff Officer
Transportation Research Board

Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA) supports mainstreaming an integrated, high-level, all-hazards, National Incident Management System (NIMS)–responsive, multimodal, consequence-driven risk management process into transportation agency programs and activities by providing a convenient and robust planning tool for top-down estimation of both capital and operating budget implications of measures intended to reduce risks to locally acceptable levels. CAPTA is intended for use by senior managers whose jurisdiction extends over multiple modes of transportation, multiple asset classes, and many individual assets. The CAPTA methodology provides a means for moving across transportation assets to address system vulnerabilities that could result in significant losses given the threats and hazards of greatest concern. This guide was reviewed by many state and local agencies and was pilot tested by the Maryland Department of Transportation (DOT), The Massachusetts Bay Transportation Authority (MBTA), and the Virginia DOT.

The guide is supplemented online with a downloadable Microsoft® PowerPoint slide show and CAPTool, a spreadsheet tool for implementing the CAPTA methodology. The slide show and CAPTool are available on the TRB website (http://trb.org/news/blurb_detail.asp?id=9579).

This volume of *NCHRP Report 525* was prepared under NCHRP Project 20-59(17) by Science Applications International Corporation (SAIC) of McLean, VA, and PB Consult of Washington, D.C.

Surface transportation agencies are recognizing that they are uniquely positioned among civilian government agencies to swiftly take direct action to protect lives and property due to their broad policy responsibility, public accountability, large and distributed workforces, heavy equipment, and robust communications infrastructure. Their institutional heft also provides a stable base for campaigns to mitigate or systematically reduce risk exposure over time through all hazards capital investments.

This is the fifteenth volume of *NCHRP Report 525: Surface Transportation Security,* a series in which relevant information is assembled into single, concise volumes—each pertaining to a specific hazard or security problem and closely related issues. These volumes focus on the concerns that transportation agencies are addressing when developing programs in response to the terrorist attacks of September 11, 2001, and the anthrax attacks that followed. Future volumes of the reports will be issued as they are completed.

To develop this volume in a comprehensive manner and to ensure inclusion of significant knowledge, available information was assembled from numerous sources, including a number of state departments of transportation. A topic panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data and to review the final document.

This volume was prepared to meet an urgent need for information in this area. It records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. Work in this area is proceeding swiftly, and readers are encouraged to be on the lookout for the most up-to-date information.

Volumes issued under *NCHRP Report 525: Surface Transportation Security* may be found on the TRB website at www.TRB.org/SecurityPubs.

CONTENTS

PART II CAPTool User Guide

SUMMARY

Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA)

This report provides transportation owners and operators with resource allocation guidelines for safety and security investments. This consequence-based approach, called "**C**osting **A**sset **P**rotection: An All Hazards Guide for **T**ransportation **A**gencies" or "CAPTA," allows an executive to consider multiple modes of transportation and assess those modes and assets that merit resource allocation above and beyond what might be available through routine capital allocation processes. This project fills a void in infrastructure protection approaches and allows owners and operators to make better informed decisions across all modes within their jurisdictions or under their influence. The consequence-based methodology underpinning CAPTA uses a rational, transparent process. The CAPTA process brings greater objectivity to the resource allocation process by using asset attributes to the greatest extent possible, thus avoiding heavy reliance on judgments. Objectivity enables decision makers both to achieve budgetary consensus across multiple modes and to make a more defensible case before legislative bodies that make budgetary decisions.

The primary result of this project is the CAPTA methodology, which provides users with a means to analyze assets, relevant threats and hazards, and consequence levels of interest in a common framework. The methodology is implemented through a computer-based Microsoft® Excel spreadsheet model that assists the user through the evaluation and resource allocation process.

This methodology was developed by a team of experienced transportation designers, builders, and operations personnel who worked with risk and security experts to determine questions that transportation owners and operators want answered, and then sought to answer these questions in a clear, concise manner. The chief question was "What adverse impacts can I not address adequately with current policies, infrastructure, and resources?" or, stated another way, "What consequences concern me most in my transportation system?" Beginning with this question designed to identify "thresholds" of concern, the project team sought to simplify the current assessment approaches by reducing the number and complexity of inputs (especially those calling for judgments) while focusing on objective attributes for comparing assets and modes.

While CAPTA does require the user to determine which assets and which threats and hazards are of greatest concern, the primary judgment required from the CAPTA user is the point (or "threshold") at which adverse consequences would merit allocation of additional resources to avoid or mitigate the effects of the consequential event. CAPTA is an iterative process, so decision makers can evaluate capital investment and other resource allocation options by varying the consequence threshold to determine both where they can apply available resources most efficaciously and what level of resources is needed to achieve a desired improvement in asset protection.

The substantive questions concerning adverse effects or consequence to an agency executive require answers to the following supporting questions:

- What hazards or threats do I face?
- What event(s) concern me most?
- What assets of high consequence do I have?
- How can I avoid these hazards and threats?
- How can I prepare myself for this disturbance if it does occur?
- Where and when should I commit resources to address my concerns?

The last question, concerning how best to allocate available resources in a resource-constrained environment, provides the motivation for the CAPTA methodology. The methodology considers categories of consequences, the numbers and types of threats and hazards, and the transportation modes to be included in order to obtain a coherent method for allocating resources among competing interests and competing modes.

The countermeasure recommendations presented in this report are intended for implementation by transportation owners/operators and are generally within their purview and control. This implementation may occur in part or whole based upon local conditions and, importantly, the level of risk faced by the owners/operators. Owners/operators will also need to balance implementation of structural or operational countermeasures with funding constraints. The project team is aware of these constraints and has packaged countermeasures as a menu of items from which the owners/operators may select, based upon risk level and available funding. Detailed cost estimates for implementing countermeasures for a specific asset are outside the scope of this methodology.

Objective

CAPTA supports ***mainstreaming*** an integrated, high-level, all-hazard, National Incident Management System–responsive, multimodal risk management process into major transportation agency programs and activities. CAPTA provides state DOTs and other users with a convenient and robust planning tool to develop estimates of both capital and operating budget implications of measures intended to reduce risks to levels that can be managed using resources typically available to operating agencies.

The goal of CAPTA is to provide users with a ***capital planning and budgeting tool*** that incorporates five major objectives:

- Demonstrate the budgetary effects of various agency consequence threshold levels chosen by the user.
- Examine the merits of various countermeasure additions and enhancements, including capital and operational measures—both singly and in combination.
- Develop an order-of-magnitude estimate for a user-chosen collection of risk mitigation strategies (countermeasures). This order-of-magnitude estimate serves as a starting point for budgeting purposes. These estimates apply in a multimodal, multiasset agency context.
- Indicate the assets for which more detailed risk analysis is needed.
- Provide guidance in an objective, transparent manner.

CAPTA provides a means to evaluate a wide range of assets and transportation modes based on generic asset attributes. CAPTA assesses threats and hazards and their potential consequences in a common framework. The initial consequence threshold established by the users at the start of the process establishes a baseline from which excursions can be run. A countermeasures database built into CAPTA provides owners with choices and evaluation criteria. This combination enables decision makers to determine appropriate risk mitigation actions and to estimate their costs.

CAPTA may be employed by a range of agencies responsible for risk management across transportation modes in an all hazards environment. The users may be

- Regional entities, such as port authorities, toll authorities, or transit authorities;
- Statewide entities, such as departments of transportation or state emergency management agencies; or
- Local entities, such as departments of public works or county highway departments.

The CAPTA methodology is applicable across agencies with risk assessment and management functions over fixed assets. The methodology and computer-based tool developed on behalf of transportation agencies can also be used by local, state, or regional emergency management agencies responsible for allocating budgetary resources to reduce adverse consequences. The CAPTA methodology described herein does not replicate or replace more detailed asset- or mode-specific methods and analytical tools developed by federal agencies or private sector entities.

CAPTA evolved in response to several emerging realities in the transportation environment:

- Current available risk management strategies are asset specific, mode specific, and threat or hazard specific. These *tactical* approaches do not accommodate *strategic,* high-level, multimodal, all-hazard considerations needed for overall agency-level planning and budgeting.
- The full range of risks faced by a transportation owner/operator forms a continuum. This range of risk requires a systematic, cohesive risk management approach that encompasses all modes.
- Transportation owners/operators are aware of the risks their systems face—from natural disasters to intentional harm (terrorism). CAPTA uses this knowledge as input to the assessment process.
- Many hazards and threats are addressed in established design standards and operational planning. New hazards and threats may exceed established practice or standards. Established and newly apparent risks must be met with mitigation measures consistent with the National Incident Management System (NIMS) and the National Infrastructure Protection Plan.

Audience

The anticipated audience for the guide includes

- Transportation executives or asset owners,
- State and local transportation departments and agencies responsible for multiple modes, and
- Transportation officials with capital budgetary discretion.

Organization of Report

This report is organized as shown in Table 1.

Part I describes the genesis of this project and the development of the CAPTA methodology. This overview provides the rationale for pursuing the consequence-based approach and summarizes other approaches and models considered by the project team before arriving at the CAPTA methodology. This opening section also identifies the outlook of the project team, assumptions made in the CAPTA methodology, the intended users, and the terms underpinning the approach.

Part II offers a step-by-step action plan for users of the Costing Asset Protection Tool (CAPTool), the spreadsheet-based product that implements the CAPTA methodology. The methodology is implemented in a "basic" and an "expanded" form so that users may apply the tool in a manner that reflects available data and the level of analysis required. Part II also provides guidance on which

Table 1. Report organization.

Part	Title	
I	Chapter 1	Project Rationale and Approach
	Chapter 2	CAPTA Development Path
	Chapter 3	CAPTA Components
	Chapter 4	Results Summary
	Chapter 5	Conclusion
	Appendix A	Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA) Test Preparation
	Appendix B	Summary Report for the CAPTA Pilot Test with the Maryland DOT, October 17, 2007
	Appendix C	Summary Report for the CAPTA Pilot Test with MBTA, November 16, 2007
	Appendix D	Summary Report for the CAPTA Pilot Test with the Virginia DOT, February 13, 2008
	Appendix E	List of Acronyms
	Appendix F	Glossary of Terms used in CAPTA
	Appendix G	Recommended Further Reading
II	CAPTool User Guide for the CAPTool Spreadsheet Tool and Data Model	

version of the tool may be most applicable to the user. CAPTool is available from the TRB website (www.trb.org/news/blurb_detail.asp?id=9579).

Project Team

The project team is composed of analysts and engineers from Science Applications International Corporation (SAIC) and PB Consult. These individuals have worked with numerous owner agencies to identify primary and secondary safety- and security-related hazards or threats, identify critical locations, suggest structural improvements at critical locations, and describe countermeasures. Team members have also worked with national organizations such as the American Association of State Highway and Transportation Officials (AASHTO) to develop transportation infrastructure hazard/threat and vulnerability assessment guidelines and guidance for owner agencies. Team members are also leaders in the transit and transportation industry.

PART I

CAPTA Final Report

CHAPTER 1

Project Rationale and Approach

Background

The CAPTA effort is a continuation of efforts begun following the attacks of September 11, 2001. That event prompted a series of risk assessment and management projects initiated through the cooperative research programs managed by the Transportation Research Board of the National Academies. Several risk management guides were prepared independently and were aimed at either state transportation agencies that own or operate specific assets, or at specific asset classes within the transportation system. They included guides to assess risk and vulnerability for highway assets, ferries, tunnels, and bridges. These asset-specific guides provide valuable, current information to owners and operators. This multimodal guide builds upon these prior mode-specific efforts.

Much of the transportation-focused risk assessment and risk management guidance available today is asset or threat specific. These approaches to risk management have the following characteristics:

- The analysis focuses on a specific asset or a select group of assets.
- The approaches assume or require substantial knowledge of likely threat/hazard scenarios.
- The approaches consider many possible scenarios that might disrupt transportation assets.

These guides often require knowledge that the user may not possess or easily obtain and are typically specific to one transportation mode or asset class, such as bridges or tunnels. They are not designed to compare transportation assets across transportation modes, such as would be the case with vehicle fleets and tunnels.

CAPTA, a strategic tool used to compare modes on an equitable basis for budgetary decisions, expands the tools available to transportation agencies to define their needs and determine an optimal distribution of funds. The CAPTA methodology provides a foundation for capital requests based on objective, transparent, defensible data and analysis. These well-thought-out requests made to a legislature or in response to a federal request for grant proposals will help transportation agencies acquire additional funding on the merits of the argument for assets that need resources. The CAPTA methodology helps manage internal resource allocation decisions among multiple modes by providing a means for analyzing needs through an equitable and transparent process that is applied consistently to all assets.

The CAPTA methodology is designed primarily to be applied by practitioners at the state level. The spreadsheet through which CAPTA is implemented may be used separately, apart from this document. Part I of this report provides an overview of why this product was developed and the development process. The model is expected to be tested and improved through use.

Overview of the CAPTA Methodology

The CAPTA methodology provides a key advance in surface transportation risk assessment. CAPTA provides users with a ***capital planning and budgeting tool, used as a strategic point of departure for resource allocation decisions.*** It is intended as the first step undertaken by an agency in formulating risk allocation decisions. CAPTA enables an executive to base allocation decisions on objective data about assets and match that data to a consequence threshold set by the agency. This capability not only guides budgeting decisions, but can also direct decision makers toward assets and asset classes that merit further attention or study.

CAPTA is intended for use by senior managers whose jurisdiction extends over multiple modes of transportation, multiple asset classes, and many individual assets. This methodology provides a means for moving across transportation assets to address system vulnerabilities that could result in significant losses given the threats and hazards of greatest concern. These losses, or consequences, could be casualties, loss of property, failure to provide services to the public successfully, or loss of public confidence in the use of existing infrastructure and facilities. These four areas of loss all represent risk to the transportation system. The level of risk that is of concern to the transportation owner/operator is explicitly brought forward through this process. CAPTA provides a transparent means of ranking assets relative to one another, avoiding reliance on subjective judgments wherever possible.

CAPTA is consequence driven. This methodology begins by asking the transportation owner/operator to set an initial consequence "threshold," indicated by the level of losses at which additional resources would likely be required. Subsequent analysis is completed iteratively by identifying (1) assets where losses would exceed the consequence threshold and (2) the countermeasures that could avoid or reduce the consequences. Users may choose to change the consequence threshold to focus resources on the highest consequence assets or vary thresholds among transportation modes to reflect variations in authority or responsibility for different modes or asset classes. This approach is ideally suited to the strategic, high-level planning undertaken by an executive with budgetary discretion. The executive faced with deciding where and how to spend funds can arrive very quickly at the most logical choices based on agency priorities and the characteristics of the assets.

The process begins with the question of "What adverse consequences do I consider beyond our ability to handle through our normal operations and capital investments?" and then asks the user to indicate the types of threats and hazards of concern that might cause such losses. The user is not, however, expected to know all of the characteristics of potential threats and hazards (e.g., severity, frequency, capability, intent, and motivation).

A consequence-based approach to capital allocation diverges from traditional risk management strategies in that it does not attempt to assess the likelihood of an event explicitly. In essence, the consequence-based approach assumes that if a decision maker perceives an event to be possible, and if the consequences are sufficiently severe, the decision maker must consider alternatives for avoiding or minimizing consequences should the event take place. The consequence-based approach is strategic, beginning with how an asset has been adversely affected regardless of why or how it became disabled.

CAPTool allows senior managers to move through multiple iterations quickly by setting consequence thresholds for losses at levels that reflect levels of responsibility and available resources. The consequence threshold may vary from jurisdiction to jurisdiction and among individual managers, depending on individual tolerance. Reasonable ranges of consequences are provided to guide the user in each of the following four consequence areas:

- Potentially exposed population
- Property loss

- Mission disruption
- Social/cultural disruption

The CAPTA methodology, as implemented in a spreadsheet (CAPTool), contains examples and default values to assist the user in choosing consequence thresholds, identifying existing means for avoiding adverse consequences, choosing countermeasures that fill gaps in coverage, winnowing those choices through a cost analysis, and then packaging them for implementation.

Basic Definitions

The basic concepts of risk management combine an understanding of what makes an asset susceptible to damage from a hazard and an understanding of what makes an asset attractive to attack by people intent on malicious action. These vulnerabilities to attack and/or failure likely trigger a consequence composed of the loss of use of that asset and the loss of the benefit that accrues to users from the use of that asset. Traditional approaches to risk assessment typically represent the frequency and severity of threats (intentional events) and hazards (natural or unintentional events) into a single factor in the general risk equation. Figure 1 illustrates the interaction of an asset with the elements of threat or hazard, vulnerability, and consequences (defined below):

- **Target/Asset.** Persons, facilities, activities, or physical systems that have value to the owner or society as a whole.
- **Threat/Hazard.** The potential natural event, or intentional or unintentional act, capable of disrupting or negatively impacting an asset. In the case of natural events, the hazard is the frequency and magnitude of a potentially destructive event. Hazards can be expressed in probabilistic terms where data are available.
- **Consequences.** The loss or degradation of use of an asset resulting from a threat or hazard. Consequences may also be determined by loss of life (casualty). Mission-related consequences include destruction or damage causing real loss or reduction of functionality. Consequences grow as a function of an asset's criticality. However, a critical asset may be damaged without total loss of functionality.
- **Vulnerability.** A weakness in asset design or operations that is exposed to a hazard or can be exploited by a threat resulting in negative consequences. Specific hazards or threats may

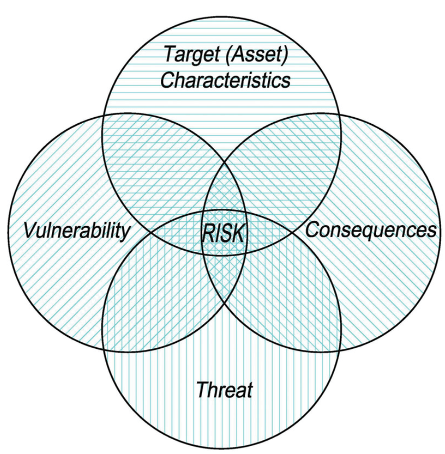


Figure 1. Elements of risk management against hazards and threats.

expose or exploit different vulnerabilities. Note that an asset may be susceptible to hazards or threats that may increase its vulnerability, such as having publicly accessible information (e.g., drawings, schedules, secure areas) that could assist a terrorist in planning and executing a successful attack.

Risk is a function of likelihood (hazard or threat plus vulnerability) and consequences of an adverse event affecting an asset and related stakeholders. It is represented in the following function:

$$\text{Risk} = f(T, C, V)$$

Where:

Risk = the quantitative or qualitative expression of possible loss that considers both the probability that a hazard or threat will cause harm and the consequences of that event.

T = hazard or threat in terms of likelihood or probability of occurrence of a specific hazard or threat, characterized by relevant dimensions (e.g., magnitude, strength).

C = a measure of the consequences of damage, destruction, or other functional losses to a critical asset resulting from a natural or unintentional event or deliberate attack.

V = a measure of relative susceptibility to the consequences of a hazard or threat.

The specific quantitative relationship among the variables in the risk equation depends on how the factors are developed and expressed. Consequences and vulnerability of assets can be judged on a relative scale with upper and lower bounds or through analytical models that assess asset criticality in terms of potential casualties, economic impacts, or physical or operational vulnerabilities; the probability of a terrorist attack is difficult to estimate in more than qualitative terms and may change over time based on changes in the intent and capability of the attacker and the political/cultural context that may make a particular asset more or less attractive to the terrorists at different points in time. As discussed below, the CAPTA methodology simply asks users to identify hazards and threats of greatest concern and does not require an estimate of likelihood. Consequently, it does not attempt to provide a formal expression of "risk" as described in the risk equation shown above. Conversely, the CAPTA methodology assumes that the user is sufficiently knowledgeable of the potential hazards and threats to make an informed decision regarding which should be included in the analysis.

Many of the approaches that emerged following the attacks of September 11, 2001, on the World Trade Center and the Pentagon attempted to apply risk assessment models that require estimates of likelihood and severity for threats and hazards of interest. These approaches generally used subjective estimates of the threat likelihood or of the factors that contribute to likelihood (e.g., target value, threat capability, probability of detection) to determine a probability of successful attack (PSA). After reviewing these methods, the project team concluded that the level of uncertainty in these estimates is so great as to cause the team to question their utility in resource allocation, especially when specialized threat expertise is unavailable and the nature of the threat is likely to change in response to changes in the local, national, or global context.

Countermeasures programs reduce risk by reducing the likelihood of or vulnerability to an attack or by reducing the consequences associated with a hazard or intentional attack that exploits these vulnerabilities.

Risk Management Taxonomy

The taxonomy of risks to multimodal transportation systems in terms of threats and hazards, shown in Figure 2, aids in understanding the nature of hazards (that may be natural and/or unintentional) or threats (that are intentional), their extent, and the potential strategies for managing

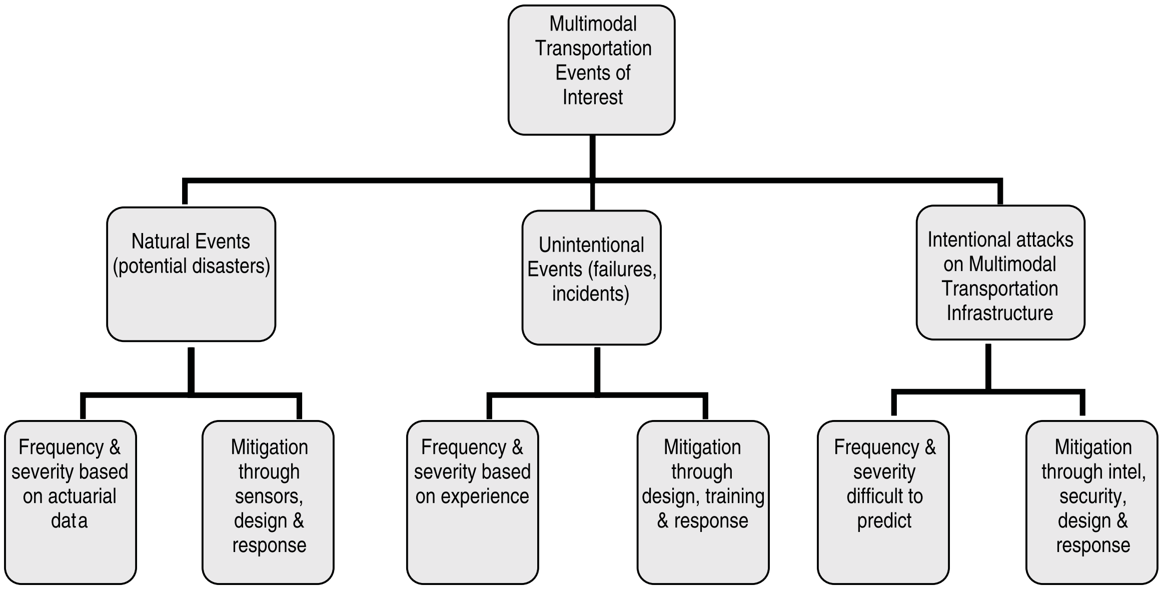


Figure 2. Taxonomy of threats and hazards for multi-modal transportation systems.

risks or mitigating consequences. The taxonomy suggests that while any of the three types of events of interest can result in highly undesirable consequences, their mitigation is not identical.

Risk management for *natural events* relies upon historical data. These sources include meteorological and seismic readings, which provide sufficient evidence of the frequency and severity of events over multiple decades. Historical data also allow a reasonable understanding of the potential consequences to transportation assets and activities. Because the frequency and severity of natural events is, for the most part, uncontrollable, risk management strategies involve

- Design decisions that avoid such events or endure their effects (including where facilities are located);
- Response preparation (i.e., planning, equipping, training, and exercising);
- Monitoring both trends and rapidly evolving circumstances (e.g., weather patterns, seismic activity);
- Warning;
- Evacuation; and
- Recovery.

Unintentional events lead to significant adverse consequences. There are actuarial data regarding the frequency, nature, and other characteristics of these events from which countermeasures can and have been developed. Approaches to mitigating the consequences include reducing the frequency, the consequence, or both through re-design, more effective regulation and enforcement, and safer operations. Operational measures include better training and more robust response preparation and recovery implementation.

Intentional events such as attacks and crime involve a threat that actively responds to risk management strategies and countermeasure implementation. Active threats are constantly seeking to increase the probability that their attack is successful. Risk management for intentional events draws upon many of the approaches used in the other two types of events, enhanced by intelligence gathering, operational security, and a well-planned and -executed response. The response, including both rescue and law enforcement, needs to take into account the possibility of secondary attacks on response forces or elsewhere while first responders are diverted.

Methodology

This CAPTA methodology employs a ***consequence***-driven approach. This methodology begins with the user setting consequence thresholds for the first three of the four consequence areas:

- Potentially exposed population
- Property loss
- Mission disruption

Adverse social impact is not addressed explicitly, but the user may see this as extremely important for some assets and thus consider the adverse social impact to be sufficient cause for the asset to be classified as "critical" for resource allocation purposes.

This initial focus on consequences guides the user to focus on outcomes rather than particular assets or threats. Users need not know the cause for the loss or the scenario that led to the loss. The consequence-driven methodology evolved from a desire to limit required inputs to information accessible to users which, to the extent possible, is objective in nature. The focus is the loss of use of the asset or assets.

Assumptions

The consequence-based CAPTA methodology makes common sense assumptions about various asset classes, threats and hazards, and countermeasures. The default values and assumptions embedded in the methodology are transparent and, in most cases, users have the opportunity to modify them to reflect local values.

The CAPTA guide and tool recognize other guidance that covers the range of routine hazards or threats to transportation infrastructure and assets, such as equipment breakdowns, derailments, utility disruptions, criminal acts, and medical emergencies. The experience of transportation operators in handling these minor incidents is already addressed in handbooks, manuals, and industry standards that are readily available. Wherever possible, references to these materials are noted in the text. Many are located at www.trb.org/securitypubs/. The following list contains individual examples of such materials:

- *TCRP Report 86/NCHRP Report 525, Volume 12: Making Transportation Tunnels Safe and Secure* (*1*). This guide focuses solely on tunnel assets.
- "A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection" (*2*). This document develops guidelines for assessing and mitigating vulnerabilities among highway assets.
- "Risk Based Prioritization of Terrorist Threat Mitigation Measures on Bridges" (*3*). This guide, developed by FHWA, provides a standardized, detailed method to assess the vulnerabilities of specific bridge components.
- *NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Methods* (*4*).
- *NCHRP Report 525, Volume 6: Guide for Emergency Transportation Operations* (*5*).

The CAPTA methodology makes the following additional assumptions:

- The user takes the information provided by CAPTA as a capital budgeting prioritization tool, not as an asset-specific assessment tool.
  - The CAPTA process delineates assets or asset classes that are of high consequence to the user. This high-level delineation will allow the user to set aside budgetary resources on a rough order of magnitude. The user will then need to apply an asset-specific tool to discern how to use any resources provided to the high-consequence assets.

  - The user follows analysis using CAPTA with an asset-specific assessment tool, which may include conducting a full engineering assessment that takes into account facility-specific conditions.
- Nuclear hazards or threats are not addressed. These catastrophic threats require mitigation and response measures that are beyond the capacity of a transportation agency.
- Cyber threats are not addressed. The evolving nature of cyber threats to the operating and control systems of a transportation agency are best addressed by commercial vendors. Standard practice for any agency is to have a robust, up-to-date cyber security plan.
- Routine inspection and maintenance issues are not addressed. These operational measures typically do not require high-level strategic capital allocation measures.
- The user has available basic data about the assets to be considered under CAPTA, including physical features, cost, and typical usage of an asset. The information requested in the CAPTA Tool, or CAPTool, was specifically designed to incorporate data known to be readily available to transportation agencies. The project team confirmed the widespread availability of these data.
- CAPTA will not provide a cost–benefit analysis for any countermeasure. Cost data for countermeasures applied for risk mitigation may be quantified. Benefit data, however, are based largely on assumptions regarding the effectiveness of a countermeasure in avoiding or mitigating the effects of an event. Moreover, these assumptions may be about an adverse event that may never have occurred, and is unlikely to occur. Such assumptions are most common for intentional acts and for operational measures arrayed against a range of threats. Engineered measures have a more reliable data record on which to base an estimate of benefit; however, such tools must be based on a specific measure for specific asset analysis. This kind of specific tactical analysis is beyond the scope of the CAPTA methodology, and any user wishing to pursue such an analysis may benefit from using an asset-specific risk tool.

Defining the Problem and Implementing the Solutions

The loss of a high-consequence transportation asset could result in casualties, billions of dollars worth of direct reconstruction costs, economic losses, and mission failure for responsible agencies. However, resources do not exist to safeguard every asset owned or operated by an agency. CAPTA attempts to bridge this gap, providing a transparent means to prioritize multimodal assets for resource allocation.

Making transportation systems safe and secure is a complex problem that requires balancing mobility, access, and personal freedom **with** access control, intelligence gathering, screening, and other means.

This guide and accompanying computer-based tool provide a resource that transportation owners and operators can use in addressing this challenging problem. The most critical element of success for the CAPTA product is to place the tool in the hands of concerned users so that they can be more effective in evaluating multiple modes of transportation. Transportation industry associations and professional organizations are the natural choices for disseminating this approach. Agencies and associations critical to disseminating this new methodology include those listed in Table 2.

Risk and Consequence

CAPTA focuses on an explicit challenge to agency management in its planning and budgeting activities. CAPTA encompasses the set of risks flowing from natural hazards and unintentional or intentional events that are not already part of mainstreamed design and standard operational practices. Recent terrorist threats and major natural disasters have stimulated concern over the wide range of risks faced by transportation modes. CAPTA emphasizes the potentially severe consequences from such major events and is an effort to further mainstream risk and security

Table 2. Transportation agencies/associations and audiences to whom they can disseminate CAPTool.

Agency or Association	Audience
AASHTO and American Railway Engineering and Maintenance Association (AREMA)	State departments of transportation (DOTs), county highway departments, local transportation authorities, and railroads
American Public Transportation Association (APTA)	Transit agencies
U.S. Department of Transportation (U.S.DOT) Transportation Security Administration (TSA), and Department of Homeland Security (DHS)	Port authorities, turnpike authorities, and bridge and tunnel authorities
American Underground Construction Association (AUA), American Society of Civil Engineers (ASCE), International Association of Emergency Managers (IAEM)	Membership

procedures in an agency, as is already the case for worker safety, traffic incident management, and routine weather events such as snow and ice storms.

CAPTA's risk management process focuses on specific threats and hazards with the following characteristics:

- These threats and hazards can cause significant damage to transportation assets and mission or loss of life.
- Designed/engineered and operational measures to reduce the risk of these threats and hazards are not yet "mainstreamed" in conventional transportation agency practice.
- Reasonable and practical consequence-reducing countermeasures to these threats and hazards are available.

In keeping with the above approach, CAPTA uses consequence thresholds (for life, property, and mission) to focus risk management only on asset and hazard or threat combinations that merit risk reduction investment at the program planning level. CAPTA defines transportation hazards or threats and the asset classes included in this analysis at generalized levels. These interpretations relate both to their potential for significant consequences and to the applicability of countermeasures. This generalization allows the user to move quickly to the issues that are of primary concern regardless of transportation mode, location, or use. This approach relieves the user of the burden of estimating probabilities related to specific threats and hazards or the likelihood that specific assets are affected. The countermeasure-oriented database relates potential countermeasure strategies directly to consequences and assets.

The modest level of effort involved in using CAPTA is intended to encourage mainstreaming an integrated, high-level, all-hazard, NIMS-responsive, multimodal risk management process into major transportation agency programs and activities. CAPTA also provides the departure point for applying asset-specific vulnerability assessment and countermeasure guides for asset-specific design and cost estimation.

Institutional Context for Risk Management

The guide does not yield designs or design specifications, but acknowledges sources for more detailed asset-specific countermeasure guidance that exists for each mode. These sources include

- The United States Coast Guard (DHS) for maritime assets;
- The Office of Grants and Training (DHS) and the Federal Transit Administration (U.S.DOT) for transit;

- The Transportation Security Administration (DHS) for general aviation; and
- The Federal Highway Administration (U.S.DOT), state DOTs, and the NCHRP for highways, bridges and tunnels.

Risk management decisions require different information and analysis depending upon the nature of the decision, the organizational level at which the decision is made, and the agency or entity making the decision. Multimodal transportation systems typically cross agency and jurisdictional boundaries, and multiple entities are often involved in managing and operating the facilities or systems. As illustrated in Figure 3, state DOTs work within the context of state and federal funding sources, multiple response agencies, and multiple local authorities. They must be capable of both justifying capital resource requests and allocating existing resources wisely. The guide is intended to assist state DOTs and others in both of these areas.

Figure 3 does not show specific authorities or a chain of command because of the differences among jurisdictions. It illustrates the complexities of seeking and allocating resources when multiple agencies and jurisdictions have interests in preparing for and responding to hazards and threats. What is most important about these relationships is that risk management decisions must be coordinated across multiple agencies and jurisdictions if they are to result in the efficient use of the limited resources available at federal, state, regional, and local levels of government.

The data model developed to support the CAPTA is the integrating mechanism among multiple modes and the variety of assets, hazards, and threats associated with these modes. The CAPTA model provides the user with a convenient interface for accessing the data used to implement the methodology.

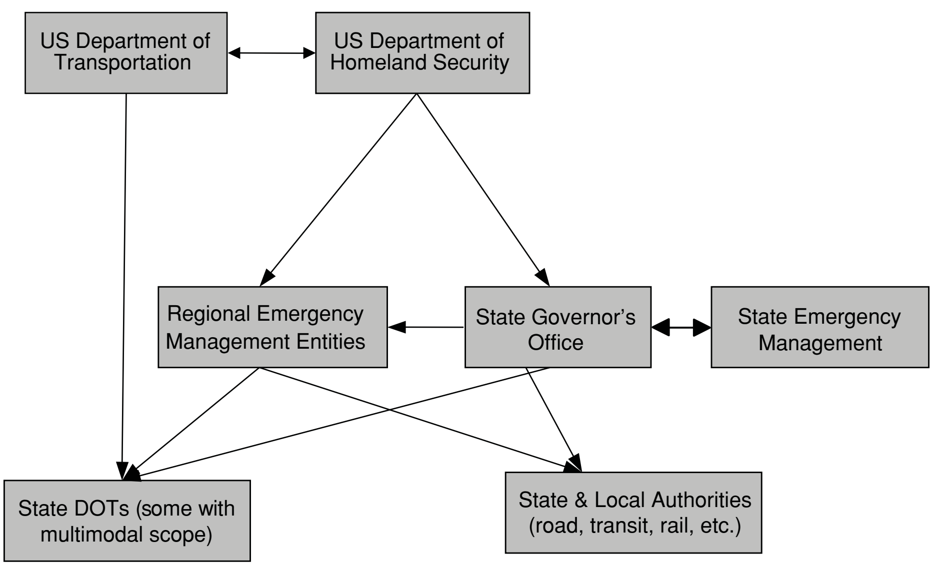


Figure 3. Government levels for risk management resource allocation decisions.

CHAPTER 2

CAPTA Development Path

Alternative Approaches

The CAPTA methodology reflects a development path guided by user requirements and current practice in risk assessment. Candidate alternative approaches that were considered but ultimately found unusable or unsustainable are summarized below.

Subjective Weighting of Threats or Hazards versus Asset Scoring

Many existing risk assessment methods require extensive weighting schemes to achieve relative ranking of threats or hazards and assets. These weight schemes are initiated by gatherings of agency subject matter experts with the institutional knowledge to judge what assets may need mitigation from what threats or hazards. The process is subjective, with rankings subject to influence by institutional biases and parochial thinking. Initial efforts of the project team focused on this type of process but restricted the expert input needed to perform the analysis. This approach proved to be more complex and to require more data than was desired by the NCHRP project panel. After discussing this option, the project team and the panel chose to move the approach towards transparency and objective data inputs, relying on expert judgments as little as possible.

Cost–Benefit Analysis for Countermeasures

The project team initially sought ways to include an objective cost–benefit analysis of candidate countermeasures as part of the methodology. This conflicted directly with the panel's and project team's intentions to keep the model a high-level executive decision tool. A high-level model such as CAPTA lacks the detailed data for a credible cost–benefit assessment. More important, the effectiveness of countermeasures against intentional attacks is speculative at best because of the responsive and reactive nature of postulated threats. The project team, therefore, chose to provide cost information for countermeasures deemed generally useful in countering identified hazards and threats but chose not to quantify the change in risk associated with specific countermeasures. This decision was reached with the knowledge that one type of countermeasure, those applicable to natural hazards, does have quantifiable benefits because frequency and severity can be derived from actuarial data.

For example, if based upon historical data, a blizzard is likely to affect a geographical area twice per season on average, the expected number of ticket holders and riders along affected rail lines can be estimated. Implementing a snow and ice melting system along the track, at a known cost, can be compared to potential lost revenue, and investments can then be made accordingly. In cases such as this, the factors needed to perform a cost–benefit analysis are known with adequate precision, including the capital and operating costs, the benefit (in terms of expected revenue recovered), and the frequency of the event.

Quality data and quantifiable benefits did not exist for the full range of threats, hazards, and mitigation measures examined within CAPTA. The project team eventually concluded that any attempt to include a cost–benefit analysis in the methodology would result in a model that most state DOTs and transportation agencies could not or would not administer without external assistance.

Development of the CAPTA Methodology

CAPTA Within the Context of Existing Risk Assessment Literature

CAPTA evolved from "A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection" and incorporates lessons learned since that document was published in 2002 (*2*). In subsequent years, federal agencies and other transportation authorities have brought ground-level experience into the application of risk management and assessment products, and excellent guides that focus on assets associated with specific modes have been introduced. These mode-specific guides were examined during the design of this multimodal guide, and elements of those previous guides influenced the development of CAPTA.

The initial objective of this guide was to update the previously referenced 2002 Guide, published shortly after the September 11th attacks. That effort was the first to help transportation agencies prioritize critical and vulnerable assets, focusing exclusively on highway assets and primarily on vulnerabilities to intentional attacks on highway-related infrastructure.

During consultation, the NCHRP project panel and the project team agreed to simplify the approach and focus more on the consequences of an event rather than the cause of the event. This approach is closer to the reality of a transportation operation. In this, the operator is very concerned about the loss of use of assets and systems and less concerned about how they came to be disrupted. The operator knows whether or not an asset or system is functioning properly and, if it is not, the operator's primary concern is how quickly it can become operational. The causes for the disruption are normally apparent after post-event investigation.

In light of this transportation reality, the CAPTA methodology begins with the consequences resulting from the loss or significant degradation of an asset or mode. Compared to previous assessment methodologies, this loss of use factor closely parallels criticality, although it places less emphasis on vulnerability assessment, because that tends to be more asset specific. The definition of consequence is designed to help owners and operators to answer the questions "What are the outcomes (consequences) that concern me most? What worries me most?"

Figure 4 demonstrates the role of the CAPTA methodology. CAPTA is the first step in a multistep approach to risk assessment and consequence management in the transportation environment. Based on the results of the CAPTA application, the user would proceed to asset- or mode-specific assessment methodologies that could be used to determine more specific vulnerabilities and mitigation measures.

The simplifications of the CAPTA model make possible a useable tool for planning and budgeting purposes. The tool can yield resource estimates that can be varied based on variations in consequence thresholds. CAPTA helps users minimize resource needs through integration with existing risk reduction practices. This synergy is achieved by allowing users to give priority to adding incremental or multipurpose capital measures for moderate- to high-consequence, moderate-frequency events, and implementing temporary operational measures for high-consequence, low-frequency events. The effort by agencies to dedicate resources is often predicated by the confluence of expected consequences and the likelihood (frequency) of occurrence. In other words, standard operating procedures are ordinarily sufficient to handle low-frequency, low-consequence events; however, escalating potential consequences require significantly greater dedication of resources to mitigate or prevent.

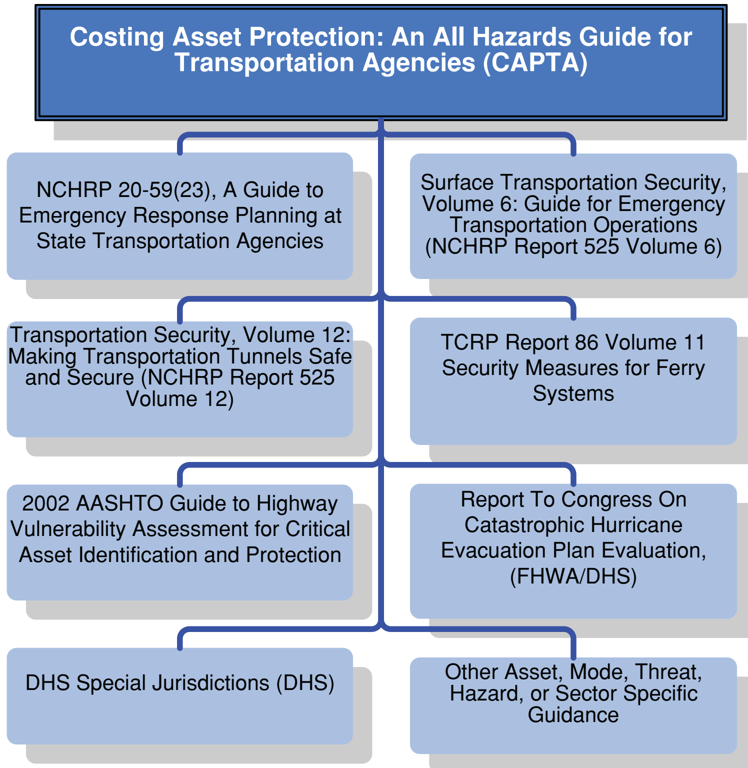


Figure 4. CAPTA relationship to asset-specific guides.

The decision of when to deploy an operational measure rather than build or install a capital asset is difficult to ascertain. CAPTA attempts to ease that decision by providing a prioritization system for all assets based on the intuitive thresholds for consequence set by the user and the funding available.

Testing

During development, the CAPTA methodology was demonstrated to transportation officials in Virginia, Maryland, Kansas, and the Massachusetts Bay Transportation Authority (MBTA) in Boston. There, as with other jurisdictions, the methodology was well received and noted as being the missing link between asset-specific risk assessment methodologies and capital budget prioritizations.

CAPTA and the Data Model

CAPTA consists of a written document that describes the methodology (Part II of this report) and an electronic spreadsheet, CAPTool (available on the TRB website: www.trb.org/news/blurb_detail.asp?id=9579), that contains the user interface and the data model. These components work together to increase users' knowledge and their ability to work through the methodology efficiently.

CAPTool manages the interaction between user preferences and prescribed definitions of consequences, threats and hazards, assets, and countermeasures using static displays. The data model contains all the formulae, definitions, and parameters needed to use CAPTA. Part II of this report contains a step-by-step CAPTool user guide to move the user through the electronic spreadsheet model. The references and diagrams help the reader understand the interactive data model. Figure 5 illustrates the interaction between user inputs, the assessment methodology, and the countermeasures database.

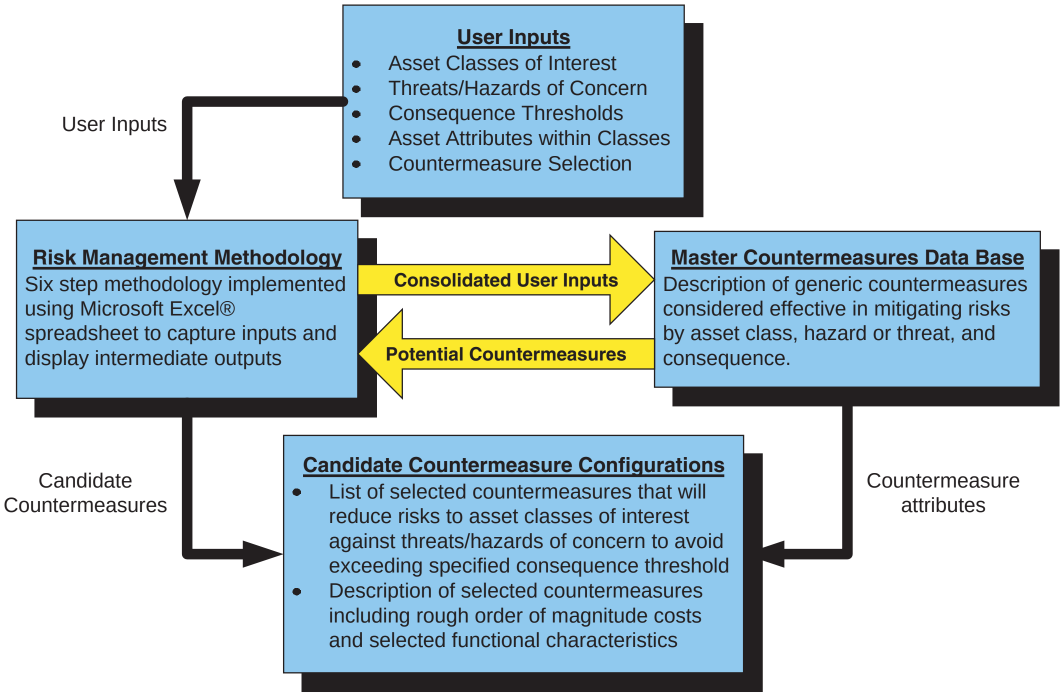


Figure 5. CAPTA data model environment.

The data model allows the user to repeat the six-step process quickly and repeatedly. The inclusion of data, formulae, and definitions provides a consistency of thought and application of CAPTA by any user.

Key Model Components

The CAPTA risk management methodology and supporting database emanate from a set of definitions and classifications relating to consequence; consequence-related threats and hazards; threatened assets; and relevant, possible countermeasures. As a high-level budgeting tool, there is a trade-off between level of detail and CAPTA utility. More detailed analysis is intended to occur in conjunction with asset-specific tools.

Taxonomy Level of Detail and Desegregation

CAPTA draws on previous experience in applying risk management methods for various modes, including the experiences of the authors. The focus of existing methods (previously discussed) allowed CAPTA to move in a different direction with the following key features:

- CAPTA uses consequence thresholds to limit the risk relevant to threats or hazards, assets, and countermeasures. For example, a moderate consequence threshold concerning the replacement cost of an asset eliminates the need to consider threats and assets that cannot combine to achieve a substantial monetary value.
- CAPTA classifies assets at a high generic level, through asset classes in which a single class can represent assets present in multiple modes. For example, an administrative and support facility can be found in transit, road, general aviation, and ferry modes of transportation.
- Threats and hazards are limited to
  - Those not currently institutionalized within an agency. Institutionalized hazards include mechanical failure, crashes, and ordinary weather events;
  - Those expected to have a significant casualty, property damage, or long-term (25+ hours) mission impact;

- Those that may present currently unbudgeted liabilities. Institutionalized hazards, mitigated by a highly advanced state of practice, are not included; and
- Those that have already occurred or are likely to occur to a transportation operator. These include events that would impact the owner's planning and budgeting.

The material that follows describes the taxonomies built into the methodology and database.

Relevant Consequences

CAPTA examines risk beginning with consequence. The consequence threshold is a linchpin for use of CAPTA in capital allocation decisions. Establishing a consequence threshold for planning and resource allocation purposes rather than focusing on assets, specific hazards, or threats simplifies the risk management process. This focuses attention on significant, relevant assets, eliminating from further consideration those assets or asset classes whose loss of use would not exceed consequence thresholds, regardless of the hazard or threat. The user may then focus on high-consequence assets that may experience multiple hazards or threats. The *consequence threshold* identifies assets or asset classes to be included and the extent to which the hazards and threats identified in Step 1 are retained in the assessment.

Consequence thresholds are not consistent throughout the United States. Regional and local variation in tolerance to risk, social or funding priorities, and the owners' institutional experience combine to provide different levels of risk acceptance. This history and these individual experiences are reflected in the users' choice of what consequences they choose to use in their assessment. It is not expected that thresholds for potentially exposed population (casualty), property loss, or mission disruption would be the same for urban systems versus rural communities, or for transit systems with rail services versus bus-only agencies. CAPTA provides objective data points and formulae to set consequence thresholds, limiting users' subjective inputs to achieve consistency. These consistent results allow for clearer interpretation during planning and budgeting processes.

The consequence threshold is the planning factor used to set the level of consequences at which the decision maker or agency assumes greater responsibility for managing the risk. Thresholds represent the point at which either the potential casualties, property loss, mission disruption, economic disruption, and/or public reaction is such that the responsible agency must consider allocating resources above and beyond those typically included in operating budgets to prevent or mitigate the effects of the hazard or postulated threat.

CAPTA consolidates consequences along four key areas:

- **Potentially Exposed Population** (fatalities and injuries). This consequence is the surrogate for casualties; it is concerned with the number of people who may become casualties. Occupancy limits, or capacity, is a surrogate data point for this category.
- **Property Loss.** This concerns the cost to repair or rebuild a damaged or destroyed structure. These monetary estimates are standardized unit cost estimates based upon square or linear footage of an asset, or an amount provided by the user for specially designed structures such as a cable stay bridge.
- **Mission Disruption.** This concerns the adverse impact on the transportation system due to the loss of the functionality of an asset. Because they indicate the redundancy of the road and rail networks, detour lengths to and from a disabled asset are used as a surrogate for mission disruption level. Detour length is readily available in current agency databases for bridges and tunnels. Transit facilities are assessed using ridership levels of an asset.
- **Social Effects.** The social consequence reflects how the population might respond to the event through significant behavioral changes. These behavioral changes may include fear of travel or avoidance of a transportation mode or route. Fear and avoidance of transportation modes will lead to a decrease of commercial activity. There may also be adverse reaction by the public to the imposition of security measures, such as personal searches, needed to prevent a disruption or mitigate the effects of a disruption. CAPTA does not determine this consequence

directly, but provides a manual opportunity for the user to input an asset for consideration. The manual entry is left to the users, as only they can know local conditions, mood, and the emotional appeal of an asset, such as a landmark bridge.

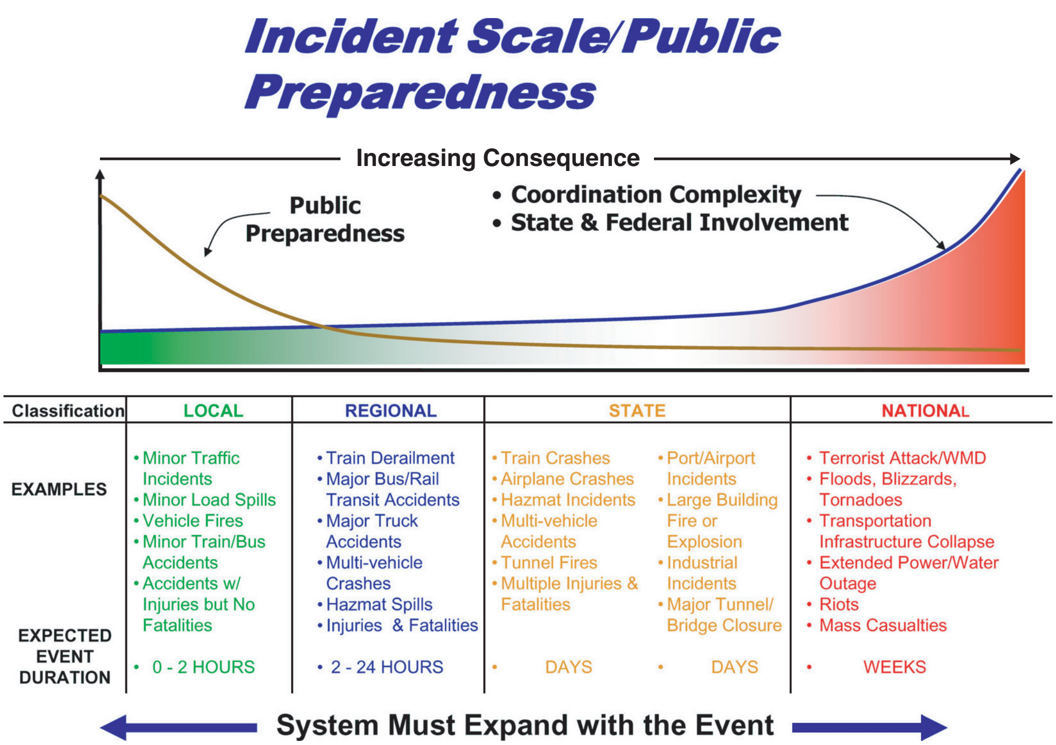
Selection of thresholds is an iterative process, given the high cost of some measures and scarce resources in transportation agencies. The CAPTA methodology encourages the user to move back and forth through the steps to examine the effects of different consequence threshold levels and the various measures available to mitigate the consequences of an event.

The selection of a certain threshold for potentially exposed population, property loss, or mission disruption does not explicitly suggest that losses below this level are unimportant or inconsequential. Threshold consequences should be chosen in relation to resources available to the agency to respond to the threat or hazard, replace or repair damaged or destroyed property, or complete the mission of moving people and goods to and from destinations. The selection of proper threshold consequence levels in CAPTA will allow users to identify a result (consequence) beyond which additional investments in countermeasures are required.

Relevant Threats and Hazards

Risk management is not new to transportation system owners and operators. State DOTs, transit operators, bridge and tunnel authorities, seaport and airport authorities, ferry operators, railroads, and state and local public safety agencies all have experience in handling risks to their assets. The localized independence of these owners ensured that there has been a difference in both planning for risk and formalizing risk management. These major disruptions may be intentional to produce terror or the result of a natural disaster.

Figure 6 illustrates threats and hazards as a risk management spectrum in terms of the magnitude of consequence, the current level of preparedness, and the degree of coordination needed



Source: SAIC (*2*).

Figure 6. Range of threats and hazards to multimodal transportation systems.

to address these risks. The figure implies that, as the severity of the event increases (to the right) the frequency of the event decreases. Frequent hazards, such as major snowstorms, have a routine response borne of regular implementation. *Force majeure* events such as earthquakes, hurricanes, and terrorist acts are at the less frequent but more complex end of this spectrum and result in mass casualties, significant property loss, and broad-based economic disruption. This last category also represents a special danger due to the infrequency of such events and a lack of institutional memory concerning how to handle them.

Balancing frequent, routine events with less frequent, severe events, many transportation agencies struggle to integrate risk assessment and strategic security with other conventional agency activities into an institutionalized program. Current institutionalized activities include developing policies and protocols to handle traffic incidents, crime, and probable natural events such as earthquakes, hurricanes, and floods. They also include institutional knowledge and the experience of personnel, which contribute to the mainstreaming or routinization of the tasks. The agencies face a challenge in establishing a program to incorporate consequence-based assessment as part and parcel of an agency program, allowing objective budgetary allocation.

CHAPTER 3

CAPTA Components

Asset Categories

CAPTA distills the modes and asset classes found in the transportation field to a manageable yet reasonably comprehensive number. Individual vehicles are not included as a separate asset class. Individual mobile assets are vulnerable to many threats and hazards, all of which have been well documented and analyzed. There are known conventional countermeasures that can be applied by owner-operators to increase the safety of a vehicle or the security of a rail car. Emerging technologies that increase the safety and security of the individual vehicle continue to evolve.

Assets and asset classes are aggregated into eight major asset categories: road bridges, road tunnels, transit/rail bridges, transit/rail tunnels, transit/rail stations, administrative and support facilities, ferries, and fleets.

Road Bridges

Road bridges include any aerial structure designed to carry vehicular traffic across a body of water or land. This category is most effective when used to capture structures whose length spans greater than one beam. Structures that can not be readily replaced or repaired by existing agency maintenance personnel should be included.

Road Tunnels

Road tunnels include all bored, mined, or immersed tunnels that convey rubber tire vehicles, buses, and trucks. Road tunnels may be aggregated by length, although subaqueous tunnels should be named separately.

Transit/Rail Bridges

The transit/rail bridges category is intended to capture all raised aerial structures designed to carry rail rolling stock. The assumption is that a rail vehicle could not be readily rerouted around a stricken structure, and neither repair nor replacement could be readily achieved.

Transit/Rail Tunnels

A transit system with a major rail capability is likely to have an extensive network of tunnels. Care should be given to collect the network into classes of tunnels for evaluation in CAPTA. Similarities in building type, length, or other characteristics should allow an aggregation.

Subaqueous tunnels should always be named in CAPTA, not entered as part of a class. The expected unique characteristics and high cost of a subaqueous tunnel merit specific consideration in CAPTA.

Transit/Rail Stations

Transit or rail stations can be aggregated into classes to ease consideration in CAPTA. Length of platform, capacity, and building type can serve as common characteristics for a class. High capacity or transfer stations handling a high percentage of ridership may be entered as single assets.

Administrative and Support Facilities

This category is intended to capture all fixed asset facilities a transportation operator may own or operate, with the exception of transit or rail stations. The fixed facilities in this category may range from executives' offices to airside passenger terminals. Particular attention may be given to the following examples of fixed facilities:

- **Operations Control Center.** Any facility designed, constructed, and equipped with systems intended to monitor and control the transportation environment and the movement of vehicle and rail traffic over and through a transportation section.
- **Substation.** Any facility specifically designed to transfer power or water, or provide sewer connections between the transportation system and the central utility building. The substation is connected to the utility building and the transportation system via distribution channels but is not the primary source of power, water, or other resources.
- **Utility Building.** Any facility specifically designed to provide power to the transportation system. This facility is operated continuously to achieve its mission, and is connected to both substations and the transportation system through a distribution channel. A utility building may also be designed to provide water or sewer removal from the transportation infrastructure (e.g., using pumps, drainage).

Ferries

This category is intended to capture any passenger-loaded vessel. The size of the vessel does not matter. In the rare cases where ferries constitute a significant portion of the transportation agency's passenger capacity, an effort should be made to separate the vessels into classes.

Fleets

Fleets may encompass any regularly used individual passenger vehicle. The most common assets in this category will be buses and passenger transit/rail cars. The base unit for this category is one asset, whereby a train may consist of four to six individual fleet cars. The similarities of fleet vehicles readily lend themselves to groupings into classes.

Hazards/Threats

All hazards or threats to a transportation system are intentional, unintentional, or a natural hazard. An unintentional hazard describes an action of which there was no predetermined intent to adversely impact the transportation, its users, or associated infrastructure. The sources of an unintentional hazard may be human, but human involvement is not wholly necessary and may be only incidental to the hazard presented by an inanimate object or acts of nature. Unintentional hazards are common to a transportation system. Such hazards include fire, power loss, or equipment breakdown. Unintentional hazards also include structural failure. Many unintentional hazards impact the safety of the below-grade transportation asset, employees, and passengers.

An intentional threat is one emanating from the deliberate intent of a person or group to disrupt the transportation asset. Normally, this deliberate intent cannot be replicated in nature or through a series of organic happenstances. Intentional threats directly affect the security of the asset. Intentional threat events, such as introducing an explosive or chemical agent, present an uncertain and threatening element into the system. Any explosive or chemical agent has the capacity to wreak havoc upon the transportation system and close it down for an extended period. These disruptions are second to the loss of life and injuries that may result from the successful delivery of a primary threat. Historical evidence shows that key decision-making factors in plotting the location of a terrorist attack are the aggressors' ability to inflict personal damage and the ability to generate publicity.

Hazards or threats that will adversely affect the normal operation of a transportation asset and its associated infrastructure are listed in Table 3.

Hazards or threats have the potential or proven capability to close a transportation system or to deprive transportation customers of the beneficial use of the facility. The hazards or threats are intended to include categories applicable to highway, rail, air, and water transportation systems. However, the needs of these modes are not exact, and neither are their points of vulnerability and access.

All hazards or threats used in the CAPTA process constitute an actual or postulated event. All hazards or threats considered in depth are capable of disrupting an asset or mode of transportation for an extended period lasting greater than 25 hours. These severe events are outside the realm of hazards or threats that a transportation operator routinely handles, such as equipment breakdown, utility disruptions, criminal acts, and medical emergencies. The experiences of transportation operators in handling these minor incidents are available in learned lessons handbooks and procedural reference materials. Where possible, additional reference material concerning these minor hazards or threats has been noted in this report.

Events that are unlikely and extraordinary have also been excluded. These include highly unlikely aggressive events such as a nuclear detonation. Extraordinary airborne hazards or threats are excluded because of the remote likelihood of such an event targeting a transportation asset,

Table 3. Hazards or threats to transportation assets across multiple modes.

Intent	Threats/Hazards
Intentional	Small explosive devices (fewer than 250 lbs TNT or equivalent)
	Large explosive devices (greater than 500 lbs TNT or equivalent)
	Chemical/biological/radiological agents
	Criminal acts
Unintentional	Fire
	Power loss
	Equipment breakdown
	Structural failure
	Hazardous Material
Natural	Flood
	Earthquake
	Extreme weather
	Mud/Landslide

and the diminished likelihood of the success of such a threat. The hazards or threats discussed in detail are those with a reasonable probability of occurring, or those emanating from available intelligence.

There is no guarantee that a transportation operator would face one of these hazards or threats by itself, or in conjunction with another hazard or threat. All transportation operators would find difficulty responding to multiple or coordinated attacks. Manpower and resource limitations would require a triage of priorities in the multiple scenario attack.

The greatest asset in preparing for a coordinated, multisite, or multiphased attack would be for a transportation operator to have accurate intelligence that allows time for adequate preparation. This intelligence is extraordinarily difficult to obtain. The transportation operator may in turn accept the possibility of multiple attacks by assembling deterrence, response, and mitigation measures for the specified scenarios. Taken individually, the scenarios can be prepared for by assembling an adequate defensive posture for all. Recommendations discussed later in this report will outline actions that can improve the defensive posture of the transportation system across several hazards or threats. As an example, if the transportation operator has prepared for an attack on the control center, then the operator is in the best position to withstand an attack on both the control center and on another transportation asset.

There are eleven major category groupings for hazards or threats in the CAPTA methodology. All categories have the capability to disable a transportation system for an extended period. The categories are further grouped by intentionality. Some categories, such as fire, may be intentional or unintentional, but have been grouped according to which is more likely to occur.

These categories are known or postulated to rail, waterborne, and vehicular transportation. To varying degrees, these cases have occurred in the United States; they will present themselves again. Their capability to disrupt a transportation system is proven; however, their detrimental effects upon the transportation system, equipment, and users may be remediated.

Intentional Threats

Explosive devices and the introduction of chemical/biological/radiological agents are prohibited and defined under United States Code Title 18, Part I, Chapter 113B. The destructive powers of various explosive devices are explained in Table 4.

Introduction of Small Explosive Devices

Small explosive devices contain fewer than 250 lbs of TNT or equivalent. Delivery is by one to five persons transporting the payload.

Introduction of Large Explosive Devices

Large explosive devices contain greater than 500 lbs of TNT or equivalent. The method of delivery is either by vehicle or through multiple persons acting in concert to transport the payload.

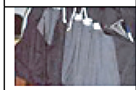
Introduction of Chemical/Biological/Radiological Agents

Chemical/biological/radiological (C/B/R) agents are gases, liquids, or solids introduced with the intent of causing physical harm or property loss.

Criminal Acts

This lower intensity threat represents the range of illegal activities as defined by federal code, state statute, or local ordinance. Examples of criminal acts include handgun violence and illegal discharge of hazardous waste.

Table 4. High explosives danger and evacuation distances.

Threat Description		Explosives Mass[a] (TNT equivalent)	Building Evacuation Distance[b]	Outdoor Evacuation Distance[c]
	Pipe Bomb	5.0 lbs 2.3 kg	70 ft 21 m	850 ft 259 m
	Suicide Belt	10.0 lbs 4.5 kg	90 ft 27 m	1,080 ft 330 m
	Suicide Vest	20 lbs 9 kg	110 ft 34 m	1,360 ft 415 m
	Briefcase/ Suitcase Bomb	50 lbs 23 kg	150 ft 46 m	1,850 ft 564 m
	Compact Sedan	500 lbs 227 kg	320 ft 98 m	1,500 ft 457 m
	Sedan	1,000 lbs 454 kg	400 ft 122 m	1,750 ft 534 m
	Passenger/Cargo Van	4,000 lbs 1,814 kg	640 ft 195 m	2,750 ft 838 m
	Small Moving Van/ Delivery Truck	10,000 lbs 4,536 kg	860 ft 263 m	3,750 ft 1,143 m
	Moving Van/ Water Truck	30,000 lbs 13,608 kg	1,240 ft 375 m	6,500 ft 1,982 m
	Semi-trailer	60,000 lbs 27,216 kg	1,570 ft 475 m	7,000 ft 2,134 m

[a]Based on the maximum amount of material that could reasonably fit into a container or vehicle. Variations possible.

[b]Governed by the ability of an unreinforced building to withstand severe damage or collapse.

[c]Governed by the greater of fragment throw distance or glass breakage/falling glass hazard distance. These distances can be reduced for personnel wearing ballistic protection. Note that the pipe bomb, suicide belt/vest and briefcase/suitcase bomb are assumed to have a fragmentation characteristic that requires greater standoff distances than an equal amount of explosives in a vehicle.

Source: *Protection of Assets Manual* (*7*).

Unintentional Hazards

Fire

Fire sources may be disparate and triggered by any combination of flammable material and ignition. Fire may result from happenstance and does not require an intentional act to occur. Fire, or the pre-fire hazard of smoke, will immediately have a negative impact upon all transportation assets by inducing the evacuation of persons and equipment within the structure and surrounding areas. Fire and smoke will decrease visibility to unsafe levels, precipitate collision of vehicles and equipment, and cause personal injury. A fire controlled by firefighting may still result in smoke and water damage at a level sufficient to render a transportation asset unfit for use or occupancy.

Structural Failure

Structure failure refers to any decrease in the physical integrity of the transportation asset to bear the weight required to carry passengers or freight. The loss of physical integrity requires the asset to be inspected by the transportation owner and major repairs to be completed before it can be reopened for beneficial use by the public.

Structural failure may be sudden or gradual. The scope of this hazard or threat may be minimal, such as a crack in the wall requiring remediation or a pavement ripple requiring the temporary relocation of traffic. Integrity loss may also be catastrophic, resulting in total collapse or flooding of a structure, wreaking widespread loss of assets and loss of life.

Despite the best efforts of engineering and maintenance, the potential hazard or threat of a structural failure will always exist. There is no known method to guarantee that a structure will never fail or deteriorate. Proper design, construction, and maintenance may drastically decline the likelihood of a sudden failure; however, unseen geotechnical or aquatic forces may go undetected by asset owners. Inconsistencies and lapses in the design, construction, and maintenance of an asset may collude to create the conditions for a sudden structural failure.

Hazardous Materials

Hazardous materials (HAZMAT) may be in liquid, solid, or gaseous form. The quantity of material introduced may be minimal but cause a hazard to users of the transportation system. Hazardous materials include common industrial cleaners used by transportation workers and canisters of pepper spray set off by transit users. In both circumstances, it is unlikely that the maintenance worker or the commuter entered the transportation system with the intent of discharging material into the air. Materials may also include hazardous liquid, which include debris or waste products moved into the transportation system by a vehicle, truck, or rail car. All hazardous materials require specialized remediation that will close a roadway or transit segment to allow processing.

Natural Hazards

Flood

Flooding of an asset is the condition of excessive water inflow that exceeds the engineered pumping capacity and causes a hazard or threat to persons and property. Flooding is typically caused by a calamitous weather event; however, it may be caused by defective pipeline transfer.

Earthquake

An earthquake is a seismic anomaly that weakens the fitness of a structure to standards less than those designed and intended by the owner. The earthquake will present a hazard to transportation users while it is occurring, because of flying debris and geotechnical instability. The earthquake may present a hazard upon its conclusion by weakening assets such that they are no longer usable.

Extreme Weather

This category includes all means and methods of extreme wind, rainwater, snow, ice, or other act of God that is unusual for its ferocity. An extreme weather event will be characterized by

- Exhaustion of all available equipment previously assembled for remediation; and
- Exceeding of all planning thresholds in place at a transportation agency for the conditions of snow, ice, wind, water, and other acts of God. This characteristic would normally include exceeding the "100-year storm" guidance gathered through observation.

Mud/Landslide

The decrease in soil properties, undermined by water or geotechnical shift may prompt the sudden massive movement of soil causing actual or potential harm to persons and property. The most common historical data in this category involve soil shifts onto roadways or rail facilities because of wet conditions.

Consequence Threshold

A critical determinant in CAPTA is the capacity of an asset to exceed the threshold consequence levels determined by the user. Presented in Table 5, and implemented in the CAPTool spreadsheet model, these consequence thresholds are surrogates and equations used to determine if an asset or asset category exceeds the threshold and will be included in further analysis as a high-consequence asset. The equations in Table 5 are derived from information provided in publications from known sources, such as standards and guidance promulgated by the National Fire Protection Association (e.g., *NFPA 101: Life Safety Code®* (*8*) and *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail* (*9*)); the applied expert knowledge of practitioners; and available cost data provided by professional engineers from Parsons Brinckerhoff.

The distinct differentiation between potentially exposed populations (PEP), property, and mission is highlighted within the equation box. This series of equations is used to determine if an asset exceeds a threshold requirement and will be considered for countermeasure application.

Table 5. Threshold consequence determination.

Asset	Potentially Exposed Population Equation	Property Equation	Mission Equation
Road Bridges	Separated into primary direction and secondary direction—for each, if vehicles/lane > 2400, assume 40 vehicles/ 1000 ft. Otherwise assume 7.5 vehicles/ 1000 ft[a]	$20,000/lf	(ADT) × (detour length) 75th, 85th, 95th percentile as thresholds relative to typical bridge inventory (Example is based on the National Bridge Inventory)
Road Tunnels	Separated into primary direction and secondary direction—for each, if vehicles/lane > 2400, assume 40 vehicles/ 1000 ft. Otherwise assume 7.5 vehicles/ 1000 ft[a]	$100,000/lf	User input for criticality
Transit/Rail Station	4 × (maximum capacity of rail cars)[b]	Below ground = critical	User input if transfer station is critical
Transit/Rail Bridge	2 × (maximum capacity of rail cars)[b]	$15,600/lf	User input percentage of ridership that regularly use this transit/rail transportation asset
Transit/Rail Tunnel	2 × (maximum capacity of rail cars)[b]	$40,000/lf	User input percentage of ridership that regularly use this transit/rail transportation asset
Administrative & Support Facilities	1 person/175 sq ft[c]	$210/sq ft	Never critical unless so designated by user
Ferries	Maximum capacity of ferry	User input	Never critical unless so designated by user
Fleets	Maximum occupancy of one fleet vehicle	Average cost per vehicle × maximum number of vehicles	Never critical unless so designated by user

[a]Derived from the *Highway Capacity Manual* (*10*).
[b]Derived from *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail* (*9*).
[c]Derived from *NFPA 101: Life Safety Code®* (*8*).

The judgments expressed within the equation box represent evaluation by the project team of current expert guidance principles for traffic engineering, transit rail safety, NFPA guidelines, and the cost estimates of professional engineers specific to this study.

There are three special inclusions within the threshold equation, for which strict numerical evaluation was not the logical process to follow. These inclusions were weighted by

- Scarcity of consistent national data, and
- Unique characteristics of the asset category.

The affected asset categories were transit/rail stations and ferries:

- **Transit/Rail Stations.** While the PEP threshold was derived from NFPA standards, and a model cost for an aboveground station can be configured, no such clear and consistent cost data exist for below-grade or transfer stations. Below-grade and transfer stations are far more unique, and affected by the character of the soil, land, and space they occupy. Current regulation and prohibitive costs indicate that all below-grade stations are critical, as they are not easily replaced from a financial or engineering perspective.
- **Ferries.** Ferries operated by a state agency are not commonplace. They provide substantial contribution in Alaska, Washington, and selected communities, but do not form the backbone of service in a majority of states. The choice of a ferry vessel varies widely, dependent on use, cost, and choice of the responsible agency. The wide variety eliminates any reasonable and consistent common cost elements.

High-Consequence (Critical) Assets

CAPTool requires the user to input assets and asset classes to be considered for analysis. The data needed for CAPTool should be readily obtainable from agency records. Data typically includes annual average daily traffic, length, travel lanes, construction type, occupancy of rail cars, and ferries. The data for each asset must be entered to allow CAPTool to process the asset.

CAPTool performs calculations matching user-designated thresholds with asset characteristics to assemble a list of high-consequence (critical) assets. These assets are sensitive to the user inputs and will be considered in CAPTA for further evaluation by a tactical guide. The assets drawn into the list of high consequence will ultimately be treated with countermeasures to gauge an understanding of resources required to decrease the risk of that asset exceeding the threshold for adverse consequences.

The list of high-consequence assets can be redrawn by the user by returning to the threshold choice portion of CAPTool and altering the levels. The flexibility of CAPTool allows the user to evaluate different levels of threshold for asset classes. This ability to assess different levels of consequence can be repeated as often as the user chooses.

Countermeasures

When utilizing these recommendations, one must recognize that most mitigation countermeasures span between two extremes. One extreme is to prevent all damage at enormous cost, and the other extreme is to spend nothing and risk enormous damage. Transportation owners, operators, and engineers must make balanced decisions in selecting countermeasures for their facilities—preferably to risk an acceptable level of damage at a reasonable cost. However, finding this balance becomes more complicated when considering possible loss of human life, for which it is extremely difficult if not impossible to assign a value.

CAPTA allows the user to organize a vast assembly of assets to discern those more deserving of mitigation measures. CAPTA separates assets and asset classes based upon their degree of consequence. This organized list can then be treated with any of a selection of measures that span a wide spectrum of cost, applicability, and potential effectiveness. The CAPTool does not prescribe any definitive cost–benefit analysis to any countermeasure. The CAPTA model will allow the user to select measures and evaluate their cost and applicability. The model also allows the user to consider various combinations of countermeasures that could be deployed within given budget constraints.

While preparing budgets for design engineering countermeasures, one must be careful to include the costs associated with local labor, materials, and professional services. The cost of a design change is very specific to individual assets, and there is no attempt in CAPTA to provide more than a general estimate.

The relative effectiveness and order of magnitude cost ratings in the countermeasures dictionary are based on engineering judgment and past project experience. They make use of a number of parameters, including the assets characteristics, construction type, construction materials, and impact to the operation of the asset. The relative effectiveness and cost estimates provided in CAPTA can be used for general guidance. Examination of specific measures for an asset should be undertaken locally, by staff with institutional, engineering, and tactical expertise. Local staff may avail themselves of the many NCHRP/TCRP guidance documents.

Countermeasures are assembled in the countermeasures dictionary. This dictionary is built into the CAPTA electronic model. The dictionary is assembled with categories along the left column and individual measures assembled along the horizontal axis. The concepts upon which the countermeasures are arrayed include prediction, deterrence deflection, detection, interdiction, response preparedness, and design engineering.

Prediction

This countermeasure concept revolves upon possessing prior knowledge that a threat or hazard may be introduced to your assets or infrastructure. In the matter of natural events, sophisticated systems exist to analyze and interpret the physical world. Great amounts of historical data are also available to assist in determining the likelihood of a natural calamity.

To attempt to predict a threat requires an intelligence-gathering infrastructure, or access to intelligence agencies that may possess information relevant to transportation assets.

Unintentional hazards generally are not predictable, but rather are spontaneous and random.

Deterrence Deflection

This category is based upon a sure strategic objective: making an asset so difficult to disrupt, or making the effort so costly to the intentional attacker, that any disruption is not attempted. This may also include the owner/operators' ability to present their asset as impervious to intentional harm such that the attacker is diverted to explore another target.

The concept of deterrence is not usable against natural hazards. Extreme weather, earthquakes, floods, and other acts of nature cannot be deterred.

Detection

This concept centers on the ability of the owner/operator to recognize that a hazard or threat to the asset exists and be able to communicate that actual or perceived hazard or threat to responders. This category is based upon those measures implemented to learn of a disruptive event. The methods, techniques, technology, and personnel deployed to learn of a pending or actual incident may vary based upon local conditions. The means of detection may range from the physical, using sensors and implanted devices, to the operational, including analysis of intelligence gleaned from various sources.

The act of detection extends to natural disasters and other unintentional events as clearly as to those of nefarious origin. Use of technology to pinpoint an unusual weather event or a faulty pump that may flood a roadway is as applicable to detecting a hazard as the police officer on fixed post at the portal inspecting cargo and discovering an explosive.

Interdiction

This category is based upon the asset owner/operator's ability to meet a hazard after it has begun the delivery process. The asset owner/operator should have pre-established personnel and material resources that may immediately be deployed upon learning of the hazard, which may be approaching, at the target, or in the process of being delivered. Interdiction most normally applies to intentional acts of disruption, such as an attacker or saboteur entering the asset. Interdiction is a less applicable strategy in dealing with natural weather events or spontaneous hazards such as equipment fires.

Response Preparedness

This category identifies measures designed to lessen the impact or disruption of any successfully delivered hazard or the concept of lessening the consequence of a successfully delivered hazard or threat. The wide-ranging measures that fall into this category include both strategic efforts requiring forethought and planning and tactical efforts conducted by on-scene responders.

Longer range strategic efforts to mitigate the disruption to an asset involve elements such as planning, emergency preparedness, pre-staged equipment, training, improving response capabilities, and establishing communication channels. All require effort and resources well in advance of a potential or actual hazard.

The planning and preparation components are key tools of successful mitigation measures. The owner/operator's ability to predict a range of possible disruptions, prepare the necessary drawings and specifications, and coordinate a set of responses can mitigate a series of adverse consequences. Planning and preparation generally include

- Institutional arrangements and plans, including memoranda of understanding;
- Communications/public outreach plan;
- Interdiction plans for intentional acts;
- Security plans;
- Continuity of operations plan;
- Emergency response and recovery plan;
- Agency preparedness plan;
- Agency mobilization plan;
- A drill and exercise guide; and
- Personal preparedness plans (for responding employees).

The sum of these components is to allow the transportation operating agency to prepare and respond to any disruption as one unified body, well-versed enough in the plans that they have practiced to facilitate last-minute, on-the-spot alterations.

Strategic mitigation may also be accomplished by the implementation of measures impervious to the impact of the hazard or threat deployed. The ability to withstand a hazard or threat is achieved through physical improvements to an asset.

Tactical efforts include an emergency response to the scene at the time of disruption. Rescue of persons, traffic diversions, and activating backup equipment can restore the asset's operations. The ability to mitigate the consequence of a hazard or threat by preparedness or response depends upon the institution's ability to have well-planned and executed operational measures in place. These measures will likely include the involvement of personnel and agencies beyond the jurisdiction of the transportation owner/operator. The need for advanced planning and tactical coordination is crucial for the success of response preparedness if it is to be employed as a mitigating measure against all hazards.

Design/Engineering

Designed/engineered measures are permanent alterations or additions to an asset requiring substantial investment and expertise. Engineered solutions typically require capital investment and planning. Many engineered measures will extend the usable life of the asset.

General Countermeasure Attributes

For purposes of application in this guide, the countermeasures have been classified and evaluated to support selection in conjunction with consequence avoidance on an asset and hazard or threat basis. The countermeasures dictionary and effectiveness rating provide a broad range of measures in 32 general categories. Appendix C presents key characteristics, and Appendix D indicates effectiveness. This information has been incorporated into the database used in the guide.

Three of the key countermeasure characteristics follow:

- **Countermeasure Function.** Functions are the classification that indicates what the measure will do. Risk management addresses the complete array of threats and hazards—although as indicated above, not all functions apply equally to given threat/asset/consequence combinations. The six basic functions of countermeasures (predict, deter, detect, interdict, response preparedness, and design/engineering) and their definitions are found in Table 6.
- **Cost.** Due to the high-level application of this guide, only general estimates of expenditure are provided. The costs are per unit of countermeasure: either a rough estimate of the piece of equipment necessary, or the cost of one person to perform a service. The cost numbers were drawn from construction estimating publications, such as RS Means, and author experience.
- **Implementation Focus.** Some countermeasures by their nature are applicable on an asset-specific basis whereas others may be applicable on a system- or area-wide basis with a multipurpose focus (area-wide). Countermeasures may also be effective on a temporary deployment basis and can be redeployed to other areas or assets upon short notice. Surveillance measures are a firm example of this last focus category. Countermeasure implementation also includes the multipurpose potential of the component measure. The ability of a measure to have another positive effect upon the asset, or asset class, is noted. A common example is CCTV, which may be used to monitor traffic, detect intrusion, and provide information to responders.

Countermeasures were assessed to determine their multipurpose potential outside of duty to increase the safety and security of transportation. Many countermeasures have dual uses to support the transportation owner/operator in achieving its mission. A measure that can protect an asset is likely to extend the usable life of the asset. A closed circuit television (CCTV) system can detect disruptions and provide real-time information on vehicular movement.

The inclusion of this category in the tables is meant to assist users in choosing their countermeasures. Multipurpose potential may change the prioritization of countermeasures. For example, some mitigation measures can decrease maintenance and increase the usable life of the structure. Use of such measures could lead to significant cost savings over the life of the structure.

Table 6. Countermeasures functions.

Functions	Description
Prediction	This function involves the establishment of an intelligence-gathering organization, including an analysis capability able to determine the probability, place, and time of a likely disruptive event. The function also includes the ability to communicate both to an organization the accurate prediction of an event that may disrupt the plan and to the asset to prepare an operational defense.
Deterrence	This function applies mainly to intentional threats. The asset owner prevents the attack by reducing the aggressor's real or perceived likelihood of success in carrying out a successful attack on or disruption of an asset of interest. This function can be accomplished in several ways. The first is to instill in the aggressor the belief that the asset owner is able to strike back so overwhelmingly that an aggressor fears retribution for their actions and chooses to move off the target asset. Another is to ensure that the functional capability of the asset is sufficiently robust (through protection or redundancy) such that a disruptive event would have minimal adverse consequences. Additionally, the owner may create uncertainty in the mind of the aggressor through random checks and partial but undisclosed security measures, reducing the aggressor's confidence in carrying out a successful attack and, perhaps, preventing the attack or diverting it to a less critical asset.
Detection	The asset owner possesses the means to detect when a disruptive event is occurring and is able to communicate this information to an appropriate response capability (e.g., law enforcement, private security patrol). Detection may occur through sensing technologies or physical observation.
Interdiction	The asset owner possesses the means to respond immediately to a hazard or threat with sufficient force to alter or prevent the introduction of the hazard or threat.
Response Preparedness	The asset owner possesses policies, plans, and procedures necessary to mitigate a hazard or threat that has been introduced. These may include training to discern a hazard or threat in the asset environment and actions to communicate the information to specially trained personnel. Plans and procedures may also include practiced actions that may be undertaken after the introduction of a hazard or threat.
Design/ Engineering	Designed and engineered durable solutions to mitigate a hazard or threat that has been introduced and delivered to an asset. These include engineered solutions intended to strengthen an asset to assure its ability to withstand a delivered hazard or threat.

The identification of multipurpose potential is based upon realistic expectations of what may be done with the countermeasure. Potential purposes include

- Pedestrian safety,
- Traffic surveillance,
- Public assurance,
- Anti-theft,
- Anti-trespassing,
- Detection of unqualified employees,
- Decrease of maintenance,
- Increase of usable life of system,
- Erosion protection,
- Protection of data integrity,
- Protection of investment in data systems, and
- Dock scheduling (for shipping).

CHAPTER 4

Results Summary

Following the application of countermeasures to the high-consequence assets, the user may assemble a summary report by asset class or in total of all asset classes. The report will list the relevant risks, threshold selections, number of critical assets, expenditure by countermeasure class, and summary totals of resources required by countermeasure category. This summary can be saved to a hard drive, or printed for reference.

The results summaries provide a snapshot of multimodal risk, consequence thresholds, and chosen measures to mitigate the exceeding of those thresholds. This snapshot can be compared to later iterations of CAPTA as the user makes different choices of threshold or selects different assets to be included. Part II portrays examples of the results summary.

The results summary is the most visual and iterative aspect of the process. The user can re-enter the model to choose different thresholds that alter the results. Alterations may occur due to increased tolerance for adverse impacts or changes in the levels of allocated resources.

CHAPTER 5

Conclusion

The CAPTA methodology is intended to help users identify high-consequence assets across multiple modes in their jurisdiction. It is a high-level examination of different assets assessed across an equal plane. The CAPTA system, when applied properly, is capable of providing an effective capital budgeting tool to a transportation executive. The ability of the user to move quickly through the CAPTA system, and repeat the process using different consequence thresholds, yields a list of high-consequence assets meriting further attention. This method of assessing consequence and mitigation is time saving and efficient. CAPTA provides a flexible tool to match user risk levels and provides a cohesive first step in the analysis of assets.

CAPTA provides the user with a means to mainstream a security program covering all hazards and threats. The institutionalization of resource allocation will promote the entrenchment of a sustainable security policy within an agency.

Part I provides the underpinning of the methodology displayed and is intended to

- Establish CAPTA as a capital budgeting tool;
- Allow general comprehension of the system;
- Explain how the CAPTA system is integrated into the existing environment of risk assessment and vulnerability documents;
- Define the major terms, steps, assumptions, and equations of CAPTA; and
- Identify the primary users of the CAPTA system.

Users of the system will use Part II, CAPTool User Guide, and the accompanying electronic model to conduct their analyses. They may refer to Part I for deeper understanding of why a step was formed, or how an equation affects the outcomes.

References

1. Parsons Brinckerhoff Quade & Douglas, Inc., Science Applications International Corporation, and Interactive Elements Incorporated. *TCRP Report 86/NCHRP Report 525: Transportation Security, Volume 12: Making Transportation Tunnels Safe and Secure.* Transportation Research Board of the National Academies, Washington, DC, 2006.
2. Science Applications International Corporation. "A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection." AASHTO, Washington, DC, 2002. security.transportation.org/?siteid=65&pageid=1363
3. Ray, J. C., "Risk Based Prioritization of Terrorist Threat Mitigation Measures on Bridges." *Journal of Bridge Engineering,* Vol. 12, No. 2, March/April 2007, pp. 140–146.
4. Blackburn, R. R., K. M. Bauer, D. E. Amsler, Sr., S. E. Boselly, and A. D. McElroy. *NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Methods.* Transportation Research Board of the National Academies, Washington, DC, 2004.
5. Lockwood, S., J. O'Laughlin, D. Keever, and K. Weiss. *NCHRP Report 525: Surface Transportation Security, Volume 6: Guide for Emergency Transportation Operations.* Transportation Research Board of the National Academies, Washington, DC, 2005.
6. Contestabile, J. "Taking Action on Interoperability." Presented to the AASHTO Special Committee on Transportation Security, Orlando, FL, September 17–20, 2006.
7. Knoke, M., Ed. *Protection of Assets Manual,* ASIS International, 2004.
8. *NFPA 101: Life Safety Code®.* National Fire Protection Association, Quincy, MA, 2006.
9. *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail.* National Fire Protection Association, Quincy, MA, 2007.
10. *Highway Capacity Manual.* TRB, National Research Council, Washington, DC, 2000.

APPENDIX A

Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA) Test Preparation

During the assembly of the CAPTA model, field tests were held with a combination of state transportation agencies and transit agencies. The tests were conducted to review the functionality of the model, the logic of the methodology, and the usefulness of the results. The agencies were expected to help the project team stress the system by inputs or demands. Recommendations from the field test did make their way into the model. These improvements included

- Establishing a basic model and an enhanced model (Maryland DOT), and
- Including ridership levels within the threshold equations for transit assets (Massachusetts Bay Transportation Authority–Boston).

The input from the participating agencies—the Maryland Department of Transportation, Virginia Department of Transportation, Kansas Department of Transportation, and the Massachusetts Bay Transportation Authority—was a tremendous influence and assistance to the completion of this product.

The instructions provided to field test participants are included below.

Purpose of Model

The Costing Asset Protection: An All Hazards Guide for Transportation Agencies (CAPTA) project was funded through the Transportation Research Board's National Cooperative Highway Research Program (NCHRP). The guide provides detailed instruction on assessing the risks to transportation assets using a consequence-based approach. The guide enables users, typically state transportation authorities, to evaluate all modes of transportation consistently based upon an initial threshold for adverse consequences set by the user. The guide offers an objective, robust means to evaluate all assets under a user's jurisdiction and requires minimal data to ease in its application. The guide presents an asset protection methodology (CAPTA) that has been implemented as a computer-assisted tool using Microsoft® Excel, which provides a data and graphical means to interact with the consequence-driven multimodal asset protection model.

CAPTA assists the user in evaluating the relative appropriateness of dedicating resources to an asset or a class of assets. The consequence-based methodology employed in CAPTA begins with the user setting an initial threshold for adverse consequences, indicating the point at which additional investments may be needed to mitigate consequences or reduce the likelihood of an event. CAPTA moves from there to anticipated consequences associated with hazards and threats to each asset or asset class under consideration. CAPTA allows users to compare dissimilar assets such as transit tunnels, highway bridges, buildings, and ferry boats. The tool also allows users to address consequences regardless of the events that precipitated them, including such dissimilar causes as explosions or extreme weather.

The guide provides detailed instructions for use of the asset protection methodology (CAPTA), which is the centerpiece of the field test. The Microsoft® Excel implementation is designed for easy data entry and report generation.

Purpose of Field Test

CAPTA is being demonstrated in the field using data provided by state transportation agencies. The test is to affirm the logic of the methodology, the ease of use of the tool, and the consistency between the inputs required and the outcome products.

The field test is also a useful platform for agency feedback concerning the methodology and the tool. The consultant team desires to make the tool as easy to use as possible, and encourages advice from agency practitioners.

Overview

The CAPTA field test is consultant led, with inputs from the state agency. The consultant will input the necessary data supplied by the state agency prior to meeting. The test is expected to last between 4 and 5 hours.

The state agency will be tasked to provide inputs concerning their consequence thresholds. These choices are expected to be different between jurisdictions. The state agency is also expected to provide information on assets or classes of assets they wish to submit for consideration under this methodology.

State Agency Preparation Prior to the Field Test

Prior to using CAPTA, the user should assemble the following data concerning multimodal assets under agency jurisdiction:

1. A list of assets previously designated as critical or potentially critical by the transportation agency. This list of named assets should be broken out by the following asset categories:
   - Road bridges/tunnels
   - Transit/rail stations
   - Transit/rail bridges/tunnels
   - Buildings
   - Ferry boats
   - Fleets of vehicles

OR

2. Gather a list of *all* assets under jurisdiction and break them out by the following categories:
   - Road bridges/tunnels
   - Transit/rail stations
   - Transit/rail bridges/tunnels
   - Buildings
   - Ferry boats
   - Fleets of vehicles (e.g., all 45 passenger buses)

Table A-1. Data detail to be collected by state agency.

Road Bridges/Tunnels	ADT	Length (ft)	Lanes	Detour (mi)	Type	User-Input Price (Only for Other (i.e. Cable-Stay))
Transit/Rail Stations	Max Car Occupancy	Below Ground?	Transfer Station?			
Transit/Rail Bridges/Tunnels	Max Car Occupancy	Type	Sq. Footage			
Building	Sq. Footage	Replacement Cost (if known)	Occupancy (if known)			
Ferry	Max Occupancy	Max Vessels				
Fleet	Max Vehicles	Max Occupancy/ Vehicle	Avg Cost/Vehicle			

Following the assembly of named assets from either of the groups described above, collect data for each asset as noted in Table A-1. The data solicited in Table A-1 is required to take full advantage of CAPTA.

CAPTA can accommodate data in spreadsheet format. Common sources for these data are the following documents or databases:

- The National Bridge Inventory (NBI)
- Transit vehicle occupancy guidelines as established by the manufacturer
- Building occupancy permits and applications
- Maritime occupancy permits designated by the federal or state government
- Purchasing records relating to transit or fleet vehicles
- Institutional memory

Table A-2 shows an example of a data set for road bridges and tunnels collected for use with CAPTA.

Table A-2. Example of data collection for each asset.

Road Bridges/Tunnels Asset ID	ADT	Length (ft)	Lanes	Detour (mi)	Type	User-Input Price (Only for Other [i.e. Cable-Stay])
Bridge Class A (25 ea)	65000	3200	4	15	Concrete	
Bridge Class B (100 ea)	25000	120	4	5	Concrete	
Bridge Class C (5 ea)	125000	2750	10	2	Steel	
Interstate Bridge X	203680	14429	8	58	Steel	
Interstate Bridge Y	173000	9049	6	58	Steel	
Interstate Bridge Z	174878	1289	8	14	Concrete	
Broad St	104000	131	6	0	Concrete	
Mayfair	104000	3520	2	13	Steel	
Cianci	180000	2245	2	1	Other	$1,000,000,000

Existing Countermeasures in Place Across Transportation Assets

Countermeasure List

Prior to the field test, the state agency user will need to have a general awareness of the measures currently deployed upon transportation assets. CAPTA includes the following common preventive, protective, and response measures for consideration. The state agency user can add other named specific measures for consideration.

Prior knowledge of the measures already in place across the transportation modes will allow the tool to present "gap" opportunities and strategies not already considered by the agency. The tool contains inputs for the following classes of countermeasures:

- Lighting
- Explosive Detection
- Barriers & Berms
- Established Clear Zones
- Fences
- Visible Signs
- CCTV
- Seismic Retrofitting
- Intrusion Detection Devices
- Fire Detection & Suppression
- Physical Inspection of Asset
- Encasement, Wrapping, Jacketing
- ID Cards
- Patrols
- Biometrics
- WX/Seismic Information
- Background Checks
- Intelligence Networking
- Metal Detectors
- HAZMAT Mitigation
- Restricted Parking
- Security Awareness Training
- Random Inspections
- Emergency Response Training
- Visible Badges
- Emergency Evacuation Planning
- Limited Access Points
- Planned Redundancy (e.g., detours)
- Visitor Control & Escort
- Public Information and Dissemination
- Locks
- Chemical Detector

Data Transmission

Following the assembly of the requested data in a Microsoft® Excel–compatible format, it may be transmitted to the consultant for entry prior to the field test.

State Agency Participation During the Field Test

Significant Hazards/Threats Likely to be Experienced by the State Agency

The user will be asked to designate which hazards and threats are of concern to the agency. These choices may be guided by experience, intelligence warnings, geographical contours, or concurrent planning activities. The categories of hazards and threats addressed in CAPTA are listed in Table A-3; users will have the opportunity to add to this list.

Array of Hazards and Threats Against the Six Major Transportation Modes

The state agency user is asked to decide if a chosen threat is likely to have an adverse effect on the selected transportation mode. These decisions are intended to reflect only the hazard

Table A-3. List of threats/ hazards.

THREATS
Small Explosives
Large Explosives
Chemical Biological Radiological
Criminal Acts
UNINTENTIONAL HAZARDS
Fire
Structural Failure
HAZMAT
NATURAL HAZARDS
Flood
Earthquake
Extreme Weather
Mud/Landslide
ADDITIONAL
User Entered 1

or threat relevant to transportation modes that are present in the agency's jurisdiction. The choices should be based on experience, intelligence warnings, geographic contours, and concurrent planning practices of the agency. The state agency user will answer "yes" or "no" for each combination of threat or hazard and transportation mode. An example is provided in Table A-4.

Consequence Thresholds

The state agency user will be asked to designate initial levels or "thresholds" where significant investments beyond normal capital budgets and operating and maintenance would be justified in order to reduce the likelihood of the event or mitigate the consequence. These consequence thresholds require judgments in the following areas:

- **Potentially Exposed Population:** Threshold for the potential number of persons adversely affected by a hazard or threat. This is an objective observation.
- **Property Damage:** Threshold for the financial cost of replacing a lost asset. This is an objective observation.
- **Mission Importance:** Threshold for the extent to which an asset is vital to the operation of the transportation system. This may be a subjective observation.

The consequence threshold choices are mapped between defined data points as determined by the user. Table A-5 is provided with illustrative data. The explanations provided in the far right column are intended to assist the user in reaching a decision.

Note that the "Mission Importance" threshold levels are set based on national bridge data. Figure A-1 shows isoquants for ADT*Detour Length, illustrating combinations of these two data elements that result in the same product; Figure A-2 shows the distribution of this product for US bridges. Note that 75%, 85%, and 95% are used as alternative threshold levels for establishing consequence thresholds.

Table A-4. Hazards/threats arrayed against transportation modes.

Threats/Hazards	Road Bridges/ Tunnels	Transit/Rail Stations	Transit/ Rail Bridges/ Tunnels	Building	Ferry	Fleet
Threats						
SCE	Y	Y	Y	Y	Y	Y
LCE	Y	Y	Y	Y	Y	Y
CBR	N	N	N	N	N	N
Criminal Acts	N	N	N	N	N	N
Unintentional Hazards						
Fire	N	N	N	N	N	N
Struct. Failure	N	N	N	N	N	N
HAZMAT	N	N	N	N	N	N
Natural Hazards						
Flood	N	N	N	N	N	N
Earthquake	Y	N	N	Y	Y	Y
Extreme Weather	Y	N	N	N	N	N
Mud/Landslide	N	N	N	N	N	N
Additional						
User Entered 1	N	N	N	N	N	N
User Entered 2	N	N	N	N	N	N

Countermeasures

The state agency user will be asked to enter information concerning the current state of preventive, protective, or readiness measures. The user will also be asked to provide inputs to the type of measures desired, and will also be given the opportunity to amend the programmed costs to reflect local influences.

CAPTA provides likely choices for countermeasures against the identified threats and hazards. The state agency user is allowed to amend these choices and the unit costs to receive a more accurate picture of their assets.

Countermeasure Intentions

Table A-6 lists the decision points the user will need to address before proceeding through the countermeasure section. They are provided here as a reference and to encourage thought and discussion by the state agency prior to the CAPTA field test.

Countermeasure Cost

CAPTA provides unit costs for all of the named countermeasures. After the input of user decision and credit given for the measures already in place, CAPTA generates reports providing financial information on the cost of measures intended to mitigate the chosen consequences. The accuracy of the financial picture is dependent upon unit costs in line with the local area. The estimates provided in CAPTA are based upon construction estimation tools, with the acknowledgement that there is cost variation from region to region. The agency user has the ability to change any of the unit costs.

Table A-5. Consequence threshold example.

	Category	Critical Threshold	Explanation
ROAD BRIDGE/TUNNEL	Potentially Exposed Population	500	PEP Threshold
	Property Damage	$500,000,000	Replacement Cost
	Mission Importance ⬇	Level III	Percentile for ADT * Detour Length
	Level I	29,000	The default threshold values for ADT * detour length are taken from the 75th, 85th, and 95th percentiles for the bridges nationally. If these are inappropriate for your state, enter different values in the appropriate fields to the left.
	Level II	68,000	
	Level III	241,000	
TRANSIT/RAIL STATION	Potentially Exposed Population	100	PEP Threshold
	Property Damage	Yes	Do you consider below-ground stations to be property-critical?
	Mission Importance	Yes	Do you consider transfer stations to be mission-critical?
TRANSIT/RAIL BRIDGE/TUNNEL	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$100,000,000	Replacement Cost
	Mission Importance	Yes	Does at least 25% of the working population utilize rail/transit transportation?
BUILDING	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$100,000,000	Replacement Cost
FERRY BOATS	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$100,000,000	Replacement Cost
TRANSIT FLEETS	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$100,000,000	Replacement Cost

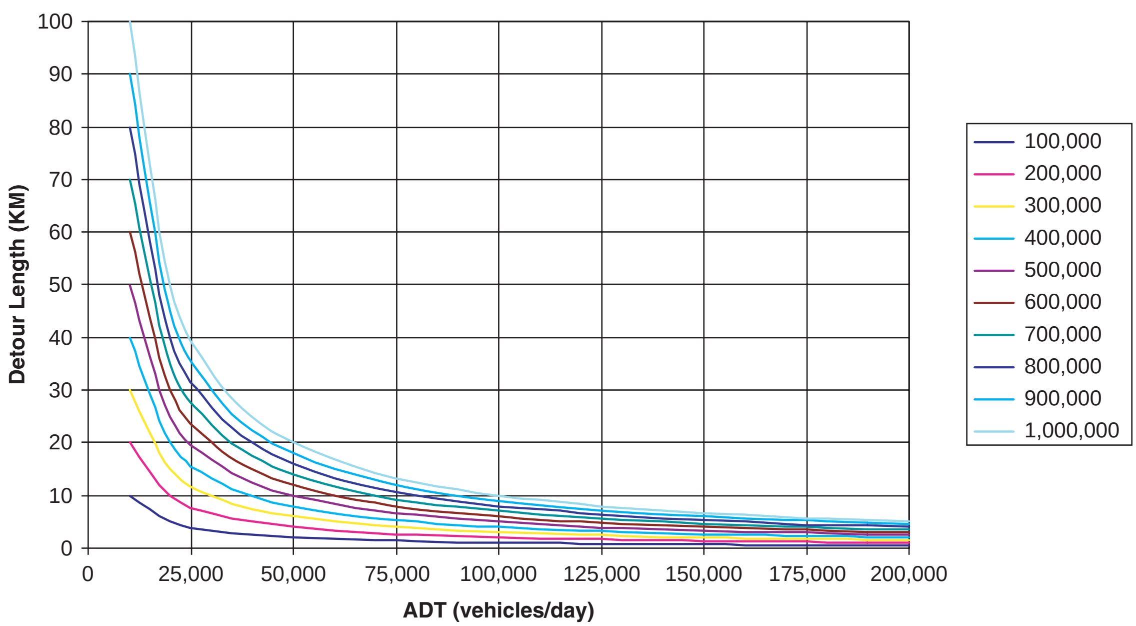


Figure A-1. Isoquants for ADT*detour length.

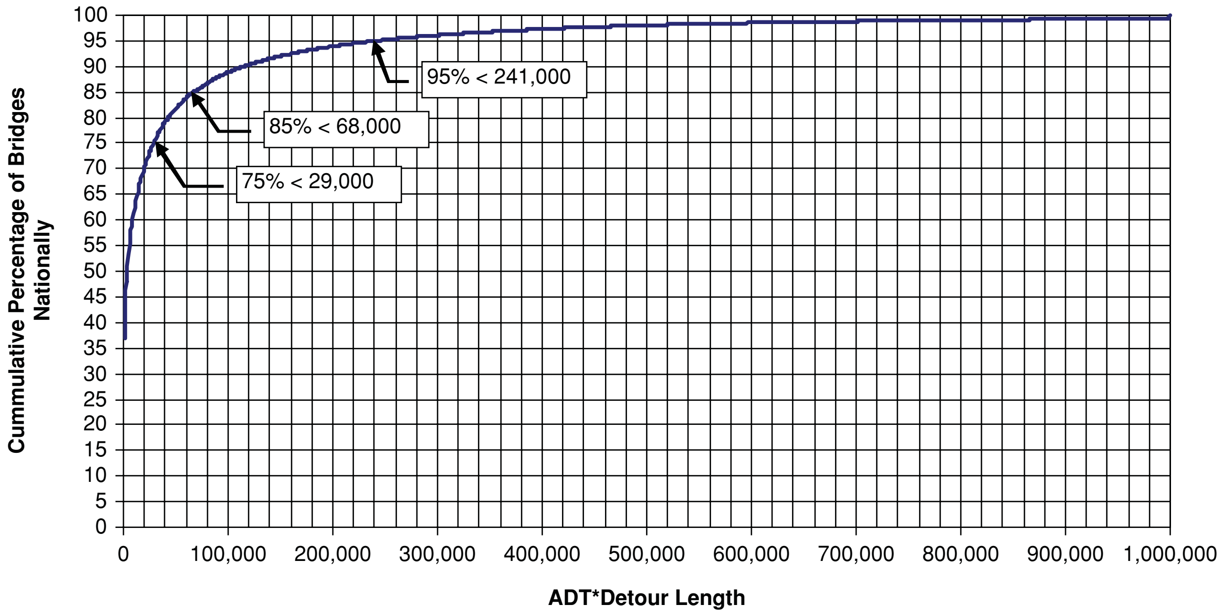


Figure A-2. Cumulative distribution of ADT*detour length for all U.S. bridges.

Table A-6. Decision points.

PREDICT	Is prediction a desirable countermeasure function?
DETER	Is deterrence a desirable countermeasure function?
DETECT	Is detection a desirable countermeasure function?
INTERDICT	Is interdiction a desirable countermeasure function?
RESPONSE PREP.	Is response preparedness a desirable countermeasure function?
DESIGN/ENGINEERING	Are countermeasures related to design/engineering desirable?
AREA-WIDE AND ASSET-SPECIFIC	Do you wish to consider only area-wide countermeasures, only asset-specific countermeasures, or both?
TEMPORARY/REDEPLOYABLE	Do you wish to consider temp/redeployable countermeasures?
MULTIPURPOSE POTENTIAL	Are you willing to consider countermeasures that are NOT multipurpose?
BASIC AND ENHANCED	Do you wish to consider only basic countermeasures, only enhanced countermeasures, or both?
THREAT RESPONSIVE	Do you wish to consider threat responsive countermeasures? (Answer "N" if you only want permanent countermeasures.)
MAX UNIT COST (X1000)	What is the maximum per unit countermeasure cost you are willing to pay?

Post Field Test

Following the one-on-one session between the consultant and the state agency user, the user will retain a copy of the data model and the reports generated. The user is free to use the data model independent of the consultant. Copies of the reports and relevant notes will be taken by the consultant.

The agency user is welcome at any time to recommend alterations to the data model that may improve ease of use.

The information gleaned from the field test will be assessed by the consultant for possible inclusion into the final data model to be presented to the NCHRP 20-59(17) panel.

APPENDIX B

Summary Report for the CAPTA Pilot Test with Maryland DOT, October 17, 2007

Attendees:

Kevin Duffy–SAIC
John Contestabile–MDOT
Matthew Basset–MDOT

Summary of Activity

On October 17, 2007, a pilot test of the CAPTA methodology was conducted with the Maryland Department of Transportation (MDOT). This pilot test was conducted using asset data supplied by MDOT. MDOT had previously been provided with a pilot test schedule depicting the content of the test and the anticipated feedback.

Utilizing the data provided, MDOT was led through the fourteen-step process. As designed, CAPTA winnowed the data fields via user-selected consequence thresholds. The summary report listed assets and asset classes that were likely to be of value to the agency.

User Feedback

The MDOT users suggested the alterations, additions, and modifications to the CAPTA model that are listed in the table on the following page. These are represented in the center column. The right column indicates the status of the comment after discussion by the project team.

Summary Result

The MDOT pilot test site was intentionally chosen due to the state's high degree of involvement in the asset vulnerability area and because Maryland is one of the few states in which the DOT controls all transportation aspects, including airline terminals.

The lengthy comment and recommendation list from Maryland was expected. Some comments, such as #1–#7 were planned for the final revision of the CAPTA model. Comment #14 was intriguing, as the same issue had been discussed by the project team and tabled pending completion of the pilot tests.

No.	Comment Description	Current Status
1	Need to relate and make consistent all screen backgrounds and colors. Recommended screen colors of grey background, yellow categories, such as in slide labeled Results Summary.	Accept
2	Need to install pop up screens (comments) to explain all terms in the spreadsheets. They would appear when then the cursors passed over it and then disappear when the cursor moved on.	Accept
3	Need to spell out all cells rather than use shorthand or just letters. Desired to see whole screen being used.	Accept
4	Need to use consistent orientation of threat/hazards and asset categories. Either assets always appear on x plane or the y plane. Currently, they change from sheet to sheet.	Accept
5	Need to insert directions box in a consistent place across sheets, such as always placing them in the top left corner.	Accept
6	Add a line to instruction boxes noting purpose of screen.	Accept
7	Need to array all buttons along top right of screen.	Accept
8	Add mission importance toggle to Ferries, Buildings, and Fleets. Recommendation has merit based on fact that some agencies have only bus fleets to operate, with limited hard infrastructure.	Accept
9	Add asset category for "Operations Control Centers" to move them apart from plain office buildings.	Accept
10	Clarify the definition of mission importance as importance to agency or to state. This change can be explored in the paper writeup.	Accept
11	Buildings should be broadened to include airport terminals.	Accept
12	Consider CAPTA for use by State Homeland Security Administrators seeking a way to determine funding across modes.	Accept
13	Change colors for countermeasure effectiveness. Use red for highly effective and orange for medium effective.	Accept
14	Break CAPTA into two sections. The first piece would move the user through only the following screens: 1. Relevant Risks 2. Threshold 3. Yellow input tabs 4. Critical Assets 5. CM Opportunity 6. Results Summary All others can be reached through user pressed buttons, if they choose to go into that amount of detail. The idea is that the user does a quick run through of the CAPTA, accepting all of the calculations we have embedded in the system. After this first pass, they can then go back and tinker with the explanations.	All Accept

APPENDIX C

Summary Report for the CAPTA Pilot Test with MBTA, November 16, 2007

Attendees:

Kevin Duffy–SAIC
Chief Paul MacMillan–MBTA Transit Police Department
Lt. Lewis Best–MBTA Transit Police Department
Sean McCarthy–OCC
John Hogan–Operations
Gerard Ruggiero–Safety

Summary of Activity

On November 16, 2007, a pilot test of the CAPTA methodology was conducted with the Massachusetts Bay Transportation Authority (MBTA). This pilot test was conducted using asset data supplied by MBTA, including a critical asset list previously generated. MBTA had previously been provided with a pilot test schedule depicting the content of the test and the anticipated feedback.

Using the data provided, MBTA was led through the recently reformulated six-step process. This process was designed after the Maryland Department of Transportation pilot test, with the CAPTA broken into a "Basic" and "Enhanced" model. The Enhanced model provides the user with greater opportunity for inputs into cost and other assumption areas.

As designed, CAPTA winnowed the data fields via user-selected consequence thresholds. The summary report listed assets and asset classes that were likely to be of value to the agency. There were no assets thought to be of value that did not appear on the summary lists.

User Feedback

The MBTA users proposed comments, alterations, additions, and modifications to the CAPTA model that are listed in the table on the following page. These are represented in the center column. The right column indicates the status of the comment after discussion by the consultant team.

Summary Result

The MBTA pilot provided great encouragement that CAPTA can be used effectively by a transit agency. The ease with which the attendees used the model and the digestible terms aided the transference of this tool. The success of the test assists in broadening the range of the methodology beyond highway agencies.

No.	Comment Description	Current Status
1	Is there value in including the 75th, 85th, and 95th traffic percentiles on road traffic threshold model?	Accept, see comment #2
2	Is there value in having the road bridge and tunnel category appear at all for transit study?	Accept. Programmer is working to ensure that unnecessary categories drop off.
3	Appreciative of using objective numbers to reach final list of assets rather than subjective opinion.	Accept
4	Does/Can the CAPTA system incorporate utilities and non-agency controlled assets?	CAPTA does not currently account across sectors. This issue will be presented to the panel as a recommended topic for further work.
5	What does the 25% of total population riding transit mean? How can we discover that number? Recommend using ***percentage of ridership***, as different assets carry proportionally greater numbers of riders that other assets.	This recommendation to be discussed by project team for implementation mechanisms.
6	Will CAPTA be used as a basis of funding?	Unknown at this time.

APPENDIX D

Summary Report for the CAPTA Pilot Test with the Virginia DOT, February 13, 2008

Attendees:

SAIC: Kevin Duffy and Michael Smith
VDOT Operations and Security Division:
Mike Washburn
Donna Pletch
Byron Marshall
Paul Szatkowski

Summary of Activity

On February 13, 2008, a pilot test of the CAPTA methodology was conducted with the Virginia Department of Transportation Operations and Security Division. The pilot test was conducted using asset data provided by VDOT. Both Kevin Duffy and Michael Smith signed non-disclosure agreements regarding protection of potentially security sensitive information about VDOT assets used in the pilot test. For the purposes of the pilot test, the VDOT Operations and Security Division provided information on a total of 67 assets representing a range of Virginia's transportation infrastructure, including bridges (rural, urban, Interstate, and arterial), tunnels (including both sub-aqueous and bored or cut-and-cover tunnels), administrative and support facilities (administrative buildings, TMCs, etc.), and ferry boats. This range of asset classes and individual assets were selected primarily to demonstrate how the CAPTA methodology works and to discover any problems with either the fundamental approach of the methodology or the functioning of the CAPTool Microsoft® Excel spreadsheet model used to implement the methodology rather than to identify critical assets for VDOT and potential countermeasures for VDOT.

The methodology was demonstrated using the selected assets, allowing VDOT participants to select hazards and threats of interest and set consequence thresholds for each asset class. VDOT participants offered suggestions and agreed to review the tool and provide comments to the study team.

User Feedback

During the course of the pilot site demonstration, several observations were made that required either enhancements or corrections to the CAPTool spreadsheet used to implement the model. The VDOT participants provided feedback following the demonstration as follows:

> The Virginia Department of Transportation participated with a pilot review of the MRAM (now CAPTA). VDOT provided data to the design team and provided comments during the review. The CAPTA tool is effective for storing, sorting, and managing the details of critical infrastructures. Direct

downloads of information to populate the CAPTA tool would be very beneficial. CAPTA allows users the flexibility to adjust the importance of a facility and expand key criteria.

CAPTA has a feature to estimate the benefits of mitigation strategies. This feature would require frequent updates for cost figures. Furthermore, this feature may or may not incorporate unique infrastructure requirements that could impact the strategy's cost or usefulness, i.e., harsh maritime climates, environmental restrictions, interference, etc. The labor impact of analyzing and updating, on a state prospective, for such detail is unknown.

Following the pilot test, the study team found additional corrections and improvements in either the performance or presentation of the tool. These are listed below along with action taken to address them.

No.	Comment Description	Current Status
1	Correct error in cost estimator for Ferry assets.	Accepted
2	Ensure that Manual Override feature is properly implemented and explained.	Accepted
3	Revise color scheme to support B&W printing.	Accepted
4	Change Highway Bridge mission threshold from "Level I", etc. to "Demand Percentile I", etc.	Accepted
5	Add 2 more rows to Summary that contain total # of countermeasures selected, total # of unique countermeasures.	Accepted
6	Place icons on each page of the spreadsheet to show progress through the six-step process.	Accepted

Summary Result

The VDOT pilot test confirmed the usefulness of the CAPTA methodology and CAPTool, the related computer-based spreadsheet. The pilot test provided an opportunity to discover several errors in the spreadsheet model as well as several enhancements that will improve the performance of the spreadsheet model, the user interface, and the presentation of the results.

APPENDIX E

List of Acronyms

AASHTO—American Association of State Highway and Transportation Officials
ADT—Average Daily Traffic
APTA—American Public Transportation Association
AREMA—American Railway Engineering and Maintenance Association
ASCE—American Society of Civil Engineers
AUA—American Underground Construction Association
CAPTA—Costing Asset Protection: An All Hazards Guide for Transportation Agencies
CAPTool—Costing Asset Protection Tool
CCTV—closed circuit television
DHS—Department of Homeland Security
DOT—Department of Transportation (state)
HAZMAT—hazardous material
IAEM—International Association of Emergency Managers
NCHRP—National Cooperative Highway Research Program
NFPA—National Fire Protection Association
NIMS—National Incident Management System
PEP—Potentially Exposed Population
TCRP—Transit Cooperative Research Program
U.S.DOT—United States Department of Transportation

APPENDIX F

Glossary of Terms Used in CAPTA

Risk Assessment Terms

Risk—The quantitative or qualitative expression of possible loss that considers both the probability that a hazard or threat will cause harm and the consequences of that event.

Target/Asset—Persons, facilities, activities, or physical systems that have value to the owner or society as a whole.

Threat/Hazard—The potential natural event or intentional or unintentional act capable of disrupting or negatively impacting an asset. In the case of natural events, the hazard is the frequency and magnitude of a potentially destructive event. Hazards can be expressed in probabilistic terms where data are available.

Consequences—The loss or degradation of use of an asset resulting from a threat or hazard. Consequences may also be determined by loss of life (casualty). Mission-related consequences include destruction or damage causing real loss or reduction of functionality. Potential for consequences grow as a function of an asset's criticality. However, a critical asset may be damaged without total loss of functionality.

Vulnerability—A weakness in asset design or operations that is exposed to a hazard or can be exploited by a threat resulting in negative consequences. Specific hazards or threats may expose or exploit different vulnerabilities. Note that an asset may be susceptible to hazards or threats that may increase its vulnerability, such as having publicly accessible information (e.g., drawings, schedules, secure areas) that could assist a terrorist in planning and executing a successful attack.

Consequence Threshold—The planning factor used to set the level of consequences at which the decision maker or agency assumes greater responsibility for managing the risk.

Consequence Categories

Potentially Exposed Population (fatalities and injuries)—This consequence is concerned with the number of people who may become a casualty. Occupancy limits, or capacity is a surrogate data point for this category.

Property Loss—This concerns the cost to repair or rebuild a damaged or destroyed structure. These monetary estimates are standardized unit cost estimates based upon square or linear footage of an asset, or an amount provided by the user for special designed structures such as a cable stay bridge.

Mission Disruption—This concerns the adverse impact on the transportation system due to the loss of the functionality of an asset. Implying the redundancy of the road and rail networks, detour lengths to and from a disabled asset are used as a surrogate for mission disruption level. Detour length is readily available in current agency databases for bridges and tunnels. Transit facilities are assessed using ridership levels of an asset.

Social/Cultural Disruption—The social consequence reflects how the population might respond to the event through significant behavioral changes. These may include fear of travel or avoidance of a transportation mode or route. Fear and avoidance of transportation modes will lead to a decrease of commercial activity. There may also be adverse reaction by the public to the imposition of security measures, such as personal searches, needed to prevent a disruption or mitigate the effects of a disruption.

Major Asset Categories

Road Bridges—Any aerial structure designed to carry vehicular traffic across a body of water or land. This category is most effective when used to capture structures whose length spans greater than one beam.

Road Tunnels—All tunnels bored, mined, or immersed that convey rubber tire vehicles, buses, and trucks.

Transit/Rail Bridges—All raised aerial structures designed to carry rail rolling stock.

Transit/Rail Tunnel—A transit system with a major rail capability is likely to have an extensive network of tunnels.

Transit/Rail Station—Classes of access rail transit points in CAPTA. Length of platform, capacity, and building type can serve as common characteristics for a class.

Administrative and Support Facilities—Fixed asset facilities a transportation operator may own or operate, with the exception of transit or rail stations. The fixed facilities in this category may range from offices of executives, to airside passenger terminals.

Ferry—All watercraft used in the regulated transportation of passengers and vehicles for a scheduled service. The size of the vessel does not matter. In the rare cases where ferries constitute a significant portion of the transportation agency's passenger capacity, an effort should be made to separate the vessels into classes.

Fleet—Regularly used individual passenger vehicle. The most common assets in this category will be buses and passenger transit/rail cars. The base unit for this category is one asset, whereby a train may consist of four to six individual fleet cars. The similarities of fleet vehicles readily lend themselves to groupings into classes.

Threats (Intentional Actions)

Small Explosive Devices—Explosive materials containing less than 250 pounds of TNT or equivalent. Delivery is by means of one to five aggressors transporting the payload.

Large Explosive Devices—Explosive materials containing greater than 500 pounds of TNT or equivalent. The method of delivery is either by vehicle or through multiple persons acting in concert to transport the payload.

Chemical/Biological/Radiological (C/B/R) agents—Gases, liquids, or solids introduced with the intent of causing physical harm or property loss.

Criminal Acts—Lower intensity threats representing the range of illegal activities as defined by federal code, state statute, or local ordinance. Examples of criminal acts include handgun violence and illegal discharge of hazardous waste.

Unintentional Hazards

Fire—Sources may be disparate and triggered by any combination of flammable material and ignition. Fire may result from happenstance and does not require an intentional act to occur. Fire, or the pre-fire hazard of smoke, will immediately have a negative impact upon all transportation assets by inducing the evacuation of persons and equipment within the structure and surrounding areas. Fire and smoke will decrease visibility to unsafe levels, precipitate collision of vehicles and equipment, and cause personal injury. A fire controlled by firefighting may still result in smoke and water damage at a level sufficient to render a transportation asset unfit for use or occupancy.

Structural Failure—Any decrease in the physical integrity of the transportation asset to bear the weight required to carry passengers or freight. The loss of physical integrity requires the asset be inspected and major repair be completed prior to its reopening for beneficial use by the public.

Hazardous Materials (HAZMAT)—Liquid, solid, or gaseous materials for which the quantity of material introduced may be minimal but that cause a hazard to users of the system. Hazardous materials include common industrial cleaners used by transportation workers and canisters of pepper spray set off by transit users. In both circumstances, it is unlikely that the maintenance worker or the commuter entered the transportation system with the intent of discharging material into the air. Materials may also include hazardous liquid, which include debris or waste products moved into the transportation system by a vehicle, truck, or rail car. For CAPTA purposes, hazardous materials require specialized remediation that will close a roadway or transit transportation to allow processing.

Natural Hazards

Flooding—The condition of excessive water inflow to an asset exceeding the engineered pumping capacity, and causing a hazard or threat to people and property. Flooding is typically caused by a calamitous weather event; however, it may be caused by defective pipeline transfer.

Earthquake—A seismic anomaly that weakens the fitness of a structure to standards less than that designed and intended by the owner. The earthquake will present a hazard to transportation users while it is occurring, due to flying debris and geotechnical instability. The earthquake may present a hazard upon its conclusion by weakening assets such that they are no longer usable.

Extreme Weather—All means and methods of extreme wind, rainwater, snow, ice, or other act of God that is unusual for its ferocity. An extreme weather event will be characterized by the exhaustion of all available equipment previously assembled for remediation and the exceeding of all planning thresholds in place at a transportation agency for the conditions of snow, ice, wind, water, and other acts of God. This characteristic would normally include exceeding the "100-year storm" guidance gathered through observation.

Mud/Landslide—The sudden massive movement of soil causing actual or potential harm to person and property, prompted by water or geotechnical shift. The most common historical data in this category involves soil shifts onto roadways or rail facilities because of wet conditions.

APPENDIX G

Recommended Further Reading

Transportation Research Board of the National Academies

Asset-Specific Guidance

- The full series of transportation-related security and risk management documents currently published by the National Academies, the TRB, and AASHTO are available at www.trb.org/SecurityPubs.
- "A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection." AASHTO, Washington, DC, 2002. Available at security.transportation.org/?siteid=65&pageid=1363.
- "A Guide to Updating Highway Emergency Response Plans for Terrorist Incidents." AASHTO, Washington, DC, 2002. Available at security.transportation.org/?siteid=65&pageid=1363.
- *NCHRP Report 525: Surface Transportation Security, Volume 3: Incorporating Security into the Transportation Planning Process.* Transportation Research Board of the National Academies, Washington, D.C., 2005. Available at www.trb.org/news/blurb_detail.asp?id=5028.
- *TCRP Report 86: Public Transportation Security, Volume 10: Hazard and Security Plan Workshop: Instructor Guide.* Transportation Research Board of the National Academies, Washington, D.C., 2006. Available at www.trb.org/news/blurb_detail.asp?id=5733.
- *NCHRP Report 525: Surface Transportation Security/TCRP Report 86: Public Transportation Security, Volume 8: Continuity of Operations (COOP) Planning Guidelines for Transportation Agencies.* Transportation Research Board of the National Academies, Washington, D.C., 2005. Available at www.trb.org/news/blurb_detail.asp?id=5612.
- *NCHRP Report 525: Surface Transportation Security, Volume 1: Responding to Threats: A Field Personnel Manual.* Transportation Research Board of the National Academies, Washington, D.C., 2004. Available at www.trb.org/news/blurb_detail.asp?id=4425.
- *NCHRP Report 525: Surface Transportation Security, Volume 2: Information Sharing and Analysis Centers: Overview and Supporting Software Features.* Transportation Research Board of the National Academies, Washington, D.C., 2005. Available at www.trb.org/news/blurb_detail.asp?id=4556.
- *TCRP Report 86: Public Transportation Security, Volume 11: Security Measures for Ferry Systems.* Transportation Research Board of the National Academies, Washington, D.C., 2005. Available at www.trb.org/news/blurb_detail.asp?ID=6068.
- *TCRP Report 86/NCHRP Report 525: Transportation Security, Volume 12: Making Transportation Tunnels Safe and Secure.* Transportation Research Board of the National Academies, Washington, D.C., 2007. Available at www.trb.org/news/blurb_detail.asp?ID=7221.

United States Department of Homeland Security

- Office of Domestic Preparedness. Information at all levels of emergency preparedness available at www.ojp.usdoj.gov/odp.
- The National Incident Management System. Available at www.nimsonline.com/.
- The National Response Plan. Available at www.dhs.gov/dhspublic/interapp/editorial/editorial_0566.xml.
- Comprehensive Preparedness Guide 101. Available at www.fema.gov/about/divisions/cpg.shtm.
- The National Infrastructure Protection Plan. Available at www.dhs.gov/xprevprot/programs/editorial_0827.shtm.
- Continuity of Operations Guidance and Assessment. Available at www.fema.gov/government/coop/index.shtm.
- Lessons Learned Information Sharing website (*password required*): www.llis.dhs.gov/.
- Personal Preparedness for Emergencies: www.ready.gov/.
- State Homeland Security Assessment and Strategy Program Special Needs Jurisdiction Tool Kit, Office of Domestic Preparedness 2003. *This document has restricted access.*
- Maritime Security Risk Analysis Model. See "The Maritime Security Risk Analysis Model: Applying the Latest Risk Assessment Techniques to Maritime Security," *Proceedings of the Marine Safety & Security Council*, Vol. 64, No. 1, available at homeport.uscg.mil/.
- Transportation Security Administration. Security clearances for selected state DOT employees, contact Julie Otto at 571-227-3609 or julie.otto@dhs.gov.

United States Department of Transportation, Federal Highway Administration

- Office of Operations, Information on Emergency Transportation Operations (ETO). Available at ops.fhwa.dot.gov/opssecurity/index.htm.
- Office of Operations, Information on transportation security funding. Available at ops.fhwa.dot.gov/opssecurity/funding/.

PART II

CAPTool User Guide

PREFACE

The *Costing Asset Protection: An All Hazards Guide for Transportation Agencies* (CAPTA) supports high-level program assessments of risk across the spectrum of transportation infrastructure. It is intended for use by senior management overseeing infrastructure in a variety of transportation modes. The CAPTA deploys a consequence-based methodology that assists in capital budgeting. This methodology may be used to assess *all hazards* and provide decision support for resource allocation. CAPTA is part of a suite of analysis and planning methodologies and tools developed to enhance safety and security for a range of assets and related hazards and threats. Figure 1 shows how asset-specific guides relate to the CAPTA methodology.

CAPTA helps transportation decision makers and other interested parties compare disparate asset classes across a range of hazards and threats on a common scale for planning and budgeting. It facilitates development of a countermeasure program to approach hazards and threats selected by the user as likely to occur in their jurisdiction. The assets, hazards, threats, and countermeasures are presented in a common format to assist users in planning mitigation measures.

CAPTA adds value to the field of risk management by providing a methodology designed to be used by transportation professionals. It does not replicate material already widely available or practices that are widely adopted. The high-level analysis provided in CAPTA helps users identify assets, or categories of assets, at risk. Users may choose to conduct a more detailed analysis in conjunction with established, more narrowly focused guides developed solely for specific assets. These guides provide a tactical assessment, accommodating local conditions or regional variations that may affect the importance of an asset, operating procedures, political considerations, labor costs, and other factors.

Several asset-specific risk management assessment and mitigation guides are already available through the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), the Transportation Security Administration (TSA), the United States Coast Guard (USCG), and other federal agencies and national organizations. However, they do not compare investment across different modes and asset classes. Used as intended, CAPTA fills a void in existing risk management literature.

CAPTA supports a broad, high-level assessment of risks to assets from a range of hazards and threats. Assets may be vulnerable to these hazards and threats because of existing design, operational standards, and current conventions. CAPTA facilitates comparisons of risks and related mitigation strategies across hazards and threats for several modes. It allows transportation decision makers to assess the risks, costs, and impacts of additional mitigation strategies through an iterative process applied at the program level. CAPTA helps to determine the cost of additional risk mitigation and to make informed judgments regarding needs for more detailed mode and asset-specific assessments that use detailed risk management analytical methods. Countermeasure costs are estimated, drawn from use of the RS Means estimating manual, practitioner knowledge,

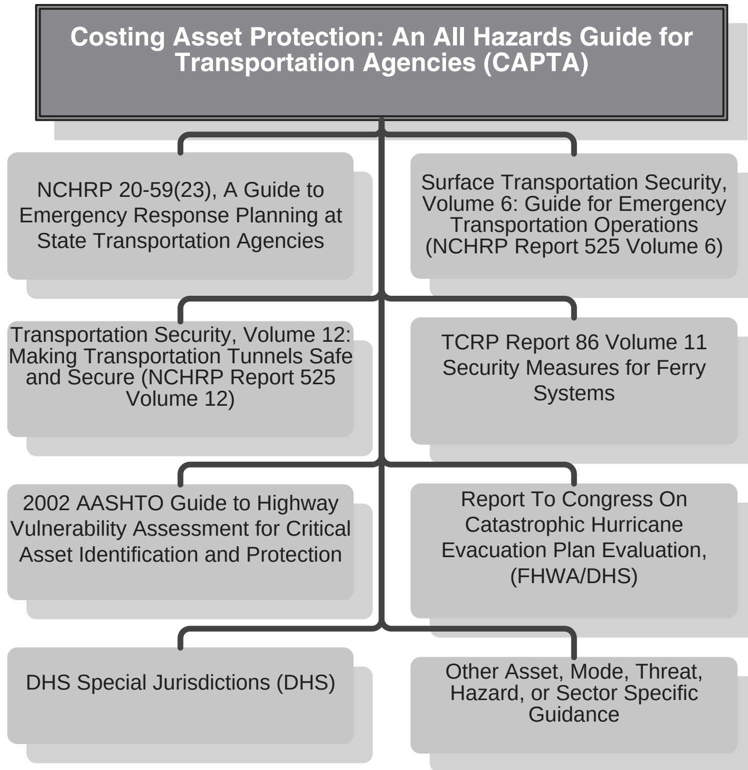


Figure 1. CAPTA relationship to asset-specific guides.

and experience of the research team. Regional labor costs, supply costs, personnel allocation, and local context will influence the final costs.

To facilitate use, the CAPTA methodology is implemented in a spreadsheet-based tool that contains embedded data and assumptions that support high-level analysis. Users may enter assets or classes of assets into the tool and receive summary reports identifying critical assets and estimating mitigation costs. The methodology and tool also match countermeasures with their general function and match effectiveness and cost characteristics with asset/threat combinations considered of interest by virtue of potential consequences.

Objective

CAPTA supports ***mainstreaming*** an integrated, high-level, all-hazard, NIMS-responsive, multimodal, risk management process into major transportation agency programs and activities. CAPTA provides state DOTs and other users with a convenient planning tool to estimate both capital and operating budget implications of measures intended to reduce risks to assets of interest.

The primary purpose of CAPTA is to provide users a ***capital planning and budgeting tool*** with five major objectives:

- Demonstrate the budgetary impacts of various agency consequence threshold levels chosen by the user.
- Examine the merits of various countermeasure additions and enhancements including capital and operation measures—both singly and in combination.

- Develop an order-of-magnitude estimate for a user-chosen selection of risk mitigation strategies (i.e., countermeasures). This order-of-magnitude estimate serves as a starting point for budgeting purposes. These estimates apply for a multimodal, multiasset agency context.
- Indicate the assets for which more detailed risk analysis is needed.
- Provide guidance in an objective, transparent manner.

CAPTA provides a means to evaluate a wide range of assets and transportation modes based on known attributes, taking into account hazards and threats and their potential consequences. A consequence threshold, applied iteratively by the user, sets a lower limit of losses associated with assets to be considered further. CAPTA's countermeasures database provides choices for mitigating consequences associated with these assets. This combination enables decision makers to determine appropriate risk mitigation measures and estimate their costs as a function of the selected consequence threshold.

CAPTA may be employed by a range of agencies responsible for risk management across transportation modes in an all-hazards environment:

- Regional entities, such as port authorities, toll authorities, and transit authorities;
- State agencies, such as departments of transportation and state emergency management agencies; and
- Local agencies, such as departments of public works and county highway departments.

CAPTA evolved in response to several emerging realities in the transportation environment:

- Current available risk management strategies are asset specific, mode specific, and threat or hazard specific. These approaches typically do not accommodate high-level, multimodal, all-hazard considerations needed for overall agency-level planning and budgeting.
- The range of risks faced by transportation agencies forms a continuum. This range of risks requires a systematic, cohesive risk management approach that encompasses all modes.
- Transportation owners/operators are aware of the risks their systems face—from natural disasters to intentional harm (terrorism). CAPTA uses this knowledge as input to the assessment process.
- Many hazards and threats are addressed in established design standards and operational planning. New hazards and threats may exceed established practice or standards. Established and newly apparent risks must be met with mitigation measures consistent with the National Incident Management System (NIMS) and National Infrastructure Protection Plan.

Introduction

Background

The CAPTA effort is a continuation of efforts begun following the terrorists attacks of September 11, 2001. That event prompted a series of risk assessment and management projects initiated through the Cooperative Research Program managed by the Transportation Research Board of the National Academies. Several risk management guides were prepared independently and were targeted at state transportation agencies that own, operate, or influence specific assets or specific asset classes within the transportation system. They included guides to assess risk and vulnerability for highway assets, rural transit, ferries, tunnels, and bridges. These asset-specific guides provide valuable, current information to owners and operators. This multimodal guide builds upon these prior mode-specific efforts.

Much of the transportation-focused risk assessment and risk management guidance available today is asset or threat specific. These approaches to risk management have the following characteristics:

- The analysis focuses on a select group of assets, or a specific asset.
- The approaches assume or require substantial knowledge of likely threat/hazard scenarios.
- The approaches consider many possible scenarios that might disrupt transportation assets.

These guides often require knowledge that the user may not possess or easily obtain. The guides are typically specific to one transportation mode or asset class, such as bridges or tunnels. They are not designed to compare transportation assets across transportation modes, such as would be the case with vehicle fleets and tunnels.

CAPTA expands the tools available to transportation agencies to acquire and distribute funds. The CAPTA methodology provides a foundation for capital requests based on objective, transparent, defensible data and analysis. These well-supported requests made to a legislature or in response to a federal request for grant proposals will help transportation agencies acquire additional funding on the merits of the argument for assets that need resources. The CAPTA methodology helps manage internal resource allocation decisions among multiple modes by providing a means for analyzing needs through an equitable and transparent process that is applied consistently to all assets.

The CAPTA methodology is designed to be applied by transportation practitioners without external assistance using the computer-based spreadsheet through which CAPTA is implemented. This introductory chapter provides an overview of why this product was developed and the development process. The tool will be tested and improved through use.

Overview of the CAPTA Methodology

The CAPTA methodology provides a starting point for transportation risk assessment. CAPTA provides users with a ***capital planning and budgeting tool, used as a strategic point of departure for resource allocation decisions.*** CAPTA enables an executive to base allocation decisions on objective data about assets. It can also direct decision makers toward assets and asset classes that merit further attention or study.

CAPTA is intended for use by senior managers whose jurisdiction or influence extends over multiple modes of transportation, multiple asset classes, and many individual assets. This methodology provides a means for moving across transportation assets to address system vulnerabilities that could result in significant losses given the hazards and threats of greatest concern. These losses, or consequences, could be casualties, property loss, failure to provide services to the public successfully, or loss of public confidence in the use of existing infrastructure and facilities. These four areas of loss all represent risk to the transportation system.

CAPTA is consequence driven. This methodology begins by asking the transportation owner/operator to set an initial consequence "threshold," indicated by the level of losses at which additional resources would likely be required. Subsequent analysis is completed iteratively by identifying assets where losses would exceed the consequence threshold and then identifying countermeasures that could avoid or reduce the consequences. Users may choose to change the consequence threshold to focus resources on the highest consequence assets or vary thresholds among transportation modes to reflect variations in authority or responsibility for different modes or asset classes. This approach is ideally suited to the strategic, high-level planning undertaken by an executive with budgetary discretion. The executive faced with deciding where and how to spend funds can arrive very quickly at the most logical choices based on agency priorities and the characteristics of the assets.

The process begins with the question of "What adverse consequences do I consider beyond our ability to handle through our normal operations and capital investments?" and then asks the user to indicate the types of hazards and threats of concern that might cause such losses. The user is not, however, expected to know all of the characteristics of potential hazards and threats (e.g., severity, frequency, capability, intent, and motivation).

A consequence-based approach to capital allocation departs from traditional risk management strategies in that it does not attempt to assess the likelihood of an event explicitly. In essence, the consequence-based approach assumes that if a decision maker perceives an event to be possible, and if the consequences are sufficiently severe, the decision maker must consider alternatives for avoiding or minimizing consequences if the event should occur. The consequence-based approach focuses on how an asset has been adversely affected regardless of why or how it became disabled.

Costing Asset Protection Tool (CAPTool) allows senior managers to move through multiple iterations quickly by setting consequence thresholds for losses at levels that reflect levels of responsibility and available resources. The consequence threshold may vary from jurisdiction to jurisdiction and among individual managers, depending on individual tolerance. Reasonable ranges of consequences are provided to guide the user in each of the following four consequence areas:

- Potentially exposed population
- Property loss
- Mission disruption
- Social/cultural disruption

The CAPTA methodology, as implemented in a spreadsheet (CAPTool), contains examples and default values to assist the user in choosing consequence thresholds, identifying existing means for avoiding adverse consequences, choosing countermeasures that fill gaps in coverage, winnowing those choices through cost estimates, and then packaging them for implementation.

The Audience

The intended audience for the CAPTA is senior state or regional transportation agency personnel engaged in evaluating risk across multiple modes to determine budgetary priorities.

These senior agency personnel use CAPTA to compare alternatives during a high-level analysis. Minimal staff support is required to complete CAPTA, because detailed engineering information is *not* required at this level of analysis. Proper use of CAPTA will reveal assets and classes of assets that require further evaluation and mitigation. This subsequent analysis will require technical expertise employing established mode- and asset-specific risk management tools.

Users can find asset-specific guides for most transportation modes through the TRB website at www.trb.org/securitypubs/.

Risk and Consequence

CAPTA helps agency management in its planning and budgeting activities. CAPTA encompasses the set of risks associated with natural hazards and unintentional or intentional events that are not already part of the mainstreamed design and standard operational practices. Recent terrorist threats and major natural disasters have stimulated concern over the wide range of risks faced by transportation modes. CAPTA emphasizes the potentially severe consequences from such major events and is an effort to further mainstream security procedures in an agency, as is already the case for worker safety, traffic incident management, and routine weather events such as snow and ice storms.

CAPTA's risk management process focuses on specific hazards and threats with the following characteristics:

- These threats and hazards can cause significant damage to transportation assets and mission or loss of life.
- Design/engineering and operational measures to reduce the risk of these threats and hazards are not yet "mainstreamed" in conventional transportation agency practice.
- Reasonable and practical consequence-reducing countermeasures to these threats and hazards are available.

In keeping with the above approach, CAPTA uses consequence thresholds (for life, property, and mission) to focus risk management on assets and hazard or threat combinations that merit risk reduction investment at the program planning level. CAPTA defines transportation hazards or threats and the assets classes included in this analysis at generalized levels. This generalization allows the user to move quickly to the issues that are of primary concern regardless of transportation mode, location, or use and does not require the user to estimate probabilities related to specific hazards and threats or the likelihood that specific assets are affected. The countermeasures database links potential countermeasure strategies directly to consequences and assets.

The modest level of effort involved in using CAPTA is intended to encourage mainstreaming an integrated, high-level, all-hazard, NIMS-responsive, multimodal risk management process into major transportation agency programs and activities. CAPTA also provides the departure point for applying asset-specific vulnerability assessment and countermeasure guides for asset-specific design and cost estimation.

Assumptions

The consequence-based CAPTA methodology makes several assumptions about asset classes, hazards and threats, and countermeasures. The default values and assumptions embedded in the methodology are transparent to users and, in most cases, users have the opportunity to modify them to reflect local values.

Transportation owners and operators face a range of routine hazards or threats to transportation infrastructure and assets, such as equipment breakdowns, derailments, utility disruptions, criminal acts, and medical emergencies. Guidance for handling these routine, often-encountered events and conditions and for asset-specific risk assessment is already addressed in handbooks, manuals, and industry standards that are readily available. Many are located at www.trb.org/securitypubs/. The following list contains individual examples of such materials:

- *TCRP Report 86/NCHRP Report 525, Volume 12: Making Transportation Tunnels Safe and Secure* (Parsons Brinckerhoff Quade & Douglas, Inc., Science Applications International Corporation, and Interactive Elements Incorporated; Transportation Research Board of the National Academies, Washington, DC, 2006). This guide focuses solely on tunnel assets.
- "A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection" (Science Applications International Corporation; AASHTO, Washington, DC, 2002). This document develops guidelines for assessing and mitigating vulnerabilities among highway assets.
- "Risk Based Prioritization of Terrorist Threat Mitigation Measures on Bridges" (J. C. Ray, *Journal of Bridge Engineering,* Vol. 12, No. 2, March/April 2007, pp. 140–146). This guide, developed by FHWA, provides a standardized, detailed method to assess the vulnerabilities of specific bridge components.
- *NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Methods* (R. R. Blackburn, K. M. Bauer, D. E. Amsler, Sr., S. E. Boselly, and A. D. McElroy; Transportation Research Board of the National Academies, Washington, DC, 2004).
- *NCHRP Report 525, Volume 6: Guide for Emergency Transportation Operations* (S. Lockwood, J. O'Laughlin, D. Keever, and K. Weiss; Transportation Research Board of the National Academies, Washington, DC, 2005).

The CAPTA methodology makes the following additional assumptions:

- The user takes the information provided by CAPTA as a capital budgeting prioritization tool, not as an asset-specific assessment tool.
  - The CAPTA process delineates assets or asset classes that are of high consequence to the user. This high-level delineation will allow the user to set aside budgetary resources on a rough order of magnitude. The user will then need to apply an asset-specific tool to discern how to use any resources provided to the high-consequence assets.
  - The user follows analysis using CAPTA with an asset-specific assessment tool, which may include conducting a full engineering assessment that takes into account facility-specific conditions.
- Nuclear hazards or threats are not addressed. These catastrophic threats require mitigation and response measures that are beyond the capacity of a transportation agency.
- Cyber threats are not addressed. The evolving nature of cyber threats to the operating and control systems of a transportation agency are best addressed by commercial vendors. Standard practice for any agency is to have a robust, up-to-date cyber security plan.
- Routine inspection and maintenance issues are not addressed. These operational measures typically do not require high-level strategic capital allocation measures.
- The user has available basic data about the assets to be considered under CAPTA, including physical features, cost, and typical usage of an asset. The information requested in the CAPTool was specifically designed to incorporate data typically available to transportation agencies.

- CAPTA will not provide a cost–benefit analysis for any countermeasure. Countermeasure cost estimates are provided. Quantifying benefit requires an estimate of the effectiveness of a countermeasure in avoiding or mitigating the effects of an event. Moreover, this estimate may be about an adverse event that has never and, while possible, is unlikely to occur. Quantifying benefits is most challenging when judging the merits of operational measures intended to prevent or mitigate the effects of intentional acts.

Exclusions

CAPTA is not intended to replace detailed examination of highly consequential assets or classes of assets. The high-level CAPTA methodology prioritizes resource allocation towards specific assets or classes of assets, which then should be examined using mode-specific guides.

CAPTA does not provide a cost–benefit analysis of countermeasures. The methodology does not calculate the extent to which specific countermeasures will keep an asset from all harm. It does, however, assist in identifying countermeasures that are likely to assist in preventing adverse consequences to an asset.

CAPTA does not attempt to offer predictions of the likelihood or frequency of intentional disruptions.

Organization of This Report

As seen in Table 1, this report is organized into two parts:

- **Part I** provides general background about the development of this methodology, its general philosophy, and approach. It also details the evolution of the CAPTool.
- **Part II,** this part, explains the CAPTA system, including all rational and calculation methods. It is intended for those who desire to examine the CAPTA methodology in greater detail. This part also provides a stepwise methodology, describing user inputs and decisions with the tool. The spreadsheet tool that implements the CAPTA methodology is available as a download from the TRB website (www.trb.org/news/blurb_detail.asp?id=9579).

Science Applications International Corporation (SAIC) developed CAPTA and the accompanying CAPTool with the assistance of PB Consult, Inc. The genesis of thought and idea promulgated in this CAPTool are derived from previous work by and experience of the authors as well as from interaction with practitioners in this field.

Basic CAPTool and Expanded CAPTool

CAPTool is the computer-based spreadsheet model that implements the CAPTA methodology. It is presented in a basic and an expanded format. The difference rests in the level of detail provided to the user and the requirement for user input. To facilitate ease of use, the User Guide is based on the Basic CAPTool application within the optional Expanded CAPTool explained in the subsequent section.

Table 1. Organization of this report.

Title	Contents	Intended Audience
Part I	Project history	All interested parties
Part II	CAPTool User Guide	Technical users of CAPTA

The Basic CAPTool has six steps:

1. Relevant Risks
2. Thresholds
3. Asset and Asset Class Inventory
4. Inventory of High-Consequence Assets/Asset Classes
5. Countermeasure Opportunities
6. Results Summary

In the Basic CAPTool process, the user accepts the default calculations, costs, and assumptions and can arrive at results quickly. The user enters minimum data, including the assets to be considered for evaluation. The assumptions made in CAPTool have been vetted by subject matter experts and are documented in Step 4 of this guide. Many users will find the Basic CAPTool sufficient for their needs.

Users who may wish to consider the Expanded CAPTool include those with

- Labor costs and/or materials and supply costs that are substantially different from national averages, and/or
- Extensive countermeasure preparations that are already in place, reducing the cost of implementing countermeasures.

The Expanded CAPTool gives users access to the entire process, including costs of measures proposed to mitigate the effects of a disruption. Users can alter the cost of countermeasures, verify assumptions concerning potential vulnerability, and apply individual filters to countermeasure selection. The added flexibility of the Expanded Tool gives users more control over countermeasure costs and choice of countermeasures.

Table 2 shows the detail available in the Basic and Expanded CAPTool versions, respectively. Note that in the Enhanced CAPTool, Steps 5a, 5b, and 5c precede Step 5 because they affect the costs and types of countermeasures available for selection in Step 5. These additional steps are not available in the Basic CAPTool. Basic CAPTool uses the default countermeasure types and costs and does not enable the user to filter the selection of countermeasures presented.

Table 2. Basic CAPTool and Expanded CAPTool.

Basic Step	Basic CAPTool	Expanded CAPTool	Expanded Step
1	Relevant Risk Selection	Relevant Risk Selection	**1**
		Threat Hazard Vulnerability	**1a**
2	Thresholds	Thresholds	**2**
3	Asset /Asset Class Inventory	Asset /Asset Class Inventory	**3**
4	High-Consequence Assets Inventory	High-Consequence Assets Inventory	**4**
		Countermeasure Costs	**5a**
		Selection of Additional Countermeasures	**5b**
		Countermeasure Filter Selection	**5c**
5	Countermeasure Opportunities (including asset-specific opportunities)	Countermeasure Opportunities (including asset-specific opportunities)	**5**
6	Results Summary, including by mode	Results Summary, including by mode	**6**

Example Agency

To ease comprehension of the CAPTA methodology, the fictional Apex Transportation Authority is used to illustrate application of CAPTool. The Apex Transportation Authority possesses a normal complement of urban transportation assets, including road bridges and tunnels, transit stations, transit bridges and tunnels, buses, and a single passenger ferry that operates seasonally.

The agency is located in an urban area along an ocean front, serving a metropolitan area of 4 million persons, with daily ridership of 350,000 and daily commuter auto traffic of 400,000. The agency is relatively well funded, has an infrastructure with some elements over 90 years old, and has a great body of institutional knowledge and data from past weather events and disruptions. Within this example, the urban agency, with the wide ranges of transportation modes under its jurisdiction, will avail itself of the full range of the CAPTool.

Welcome to the CAPTA Process

The CAPTool User Guide

The CAPTool User Guide is a reference for those using CAPTool to apply the CAPTA methodology. The Guide provides definitions, the purpose of each step, and step-by-step instructions. The user is guided through the process, aided by examples and illustrations.

The outline for each step instruction section is as follows:

- Introduction: Provides an overview of the step.
- Purpose: Provides information on what the step will accomplish.
- Definition: Provides information on terms used within the step.
- Assumptions: Provides information on assumptions inherent within the step.
- User Inputs: Provides instruction on the actions required of the user during the step.
- Output: Provides information on the data available after processing the inputs in the step.
- Example: Provides an illustration using the fictional Apex Transportation Authority (ATA).

Preparation

CAPTool is Microsoft® Excel based and requires that the user have a rudimentary knowledge of that application. The tool uses Microsoft® Excel macros and Visual Basic embedded in a Microsoft® Excel spreadsheet. Changes to the Visual Basic subroutines will change the results, and thus changes should not be made without careful testing.

Upon startup of the program, the tool will ask the user to "Enable Macros." Click the box corresponding to "Enable Macros."

The tool requires data concerning the asset categories to be considered in the analysis. The user is best served by compiling these data before using CAPTool. The required data are described in Table 3.

Data Consistency

Asset data should be vetted to ensure that measures of capacity, occupancy, detour length, replacement costs, and other factors are verified and applied consistently.

Specific attention should be paid to the following measures:

- **Maximum Train Capacity (Occupancy):** The rated occupancy of a rush-hour train set should be entered. The agency should use rated data from the manufacturer and the size of a rush-hour train set assembled according to standard operating procedure. Using these existing data

Table 3. List of required data for use in the CAPTool.

Category	Required Data
Road Bridges	Identification of asset or asset class, quantity, annual average daily traffic, length (ft), travel lanes, detour length to nearest available crossing, type of construction, replacement cost (if known).
Road Tunnels	Identification of asset or asset class, quantity, annual average daily traffic, length (ft), travel lanes, detour length to nearest available crossing, replacement cost.
Transit/Rail Stations	Identification of asset or asset class, quantity, maximum train capacity (occupancy), knowledge that the structure is below grade or above grade, knowledge that station is a transfer point.
Transit/Rail Bridges	Identification of asset or asset class, quantity, maximum train capacity (occupancy), type of construction, length (feet), percentage of total ridership using the bridge.
Transit/Rail Tunnels	Identification of asset or asset class, quantity, maximum train capacity (occupancy), replacement cost, length, percentage of total ridership using the bridge.
Administrative & Support Facilities	Identification of asset or asset class, quantity, square footage of facility, replacement cost, maximum occupancy of facility.
Ferries	Identification of asset or asset class, quantity, maximum occupancy (persons), maximum occupancy (vehicles).
Fleets	Identification of asset or asset class, quantity, maximum occupancy (vehicles), average cost per vehicle.

eliminates ambiguity concerning both smaller train sets that may operate during non-rush hours and under-filled trains.

- **Administrative and Support Facilities Capacity (Occupancy):** Occupancy data entered should correspond to the occupancy limitations as set by local fire code.
- **Maximum Occupancy of Persons and Vehicles for Ferries:** Occupancy data should correspond to the maximum limitations set by the United States Coast Guard.
- **Maximum Occupancy for Fleets:** Occupancy data should correspond to that provided by the vehicle manufacturer.
- **Detour Length:** Detour length should be measured from the point of the impacted bridge or tunnel to the point of the nearest structure capable of providing at least 50 percent capacity replacement. Capacity replacement may be measured in private vehicles only, or in combined private and commercial vehicular traffic. This percentage can be adjusted upward based upon specific situations as long as all the structures are treated similarly. For example, if "detour" is determined to be the distance to a crossing that can accommodate commercial and private vehicles for road bridges, then that criterion applies to all crossings.

The Basic CAPTool Guide

The Basic CAPTool follows a six-step process:

1. Relevant Risks
2. Thresholds
3. Asset and Asset Class Inventory
4. Inventory of High-Consequence Assets/Asset Classes
5. Countermeasure Opportunities
6. Results Summary

Step 1: Relevant Risks

Introduction

In the first step of this high-level assessment, the owner identifies

- Hazards and threats, and
- Asset classes of interest

This initial step limits the range of assets considered. In this step, the user identifies asset classes of interest that fall under the jurisdiction, influence, or control of the relevant entities. In the event that a user is concerned with a transportation asset class that is not under the control of the agency conducting the analysis, such as when a state DOT might include a privatized ferry service in the analysis, the user may still use CAPTool and the results can be included or excluded from the agency's own budget as appropriate.

The user is asked to choose which threats and/or hazards are relevant in the jurisdiction of interest. For example, an area that experiences hurricanes may not experience earthquakes or landslides. The user can tailor the assessment to the local area and include asset classes for which data are available, e.g., type, occupancy, length, and cost. These details will be called for later in the CAPTool.

CAPTool includes a range of hazards and threats. The hazards and threats of interest in a specific situation may be a subset of those listed. Table 4 lists most of the hazards and threats that a state DOT or transit authority has the capacity to address.

Purpose

The objectives of Step 1 are to

1. Identify asset classes under agency jurisdiction, influence, or control, and
2. Identify regionally relevant hazards and threats.

Table 4. Hazards and threats.

Type	Hazard/Threat
Unintentional Hazard	Fire Structural Failure HAZMAT
Natural Hazard	Flood Earthquake Extreme Weather Mud/Landslide
Intentional Threat	Small Explosive (hand carried) Large Explosive (vehicle borne) Chemical/Biological/Radiological Criminal Acts

Asset classes and hazards and threats should be chosen based upon fact. Hazards and threats should be chosen based on their relevance in the area. This relevance may be based on historical data, actuarial data, expert projections (such as potential for seismic activity), or concerns about intentional attacks.

Definitions

Hazards

Some of the hazards and threats shown in Table 4 are regional in nature and will affect multiple assets in an area. Most of the natural events, including earthquake, flood, extreme weather (snow, ice, wind), and landslides, affect all assets in the geographic area where the event takes place. These wide-scope events are indifferent to assets, asset categories, or persons within the path of the destruction.

Fire—A conflagration and smoke condition causing greater than 100 MW of energy. A fire of that size is not controllable.
Structural Failure—Any decline in the fitness and integrity of a structure such that a loss of composite strength is attained.
HAZMAT—The introduction and release of liquids, gas, or solids that pose a harm to persons or property upon contact.
Flood—The condition of excessive water inflow to an area exceeding the pumping capacity of that area and causing a hazard to persons and property.
Earthquake—The release of seismic waves resulting from geothermal disturbance.
Extreme Weather—Any naturally occurring act exceeding the predicted 100-year benchmarks for wind, snow, rain, or ice.
Mud/Landslide—Any dislocation of soil conditions sufficient to cause a hazardous condition to persons or property.

Threats

Most human-caused unintentional events and several of the intentional events only affect specific assets. However, events such as HAZMAT spills or large conventional explosives—especially if they involve chemical, radiological, or biological materials—can affect multiple assets either through destruction or by rendering them unusable for long periods of time.

Small Explosive—Hand-carried explosive force equivalent to fewer than or equal to 250 lbs TNT.
Large Explosive—Vehicle-borne explosive force equivalent to or greater than 500 lbs TNT.
Chemical/Biological/Radiological—The introduction of a harmful chemical, biological or radiological agent into an environment in quantity sufficient to contaminate the asset. The contamination is sufficient to cause harm to persons, or render property unfit for habitation.
Criminal Acts—Any act of civil disturbance that violates local, state, or federal laws.

Asset Categories

CAPTA recognizes eight asset categories in transportation:

Road Bridges—All aerial platforms for vehicular transportation, including steel, concrete, beam, viaduct, suspension, or cable stay.

Road Tunnels—All below-grade or mined segments designed for vehicular transportation. These include cut and cover, mined, bored, or immersed tube tunnel construction and roadways penetrating mountains.

Transit/Rail Stations—All above-grade or below-grade facilities designed to allow the embarkation and disembarkation of passengers.

Transit/Rail Bridges—All aerial platforms for rail transportation, including steel, concrete, beam, viaduct, suspension, or cable stay.

Transit/Rail Tunnels—All below-grade or mined segments designed for rail transportation. These include cut and cover, mined, bored, or immersed tube tunnel construction and roadways penetrating mountains.

Administrative & Support Facilities—All fixed facilities used in the support of a transportation agency's mission, excluding passenger rail stations. These may include terminals for air, ship or bus; headquarters buildings; supply depots; maintenance facilities; and operations control centers.

Ferries—All watercraft used in the regulated transportation of passengers and vehicles for a scheduled service.

Fleets—All individual passenger conveyance vehicles, including rail cars and buses. All maintenance vehicles.

Assumptions

To perform Step 1 and detail the relevant risks to a transportation category of assets, the user should possess

1. Hazard maps and historical records and data pertaining to experienced hazards and threats, and
2. Other events or disruptions to be included in the analysis. This requirement pertains to events that have never occurred within the jurisdiction, such as a terrorist attack or earthquake but will be included in the analysis.

Terrorist threats can vary with domestic and international politics, visibility of assets, terrorists' perceptions of asset values, and the perceived risk to the attacker of being denied success in executing the attack. Therefore, frequency or likelihood of attack is highly subjective and no attempt is made within CAPTool to quantify the likelihood of a terrorist attack against a specific asset or asset class.

User Input

In Step 1, the user selects hazards and threats (from a screen shown in Figure 2) that are relevant to the asset classes and individual assets.

Figure 2 shows the input screen from the spreadsheet where the user selects "Y" or "N" (yes or no), indicating which combination of hazards and threats and transportation asset classes are to be considered.

The distinction between road assets and transit assets is intentional. These categories of assets are different in structure, capacity, and tolerances to disruption.

Users will select only the asset categories of interest and only the hazards and threats likely to be faced.

(1)—(2)-(3)-(4)—(5)-(6) Basic CAPTool
(1)-(1a)-(2)-(3)-(4)-(5a)-(5b)-(5c)-(5)-(6) Expanded CAPTool

Identify Relevant Risks and Asset Classes
Instructions:
It is highly recommended that you save this as a new project. The "Save" button to the right will rename the file as a time and date-stamped copy to your default folder with the filename: "TransRiskManagementYYYY-MM-DD HH.MM.SS.xls"

For the asset classes of interest, please indicate the threats/hazards that you wish to include in your analysis by toggling the response from "N" to "Y" for each cell. Threat/hazard and asset combinations that are likely to result in serious loss will be considered in subsequent steps. When done, click "Next."

Save Time-Stamped Copy to Default Folder
Previous
Reset Answers to "N"
Next
User-Entered On/Off

	Road Bridges	Road Tunnels	Transit/Rail Station	Transit/Rail Bridges	Transit/Rail Tunnels	Admin & Support Facilities	Ferry	Fleet
THREATS								
Small Explosives	Y	Y	Y	Y	Y	Y	Y	Y
Large Explosives	Y	Y	Y	Y	Y	Y	Y	Y
Chemical/Biological/Radiological	Y	Y	Y	Y	Y	Y	Y	Y
Criminal Acts	Y	Y	Y	Y	Y	Y	Y	Y
UNINTENTIONAL HAZARDS								
Fire	Y	Y	Y	Y	Y	Y	Y	Y
Struct. Failure	Y	Y	Y	Y	Y	Y	Y	Y
HAZMAT	Y	Y	Y	Y	Y	Y	Y	Y
NATURAL HAZARDS								
Flood	Y	Y	Y	Y	Y	Y	Y	Y
Earthquake	Y	Y	Y	Y	Y	Y	Y	Y
Extreme Weather	Y	Y	Y	Y	Y	Y	Y	Y
Mud/Landslide	Y	Y	Y	Y	Y	Y	Y	Y
ADDITIONAL								
Userentered threat/hazard 1	N	N	N	N	N	N	N	N
Userentered threat/hazard 2	N	N	N	N	N	N	N	N

Figure 2. Input screen for threat/hazard and asset class.

Output

The output for this step is the completed table of transportation asset categories arrayed against relevant hazards and threats.

As shown in Figure 2, the result of Step 1 is the selected hazards and threats of concern and the asset classes where events caused by these hazards and threats might produce high-consequence outcomes. Note that some combinations of threats or hazards and asset classes may not appear on the output table because the rules implemented in the CAPTA reflect judgments regarding whether the hazard or threat could result in the destruction of the asset class in question.

ATA Example

As shown in Figure 3, the fictional ATA has road, transit, and ferry components and will consider the asset classes and hazards and threats marked with a “Y” in CAPTool.

1 — 2 - 3 - 4 — 5 - 6 Basic CAPTool
1 - 1a - 2 - 3 - 4 - 5a - 5b - 5c - 5 - 6 Expanded CAPTool

Identify Relevant Risks and Asset Classes
Instructions:
It is highly recommended that you save this as a new project. The "Save" button to the right will rename the file as a time and date-stamped copy to your default folder with the filename: "TransRiskManagementYYYY-MM-DD HH.MM.SS.xls"

For the asset classes of interest, please indicate the threats/hazards that you wish to include in your analysis by toggling the response from "N" to "Y" for each cell. Threat/hazard and asset combinations that are likely to result in serious loss will be considered in subsequent steps. When done, click "Next."

Save Time-Stamped Copy to Default Folder | Previous
Reset Answers to "N" | Next
User-Entered On/Off

	Road Bridges	Road Tunnels	Transit/Rail Station	Transit/Rail Bridges	Transit/Rail Tunnels	Admin & Support Facilities	Ferry	Fleet
THREATS								
Small Explosives	N	N	Y	N	N	Y	Y	Y
Large Explosives	Y	Y	Y	Y	Y	Y	Y	Y
Chemical/Biological/Radiological	Y	Y	Y	Y	Y	Y	Y	Y
Criminal Acts	Y	N	Y	N	N	Y	Y	Y
UNINTENTIONAL HAZARDS								
Fire	Y	Y	Y	Y	Y	Y	Y	N
Struct. Failure	Y	Y	Y	Y	Y	Y	N	N
HAZMAT	Y	Y	Y	Y	Y	Y	Y	Y
NATURAL HAZARDS								
Flood	N	Y	Y	N	Y	Y	N	Y
Earthquake	Y	Y	Y	Y	Y	Y	Y	Y
Extreme Weather	Y	Y	Y	Y	Y	Y	Y	Y
Mud/Landslide	Y	N	Y	Y	N	N	N	Y
ADDITIONAL								
Userentered threat/hazard 1	Y	Y	Y	Y	Y	Y	Y	Y
User entered threat/hazard 2	Y	Y	Y	Y	Y	Y	Y	Y

Figure 3. ATA example of threat/hazard applicability.

Step 2: Thresholds

Introduction

In Step 2, the user sets the consequence threshold assets and asset classes. The *consequence threshold* is the point set by the owner, operator, or system user that goes beyond the effects of routine disruptions and losses that current preparations and responses are designed to manage.

Setting a consequence threshold focuses attention on the relevant assets, eliminating from further consideration those assets that cannot exceed consequence thresholds, regardless of the hazard or threat. The *consequence threshold* is used to identify assets or asset classes to be included and the extent to which the hazards and threats identified in Step 1 are retained in the assessment.

Thresholds are set for each asset class and for each consequence category. The threshold is used to identify assets that are to be considered in later steps as candidates for countermeasure application. The user can adjust the threshold for any of the consequences to determine how such changes might affect the number and types of assets that remain on the high-consequence list and thus are candidates for investment of additional resources.

Purpose

The objective of this step is to establish the consequence threshold beyond which the asset owner, operator, or system user would consider investments in countermeasures to prevent losses or mitigate consequences.

Definitions

Consequence—An indication of the negative effects from an event on assets of interest. Assets of interest are typically people, structures, or equipment.

Direct Consequence—The loss of life, or injury, to a person or damage or destruction of property.

Indirect Consequence—Adverse social, economic, or psychological effects resulting from an event.

Consequence Threshold—A planning factor used to set the level of consequences beyond which additional investments in countermeasures may be justified. The user may choose this level because beyond it, the physical, economic, or mission damages cannot be readily restored with available resources. The choice of a threshold does not mean that losses below this level are unimportant or inconsequential; it means that losses below this level can be managed operationally and within the existing resources of the agency.

Assumptions

1. The consequence levels chosen are consistent with an agency's intent to commit resources to eliminate or mitigate consequences that exceed the threshold.
2. The user can alter and adjust the threshold levels in subsequent iterations with the CAPTool.

User Input

User inputs in this step establish the consequence thresholds for each of these consequence categories for each asset category (Figure 4). This step requires the user to select a combination of consequence thresholds.

The user will select threshold values for each of the consequence areas consistent with the level of responsibility and concern the user acknowledges. The threshold selected is not meant to imply that losses below the threshold are of no consequence, but that losses below the selected threshold are within responsibilities and concern of other entities (e.g., subordinate jurisdictions

(1)—(2)(3)(4)—(5)(6) Basic CAPTool
(1)(1a)(2)(3)(4)(5a)(5b)(5c)(5)(6) Expanded CAPTool

Reset Thresholds to Lowest Levels | Previous | Next | Jump to Critical Assets Summay (Only if Data on Individual Assets is Already Entered

Establish Consequence Thresholds Instructions
For each asset class, set the appropriate thresholds.
When done, click "Next."
"Reset" sets all thresholds to their lowest levels.

	Category	Critical Threshold	Explanation
ROAD BRIDGE	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	Level I	Demand percentile for ADT * Detour Length
	Level I	29000	The default threshold values for ADT * detour length are taken from the 75th, 85th, and 95th percentiles for the U.S. If these are inappropriate for your state, enter different values in the appropriate fields to the left. (Restore Defaults)
	Level II	68000	
	Level III	241000	
ROAD TUNNEL	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	Yes	Do you consider all road tunnels to be mission critical?
TRANSIT/RAIL STATION	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	Yes	Do you consider below-ground stations to be property critical?
	Mission Importance	Yes	Do you consider all transfer stations to be mission critical?
TRANSIT/RAIL BRIDGE	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	0	What % of ridership does a bridge need to serve in order to be mission critical?
TRANSIT/RAIL TUNNEL	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	0	What % of ridership does a tunnel need to serve in order to be mission critical?
ADMIN & SUPPORT FACILITIES	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	Yes	Do you consider all administrative and support facilities to be mission critical?
FERRY BOATS	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	Yes	Do you consider all ferry boats to be mission critical?
TRANSIT FLEETS	Potentially Exposed Population	0	Potentially exposed population threshold
	Property Loss	$5,000	Replacement cost
	Mission Importance	Yes	Do you consider all transit fleets to be mission critical?

Figure 4. Consequence threshold values.

or agencies or offices within agencies). The losses below the threshold may be within the means of response for the agency.

The user begins by identifying consequence thresholds where additional capital investments might be considered. This consequence can be adjusted through successive iterations but identifies an outcome that is considered worthy of avoiding and may require investments in countermeasures. The level of investment is determined in Step 5. After seeing the resource implications of a selected consequence threshold, the decision maker may choose to raise or lower the threshold to determine how the costs vary with changes in the threshold values.

For the purposes of this step, the body of previous work in this area provides the basis for the consequence categories. When applied to particular assets or asset classes, consequence categories assume total destruction of the asset. The following consequence categories are used in Step 1:

- **Potentially Exposed Population:** This category is expressed in terms of potential casualties. The expression is a range of casualties for each threshold level. The CAPTool uses the phrase "potentially exposed population" (PEP) because the analysis assumes that this is the upper bound on harm to people associated with the maximum threat. Therefore, the reference is to exposure to risk rather than an estimate of the actual casualties resulting from the hazard or threat.
- **Property Loss:** This category is expressed in terms of asset replacement costs. The expression is in millions of dollars across the cost range.
- **Mission Importance:** This category is expressed in terms of loss of function and/or transport delays and is relevant to specific assets or asset classes, including the relative importance of assets to the transportation network as indicated by their system role (e.g., Interstate Highway System, National Highway System designation) and the volume of use (e.g., Average Daily Traffic (ADT)) across a volume range. For highway bridges, the CAPTA uses the product of ADT and detour distance as a surrogate for mission or function impact. The user can set the values of this factor based on local data. For purposes of illustration, this CAPTool example uses the 75, 85, and 95 percentile of this product based on bridges in the National Bridge Inventory.

Note that other major consequences may also occur, including loss of specific government services, delays to emergency response, and impediments to military deployment. However, such consequences tend to be highly correlated with the primary consequences that capture loss of life; loss of property; and disruption of functions and related economic, government, military, and emergency response activities.

The consequence categories are provided as a starting point so that decision makers may make an initial pass through the process and then, through feedback and adjustments, converge on solutions that make sense within the context for which they are developed.

Output

The product of this step is the user-selected consequence thresholds by consequence categories. The information entered into CAPTool during this step is used in identifying assets and asset classes that are judged to be of high consequence (critical) and will remain in the analysis for further consideration.

ATA Example

As shown in Figure 5, ATA's available resources, including additional capital from the state legislature and bond markets, enable it to set a consequence threshold of about $100 million for sustaining damages to infrastructure. ATA is realistic about casualties, setting thresholds appropriate to the mode of transportation, averaging 100 potentially exposed persons. It does not consider its transit fleets to be critical to the mission of the agency.

1 – 2 – 3 – 4 – 5 – 6 Basic CAPTool
1 – 1a – 2 – 3 – 4 – 5a – 5b – 5c – 5 – 6 Expanded CAPTool

Establish Consequence Thresholds Instructions
For each asset class, set the appropriate thresholds.
When done, click "Next."
"Reset" sets all thresholds to their lowest levels.

Reset Thresholds to Lowest Levels | Previous | Next | Jump to Critical Assets Summay (Only if Data on Individual Assets is Already Entered

	Category	Critical Threshold		Explanation
ROAD BRIDGE	Potentially Exposed Population	200		Potentially exposed population threshold
	Property Loss	$101,699,661		Replacement cost
	Mission Importance	Demand Percentile II		Demand percentile for ADT * Detour Length
	Level I	29000	Restore Defaults	The default threshold values for ADT * detour length are taken from the 75th, 85th, and 95th percentiles for the U.S. If these are inappropriate for your state, enter different values in the appropriate fields to the left.
	Level II	68000		
	Level III	241000		
ROAD TUNNEL	Potentially Exposed Population	101		Potentially exposed population threshold
	Property Loss	$101,699,661		Replacement cost
	Mission Importance	No		Do you consider all road tunnels to be mission critical?
TRANSIT/RAIL STATION	Potentially Exposed Population	100		Potentially exposed population threshold
	Property Loss	Yes		Do you consider below-ground stations to be property critical?
	Mission Importance	Yes		Do you consider all transfer stations to be mission critical?
TRANSIT/RAIL BRIDGE	Potentially Exposed Population	200		Potentially exposed population threshold
	Property Loss	$100,004,750		Replacement cost
	Mission Importance	20		What % of ridership does a bridge need to serve in order to be mission critical?
TRANSIT/RAIL TUNNEL	Potentially Exposed Population	200		Potentially exposed population threshold
	Property Loss	$100,004,750		Replacement cost
	Mission Importance	20		What % of ridership does a tunnel need to serve in order to be mission critical?
ADMIN & SUPPORT FACILITIES	Potentially Exposed Population	101		Potentially exposed population threshold
	Property Loss	$101,699,661		Replacement cost
	Mission Importance	No		Do you consider all administrative and support facilities to be mission critical?
FERRY BOATS	Potentially Exposed Population	305		Potentially exposed population threshold
	Property Loss	$101,699,661		Replacement cost
	Mission Importance	No		Do you consider all ferry boats to be mission critical?
TRANSIT FLEETS	Potentially Exposed Population	50		Potentially exposed population threshold
	Property Loss	$100,004,750		Replacement cost
	Mission Importance	No		Do you consider all transit fleets to be mission critical?

Figure 5. ATA consequence threshold choices.

Step 3: Asset and Asset Class Inventory

Introduction

Transportation asset owners and operators often have responsibilities for or influence over multiple modes. In this step, the user lists the assets or asset classes to be evaluated by the CAPTool. The data entered in this step will be assessed against the thresholds chosen in Step 2 to screen the assets and asset classes for further consideration.

These inputs can be entered individually, by name or designation, or by class of assets. Named or designated assets are normally well-known structures that are unique in the jurisdiction. Named assets may also be entered onto the list because of their special significance or importance to the region.

Prior to the entry into the CAPTool, the user should screen the list to group similar assets into asset classes. Examples of assembling classes of assets may be

- Concrete highway bridges between 1,000 and 2,000 ft total length with ADT between 20,000 and 30,000 vehicles,
- Buildings with office space between 20,000 and 30,000 sq ft, and
- At-grade transit stations with dual tracks.

When these asset classes are entered, the user should carefully note representative values such as key design and operational parameters that are used to represent the entire class.

This approach seeks to reduce the number and types of assets to be considered by consolidating assets into classes that can be treated as a group. The user can also enter individual assets likely to be at or near the threshold levels chosen in Step 2.

The owner's inventory is combined with the thresholds from Step 2 to identify high-consequence assets—those assets that exceed the selected consequence thresholds.

The user may consult and obtain information from available inventories, such as the National Bridge Inventory, or from prior criticality assessments to generate the information needed for this step.

Purpose

The principal purpose of this step is to enter assets or classes of assets of interest to the user, either because of direct ownership or because they are influenced by the user and the user would like them to be considered by the CAPTool in the analysis. The secondary purpose is to calculate whether an asset or asset class surpasses the consequence thresholds chosen by the user.

Definitions

Asset Class—An aggregation of similar transportation assets. These assets are grouped together because of universal possession of like design specifications.

High-Consequence (Critical) Asset—An asset for which a hazard or threat could produce an outcome where one or more consequence thresholds is likely to be exceeded and, therefore, risk mitigation countermeasures should be considered.

Assumptions

1. CAPTool uses nominal relationships between asset classes and their threshold-related characteristics based on asset parameters. Asset classes unlikely to result in losses that exceed thresholds are eliminated from further consideration.

2. Table 5 shows the criteria used to determine whether an event involving the asset (or asset class) could result in an outcome that exceeds the designated consequence threshold. These criteria require data for assets so that the measures associated with the criteria can be calculated and compared to threshold values.
3. The PEP is calculated by estimating the maximum number of persons who might be present when an adverse event occurs using National Fire Protection Association (NFPA) or similar standards.
4. The property criterion is based on planning factors for replacing a destroyed asset.

User Inputs

The user enters all the assets and asset classes to be considered by the CAPTool into the appropriate transportation asset category sheet. The categories are those selected in Step 1, from among the following:

- Road Bridge
- Road Tunnel

Table 5. Criteria used to determine if assets exceed consequence thresholds.

Asset Class	PEP Equation	Property Equation	Mission Equation
Road Bridges	Separated into primary direction and secondary direction -- for each, if vehicles/lane > 2400, assume 40 vehicles/ 1000ft. Otherwise assume 7.5 veh./1000 ft[a]	$20,000/lf	(ADT) × (detour length) 75th, 85th, 95th percentile as thresholds relative to typical bridge inventory (Example is based on the National Bridge Inventory)
Road Tunnels	Separated into primary direction and secondary direction—for each, if vehicles/lane > 2400, assume 40 vehicles/ 1000 ft. Otherwise assume 7.5 vehicles/1000 ft[a]	$100,000/lf	User Input for criticality
Transit/Rail Station	4 × (maximum capacity of rail cars)[b]	Below ground = critical	User input if transfer station is critical
Transit/Rail Bridge	2 × (maximum capacity of rail cars)[b]	$15,600/lf	User input percentage of ridership that regularly use this transit/rail transportation asset
Transit/Rail Tunnel	2 × (maximum capacity of rail cars)[b]	$40,000/lf	User input percentage of ridership that regularly use this transit/rail transportation asset
Administrative & Support Facilities	1 person/175 sq ft[c]	$210/sq ft	Never critical unless so designated by user
Ferries	Maximum capacity of ferry	User input	Never critical unless so designated by user
Fleets	Maximum occupancy of one fleet vehicle	Average cost per vehicle × maximum number of vehicles	Never critical unless so designated by user

[a]Derived from the *Highway Capacity Manual*. TRB, National Research Council, Washington, DC, 2000.
[b]Derived from *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail*. National Fire Protection Association, Quincy, MA, 2007.
[c]Derived from *NFPA 101: Life Safety Code®*. National Fire Protection Association, Quincy, MA, 2006.

- Transit/Rail Bridge
- Transit/Rail Tunnel
- Transit/Rail Station
- Administrative and Support Facilities
- Ferries
- Fleets (Rail and Bus)

The user initiates the consequence threshold screening for each transportation asset category.

Instructions for Entering Assets/Asset Classes into CAPTA

The specific data needed varies by the asset category.

Figure 6 shows the data required for road bridges. CAPTool uses these entries to calculate the potential consequences of each asset or asset class.

Specific data required for each asset or asset class within each asset category follow:

- Road Bridges/Tunnels
  - Annual average daily traffic (AADT)
  - Length
  - Lanes
  - Detour
  - Type of construction material
  - A determination if a bridge is cable stay or suspension (requiring a unique input)
- Transit/Rail Bridges/Tunnels
  - Maximum car occupancy
  - Type of construction material (steel vs. concrete)
  - Square footage
- Transit/Rail Stations
  - Unique identification
  - Maximum occupancy
  - Above- or below-grade indicator
  - Transfer point indicator
- Administration and Support Facilities
  - Square footage
  - Replacement cost
  - Maximum occupancy
- Ferries
  - Maximum occupancy
  - Maximum number of vehicles loaded
- Fleets
  - Maximum number of vehicles
  - Maximum occupancy of vehicles
  - Replacement cost of individual vehicles

The inputs for road bridges/tunnels also contain a user input for cable stay and suspension bridges. These highly individual structures require specific replacement cost data. Figure 7 shows data required for administrative and support facilities. These data are used to determine if assets are likely to exceed nominal consequence threshold values in the event of the postulated hazards or threats. Note from Figure 7 that buildings are only critical if the user marks them as such in the last column. By reviewing Figure 7 and related output, transportation owners and operators can quickly determine which assets are most likely to be vulnerable to hazards and threats and, ultimately, where countermeasures are likely to be needed to mitigate risks.

(1) — (2) (3) (4) — (5) (6) Basic CAPTool
(1) (1a) (2) (3) (4) (5a) (5b) (5c) (5) (6) Expanded CAPTool

Specified Thresholds
Potentially Exposed Population
Property Loss
Mission *Importance*

Describe Infrastructure Assets (Road bridges)
Instructions:
Enter all road bridge assets below, along with the necessary data. If you wish to manually mark certain assets as definitely critical, toggle the "Manual Override" button on, and indicate the assets you deem to be critical by toggling from "No" to "Yes" in the manual override column.

To add comments, toggle the "Comments" button on, and insert any desired comments for each asset. To hide the comments column, toggle the "Comments" button off.

Click "Calculate Criticality" to view a summary of criticality areas for your assets. When done, click "Next.

Calculate Criticality | Previous
Manual Override On/Off | Next
Comments Hide/Unhide

ROAD BRIDGES

Asset ID	Quantity	ADT	Length (ft)	Lanes	Detour (mi)	Replacement Cost Per Asset (Optional)

CRITICALITY

Potentially Exposed Population	Property Loss	Mission Importance	Manual Override

Figure 6. Sample asset inventory data entry template for road bridges.

1 — 2 — 3 — 4 — 5 — 6 Basic CAPTool
1 — 1a — 2 — 3 — 4 — 5a — 5b — 5c — 5 — 6 Expanded CAPTool

Describe Infrastructure Assets (Admin & Support Facilities)
Instructions
Enter all building assets below, along with the necessary data. If you wish to manually mark certain assets as definitely critical, toggle the "Manual Override" button on, and indicate the assets you deem to be critical by toggling from "No" to "Yes" in the manual override column.

To add comments, toggle the "Comments" button on, and insert any desired comments for each asset. To rehide the comments column, toggle the "Comments" button off.

Click "Calculate Criticality" to view a summary of criticality areas for your assets.
When done, click "Next."

Specified Thresholds	
Potentially Exposed Population	101
Property Loss	$101,699,661
Mission Importance	No

Calculate Criticality | Previous | Manual Override On/Off | Next | Comments Hide/Unhide

ADMIN & SUPPORT FACILITIES					CRITICALITY			
Asset ID	Quantity	Sq. Footage	Replacement Cost Per Asset (Optional)	Occupancy (Optional)	Potentially Exposed Population	Property Loss	Mission Importance	Manual Override
Northern Region TMC	1	4609						
Eastern Region TMC	1	12074						
Central Region TMC	1	14997						
SW Region TMC	1	22000			Y			
NW Region TMC	1	23011			Y			
Central Office	1	206000			Y			
Maintenance Division	1	78000			Y			
Central Services	1	87000			Y			
Brighton Office - Materials	1	45000			Y			
Western District - Administration Building	1	36000			Y			
Eastern District - Administration Building	1	34000			Y			
South District - Administration Building	1	56000			Y			
North District - Administration Building	1	21000			Y			

Figure 7. ***Criticality assessment for administrative and support facilities.***

Instruction for Calculating High Consequence (Criticality)

Following entry of all assets/asset classes to be considered, CAPTool calculates which of the assets/asset classes exceed the thresholds chosen by the user and will continue forward for countermeasure assessment.

On each transportation asset category entry form, the "Calculate Criticality" button is located to the upper right with the other choice boxes. This option evaluates each entered asset/asset class against the selected consequence thresholds. The assets/asset classes that exceed the threshold values will be designated in the far right columns with a "Y."

Figure 7 illustrates Step 3. Note that each of the assets identified in this figure may represent a class of assets with similar attributes. The "Y" in the "criticality" table on the right of each figure indicates that the attributes of the asset (or asset class) are such that, if exposed to the previously identified hazards and threats, the result could exceed one or more of the consequence thresholds (E=exposed population, P=property damage, M=mission, MO=manual override). The MO code can be entered by the user to ensure that a specific asset is included among those identified as of high consequence.

Output

Based on the inventory provided by the user, CAPTool identifies the assets/asset classes that exceed the consequence thresholds chosen in Step 2. Those that do not exceed thresholds are not carried forward in the process.

The asset classification step will most likely have the following effects on the list of critical assets:

- Vehicle assets are grouped in common classes and are not likely to meet criticality thresholds and therefore, in most cases, will be eliminated from further consideration unless the user chooses to include them using the manual override. Special purpose vehicles (e.g., law enforcement or those used to transport national leadership) will undoubtedly be subjected to much more thorough analysis than can be afforded in this process.
- Facilities such as yards, terminals, and traffic management centers (TMC) differ in size and configuration. Recommended countermeasures will vary, with some exceptions, principally based on facility size. Their relative lack of personnel and ease of replacement indicate that they are not likely to meet criticality thresholds for either casualties or replacement cost.
- Stations and terminals are divided into size classes based on potentially exposed population. Smaller stations are unlikely to meet criticality thresholds.
- Assets that accommodate large populations, are high cost, and/or play major or critical transportation roles are most likely to fall above criticality thresholds. These assets (bridges, tunnels, office buildings) require a second level of classification based on:
  - Data available in existing databases (e.g., the National Bridge Inventory)
  - General classifications based on high-level parameters (e.g., square feet of office space).

ATA Example

Figure 8 shows the data ATA entered into CAPTA on road bridges within their jurisdiction or influence.

1 — 2 3 4 — 5 6 Basic CAPTool
1 1a 2 3 4 5a 5b 5c 5 6 Expanded CAPTool

Specified Thresholds	
Potentially Exposed Population	200
Property Loss	$101,699,661
Mission Importance	Demand Percentile II

Describe Infrastructure Assets (Road bridges)
Instructions:
Enter all road bridge assets below, along with the necessary data. If you wish to manually mark certain assets as definitely critical, toggle the "Manual Override" button on, and indicate the assets you deem to be critical by toggling from "No" to "Yes" in the manual override column.

To add comments, toggle the "Comments" button on, and insert any desired comments for each asset. To hide the comments column, toggle the "Comments" button off.

Click "Calculate Criticality" to view a summary of criticality areas for your assets. When done, click "Next."

Calculate Criticality | Previous | Manual Override On/Off | Next | Comments Hide/Unhide

ROAD BRIDGES

Asset ID	Quantity	ADT	Length (ft)	Lanes	Detour (mi)	Replacement Cost Per Asset (Optional)	Manually mark as critical?
Fair St. Bridge	1	1469	2389	2	76		Yes
ES Rhodes Bridge	1	9753	3409	2	54		No
Peck Bridge	1	234000	1428	8	21		No
Tucker Channel Bridge	1	4967	671	2	89		No
Broad Bridge	1	56099	4530	4	43		No
Shaw Bridge	4	45032	7927	4	78		No
I-95 Bridge	1	2390	801	2	65		No
High Bridge	1	89345	5609	4	92		No
Little River Bridge	1	50345	10478	4	23		No
McDonald Bridge	1	42000	12093	6	56	$50,000,000	No

CRITICALITY

Potentially Exposed Population	Property Loss	Mission Importance	Manual Override
			Y
Y			
Y			
Y	Y		
Y	Y		
Y	Y		
Y			

Figure 8. ATA example.

Step 4: Inventory of High-Consequence Assets/Asset Classes

Introduction

Step 4 combines results from Steps 2 and 3 to identify the assets and asset classes that exceed one or more consequence thresholds. This is the first opportunity the user has to view the assets deemed of high consequence. CAPTool arrays the assets (in columns) against the hazards and threats (in rows) to which they are vulnerable.

Purpose

The primary purpose of this step is to identify assets or asset classes that exceed consequence thresholds. A secondary purpose is to present the systemwide high-consequence assets arrayed against the hazards/threats to which they are vulnerable.

Definitions

Asset Classes—Those used in this step are a reduced set from Step 2, having been screened based on the postulated hazards and threats of concern.

Proper Name Assets—Specific assets that have special characteristics and are not part of a larger asset class. These typically involve large and well-known bridges, buildings, and stations.

Systemwide—The assets/asset classes collected from among the full range of those of concern to transportation agencies.

Assumptions

1. The CAPTA methodology determines potential consequences as a function of asset characteristics regardless of the hazard or threat that leads to the losses.
2. Default values are based on the nature of the assets and their typical function as they relate to missions or functions, potential occupancy, physical characteristics, and public perception.
3. All default values are within a range consistent with the purposes of this process.
4. Consequences are event-neutral; that is, focus is on assets that could conceivably be at risk rather than the specific hazards and threats that put them at risk.
5. The user has the ability to select any named asset for further consideration. This selection may be based on attributes not considered in the CAPTA methodology.

User Inputs

No additional inputs are required from the user in this step. This step produces results based on default values unless the user overrides them.

Output

The result of this step is a list of assets with the potential for consequences that exceed the selected consequence threshold given the hazards and threats considered (Figure 9.) Using the assets and asset classes of concern, the user then proceeds to select measures to consider for mitigating consequences.

ATA Example

In the ATA example in Figure 10, the road bridge, road tunnel, and some administrative and support assets are shown compared against the relevant hazards/threats to which they are exposed that result in consequences that exceed the thresholds set by the user.

1 — 2 — 3 — 4 — 5 — 6 Basic CAPTool

1 — 1a — 2 — 3 — 4 — 5a — 5b — 5c — 5 — 6 Expanded CAPTool

Identify Critical Assets Across Modes
Instructions

The following is a list of all critical assets, their thresholds of interest, and their relevant threats or hazards.

If you wish to modify the relevant risks for an asset, delete an "X" from any cell to remove that as a risk for the corresponding asset. Likewise, add an "X" to any field where you believe a threat/hazard is relevant to the asset.

In particular, look closely at assets that have been manually marked critical (these cells are highlighted yellow), as you may wish to adjust the threats or hazards associated with these assets. When done, click "Next."

Asset Type	# of critical assets	# of assets considered
Road bridges	3	26
Road tunnels	3	11
Stations	13	13
Rail bridges	6	6
Rail tunnels	4	4
Facilities	5	12
Ferry	0	2
Fleet	5	8
Other	0	0
Total	39	82

Return to Thresholds Sheet

Previous

Next

		Road Bridges			Road Tunnels			Transit/Rail Station						
		Blue River Bridge	State Line Bridge	Veteran's Bridge	Downtown Tunnel	Uptown Tunnel	Memorial Tunnel	North Station	South Station	Bay Station	Downtown Station	Market Station	Park Street Station	Government Center
CRITICALITY	Potentially Exposed Population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Property Loss					Y	Y			Y	Y	Y	Y	
	Mission Importance													
	Manual Override													
RELEVANT THREATS/ HAZARDS	Small Explosives	X	X	X	X	X	X	X	X	X	X	X	X	X
	Large Explosives	X	X	X	X	X	X	X	X	X	X	X	X	X
	Fire	X	X	X	X	X	X	X	X	X	X	X	X	X
	HAZMAT													

Figure 9. *Assembly of high-consequence assets.*

1 — 2 — 3 — 4 — 5 — 6 Basic CAPTool
1 — 1a — 2 — 3 — 4 — 5a — 5b — 5c — 5 — 6 Expanded CAPTool

Identify Critical Assets Across Modes
Instructions
The following is a list of all critical assets, their thresholds of interest, and their relevant threats or hazards.

If you wish to modify the relevant risks for an asset, delete an "X" from any cell to remove that as a risk for the corresponding asset. Likewise, add an "X" to any field where you believe a threat/hazard is relevant to the asset.

In particular, look closely at assets that have been manually marked critical (these cells are highlighted yellow), as you may wish to adjust the threats or hazards associated with these assets. When done, click "Next."

Asset Type	# of critical assets	# of assets considered
Road bridges	7	10
Road tunnels	4	7
Stations	0	0
Rail bridges	0	0
Rail tunnels	0	0
Facilities	10	13
Ferry	0	0
Fleet	0	0
Other	0	0
Total	21	30

Return to Thresholds Sheet

Previous

Next

		Road Bridges							Road Tunnels				Admin & Support Facilities			
		Fair St. Bridge	Peck Bridge	Broad Bridge	Shaw Bridge	High Bridge	Little River Bridge	McDonald Bridge	Walker Tunnel	Downtown	Post Road Bridge Tunnel	Woodbury Bridge Tunnel	SW Region TMC	NW Region TMC	Central Office	Maintenance Division
CRITICALITY	Potentially Exposed Population		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
	Property Loss				Y	Y	Y		Y	Y						
	Mission Importance															
	Manual Override	Y										Y				
RELEVANT THREATS/HAZARDS	Small Explosives												X	X	X	X
	Large Explosives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Chemical/Biological/Radiological	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Criminal Acts	X														
	Fire	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Struct. Failure	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	HAZMAT	X										X				
	Flood								X	X	X	X				
	Earthquake	X	X	X	X	X	X	X	X	X	X	X				
	Extreme Weather	X			X	X	X		X	X		X	X	X	X	X
	Mud/Landslide	X			X	X	X									
	User entered threat/hazard 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	User entered threat/hazard 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Figure 10. ATA example of critical assets arrayed against threshold-exceeding events.

Step 5: Countermeasure Opportunities

Introduction

In Step 5, CAPTA combines data from the countermeasures database with options of countermeasures. These countermeasures have been deemed appropriate and likely to assist in mitigating the consequence to the specific asset or asset class. The displayed set of countermeasures is a subset of the entire countermeasures database, which contains a wide range of security, design, and operational countermeasures. Countermeasures only display for the combinations of asset–hazard/threat–consequence for which they are considered appropriate.

Purpose

The purpose of this step is to determine countermeasures capable of reducing risks as determined by the assessment in Step 4.

Definitions

Potentially Effective Countermeasures—Measures determined to have potential for mitigating disruption or loss of life, property, or mission.

Assumptions

1. CAPTool displays all countermeasures considered appropriate for the hazards and threats considered.
2. CAPTool uses a color code to indicate countermeasures considered to be highly or moderately effective: orange (seen in print as shaded gray) for high effectiveness, yellow (seen in print as shaded lighter gray) for medium effectiveness.
3. Countermeasures are identified without regard for costs.
4. CAPTA allows the user to select from a range of countermeasures and assign them to individual assets/asset classes.
5. Costs are displayed on an asset-by-asset basis, or in Step 6.

User Inputs

The user selects the quantity of each of the displayed countermeasures for any of the assets or asset classes for which it is shown as appropriate. CAPTool automatically displays the combinations of assets and countermeasures together. This display is illustrated in Figure 11.

The user may choose the set of potential countermeasures based on the relevant hazards and threats and the owner's assets of interest.

Because many countermeasures are widely applicable across a range of asset categories, hazards, and threats, the user may wish to limit the number of countermeasures identified based on additional criteria that reflect the user's primary concerns, the availability of resources, preferences for certain countermeasure strategies, and other considerations. Furthermore, some countermeasures apply to multiple assets or asset classes and need not be selected for each asset or asset class.

After the initial choice of countermeasures for the arrayed assets and asset classes, the user may select a specific asset and view the countermeasure choices for that asset as well as the cost of those measures. The user can access asset-specific data and countermeasure options by clicking the mouse on the specific asset listed across the top of the table and then clicking the "Analyze Asset" button at the top of the page. This enables the user to compare all of the countermeasure options and see their relative cost while assigning them to a particular asset.

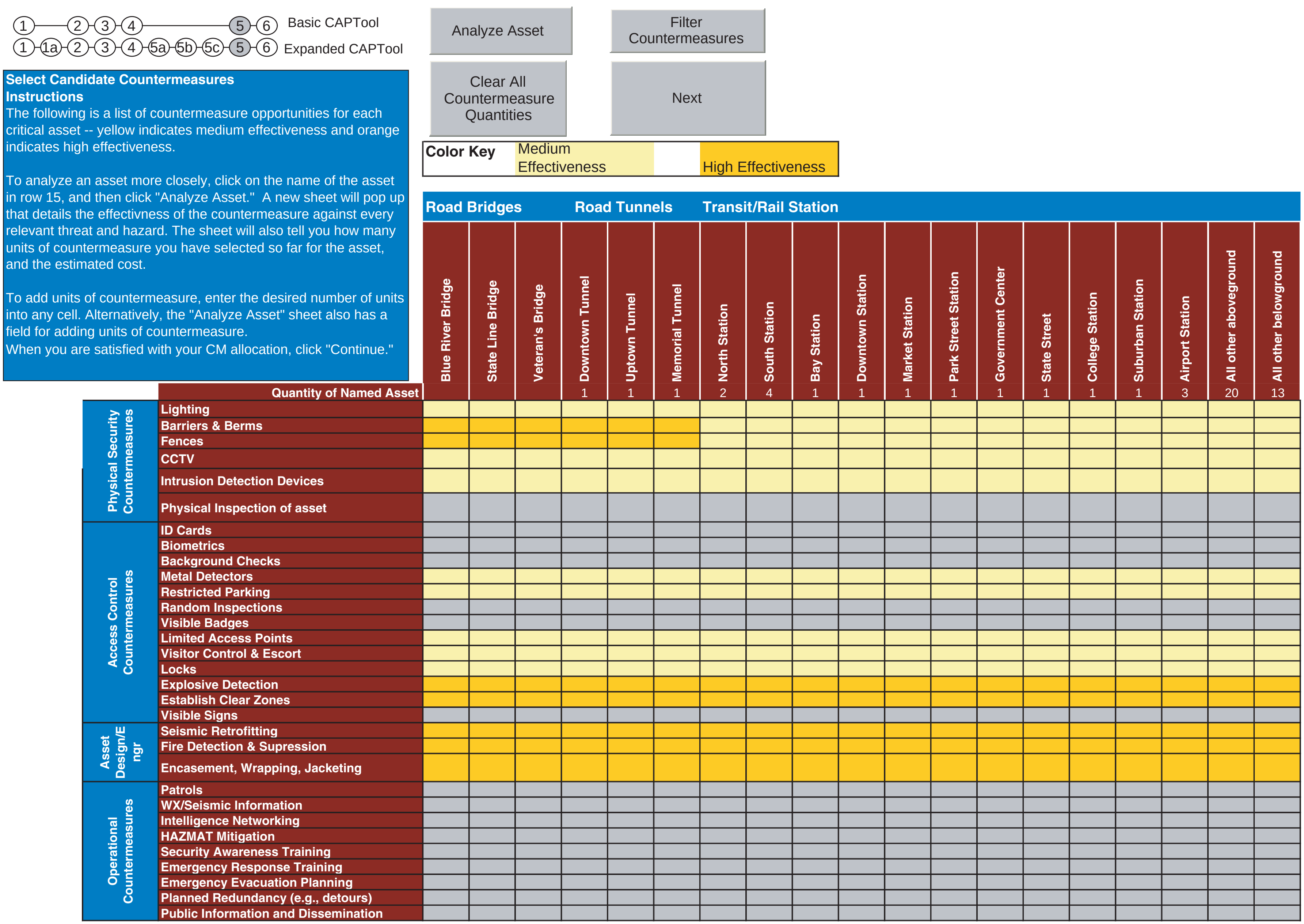


Figure 11. Countermeasure selection.

Output

The product of this step is a list of potential countermeasures for each asset class or proper name asset. The countermeasure opportunities are drawn from the countermeasures database described in Part I based on their effectiveness in mitigating risks associated with the asset class, threat or hazard, and consequence area. This set of countermeasures represents the range of possible countermeasures that should be considered when making capital budgeting decisions. Countermeasures with orange (shaded darker gray in the printed guide) cells are judged most effective against one or more of the hazards or threats associated with the asset or asset class; countermeasures with yellow (shaded lighter gray in the printed guide) cells are judged at least moderately effective in mitigating one or more of the identified hazards or threats associated with the corresponding asset or asset class.

ATA Example

The ATA example is shown in Figure 12. The example screen is limited to road bridges and road tunnels to ease presentation. This example focuses the countermeasure selection on the hazards and threats deemed most appropriate for the road bridge and road tunnel assets. Fire was chosen in an earlier step as a likely hazard, and fire protection and suppression are prominently chosen countermeasures. The user has also chosen to fund more inspections of bridges and tunnels and to install lighting. The inspections and lighting add to both security and safety of the bridges and tunnels, while the fire protection system enhances response capabilities.

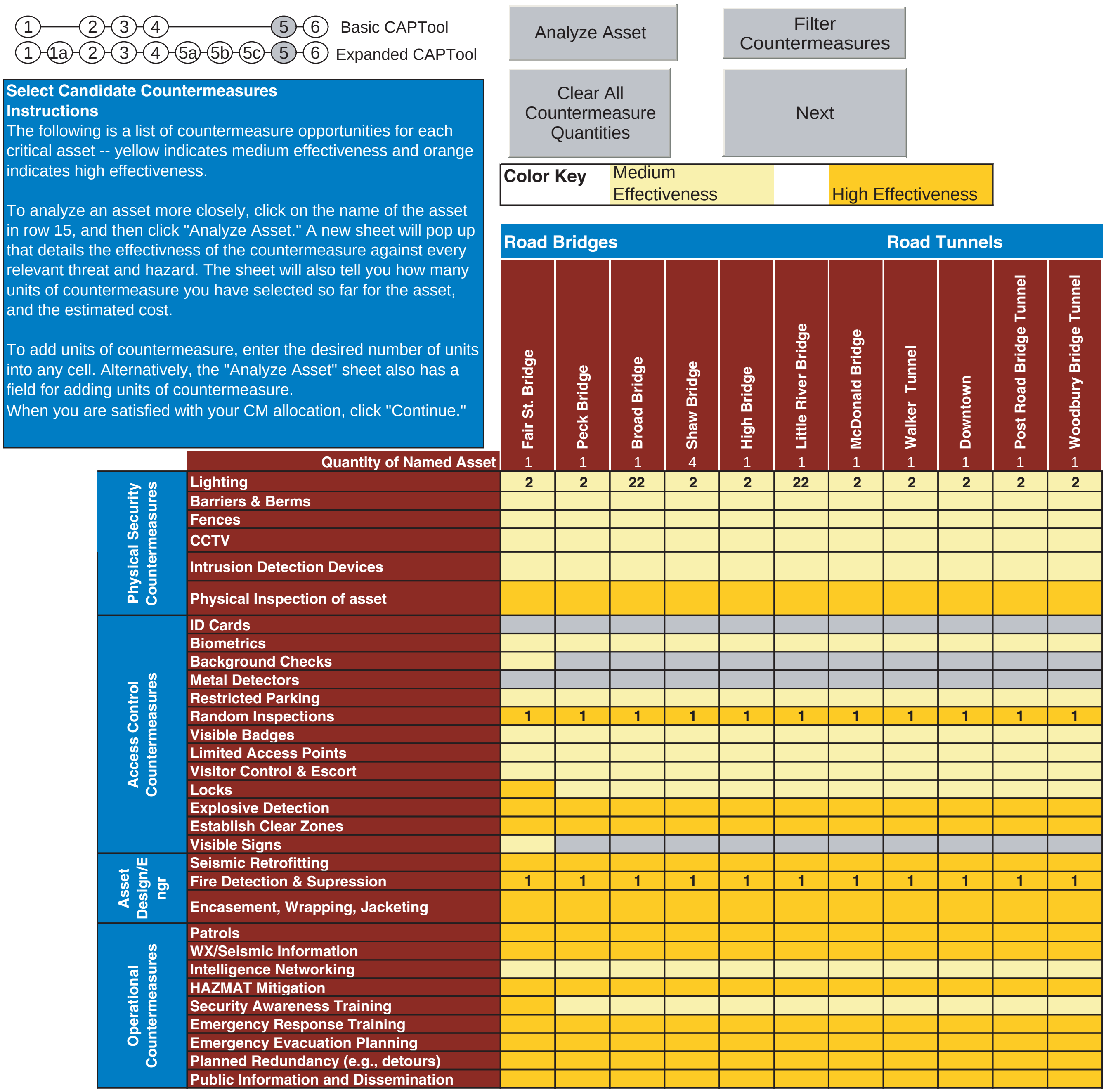


Figure 12. ATA countermeasure selection example.

Step 6: Results Summary

Introduction

In Step 6, CAPTool provides the user with a one-page summary of results based upon all inputs and the CAPTool default values. The summary is provided by asset category with optional spreadsheets available for individual assets.

Purpose

The purpose of this step is to provide the decision maker with a concise summary of consequence-based results and countermeasure combinations across multiple modes of transport.

Definitions

Results Summary—A one-page report exhibiting the results of the CAPTA process and the combination of countermeasures chosen by the user to lessen the consequence to assets under the agency's jurisdiction or influence. The results summary step does not require additional data but provides an opportunity for the user to cycle back through the process after observing the result based on the selected threshold values and countermeasure configuration.

Assumptions

All assumptions made and calculations performed throughout the CAPTA process are reflected in the results summary.

User Inputs and Actions

No user input is required in this step. Based upon the results shown in the summary, the user has the option to return to the beginning and

- Repeat the process using different threshold values; or
- Use the Enhanced CAPTool, which allows the user to enter cost and other data and set countermeasure filters to limit the countermeasures considered.

ATA Example

The ATA example is displayed in Figures 13 and 14. The figures show a range of countermeasures applied against a range of assets. Focusing on the first asset column in Figure 13, road bridges, and moving downward, all the relevant data about this asset class appear: the consequence choices, the countermeasures chosen, and the costs associated with these choices. The countermeasure choices for road bridges were modest and focused on lighting, inspections, and fire protection and suppression.

①—②-③-④—⑤-⑥ Basic CAPTool
①-①a-②-③-④-⑤a-⑤b-⑤c-⑤-⑥ Expanded CAPTool

Summary Report
Click Heading for Detailed Expenditure Report

Return to Beginning | Save Results Only
Edit Countermeasure Selection | Save Time-Stamped Copy to Default Folder

Report Date and Time:

8/19/2008 21:00

		Road Bridges	Road Tunnels	Transit/Rail Stations	Transit/Rail Bridges	Transit/Rail Tunnels	Admin & Support Facilities	Ferries	Fleets	Other
Relevant Risks	Small Explosives			X			X	X		
	Large Explosives	X	X	X	X	X	X	X		
	Chemical/Biological/Radiological	X	X	X	X	X	X	X		
	Criminal Acts	X		X			X	X		
	Fire	X	X	X	X	X	X	X		
	Struct. Failure	X	X	X	X	X	X			
	HAZMAT	X	X	X	X	X	X	X		
	Flood		X	X		X	X			
	Earthquake	X	X	X	X	X	X	X		
	Extreme Weather	X	X	X	X	X	X	X		
	Mud/Landslide	X		X	X					
	User entered threat/hazard 1	X	X	X	X	X	X	X		
	User entered threat/hazard 2	X	X	X	X	X	X	X		
Thresholds	Potentially Exposed Population	Persons	Persons	Persons	Persons	Persons	Persons	Persons	Persons	--
		200	101	100	200	200	101	305	50	--
	Property Loss	Damage	Damage	Below Ground Stations Critical?	Damage	Damage	Damage	Damage	Damage	--
		$101,699,661	$101,699,661	Yes	$100,004,750	$100,004,750	$101,699,661	$101,699,661	$100,004,750	--
	Mission Importance	ADT * Detour Length	Road tunnels critical?	Transfer Stations Critical?	% of ridership that causes mission criticality	% of ridership that causes mission	Facilities critical?	Ferries critical?	Fleets critical?	--
		Demand Percentile II	No	Yes	20	20	No	No	No	--
Counts	# of Unique Critical Assets	7	4	0	0	0	10	0	0	0
	# of Unique Countermeasures	3	3	0	0	0	0	0	0	0
	Total # of Countermeasures	68	16	0	0	0	0	0	0	0
Expenditures	Physical Security Countermeasures (x1000)	$610.2	$90.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Access Control Countermeasures (x1000)	$210.0	$120.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Asset Design/Engr Countermeasures (x1000)	$3,219.9	$1,840.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Operational Countermeasures (x1000)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Other Countermeasures (x1000)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Total Countermeasure Expenditures (x1000)	**$4,040.1**	**$2,050.4**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**

Totals	Physical Security Countermeasures	$700,600
	Access Control Countermeasures	$330,000
	Design/Engr Countermeasures	$5,059,912
	Operational Countermeasures	$0
	Other Countermeasures	$0
	Overall Total	**$6,090,501**

Figure 13. Tabular results of ATA example results summary.

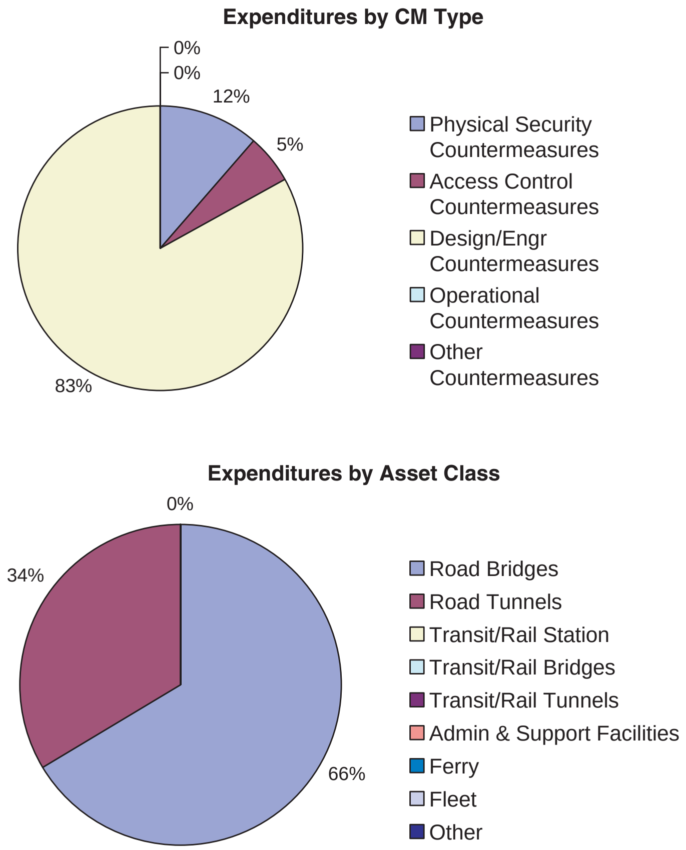


Figure 14. Pie charts of ATA example results summary.

The Enhanced CAPTool Guide

The Enhanced CAPTool provides the user with the opportunity to examine and change several factors that are set at default values in Basic CAPTool. These factors are largely concerned with adjusting the CAPTool default values to reflect characteristics associated with assets being analyzed and countermeasures considered. The Enhanced CAPTool functionality also provides the opportunity for the user to alter cost estimates of countermeasures to reflect local conditions. The user can provide the costs and other factors, which will then be applied by CAPTool to the assets and consequence threshold chosen by the user.

The enhanced version steps include

- Access to the threat and hazard vulnerability table,
- Access to countermeasure costs,
- The ability to select additional countermeasures,
- The ability to select countermeasure filters, and
- Access to the countermeasure dictionary.

Step 1a: Threat/Hazard Vulnerability Table

Introduction

In the Enhanced CAPTool, the threat/hazard vulnerability table, Step 1a, comes immediately after Step 1. This spreadsheet will allow the user to adjust the hazard/threat to asset combinations. The Basic CAPTool uses default assumptions to match hazards and threats to the asset classes. In this enhanced feature, the user may enter the screen and change any of the assumptions.

Purpose

Access to the threat/hazard screen allows the user to customize CAPTool to reflect the user's perceptions of hazards and threats that could result in loss of assets. This process allows the introduction of local knowledge and unusual conditions.

Assumptions

The user prefers to adjust the threat/hazard vulnerability table to reflect hazard or threat conditions within the jurisdiction or area of concern.

User Inputs

The user manually selects a threat/hazard–asset combination by inserting an “X” into a vacant cell, or deleting a hazard or threat by removing the “X” from a filled cell (Figure 15). The user may also choose to mark the “Manual Override” cell to include an asset into a consequence threshold automatically. Note that only cells associated with the asset categories and hazards and threats selected in Step 1 will display in this step.

Output

The user has identified specific combinations of assets and hazards/threats for assets of interest.

Previous

Next

Restore Defaults

1 1a 2 3 4 5a 5b 5c 5 6 Expanded CAPTool

Verify High Consequence Threats and Hazards
Instructions
For each asset class, indicate which threats or hazards could cause unacceptable consequences for exposed population, property damage, or loss of mission capabilities by placing an "X" in the appropriate square. Additionally, if you plan to manually mark certain assets as critical (manual override), indicate the threats or hazards of concern in the event of a manual override.

"Restore Defaults" gives default values for exposure, property, and mission, but leaves all fields blank for manual override.

When done, click "Next".

	Road Bridges				Road Tunnels				Transit/Rail Station			
	Potentially Exposed Population	Property Loss	Mission Importance	Manual Override	Potentially Exposed Population	Property Loss	Mission Importance	Manual Override	Potentially Exposed Population	Property Loss	Mission Importance	Manual Override
Small Explosives	X			X	X			X	X			X
Large Explosives	X	X	X	X	X	X	X	X	X	X	X	X
Fire	X	X	X	X	X	X	X	X	X	X	X	X
HAZMAT			X	X			X	X			X	X

Figure 15. Enhanced CAPTool hazard/threat–asset entry.

Step 5a: Countermeasure Costs

Introduction

The Basic CAPTool uses logical cost assumptions based upon information from the RS Means cost estimating manual, practitioner advice, and the experience of the research team. In this enhanced feature, the user may enter the screen and change any of the assumptions concerning costs.

Purpose

This step allows the user to apply local cost information. Local cost information provides more accurate cost estimates in the reports summary.

Assumptions

The user desired to apply local cost figures using the Enhanced CAPTool.

User Inputs

The user manually enters cost data for selected countermeasures (Figure 16).

Output

The user has access to more accurate costs for countermeasures to be considered.

1 1a 2 3 4 5a 5b 5c 5 6 Expanded CAPTool

Review Countermeasure Unit Costs
Instructions
If you wish to modify any of the per-unit countermeasure costs, please do so below by entering the new value into the appropriate field. When finished modifying, or if the defaults are acceptable, click "Continue."

"Reset" restores the defaults.

Reset | Previous | Next

		ESTIMATED PER-UNIT COST (x1000)	Comments	Unit of measure
Physical Security Countermeasures	1 Lighting	$11.30	one per 100 feet of road or perimeter. Assumes nearby power connection, no demolition or excavating.	1
	2 Barriers & Berms	$3.30	10 jersey barriers and two end planters to cover 100 feet of space	1
	3 Fences	$21.00	12 foot height security fence, in concrete with 4 gates (6 feet high, 3 feet wide). Infrared detection system. Power install, relay to central monitor. Excludes central monitoring station operation.	100 linear feet
	4 CCTV	$17.50	4 remote PTZ cameras, one control panel	1
	5 Intrusion Detection Devices	$0.90	1 burglar alarm with remote signal installed	1
	6 Physical Inspection of asset	$30.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE employee per year
Access Control Countermeasures	7 ID Cards	$10.00	6 zone system with database, installed	6 zones
	8 Biometrics	$50.00	6 facial and fingerprint scanners, database, installed	6 zones
	9 Background Checks	$57.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	10 Metal Detectors	$138.00	6 portals, 4 handhelds, installed. Assumes no demolition and nearby power source	
	11 Restricted Parking	$18.45	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	12 Random Inspections	$30.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	13 Visible Badges	$30.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	14 Limited Access Points	$30.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	15 Visitor Control & Escort	$30.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	16 Locks	$1.20	1 cipher lockset, installed. Assumes no demolition or heavy construction	Each
	17 Explosive Detection	$257.00	2 portals, 2 handhelds, with power	2+2
	18 Establish Clear Zones	$0.10	100 sq yards. Assumes no demolition	100-SY
	19 Visible Signs	$0.09	1 aluminum sign 18 inches high, with base	Each
Asset Design/Engineering	20 Seismic Retrofitting	$10,000.00	Estimates must be changed to reflect local variation	Per application
	21 Fire Detection & Supression	$459.99	Class III standpipe system with Type 2 water supply to 10,000 sf building. System includes minimum 20 pull stations with master box, annunciator, and central station relay. Assumes minimal demolition.	
	22 Encasement, Wrapping, Jacketing	$0.60	Estimates must be changed to reflect local variation	100-SF
Operational Countermeasures	23 Patrols	$30.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	24 WX/Seismic Information	$100.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	25 Intelligence Networking	$100.00	1 full time equivalent (FTE) contract employee dedicated to this task	1 FTE contract employee per year
	26 HAZMAT Mitigation	$1,329.60	Assumes complete start up of hazmat remediation program providing 24 hour coverage. Mechanized crew of 8 persons. Excludes material dumping costs	1 crew
	27 Security Awareness Training	$100.00	Contracted	1 program
	28 Emergency Response Training	$100.00	Contracted	1 program
	29 Emergency Evacuation Planning	$100.00	Designed program for structures and stations	1 program
	30 Planned Redundancy (e.g., detours)	$220.00	Pre-staged and marked detours. Deploys one FT traffic engineer, 1 PT carpenter, 1 PT operating engineer,	$9,000 fixed cost - $211,000 per year
	31 Public Information and Dissemination	$150.00	1 PIO, 1 web technician.	2FT employee per year

Figure 16. Countermeasure cost entry.

Step 5b: Selection of Additional Countermeasures

Introduction

The Basic CAPTool uses logical assumptions concerning the array of countermeasures contained within CAPTA. The selected countermeasures have been chosen because of both their applicability to the hazards and threats examined and their applicability to transportation assets. In the Enhanced CAPTool, users can add countermeasures that are not in the CAPTool countermeasures database.

Purpose

This process allows the introduction of additional countermeasures.

Assumptions

The user desires to consider additional countermeasures in the CAPTA process that are not already contained within the CAPTool countermeasures database.

User Inputs

The user enters the additional countermeasures to be included in the Enhanced CAPTool, as shown in Figure 17. The user also enters all of the characteristics of the additional countermeasures.

Output

The user will have now entered all countermeasures they desired to have incorporated into the CAPTool.

1 – 1a – 2 – 3 – 4 – 5a – 5b – 5c – 5 – 6 Expanded CAPTool

Clear Entries on Sheet | Previous | Next

Identify and Describe Additional Countermeasures
Instructions
If you wish to add additional countermeasures, select "ON" to turn on each CM column. Then, rename the countermeasure as desired. To indicate functionality, implementation, and package, place an "X" in the appropriate fields if the CM possesses the attribute. Additionally, enter an estimated cost in the appropriate field. Then, for each CM, use the drop-down list to rank the effectiveness of the CM against each threat/hazard and asset class -- L,M, or H.

"Reset" will turn off all additional CMs and reset the associated information. When done, click "Continue".

		OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
		Other 1	**Other 2**	**Other 3**	**Other 4**	**Other 5**	**Other 6**	**Other 7**	**Other 8**	**Other 9**	**Other 10**
Functions	PREDICT										
	DETER										
	DETECT										
	INTERDICT										
	RESPONSE PREP.										
	DESIGN/ENGINEERING										
Cost	Investment $ (x1000)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Implementation	Area-Wide										
	Asset Specific										
	Temporary/Redeployable										
	Multipurpose Potential										
Package	Basic										
	Enhanced										
	Threat Responsive										
Road Bridges	Small Explosives	M	M	M	M	M	M	M	M	M	M
	Large Explosives	M	M	M	M	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	M	M	M	M	M	M	M	M	M
	Criminal Acts	M	M	M	M	M	M	M	M	M	M
	Lighting	M	M	M	M	M	M	M	M	M	M
	Struct. Failure	M	M	M	M	M	M	M	M	M	M
	HAZMAT	M	M	M	M	M	M	M	M	M	M
	Flood	M	M	M	M	M	M	M	M	M	M
	Earthquake	M	M	M	M	M	M	M	M	M	M
	Extreme Weather	M	M	M	M	M	M	M	M	M	M
	Mud/Landslide	M	M	M	M	M	M	M	M	M	M

Figure 17. Additional countermeasure entry.

Step 5c: Countermeasure Filter Selection

Introduction

Step 5c allows the user to apply countermeasure filters. The Basic CAPTool displays all countermeasures applicable to threat/hazard–asset combinations. In the Enhanced CAPTool, the user may screen the countermeasures so that only those that meet the filtering criteria are displayed.

Purpose

This enhanced step allows the user to filter countermeasures contained in the CAPTool countermeasures database.

Definitions

Countermeasure Filters—Applied criteria designed to screen measures to achieve a minimum standard of effectiveness.

Countermeasure Criteria:

- *Function*—Possessing attributes to predict, deter, detect, or interdict a disruption; boost response preparedness; or be installed as part of design/engineering.
- *Implementation*—Area(s) specific or asset specific, temporary/redeployable, multipurpose.
- *Package*—Belonging to basic, advanced, and/or threat-responsive assemblies of measures.
- *Cost*—A maximum unit cost per single application.

Assumptions

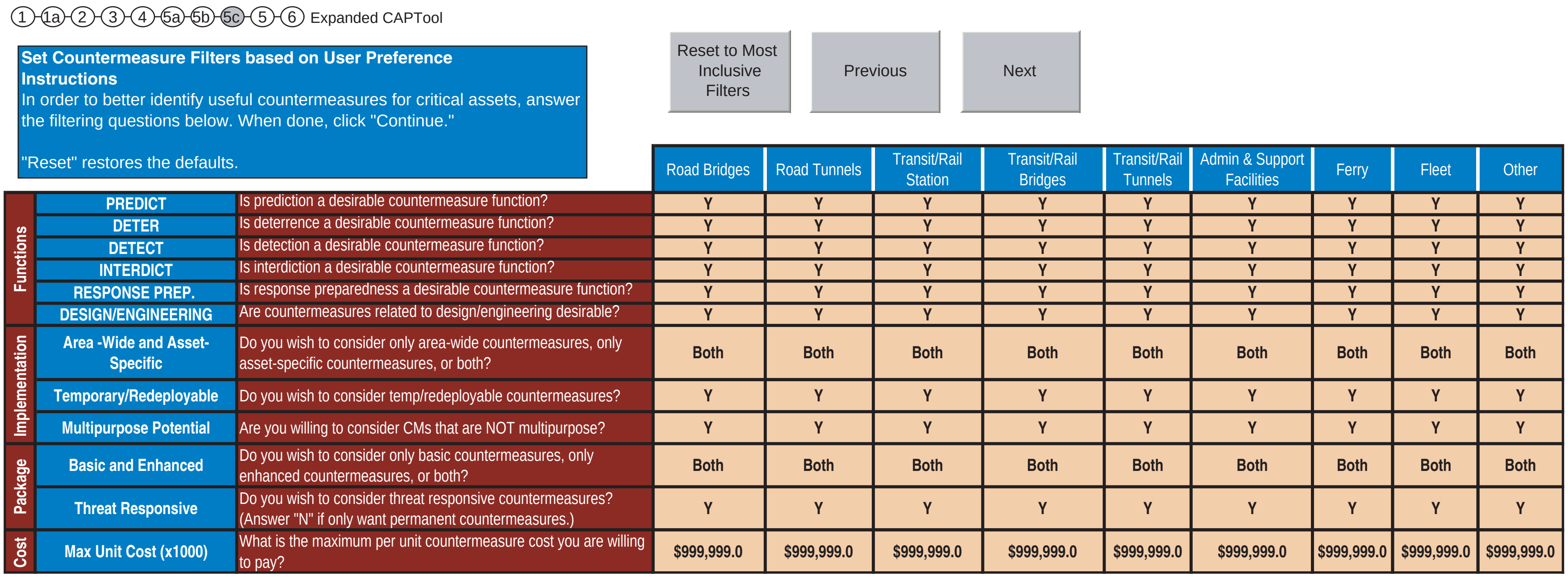
The user chooses to screen the display of CAPTool countermeasures.

User Inputs

The user will manually enter cost data to the desired countermeasure as in Figure 18.

Output

The user will have now entered all countermeasure filters they desire to have incorporated into the CAPTool.



			Road Bridges	Road Tunnels	Transit/Rail Station	Transit/Rail Bridges	Transit/Rail Tunnels	Admin & Support Facilities	Ferry	Fleet	Other
Functions	PREDICT	Is prediction a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y	Y	Y
	DETER	Is deterrence a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y	Y	Y
	DETECT	Is detection a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y	Y	Y
	INTERDICT	Is interdiction a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y	Y	Y
	RESPONSE PREP.	Is response preparedness a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y	Y	Y
	DESIGN/ENGINEERING	Are countermeasures related to design/engineering desirable?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Implementation	Area -Wide and Asset-Specific	Do you wish to consider only area-wide countermeasures, only asset-specific countermeasures, or both?	Both	Both	Both	Both	Both	Both	Both	Both	Both
	Temporary/Redeployable	Do you wish to consider temp/redeployable countermeasures?	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Multipurpose Potential	Are you willing to consider CMs that are NOT multipurpose?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Package	Basic and Enhanced	Do you wish to consider only basic countermeasures, only enhanced countermeasures, or both?	Both	Both	Both	Both	Both	Both	Both	Both	Both
	Threat Responsive	Do you wish to consider threat responsive countermeasures? (Answer "N" if only want permanent countermeasures.)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cost	Max Unit Cost (x1000)	What is the maximum per unit countermeasure cost you are willing to pay?	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0

Figure 18. Countermeasure filter entry.

Conclusion

Properly used, CAPTool allows users to compare multiple modes of transportation assets on a common basis. CAPTool identifies assets and asset classes that are of highest consequence and thus most important to the functionality of the transportation mission. CAPTool provides an effective means to analyze assets in an objective, transparent manner.

CAPTool results depend upon the quality of the information and judgments used in applying it. Missing or unsubstantiated data concerning asset characteristics—such as length, cost, and usage—skew results inappropriately. Inconsistent input data also cause assets to be identified as more or less consequential than they should be. Efforts should be made to ensure consistent inputs to the CAPTool.

CAPTool is designed to be iterative. Users can apply different consequence thresholds to assets and consider various countermeasures. CAPTool is more effective when the user alters thresholds and reviews results of these scenarios. This iterative process allows the user to determine the assets of highest consequence for further evaluation. CAPTool makes the iterative process easy by supplying informative summary reports that allow a decision maker to choose between different threshold settings and countermeasure selections.

CAPTool provides a summary report designed for submission and presentation to decision makers. The summary report, displayed at the end of CAPTool, provides the thresholds chosen, results, and allocation of resources by mode. Various iterations of consequence threshold and countermeasures can be chosen and summarized, such that a range of alternatives can be displayed. This iterative approach allows the decision maker to make the best decision.

The Basic CAPTool is designed to suit the needs of a majority of transportation officials. The embedded equations and data are drawn from practical experience, and engineering judgments. Costs are based on national averages. The CAPTool recognizes that transportation agencies have access to data and resources to identify costs applicable to the area and assets of interest. The Enhanced CAPTool allows the user to alter costs and to apply countermeasure screening judgments.

Used properly, the CAPTool provides decision support to the difficult task of resource allocation across multiple modes. CAPTA combines a transparent means to capture management judgments on consequence thresholds with the objective characteristics of the assets analyzed to produce a list of high-consequence assets that merit further examination. CAPTool identifies high-consequence assets and links them to objective data and user choices.

APPENDIX A

Countermeasure Unit Costs and Descriptions

Measure	Estimated Per-Unit Cost (x1000)	Description	Unit of Measure
Lighting[a]	$11.30	One per 100 ft of road or perimeter. Assumes nearby power connection, no demolition or excavating.	One installation
Barriers and Berms[a,b]	$3.30	10 jersey barriers and two end planters to cover 100 ft of space.	One installation
Fences[a,b]	$21.00	12 ft high security fence, in concrete with four gates (6 ft high, 3 ft wide). Infrared detection system. Power install, relay to central monitor. Excludes central monitoring station operation.	100 linear feet (lf)
CCTV[a]	$17.50	Four remote PTZ cameras, one control panel.	One
Intrusion Detection Devices[a]	$0.90	One burglar alarm with remote signal installed.	One
Physical Inspection of Assets[f]	$30.00	One contracted full-time equivalent (FTE) dedicated to this task.	One full-time employee per annum (p.a.)
ID cards[a,b]	$10.00	Six-zone system with database, installed.	Six zones
Biometrics[a,b,c]	$50.00	Six facial and fingerprint scanners, database, installed.	Six zones
Background Checks[f]	$57.00	One contracted FTE dedicated to this task.	One full-time employee p.a.
Metal Detectors[a,b]	$138.00	Six portals, four handhelds, installed. Assumes no demolition and nearby power source.	One system
Restricted Parking[f]	$18.45	One contracted FTE dedicated to this task.	One full-time employee p.a.
Random Inspections[f]	$30.00	One contracted FTE dedicated to this task.	One full-time employee p.a.
Visible Badges[f]	$30.00	One contracted FTE dedicated to this task.	One full-time employee p.a.
Limited Access Points[f]	$30.00	One contracted FTE dedicated to this task.	One full-time employee p.a.
Visitor Control and Escort[f]	$30.00	One contracted FTE dedicated to this task.	One full-time employee p.a.
Locks[a,b]	$1.20	One cipher lockset, installed. Assumes no demolition or heavy construction.	One lock
Explosive Detection[b]	$257.00	Two portals, two handhelds, with power.	One entry
Establish Clear Zones[a]	$0.10	100 sq yd. Assumes no demolition.	One application
Visible Signs[a,b]	$0.09	One aluminum sign 18 in. high, with base.	One placement

Measure	Estimated Per-Unit Cost (x1000)	Description	Unit of Measure
Seismic Retrofitting[e]	$10,000.00	Estimates must be changed to reflect local variation.	One application
Fire Detection & Suppression[a]	$460.00	Class III standpipe system with Type 2 water supply to 10,000 sq ft building. System includes minimum 20 pull stations with master box, annunciator, and central station relay. Assumes minimal demolition.	One system
Encasement, Wrapping, Jacketing[d]	$0.60	Estimates must be changed to reflect local variation.	100 sq ft
Patrols[f]	$30.00	One contracted FTE dedicated to this task.	One full-time employee p.a.
Weather/Seismic Information[a]	$100.00	Contracted to a service provider.	One system
Intelligence Networking	$208.00	One full-time in-house person with all benefits.	One full-time employee
HAZMAT Mitigation[a]	$1329.60	Assumes complete startup of HAZMAT remediation program providing 24-hour coverage. Mechanized crew of eight persons. Excludes material dumping costs.	One crew
Security Awareness Training	$100.00	Contracted to a service provider.	One program for 1 year
Emergency Response Training	$100.00	Contracted to a service provider.	One program with trainer
Emergency Evacuation Planning	$100.00	Designed program for structures and stations.	One program with trainer.
Planned Redundancy[a]	$220.00	Pre-staged and marked detours. Deploys one full-time traffic engineer, 1 part-time carpenter, 1 part-time operating engineer.	One application
Public Information and Dissemination[f]	$150.00	One PIO, one web technician.	One program for 1 year

[a] Estimated cost from 2008 RS Means.
[b] Estimated cost based on 2008 escalated construction cost from PB's Database based on previous information and projects.
[c] Estimated cost based on 2008 Manufacturer's baseline quote.
[d] Estimated cost based on 2008 Manufacturer's website.
[e] Estimated cost based on professional engineering judgment. Costs associated with seismic retrofitting are typically expensive, and very specific to the asset being treated.
[f] Estimated income based on 2008 cost from web searches/the US Bureau of Labor Statistics.

APPENDIX B

Threshold Equations

Asset	PEP Equation	Property Equation	Mission Equation
Road Bridges	Separated into primary direction and secondary direction—for each, if vehicles/lane > 2400, assume 40 vehicles/1000 ft. Otherwise assume 7.5 vehicles/1000 ft[a]	$20,000/linear foot (lf)	(ADT) × (detour length) 75th, 85th, 95th percentile as thresholds relative to typical bridge inventory (Example is based on the National Bridge Inventory)
Road Tunnels	Separated into primary direction and secondary direction—for each, if vehicles/lane > 2400, assume 40 vehicles/1000 ft. Otherwise assume 7.5 vehicles/1000 ft[a]	$100,000/lf	User input for criticality
Transit/Rail Station	4 × (maximum capacity of rail cars)[b]	Below ground are property critical	User input if transfer station are critical
Transit/Rail Bridge	2 × (maximum capacity of rail cars)[b]	$15,600/lf	User input percentage of ridership that regularly use this transit/rail transportation asset
Transit/Rail Tunnel	2 × (maximum capacity of rail cars)[b]	$40,000/lf	User input percentage of ridership that regularly use this transit/rail transportation asset
Administrative & Support Facilities	1 person/175 sq ft[c]	$210/sq ft	Never critical unless so designated by user
Ferries	Maximum capacity of ferry	User input of cost	Never critical unless so designated by user
Fleets	Maximum occupancy of one fleet vehicle	(Average cost per vehicle) × (maximum number of vehicles) Input by user	Never critical unless so designated by user

[a]Derived from the *Highway Capacity Manual.* TRB, National Research Council, Washington, DC, 2000.
[b]Derived from *NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail.* National Fire Protection Association, Quincy, MA, 2007.
[c]Derived from NFPA *101: Life Safety Code®*. National Fire Protection Association, Quincy, MA, 2006.

APPENDIX C

CAPTool Initial Startup Instructions

This tool provides for a consequence-based assessment across multiple modes of transportation assets. It is an initial tool for high-level budgeting decisions, providing a platform where all modes are compared on equal footing. This tool allows for an iterative process where the user can return to the beginning of the model and plot different threshold variables. Opportunities are available at Step 1 and Step 6 in the tool to save your work to your hard drive.

Getting Started with the Tool

STEP 1: Save the Microsoft® Excel file named "Costing Asset Protection Tool.xls" to your computer.

STEP 2: Open the file.

STEP 3: Enable macros in the file.

The tool requires that you enable the use of macros in this spreadsheet. When you open the file, if a dialogue box opens up regarding enabling macros, click "Enable Macros." You are now ready to start using CAPTool. If you do not see a dialogue box when you open the file, you will need to make sure that your macro security level is set to Medium. To do this, follow these steps:

a. Select the Tools dropdown menu and then select "Macro," then "Security."
b. A security dialogue box will appear. Make sure you are looking at the "Security Level" tab inside the dialogue box.
c. Set the security level to Medium by clicking the radio button. Medium security allows you to choose whether you use macros in this tool.
d. Close the file and any other instances of the application currently running on the computer.
e. Open the file again and click "Enable Macros" when prompted to allow the macro to run.

You are now ready to use CAPTool. If you have further questions, please consult the CAPTool User Guide.

APPENDIX D

Countermeasures Dictionary

Overview

The countermeasures dictionary contains the default list of countermeasures and their attributes from which users may select to mitigate the consequences of the hazards and threats that are relevant for the assets they own or operate. Countermeasures are classified by type, and attributes are provided for countermeasures within each type. These attributes are used in the countermeasure-filtering step available in the Enhanced CAPTool. The countermeasures dictionary also includes a baseline assessment of the relative appropriateness or effectiveness of each of the countermeasures for each asset category and threat or hazard. Countermeasures are given a relative assessment of "L" for low, "M" for medium, and "H" for high. Users may change the values of attributes or the baseline assessments based on additional information or experience with the countermeasures in the applications of interest.

Countermeasures Attributes

Tables D-1 through D-3 show the attributes of countermeasures in the countermeasures dictionary, organized into countermeasure categories.

Baseline Assessment of Relative Value

Tables D-4 through D-12 show the baseline assessment of the relative value of each of the countermeasures included in the countermeasures dictionary. Note that these judgments do not quantify effectiveness in terms of risk reduction but are intended to give users some sense of which countermeasures are most likely to reduce consequences associated with specific hazards and threats.

Table D-1. Attributes of physical security countermeasures.

		Physical Security Countermeasures					
		1	2	3	4	5	6
	Countermeasure	Lighting	Barriers & Berms	Fences	CCTV	Intrusion Detection Devices	Physical Inspection of asset
Functions	PREDICT						X
	DETER	X	X	X	X	X	
	DETECT	X	X	X	X	X	
	INTERDICT						
	RESPONSE PREP.						
	DESIGN/ENGINEERING						
Cost	Investment $ (x1000)	$11.3	$3.3	$21	$17.5	$0.9	$30
Implementation	Area-Wide						
	Asset Specific	X	X	X	X	X	X
	Temporary/Redeployable						X
	Multipurpose Potential	X	X	X	X	X	X
Package	Basic	X	X	X	X	X	X
	Enhanced						
	Threat Responsive						X

Table D-2. Attributes of access control countermeasures.

		Access Control Countermeasures												
		7	8	9	10	11	12	13	14	15	16	17	18	19
	Countermeasure	ID Cards	Biometrics	Background Checks	Metal Detectors	Restricted Parking	Random Inspections	Visible Badges	Limited Access Points	Visitor Control & Escort	Locks	Explosive Detection	Establish Clear Zones	Visible Signs
Functions	PREDICT													
	DETER	X	X			X		X			X			X
	DETECT			X	X		X		X			X	X	
	INTERDICT									X				
	RESPONSE PREP.													
	DESIGN/ENGINEERING													
Cost	Investment $ (x1000)	$10	$50	$57	$138	$18.5	$30	$30	$30	$30	$1.2	$257	$0.1	$0.1
Implementation	Area-Wide	X	X	X			X	X						
	Asset Specific				X	X			X	X	X	X	X	X
	Temporary/Redeployable						X		X	X		X		
	Multipurpose Potential													
Package	Basic	X		X		X		X		X	X		X	X
	Enhanced		X		X							X		
	Threat Responsive						X		X					

Table D-3. Attributes of design/engineering and operational countermeasures.

		Asset Design/Engineering			Operational Countermeasures								
		20	21	22	23	24	25	26	27	28	29	30	31
	Countermeasure	Seismic Retrofitting	Fire Detection & Supression	Encasement, Wrapping, Jacketing	Patrols	WX/Seismic Information	Intelligence Networking	HAZMAT Mitigation	Security Awareness Training	Emergency Response Training	Emergency Evacuation Planning	Planned Redundancy (e.g., detours)	Public Information and Dissemination
Functions	PREDICT					X	X						
	DETER												
	DETECT		X		X								
	INTERDICT												
	RESPONSE PREP.		X	X		X		X	X	X	X	X	X
	DESIGN/ENGINEERING	X											
Cost	Investment $ (x1000)	$10,000	$460	$0.6	$30	$100	$100	$1,330	$100	$100	$100	$220	$150
Implementation	Area-Wide				X	X	X	X	X	X	X	X	X
	Asset Specific	X	X	X									
	Temporary/Redeployable				X		X	X					
	Multipurpose Potential	X	X	X	X	X							X
Package	Basic				X	X	X	X	X	X	X	X	X
	Enhanced	X	X	X									
	Threat Responsive				X		X						X

Table D-4. Relative value of physical security countermeasures for road bridges, road tunnels, and transit/rail stations.

		Physical Security Countermeasures					
		1	2	3	4	5	6
Countermeasure		Lighting	Barriers & Berms	Fences	CCTV	Intrusion Detection Devices	Physical Inspection of asset
Road Bridges	Small Explosives	L	H	H	M	M	H
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	L	L	L	M	H
	Criminal Acts	M	M	M	M	M	M
	Fire	M	M	L	M	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	H
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	H
	Mud/Landslide	L	M	L	L	L	H
Road Tunnels	Small Explosives	L	H	H	M	M	H
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	L	L	L	M	H
	Criminal Acts	M	M	M	M	M	M
	Fire	M	M	L	M	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	H
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	H
	Mud/Landslide	L	M	L	L	L	H
Transit/Rail Station	Small Explosives	M	L	L	M	M	H
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	L	L	L	M	H
	Criminal Acts	M	L	L	M	M	M
	Fire	M	M	L	M	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	H
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	H
	Mud/Landslide	L	M	L	L	L	H

Table D-5. Relative value of access control countermeasures for road bridges, road tunnels, and transit/rail stations.

		Access Control Countermeasures												
		7	8	9	10	11	12	13	14	15	16	17	18	19
	Countermeasure	ID Cards	Biometrics	Background Checks	Metal Detectors	Restricted Parking	Random Inspections	Visible Badges	Limited Access Points	Visitor Control & Escort	Locks	Explosive Detection	Establish Clear Zones	Visible Signs
Road Bridges	Small Explosives	L	M	L	M	L	H	L	M	M	M	H	H	L
	Large Explosives	L	M	L	L	M	M	M	M	M	M	H	M	L
	Chemical/Biological/Radiological	L	M	L	L	M	H	L	M	M	M	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	H	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L
Road Tunnels	Small Explosives	L	M	L	M	L	H	L	M	M	M	H	H	L
	Large Explosives	L	M	L	L	M	M	M	M	M	M	H	M	L
	Chemical/Biological/Radiological	L	M	L	L	M	H	L	M	M	M	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	H	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L
Transit/Rail Station	Small Explosives	L	M	L	M	L	H	L	M	M	M	H	H	L
	Large Explosives	L	M	L	L	M	M	M	M	M	M	H	M	L
	Chemical/Biological/Radiological	L	M	L	L	M	H	L	M	M	M	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	H	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L

Table D-6. Relative value of design/engineering and operational countermeasures for road bridges, road tunnels, and transit/rail stations.

		Asset Design/Engineering			Operational Countermeasures								
		20	21	22	23	24	25	26	27	28	29	30	31
Countermeasure		Seismic Retrofitting	Fire Detection & Supression	Encasement, Wrapping, Jacketing	Patrols	WX/Seismic Information	Intelligence Networking	HAZMAT Mitigation	Security Awareness Training	Emergency Response Training	Emergency Evacuation Planning	Planned Redundancy (e.g., detours)	Public Information and Dissemination
Road Bridges	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	M	H	H	L	M	L	M	M	M	M	H
	Chemical/Biological/Radiological	L	M	L	H	M	M	H	L	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	H	L	L	L	L	H	H	H	H
	Struct. Failure	H	L	H	L	L	L	L	L	H	H	H	H
	HAZMAT	L	H	L	M	M	L	H	L	H	H	H	H
	Flood	H	L	L	H	H	L	L	L	H	H	H	H
	Earthquake	H	M	H	M	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	M	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	M	H	L	L	L	H	H	H	H
Road Tunnels	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	M	H	H	L	M	L	M	M	M	M	H
	Chemical/Biological/Radiological	L	M	L	H	M	M	H	L	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	H	L	L	L	L	H	H	H	H
	Struct. Failure	H	L	H	L	L	L	L	L	H	H	H	H
	HAZMAT	L	H	L	M	M	L	H	L	H	H	H	H
	Flood	H	L	L	H	H	L	L	L	H	H	H	H
	Earthquake	H	M	H	M	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	M	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	M	H	L	L	L	H	H	H	H
Transit/Rail Station	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	M	H	H	L	M	L	M	M	M	M	H
	Chemical/Biological/Radiological	L	M	L	H	M	M	H	L	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	H	L	L	L	L	H	H	H	H
	Struct. Failure	H	L	H	L	L	L	L	L	H	H	H	H
	HAZMAT	L	H	L	M	M	L	H	L	H	H	H	H
	Flood	H	L	L	H	H	L	L	L	H	H	H	H
	Earthquake	H	M	H	M	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	M	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	M	H	L	L	L	H	H	H	H

Table D-7. Relative value of physical security countermeasures for transit/rail bridges, transit/rail tunnels, and administrative and support facilities.

		Physical Security Countermeasures					
		1	2	3	4	5	6
Countermeasure		Lighting	Barriers & Berms	Fences	CCTV	Intrusion Detection Devices	Physical Inspection of asset
Transit/Rail Bridges	Small Explosives	M	M	L	M	L	H
	Large Explosives	M	H	H	M	H	H
	Chemical/Biological/Radiological	M	L	L	M	L	H
	Criminal Acts	M	L	L	M	M	M
	Fire	M	M	L	M	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	H
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	H
	Mud/Landslide	L	M	L	L	L	H
Transit/Rail Tunnels	Small Explosives	M	M	L	M	L	H
	Large Explosives	M	H	H	M	H	H
	Chemical/Biological/Radiological	M	L	L	M	L	H
	Criminal Acts	M	L	L	M	M	M
	Fire	M	M	L	M	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	H
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	H
	Mud/Landslide	L	M	L	L	L	H
Admin & Support Facilities	Small Explosives	M	L	L	M	M	H
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	L	L	L	M	H
	Criminal Acts	M	L	L	M	M	M
	Fire	L	L	L	L	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	M
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	L
	Mud/Landslide	L	M	L	L	L	L

Table D-8. Relative value of access control countermeasures for transit/rail bridges, transit/rail tunnels, and administrative and support facilities.

		Access Control Countermeasures												
		7	8	9	10	11	12	13	14	15	16	17	18	19
	Countermeasure	ID Cards	Biometrics	Background Checks	Metal Detectors	Restricted Parking	Random Inspections	Visible Badges	Limited Access Points	Visitor Control & Escort	Locks	Explosive Detection	Establish Clear Zones	Visible Signs
Transit/Rail Bridges	Small Explosives	H	L	L	M	L	H	L	H	H	M	H	H	L
	Large Explosives	H	H	H	H	L	H	L	H	H	H	H	M	L
	Chemical/Biological/Radiological	L	L	L	L	L	L	L	L	L	L	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	L	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L
Transit/Rail Tunnels	Small Explosives	H	L	L	M	L	H	L	H	H	M	H	H	L
	Large Explosives	H	H	H	H	L	H	L	H	H	H	H	M	L
	Chemical/Biological/Radiological	L	L	L	L	L	L	L	L	L	L	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	L	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L
Admin & Support Facilities	Small Explosives	L	M	L	M	L	H	L	M	M	M	H	H	L
	Large Explosives	L	M	L	L	M	M	M	M	M	M	H	M	L
	Chemical/Biological/Radiological	L	M	L	L	M	H	L	M	M	M	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	H	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L

Table D-9. Relative value of design/engineering and operational countermeasures for transit/rail bridges, transit/rail tunnels, and administrative and support facilities.

		Asset Design/Engineering			Operational Countermeasures								
		20	21	22	23	24	25	26	27	28	29	30	31
	Countermeasure	Seismic Retrofitting	Fire Detection & Supression	Encasement, Wrapping, Jacketing	Patrols	WX/Seismic Information	Intelligence Networking	HAZMAT Mitigation	Security Awareness Training	Emergency Response Training	Emergency Evacuation Planning	Planned Redundancy (e.g., detours)	Public Information and Dissemination
Transit/Rail Bridges	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Chemical/Biological/Radiological	L	H	L	M	L	M	H	H	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	H	L	L	L	L	H	H	H	H
	Struct. Failure	H	L	H	L	L	L	L	L	H	H	H	H
	HAZMAT	L	H	L	M	M	L	H	L	H	H	H	H
	Flood	H	L	L	H	H	L	L	L	H	H	H	H
	Earthquake	H	M	H	M	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	M	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	M	H	L	L	L	H	H	H	H
Transit/Rail Tunnels	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Chemical/Biological/Radiological	L	H	L	M	L	M	H	H	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	H	L	L	L	L	H	H	H	H
	Struct. Failure	H	L	H	L	L	L	L	L	H	H	H	H
	HAZMAT	L	H	L	M	M	L	H	L	H	H	H	H
	Flood	H	L	L	H	H	L	L	L	H	H	H	H
	Earthquake	H	M	H	M	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	M	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	M	H	L	L	L	H	H	H	H
Admin & Support Facilities	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	M	H	H	L	M	L	M	M	M	M	H
	Chemical/Biological/Radiological	L	M	L	H	M	M	H	L	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	M	L	L	L	M	H	H	H	H
	Struct. Failure	H	L	H	L	M	L	L	L	H	H	H	H
	HAZMAT	L	M	L	L	L	L	H	L	H	H	H	H
	Flood	H	L	H	L	H	L	L	L	H	H	H	H
	Earthquake	H	L	H	L	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	L	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	L	H	L	L	L	H	H	H	H

Table D-10. Relative value of physical security countermeasures for ferries, fleets, and others.

	Countermeasure	1 Lighting	2 Barriers & Berms	3 Fences	4 CCTV	5 Intrusion Detection Devices	6 Physical Inspection of asset
Ferries	Small Explosives	M	L	L	M	M	H
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	L	L	L	M	H
	Criminal Acts	M	L	L	M	M	M
	Fire	L	L	L	L	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	M
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	L
	Mud/Landslide	L	M	L	L	L	L
Fleets	Small Explosives	M	L	L	M	M	H
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	L	L	L	M	H
	Criminal Acts	M	L	L	M	M	M
	Fire	L	L	L	L	L	L
	Struct. Failure	L	L	L	L	L	H
	HAZMAT	L	L	L	L	L	M
	Flood	L	M	L	L	L	H
	Earthquake	L	L	L	L	L	L
	Extreme Weather	L	M	L	L	L	L
	Mud/Landslide	L	M	L	L	L	L
Other	Small Explosives	M	M	M	M	M	M
	Large Explosives	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	M	M	M	M	M
	Criminal Acts	M	M	M	M	M	M
	Fire	M	M	M	M	M	M
	Struct. Failure	M	M	M	M	M	M
	HAZMAT	M	M	M	M	M	M
	Flood	M	M	M	M	M	M
	Earthquake	M	M	M	M	M	M
	Extreme Weather	M	M	M	M	M	M
	Mud/Landslide	M	M	M	M	M	M

Physical Security Countermeasures: columns 1–6.

Table D-11. Relative value of access control countermeasures for ferries, fleets, and others.

		Access Control Countermeasures												
		7	8	9	10	11	12	13	14	15	16	17	18	19
	Countermeasure	ID Cards	Biometrics	Background Checks	Metal Detectors	Restricted Parking	Random Inspections	Visible Badges	Limited Access Points	Visitor Control & Escort	Locks	Explosive Detection	Establish Clear Zones	Visible Signs
Ferries	Small Explosives	L	M	L	M	L	H	L	M	M	M	H	H	L
	Large Explosives	L	M	L	L	M	M	M	M	M	M	H	M	L
	Chemical/Biological/Radiological	L	M	L	L	M	H	L	M	M	M	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	H	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L
Fleets	Small Explosives	L	M	L	M	L	H	L	M	M	M	H	H	L
	Large Explosives	L	M	L	L	M	M	M	M	M	M	H	M	L
	Chemical/Biological/Radiological	L	M	L	L	M	H	L	M	M	M	L	M	L
	Criminal Acts	L	L	M	L	M	M	M	M	M	H	L	H	M
	Fire	L	L	L	L	L	L	L	L	L	L	L	H	L
	Struct. Failure	L	L	L	L	L	L	L	L	L	L	L	L	L
	HAZMAT	L	L	L	L	L	L	L	L	L	L	L	M	L
	Flood	L	L	L	L	L	L	L	L	L	L	L	M	L
	Earthquake	L	L	L	L	L	L	L	L	L	L	L	L	L
	Extreme Weather	L	L	L	L	L	L	L	L	L	L	L	L	L
	Mud/Landslide	L	L	L	L	L	L	L	L	L	L	L	L	L
Other	Small Explosives	M	M	M	M	M	M	M	M	M	M	M	M	M
	Large Explosives	M	M	M	M	M	M	M	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	M	M	M	M	M	M	M	M	M	M	M	M
	Criminal Acts	M	M	M	M	M	M	M	M	M	M	M	M	M
	Fire	M	M	M	M	M	M	M	M	M	M	M	M	M
	Struct. Failure	M	M	M	M	M	M	M	M	M	M	M	M	M
	HAZMAT	M	M	M	M	M	M	M	M	M	M	M	M	M
	Flood	M	M	M	M	M	M	M	M	M	M	M	M	M
	Earthquake	M	M	M	M	M	M	M	M	M	M	M	M	M
	Extreme Weather	M	M	M	M	M	M	M	M	M	M	M	M	M
	Mud/Landslide	M	M	M	M	M	M	M	M	M	M	M	M	M

Table D-12. Relative value of design/engineering and operational countermeasures for ferries, fleets, and others.

		Asset Design/Engineering			Operational Countermeasures								
		20	21	22	23	24	25	26	27	28	29	30	31
	Countermeasure	Seismic Retrofitting	Fire Detection & Supression	Encasement, Wrapping, Jacketing	Patrols	WX/Seismic Information	Intelligence Networking	HAZMAT Mitigation	Security Awareness Training	Emergency Response Training	Emergency Evacuation Planning	Planned Redundancy (e.g., detours)	Public Information and Dissemination
Ferries	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	M	H	H	L	M	L	M	M	M	M	H
	Chemical/Biological/Radiological	L	M	L	H	M	M	H	L	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	M	L	L	L	M	H	H	H	H
	Struct. Failure	H	L	H	L	M	L	L	L	H	H	H	H
	HAZMAT	L	M	L	L	L	L	H	L	H	H	H	H
	Flood	H	L	H	L	H	L	L	L	H	H	H	H
	Earthquake	H	L	H	L	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	L	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	L	H	L	L	L	H	H	H	H
Fleets	Small Explosives	H	H	H	H	L	M	L	H	H	H	H	H
	Large Explosives	H	M	H	H	L	M	L	M	M	M	M	H
	Chemical/Biological/Radiological	L	M	L	H	M	M	H	L	H	H	H	H
	Criminal Acts	M	M	H	H	L	L	L	H	M	M	M	H
	Fire	H	H	H	M	L	L	L	M	H	H	H	H
	Struct. Failure	H	L	H	L	M	L	L	L	H	H	H	H
	HAZMAT	L	M	L	L	L	L	H	L	H	H	H	H
	Flood	H	L	H	L	H	L	L	L	H	H	H	H
	Earthquake	H	L	H	L	H	L	L	L	H	H	H	H
	Extreme Weather	H	L	H	L	H	L	L	L	H	H	H	H
	Mud/Landslide	H	L	H	L	H	L	L	L	H	H	H	H
Other	Small Explosives	M	M	M	M	M	M	M	M	M	M	M	M
	Large Explosives	M	M	M	M	M	M	M	M	M	M	M	M
	Chemical/Biological/Radiological	M	M	M	M	M	M	M	M	M	M	M	M
	Criminal Acts	M	M	M	M	M	M	M	M	M	M	M	M
	Fire	M	M	M	M	M	M	M	M	M	M	M	M
	Struct. Failure	M	M	M	M	M	M	M	M	M	M	M	M
	HAZMAT	M	M	M	M	M	M	M	M	M	M	M	M
	Flood	M	M	M	M	M	M	M	M	M	M	M	M
	Earthquake	M	M	M	M	M	M	M	M	M	M	M	M
	Extreme Weather	M	M	M	M	M	M	M	M	M	M	M	M
	Mud/Landslide	M	M	M	M	M	M	M	M	M	M	M	M

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation