

THE HOMELAND SECURITY VULNERABILITIES OF THE US NATIONAL
CAPITAL REGION'S BRIDGES

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MASTER OF MILITARY ART AND SCIENCE
Homeland Security Studies

by

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE HOMELAND SECURITY VULNERABILITIES OF THE US NATIONAL CAPITAL REGION'S BRIDGES, by MAJ Benjamin J. Lukas, 71 pages.

The National Capital Region (NCR) is plagued by the same critical infrastructure vulnerabilities, disrepair, and degradation as the rest of the United States. The ground transportation infrastructure, especially the bridges, in the NCR presents an interesting case study. There are over 230 bridges connecting the region with over 60 percent rated as functionally obsolete as of 2013. The NCR is complex in the amount of agencies and departments that play a part in its security and defense. Bridge ownership in the NCR is approximately 70 percent State, 26 percent local, and 4 percent under Federal control.

This thesis studies the homeland security vulnerabilities of the bridges in the NCR. The NCR bridges enable vital commerce, public transportation, etc. Also discussed is the responsibility of upkeep and resourcing for the NCR bridges and the historical difficulties for repair or renovation. The purpose of this thesis is the increased awareness of the issue of NCR bridge vulnerabilities and analysis that can be applied to other regions of the nation.

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Thank you to my children (Kaylee, Benjamin, and Elek) for your tolerance of my grumpiness and for the times that had to do homework instead of play.

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ACRONYMS

| | |
|--------|---|
| CRS | The Congressional Research Service |
| DC | US District of Columbia |
| DDOT | District of Columbia Department of Transportation |
| FHWA | US Federal Highway Administration |
| MAP-21 | Moving Ahead for Progress in the 21st Century Act |
| NCR | National Capital Region |
| ODOT | Oklahoma Department of Transportation |
| US | The United States of America |

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CHAPTER 1

INTRODUCTION

So all told, our aging transportation infrastructure costs American businesses and families about \$130 billion a year. That's a tax on our businesses; that's a tax on our consumers. It is coming out of your pocket. It's a drag on our overall economy. And if we don't act now, it could cost America hundreds of billions of dollars and hundreds of thousands of jobs by the end of the decade.

— President Barack Obama, *Remarks by the President Urging Congress to Pass the Infrastructure Piece of the American Jobs Act*

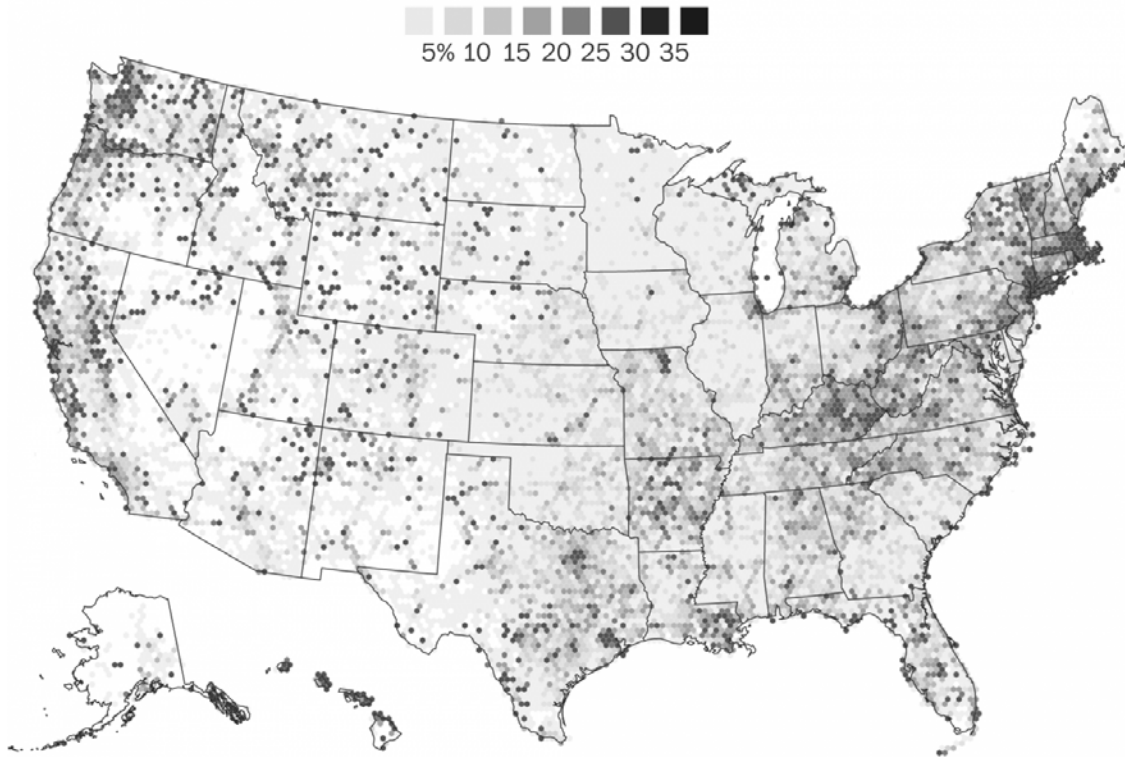
Federal agencies that own bridges have some of the worst records for on-time inspections. Nearly 3,000 bridges owned by U.S. government agencies went more than two years between checkups.

— Journalist Bill Dedman, *BrainyQuote.com*

The word infrastructure originated from the French language. English use started in the 1920s. Only since the 1970s has the term been utilized for describing the physical infrastructure of our communities. It encompasses the basic and physical organizational structure needed for the operation of a society or enterprise (Metropolitan Washington Council of Governments 2015, 9). It includes everything from electrical and water facilities to rail lines and telecommunications. Infrastructure is not indestructible and requires some level of maintenance. Environmental factors play a large part of the degradation of manmade infrastructure. Ground transportation networks, including bridges, interstate highways, rail, and tunnels, provide the worst-case emergency evacuation scenario (an electromagnetic pulse aka an EMP from a nuclear blast, catastrophic natural disaster, or severe weather limitations) transportation method. During non-incident times, interstate and other arterial bridges carry almost 90 percent of average daily traffic (ADT) (Kirk and Mallett 2007, CRS-1 – CRS-2). Transportation by

air (airplanes and helicopters) are restricted in their use during some catastrophic events and weather leaving ground transportation as the primary means throughout the majority of the continental United States (CONUS). Bridges, roadways, and tunnels, among others, require maintenance and upkeep in order to remain functional. Across the United States of America, the ground transportation system, specifically its bridges, is in disrepair (US Department of Transportation 2004). The American Society of Civil Engineers (ASCE) rated US bridges a C+ in their 2013 Report Card for America's Infrastructure (Metropolitan Washington Council of Governments 2015, 10). When bridges over waterways fall, maritime arteries are blocked or severed. Many times utilities cross bridges to span territorial gaps.

Infrastructure typically provides soft or easy targets. According to the Oxford dictionary, infrastructure consists of “the basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a society or enterprise.” Soft targets are defined as things mostly unprotected and especially vulnerable to primarily military and terrorist attack.



WASHINGTONPOST.COM/WONKBLOG

Source: Federal Highway Administration

Figure 1. America’s Outdated Bridges: Percent of Bridges Rated “Functionally Obsolete.”

Source: Christopher Ingraham, “Mapping America’s Most Dangerous Bridges,” *Washington Post*, February 4, 2015, accessed October 23, 2015, <https://www.washingtonpost.com/news/wonk/wp/2015/02/04/mapping-americas-most-dangerous-bridges/>.

For this thesis, the author will focus on the ground transportation infrastructure of the bridges within and connecting the National Capital Region (NCR). Currently the state of the NCR’s bridges are in disrepair. In the District of Columbia alone, as of 2012, of its 239 total bridges, 30 (13 percent) were rated structurally deficient (CRS 2013). More strikingly, 155 (65 percent) of its bridges were rated functionally obsolete (CRS 2013).

The materials that bridges are made from are susceptible to elemental and man-made erosion.

For the purpose of this paper and in accordance with section 2674 of Title 10, United States Code (Reference (f)), the NCR is defined as the geographic area located in the following boundaries:

1. District of Columbia.
2. Montgomery and Prince George's Counties in the State of Maryland and all cities now and hereafter existing in the geographic area bounded by the outer boundaries of the combined areas of the countries listed above.
3. Arlington, Fairfax, Loudoun, and Prince William Counties in the Commonwealth of Virginia, and all cities now and hereafter existing in the geographic area bounded by the outer boundaries of the combined areas of the counties listed above and other units of government within the geographic areas of such district, counties, and city (US DoD 2013).

Funding for US roads and bridges is largely supplied from the Federal/National Highway Trust Fund. It currently gains 18 cents from the gasoline tax applied to every gallon of gasoline sold in the US. The gas tax has not increased since 1993. Based upon inflation, the gasoline tax has lost 39 percent of its worth (Oliver 2015).

Problem Identified

The condition of the US roads and bridges has been heavily debated since the 1980s.

There are 10 bridge spans crossing the Potomac River within the Washington DC Beltway. The two Beltway bridges, Woodrow Wilson and American Legion, are both part of the interstate highway system as are the 14th Street Bridge (which has

multiple spans) and the Theodore Roosevelt Bridge. Other highway bridges include Memorial Bridge, Key Bridge, and Chain Bridge. Less noticed, but also important components of the area's transportation infrastructure are the rail and Metrorail bridges that parallel the 14th Street Bridge. One additional crossing of the Potomac exists, the Metrorail tunnel between Foggy Bottom and Rosslyn stations. (Cogwell 2003, 22)

The NCR, also commonly referred to as the Washington DC metropolitan area, is one of the nation's most complex multijurisdictional areas. The amount of federal and state agencies that are required to coordinate and cooperate with state and local governments presents an interesting challenge (Science Applications International Corporation 2002b, 1.1). The NCR relies on its bridge infrastructure for everything from commerce to public transportation. They are also a critical vulnerability needing maintenance and protection. Critical infrastructure, to include bridges, was first identified by the US Government in 1996. President Clinton highlighted the protection of critical infrastructure in 1998. Since that time, there has been an overall decrease in infrastructure funding and an increase in global terrorism.

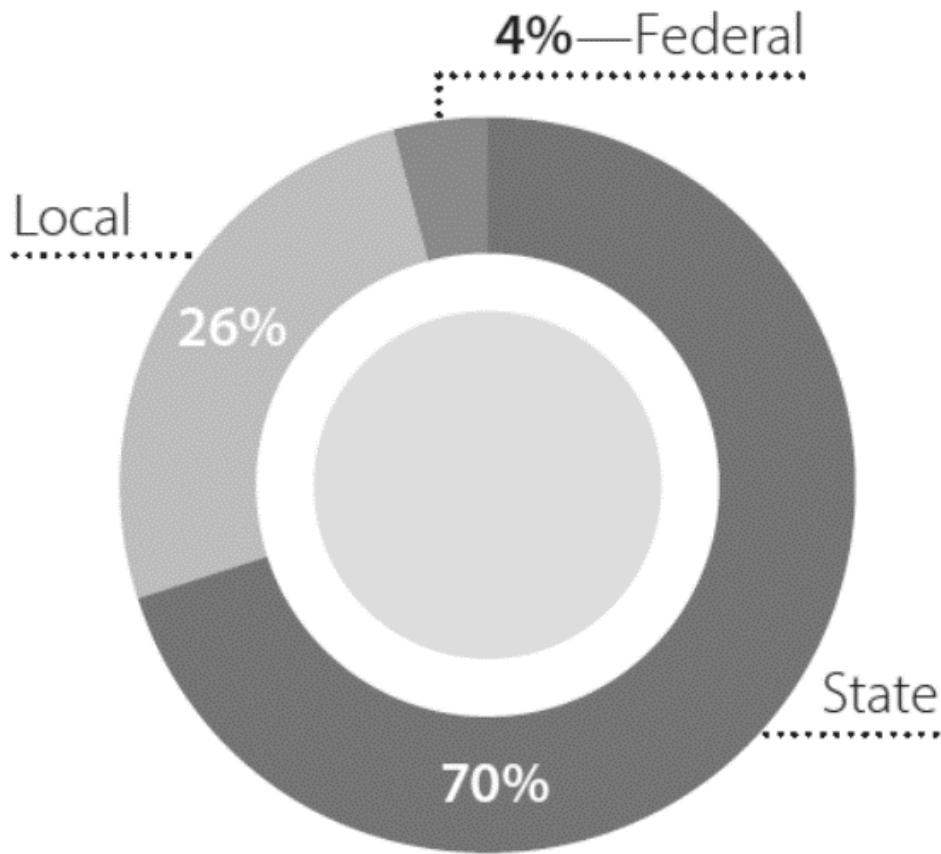


Figure 2. NCR Bridge Ownership

Source: Metropolitan Washington Council of Governments, 2015 State of the Region: Infrastructure Report (Washington, DC: The Metropolitan Washington Council of Governments, January 14, 2015).

Research Question

The thesis question concerns the state of disrepair and security of the bridges within the United States National Capital Region. This question will focus on the directives from the US President and how the intents are being met or not. The thesis question is: how are US federal and state governments (Maryland and Virginia) taking

appropriate actions to mitigate the vulnerabilities of bridges within the National Capital Region in order to support homeland security measures?

Secondary Questions

The following are subordinate questions to this thesis.

1. Who is responsible for the upkeep, security, and resourcing of the bridges and roads that connect the District of Columbia to the rest of the continental United States?
2. What historical difficulties have hindered the repair of NCR bridges?
3. What are the most critical and vulnerable components of bridges in the NCR?

Assumptions

If actions are not taken to improve the NCR's bridges, they will continue to self-degrade and erode until they are unsafe for use and potential collapse. Environmental factors (such as temperature extremes, precipitation, and wind) are capable of eroding all current commercial building materials. The author also makes the assumption that the bridges in the NCR are capable of being better protected against erosion/corrosion and sabotage. US policies regarding the protection and improvement of US bridges will remain unchanged. The gasoline tax will not be raised prior to publishing this thesis.

Key Terms

The following identify and define the terms presented in this thesis and indicate the manner in which they will be used within context of this research.

Bridge. A structure including supports erected over a depression or an obstruction including water, highway, or railway. Also having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the

roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes. It may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening (US Government Publishing Office 2016).

Catastrophic Event. Any natural or man-made incident, including terrorism, which results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, national morale, and/or government functions (Joint Chiefs of Staff 2013, GL-5).

Critical Infrastructure. Infrastructure that is so vital that its incapacitation or destruction would have a debilitating impact on defense or economic security. Physical and/or cyber-based systems essential to the minimum operations of the economy and government. They include, but are not limited to, telecommunications, energy, banking and finance, transportation, water systems and emergency services, both governmental and private (US President 1998).

Critical Infrastructure Protection. Actions taken to prevent, remediate, or mitigate the risks resulting from vulnerabilities of critical infrastructure assets (Joint Chiefs of Staff 2013, GL-5).

Critical Vulnerability. An aspect of a critical requirement, which is deficient or vulnerable to direct or indirect attack that will create decisive or significant effects (Joint Chief of Staff 2010, 57).

Homeland Security. A concerted national effort to prevent terrorist attacks within the United States; reduce America's vulnerability to terrorism, major disasters, and other

emergencies; and minimize the damage and recover from attacks, major disasters, and other emergencies that occur (Joint Chief of Staff 2010, 104).

Incident. An occurrence, caused by either human action or natural phenomena that requires action to prevent or minimize loss of life or damage to property and/or natural resources (Joint Chiefs of Staff 2013, GL-6).

Life-essential Services. Infrastructure that provides electricity, natural gas and fuels; potable water and wastewater services; healthcare; public safety, fire suppression and emergency medical care; transportation and shipping; financial services and telephone service (McCarthy et al. 2005). Bridges fall under the transportation and shipping category.

National Capital Region. The NCR is defined in the United States Code [40 USC 71 (b)] as the District of Columbia; Montgomery and Prince Georges Counties in Maryland; Arlington, Fairfax, Loudoun, and Prince William Counties in Virginia; and all cities existing in Maryland or Virginia within the geographic area designated by the outer boundaries of the combined counties listed. For consistency with the Metropolitan Washington Council of Governments (WashCOG) this research expands the definition of the NCR to include Frederick County in Maryland (Smith 2005).

Physical Security. Actions taken for the purpose of restricting and limiting unauthorized access, specifically, reducing the probability that a threat will succeed in exploiting critical infrastructure vulnerabilities including protection against direct physical attacks, e.g., through use of conventional or unconventional weapons (Lazari 2014, XV). That part of security concerned with physical measures designed to safeguard personnel; to prevent unauthorized access to equipment, installations, material, and

documents; and to safeguard them against espionage, sabotage, damage, and theft (Joint Chief of Staff 2010, 185).

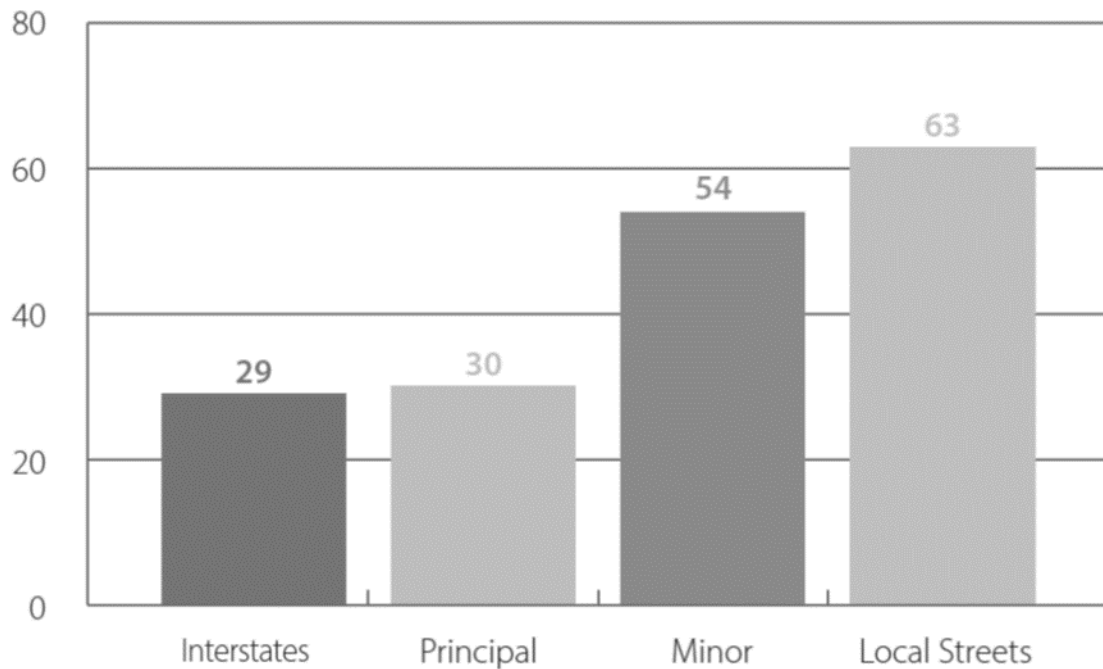
Limitations

The sheer number of bridges within the NCR present the largest limitation for the author's study. It is extremely challenging to find sufficient individual reports for over 250 bridges in DC alone. The National Bridge Inspection Program (NBIP) only requires the inspection of bridges on public roads that are longer than 20 feet. Federal bridges are also subject to this requirement (Kirk and Mallett 2013, 6). A database for bridges less than 20 feet does not exist for the NCR.

Scope and Delimitations

This study will examine the policies and assess feasibility of improving, maintaining, and protecting bridge infrastructure within the NCR. It will also examine the implications of balancing policy from both the US Department of Homeland Security and Department of Highway Administration. In regards to delimitations, the research will focus specifically on the limited period from 1995 through 2015. Bridges that serve as primarily rail transportation infrastructure are excluded. Although the DC boundary includes two major rivers, neither produces a significant amount of freight traffic based upon its lack of accessibility and shipping infrastructure (District of Columbia Department of Transportation 2014, 22). For these reasons, the use of maritime-river transportation is not addressed. Structures designated only as culverts will also be excluded. The method of inspection prescribed by the Federal Highway Administration (FHWA) will not be discussed, nor will how bridges are rated.

Table 1. Number of Structurally Deficient Bridges in Washington, DC



Source: Metropolitan Washington Council of Governments, *2015 State of the Region: Infrastructure Report* (Washington, DC: The Metropolitan Washington Council of Governments, January 14, 2015).

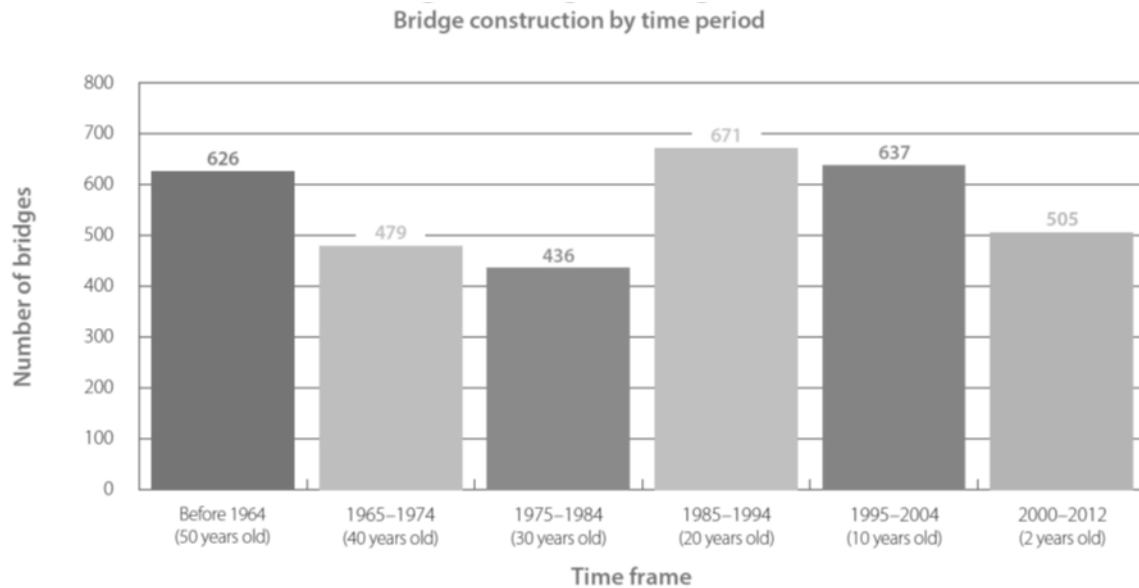
Significance of Study

The NCR is the fourth-largest metropolitan area in the United States. It has a large populace of more than 5.5 million people.

The NCR is the home to all three branches of the Federal government, 271 Federal departments and agencies, and approximately 340,000 Federal personnel. More than 2,100 non-profit organizations, 40 colleges and universities, the World Bank, the International Monetary Fund, and more than 170 embassies are located in the NCR. The regional transportation infrastructure includes two major airports which serve more than 40 million passengers a year; the Nation's second-largest rail transit system; and the fifth-largest bus network in the United States. Approximately 20 million tourists visit the NCR each year. (US Department of Homeland Security 2013, 6)

In the District of Columbia alone, of its 253 bridges, 14 are rated as deficient and 164 are rated as obsolete. That is over 64 percent of the US capital’s bridges rated as obsolete! (Ingraham 2015b, table). The need for infrastructure improvement is almost universally agreed upon. However, the funding for it has hit repeated roadblocks. This study aims to bring increased awareness to what the author sees as a critical vulnerability. The author plans to expound on previous research and highlight improvements and how it applies to the nation’s homeland security strategy. An additional hope is for bridge infrastructure repair to gain an increase in nation-wide prioritization.

Table 2. Age of Bridges in DC Region



Source: Metropolitan Washington Council of Governments, *2015 State of the Region: Infrastructure Report* (Washington, DC: The Metropolitan Washington Council of Governments, January 14, 2015).

Conclusion

The fiscal constraints of federal funding are expected to continue for years to come. Based upon the US Department of Transportation's own 2012 assessment, compared to the national total of 14 percent functionally obsolete bridges of all states (including Puerto Rico), DC has 65 percent (Congressional Research Service 2013). During a transportation emergency, ground transportation infrastructure, especially bridges, is utterly critical. "There are several bridges, interchanges and intersections whose disablement would severely impair travel within the region. Depending on the severity of the damage, disruption of traffic could continue for days or even weeks, shutting down not only commercial activity but vital functions of the federal government" (McCarthy et al. 2005). To support first responders and security enablers, the majority of the NCR's bridges need to be repaired or replaced quickly and safely.

CHAPTER 2

LITERATURE REVIEW

A bridge has no allegiance to either side.

— Les Coleman, Brainyquote.com

Our responsibility is to build the world of tomorrow by embarking on a period of construction—one based on current realities but enduring American values and interests.

— President William J. Clinton,
A National Security Strategy for a New Century

President Bill Clinton solidified the modern concern for infrastructure protection. He issued Executive Order No. 13010, “Critical Infrastructure Protection” on July 15, 1996. It was followed up in May of 1998 with his Presidential Decision Directive (PDD) number 63, entitled “Critical Infrastructure Protection.” This guidance required the determination of what constituted critical infrastructure. In support of critical infrastructure protection, the author wants to determine if the US government (both federal and state) are taking the appropriate actions in order to mitigate the vulnerabilities of the bridges within the National Capital Region in order to support homeland security measures. In the review of available literature, the author focused primarily on existing national strategies and plans, key congressional acts that relate to bridge infrastructure and government reports that provide assessments of condition.

The previous chapter introduced the research topic and the primary research question of, how are US federal and state governments (Maryland and Virginia) taking the appropriate actions in order to mitigate the vulnerabilities of the bridges within the National Capital Region in order to support homeland security measures? Additionally,

there are three secondary research questions: (1) Who is responsible for the upkeep, security, and resourcing of the bridges and roads that connect the District of Columbia to the rest of the continental United States?; (2) What historical difficulties have hindered the repair of NCR bridges?; and 3) What are the most critical and vulnerable components of bridges in the NCR?

Existing Publications

There have been numerous reports, books, news reports, and blogs about the condition of our nation's bridges over the last 15 years. The Federal Highway Administration (FHWA) administers federal assistance for the maintenance, rehabilitation and construction of highway bridges (Kirk and Mallett 2013, 4), and has published numerous reports and findings since its inception. Many of the incidents that involve catastrophic bridge collapse have case studies detailing their events. Existing publications are essential to furthering discussion and developing courses of action to address existing and future issues.

National Strategies and Plans

The National Infrastructure Protection Plan (NIPP) 2013: Partnering for Critical Infrastructure Security and Resilience states the word "bridge" only once. It is mentioned in conjunction with shared physical infrastructure, such as water or power lines running under one.

The Transportation Systems Sector-Specific Plan: An Annex to the National Infrastructure Protection Plan (2010) identifies and prioritizes the transportation sub-systems. This document was created to fulfill Homeland Security Presidential Directive

7. The Department of Transportation and the Department of Homeland Security are co-owners of the transportation subsystems. Bridges fall under the Highway Infrastructure and Motor Carrier subsystem.

Governments currently employ multiple sources to pay for infrastructure investments. Often sources including tax collections, utility rates, and user fees paid for services (i.e. tolls on toll roads) are utilized (Metropolitan Washington Council of Governments 2015, 7). Several government programs instituted by Federal Acts are also sources of funding.

Key Bridge Infrastructure Acts

The Federal-Aid Highway Act of 1970: (P.L. 91-605) Inventory requirement for all bridges on the Federal-aid system established: minimum data collection requirements, minimum qualifications and inspector training programs, and the Special Bridge Replacement Program. The Surface Transportation Assistance Act of 1978 (P.L. 95-599) provided \$4.2 billion for the Highway Bridge Replacement and Rehabilitation Program (HBRRP) over four years. It extended inventory requirements to all bridges on public roads in excess of 6.1 meters and established Highway Bridge Rehabilitation and Replacement Program (extending funding to Rehab) to replace the Special Bridge Replacement Program. The Highway Improvement Act of 1982, provided \$7.1 billion for the HBRRP over four years. The Surface Transportation and Uniform Relocation Assistance Act of 1987 provided \$8.2 billion for the HBRRP over five years and added requirements for underwater inspections and fracture-critical inspections. It also allowed increased inspection intervals for certain types of bridges. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provided \$16.1 billion for the HBRRP

over six years. The ISTEA mandated State implementation of bridge management systems and increased funding in HBRRP. The National Highway System Designation Act of 1995 repealed the mandate for management system implementation (US Department of Transportation 2004, 15-5). The Transportation Infrastructure Finance and Innovation Act (TIFIA) of 1998 established a Federal credit program for various eligible transportation projects where the U.S. Department of Transportation (DOT) was able to offer three forms of credit assistance in the form of secured (direct) loans, loan guarantees, and standby lines of credit (Transportation.gov 2015b). The TIFIA credit program was created to fill market gaps and leverage substantial private co-investment by providing supplemental and subordinate capital (Transportation.gov 2015a). As a part of the Fiscal Year 2010 Department of Transportation Appropriations Conference Report (Public Law 111-117), the US Congress requested DOT, in cooperation with the Department of Homeland Security (DHS) to do the following:

Ensuring the success of mass evacuations—The conferees direct the Department of Transportation (DOT), in cooperation with the Department of Homeland Security (DHS), to assess mass evacuation plans for the country’s most –high-threat, high-density areas and identify and prioritize deficiencies on those routes that could impede evacuations. The conferees also direct DOT, in cooperation with DHS and the Office of the National Capital Region Coordination, to conduct an analysis of how national highway system projects under construction west of the National Capital Region (NCR) could increase the NCR’s evacuation capacity and provide a detailed plan to accelerate such projects. DOT shall submit its report to the House and Senate Committees on Appropriations no later than 90 days after the enactment of this Act. (Vasconez and Kehrl 2010, 12)

The 2012 surface transportation reauthorization titled the Moving Ahead for Progress in the 21st Century Act (MAP-21). MAP-21 strengthened individual states’ ability to self-determine spending on bridges because it eliminated the Highway Bridge Program (HBP). While HBP saw an increase of funding, especially from fiscal year (FY)

2007 to FY 2012, it had numerous flaws that were exploited by states. It was legal for funds allocated for bridge repair to be transferred to other highway programs (Kirk and Mallet 2013, 5). MAP-21 created two programs that could fund bridge improvements. The two programs are the National Highway Performance Program (NHPP) and the Surface Transportation Program (STP) (Kirk and Mallett 2013, 4). Both programs served to determine the amount of federal funding for bridges specifically versus other uses. Another use of MAP-21 funding is for seismic retrofitting of bridges to help mitigate earthquake failure risk (Kirk and Mallett 2013, 4). The Transportation Equity Act for the 21st Century (TEA-21, 1998 H.R.1846 - Bridge to Sustainable Infrastructure Act) was introduced in the House of Representatives in April of 2015.

Table 3. HBP Apportionments/Obligations and Obligations from All FAHP Sources: FY2007 – 2012

| | Dollars in Millions | | | | | |
|--|---------------------|---------|---------|---------|---------|---------|
| | FY2007 | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 |
| HBP Apportionments (gross) | \$5,041 | \$5,058 | \$5,177 | \$5,612 | \$5,897 | \$5,509 |
| HBP Obligations | \$3,761 | \$4,066 | \$4,212 | \$4,284 | \$4,193 | \$3,575 |
| Total: All Federal-Aid Highway Programs' Bridge Obligations | \$6,418 | \$6,837 | \$9,386 | \$8,472 | \$7,043 | \$6,014 |

Source: Robert Kirk and William Mallett, *Highway Bridge Conditions: Issues for Congress* (Washington, DC: Congressional Research Service, December 19, 2013).

Key Government Reports

Many reports on transportation infrastructure are published by the US Congressional Research Service (CRS). The CRS is the United States Congress' "think tank." Its main purpose is to field questions and inquiries from Congress in order to

inform them on policy and facts. The authors of these reports are specialists in their research field. The CRS researchers routinely derive conclusions from primary sources of legislation and policy including Presidential Executive Orders and U.S. Senate testimonies. John D. Moteff, Robert S. Kirk, and William J. Mallet appear to be the authors of the majority of the CRS reports on critical infrastructure. Moteff is a specialist in Science and Technology Policy from CRS' Resources, Science, and Industry Division (Moteff 2005, Cover). Kirk and Mallett are both specialists in transportation policy (Kirk and Mallett 2013, 14).

The Metropolitan Washington Council of Governments presented its *Region Forward* vision in the 2015 State of the Region: Infrastructure Report. The vision contains five recommendations intended to reinforce infrastructure's critical role in the region and its need for investment. The first recommendation is the establishment of a regional or mid-Atlantic infrastructure exchange to take form as an organization or council. It would prioritize infrastructure costs, funding needs and mechanisms, and periodically assess the condition of the region's infrastructure (Metropolitan Washington Council of Governments 2015, 41). The other recommendations are a public education campaign, the continued sharing of best practices (regionally and across the US), the facilitation of workshops on developing unique funding ideas for essential infrastructure projects, and increased use of advocacy (Metropolitan Washington Council of Governments 2015, 8).

Phil Mendelson, the Chairman of the Board of Directors, Metropolitan Washington Council of Governments (COG) and the Chairman of the Council of the District of Columbia (DC), rightfully states, "Infrastructure is usually under-appreciated

until something goes wrong” (Metropolitan Washington Council of Governments 2015, 3). Over the last few decades, local and national leaders from all over the nation have faced contending priorities that have deferred maintenance and replacement costs for infrastructure. The projected cost needed to invest in new systems to address growth and that of maintaining the working order of current systems easily ranges in the billions of dollars. The National Capital Region’s Metropolitan Washington COG has conservatively determined that as of 2015, it has a funding gap of one billion dollars over thru 2025 (Metropolitan Washington Council of Governments 2015, 7).

Existing Issues and Challenges

The primary issue concerning the bridges in the NCR is the issue of ownership. DC has 315 bridges based upon 2014 data. DC Department of Transportation (DDOT) owns 239 of them (75.8 percent), consisting of 205 highway bridges, 16 tunnels, and 18 pedestrian bridges. The National Park Service owns 39 (12.3 percent). Private railways are responsible for the remaining 37 (11.7 percent) (District of Columbia Department of Transportation 2014, 66).

There are numerous existing challenges to the current bridge population within the NCR. The weight restriction signage is not posted for the majority of the bridges. This is increasingly hazardous for the bridges classified as functionally obsolete or fracture critical. Another issue is the lack of weight restriction except through a single weight bridge on southbound I-295 near Blue Plains. If enforced the vehicles also do not have an off-load facility within DC to bring themselves within tolerance. A DDOT Truck Safety Enforcement Study from 2011 identified that the total bridge impacts or costs

from overweight trucks in DC to be an estimated seven million dollars per year (District of Columbia Department of Transportation 2014, 66).

Previous Recommendation

Most published recommendations for bridge protection are intended to target commercial trucks and not terrorist acts. To provide in-transit overweight data that could be actioned upon, the 2014 District of Columbia Freight Plan recommends weigh-in-motion (WIM) sensors at key locations (District of Columbia Department of Transportation 2014, 77). Two district bridges included as key locations are the Francis Case Memorial Bridge (I-395) and 14th Street Bridges. Both are recommended to have WIMs installed on both inbound and outbound directions. Adding signage that is easy to read and well placed could mitigate instances of overweight travel or damage to low clearance bridges.

Conclusion

This chapter identified and described key publications that have impact on the bridges within the NCR. These publications included US national strategies and plans, federal acts, and government reports. There is some information that is lacking due to an inability to discover it. A percentage breakdown of the bridge ownership was found but not a specific listing of bridges by their ownership. It is important to clearly delineate ownership in order to hold civil authorities or agencies accountable for poor maintenance or functionality standards. During the literature review, the author identified several inconsistencies in regards to NCR bridge statistics. While numbers of deficient bridges within the NCR may vary by report, it is worth noting that there has been a downward

trend of structural deficiency over the last decade. This thesis as a whole is expected to contribute to the current body of knowledge by adding new analysis to existing case studies and by consolidating information and sources on this topic to help further research.

CHAPTER 3

RESEARCH METHODOLOGY

The previous two chapters identified the research topic and some of the existing publications that support its importance. The primary research question is, how are US federal and state governments (Maryland and Virginia) taking the appropriate actions in order to mitigate the vulnerabilities of the bridges within the National Capital Region in order to support homeland security measures? The secondary research questions are as follows: Who is responsible for the upkeep, security, and resourcing of the bridges and roads that connect the District of Columbia to the rest of the continental United States? What historical difficulties have hindered the repair of NCR bridges? What are the most critical and vulnerable components of bridges in the NCR? Chapter 2 highlighted the literature review areas focused on during this project. They are the existing national strategies and plans, key congressional acts that relate to bridge infrastructure and government reports that provide assessments of condition. This chapter looks to identify the plan for conducting further research on this topic and add to the current body of scholarly knowledge.

This chapter is organized into three sections. The first section will contain a description of the methodology used. It will also include a breakdown of both the strengths and weaknesses of the identified methodology. The second section presents a description of the primary case studies. The last section is the conclusion of the chapter. It provides a summary of chapter 3 and a brief description of the following chapters of the thesis.

Methodology

The research methodology used for this thesis paper is a qualitative study with a multiple case study design. The qualitative case study variation used in this thesis is the collective case study. The research includes an extensive collection of data from multiple sources of information. The research primarily used published documents, government reports, and audiovisual materials. Original personal interviews or observations did not take place. The collection of information did not involve any direct engagement with living persons requiring approval from the CGSC Quality Assurance Office (QAO).

The first step was a gathering and assessment of related published materials on the subject of bridges within the NCR. This step produced a case study from the US Department of Transportation's Intelligent Transportation Systems (ITS) Joint Program Office on the responses at the US Pentagon and the NCR on September 11, 2001. The second step focused on a thorough review of selected documents and sources in order to focus further refinement of the problem statement and additional research. The problem statement received refinement by the thesis committee. This prompted additional research and subsequent content scrutinization of pertinent documents and reports. Additionally, three other case studies were selected. The second discusses the 2011 Virginia earthquake that affected the NCR. The third deliberates the I-40 bridge collapse in Oklahoma from 2002. The final selected case study evaluates the emergency highway evacuations of 26 US metropolitan areas including the NCR.

Method Strengths

The following identifies the strengths of this method. The case study method of qualitative research has several key strengths. As defined by Creswell (Creswell 2007a,

73), “case study research is a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information”. A strength of this method is the familiarity that multiple social scientist disciplines have with its employment, including law, political science, psychology, and medicine (Creswell 2007a, 73).

Method Weaknesses

The following identifies the weaknesses of this method. The case study method of qualitative research also has several inherent weaknesses or challenges. The primary challenge is the selection of what to study. It is the challenge of the researcher to prove the worth of the selected study. Additionally, there is not a set rule for how many cases should be studied. The more cases a researcher studies, the more diluted and less in-depth the research becomes. In addition, some case studies may not have well defined beginnings or endings (Creswell 2007, 76). This chapter will analyze only four case studies in order to combat the dilution of the research.

Selected Case Studies

The author selected four case studies for analysis. Case study 1 is of post 9-11 actions in the NCR. Case study 2 is on the 2011 Virginia earthquake response. Case Study 3 is of the 2002 I-40 bridge collapse in Oklahoma. Case study 4 examines the emergency highway evacuations required for 26 US metropolitan areas. All of the case studies have several factors in common. All of the selected case studies are concerned

with the US only. All also mention bridges and had an impact of both transportation and infrastructure. Additionally, all have applicability to a terrorist attack.

Case Study #1 Introduction

The first case study documents the actions taken by US transportation agencies as a response to the terrorist actions directed at the Pentagon in Arlington, Virginia on September 11, 2001 (Science Applications International Corporation 2002b, foreword). The primary incident that resulted in major impacts to key transportation networks within the NCR was the impact of Flight 77 into the Pentagon. This incident resulted in physical damage to the Pentagon and loss of life (125 from the Pentagon and 64 from Flight 77). It also created a psychological impact to local, state, and federal agencies and the nation as a whole (in addition to the twin tower collapse in New York City).

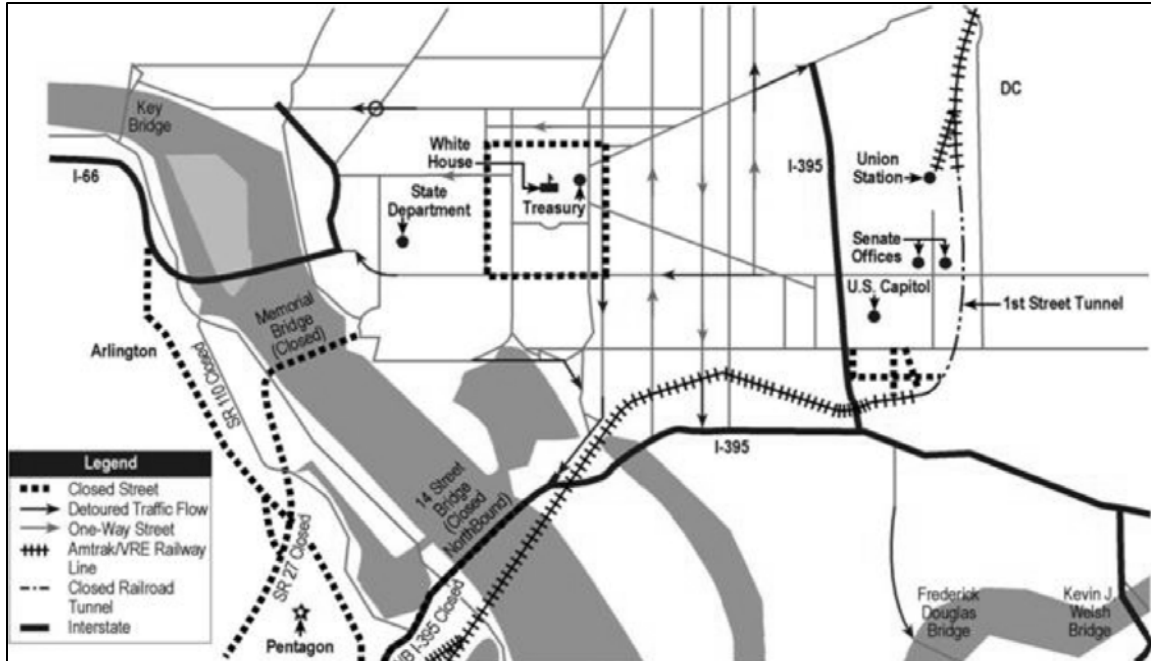


Figure 3. Transportation Facility Closings on September 11, 2001

Source: Intelligent Transportation Systems (ITS) Joint Program Office, *Effects of Catastrophic Events on Transportation System Management and Operations: The Pentagon and the National Capital Region September 11, 2001; Draft Report: Findings* (Washington, DC: US Department of Transportation, March 2002).

Case Study #2 Introduction

On Tuesday, August 23, 2011, at 1:51 p.m. Eastern Daylight Time (EDT), the Piedmont region of Virginia experienced a 5.8 magnitude earthquake. The epicenter, in the town of Mineral, Louisa County, was located 38 miles northwest of Richmond and 84 miles southwest of Washington, DC (US Department of Homeland Security 2013, 3). As seen in the following figure, the earthquake was felt throughout the eastern United States and in Canada according to US Geological Survey (USGS) data (US Department of Homeland Security 2013, 3). Despite the earthquake’s extended range and relatively high

magnitude, there were zero reported fatalities and caused limited damage to buildings and transportation infrastructure.

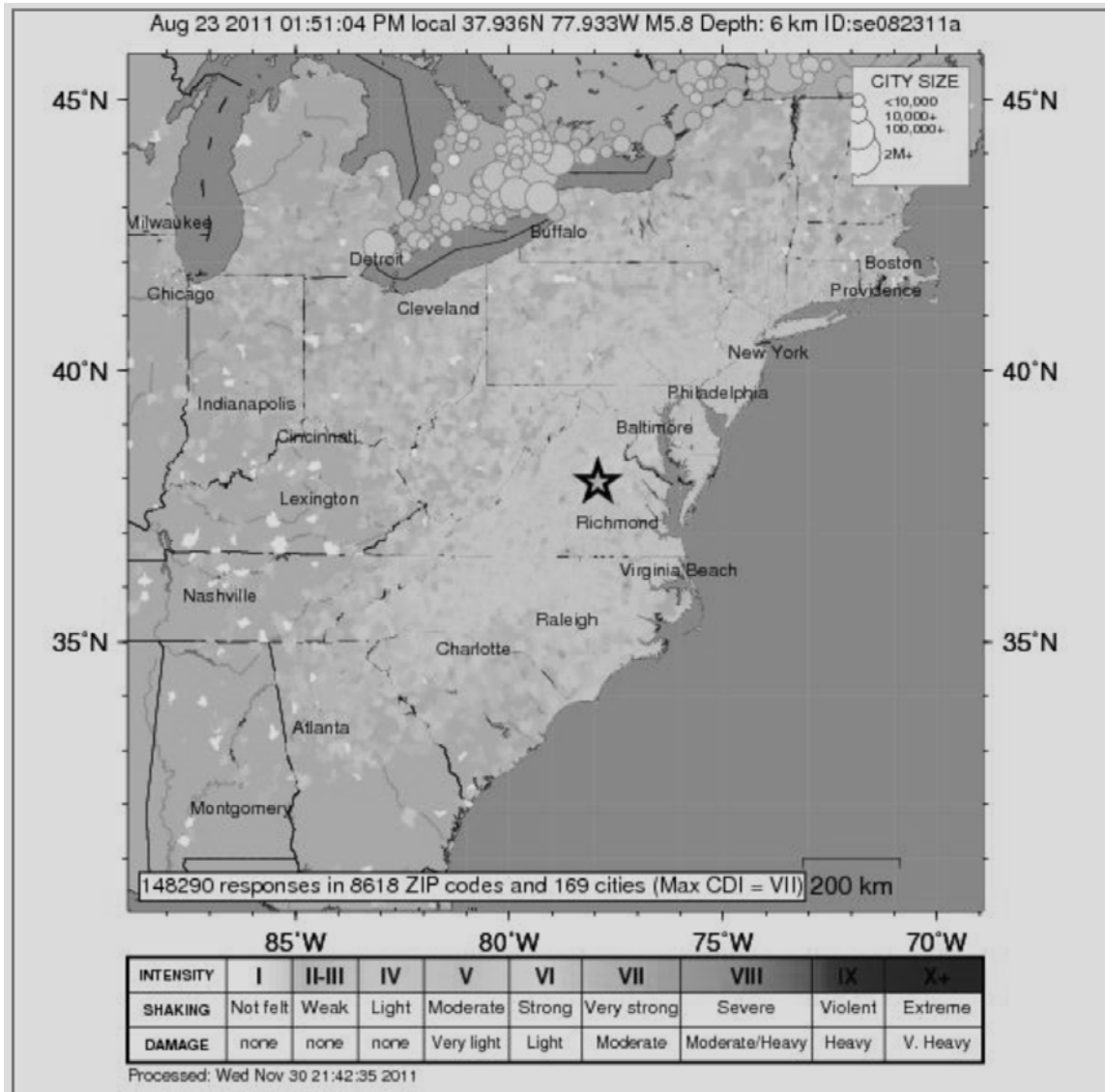


Figure 4. Map of the Intensity of the August 23, 2011, Earthquake

Source: David DeMorat, *Federal Actions in Response to the August 23, 2011, Virginia Earthquake Report* (Washington, DC: US Department of Homeland Security, December 5, 2013).

Case Study #3 Introduction

This case study provides the results of a study of the events surrounding the partial collapse of the I-40 Webbers Falls Bridge near Webbers Falls, Oklahoma. The incident caused a portion of the bridge, which is part of McClellan-Kerr Arkansas River Navigation System waterway, to plunge into the Arkansas River during Memorial Day weekend of May 26, 2002. The collapse was caused by a towboat pushing two empty barges when it knocked down two of the bridge's piers and damaged a third. This incident caught the drivers of 11 vehicles by surprise. All 11 vehicles plunged 19 m (62 ft) into the river resulting in the deaths of 14 people (Yong Bai, Burkett, and Nash 2006, 339). The incident triggered the Oklahoma Department of Transportation (ODOT) to close I-40 near the bridge and the Navigation System. It is an important note that Interstate 40 is one of the nation's three major east-west interstate highways and carries about 20,000 vehicles each day (Yong Bai, Burkett, and Nash 2006, 339).

Case Study #4 Introduction

The fourth selected case study presents case study analysis of 26 metropolitan areas to assess mass evacuation plans for the country's high-threat, high-density areas and identify and prioritize deficiencies on those routes that could impede evacuations. Seven of the areas are found to have bridges listed as a top impediment to evacuation (Atlanta, Charleston, Portland, San Francisco, St. Louis, Tampa-St. Petersburg). For this study, the DOT used a structured methodology to collect, review and assess information on mass evacuations in high-risk, high-population locations around the country (Vasconez and Kehrlı 2010, 15).

Conclusion

This chapter served to present the research methodology used in this thesis and dissect multiple case studies. This chapter also introduced the case studies used for analysis. The following chapter, chapter 4, will illustrate the analysis and interpretation of the evidence discovered during researching this subject. Chapter 5 will present the conclusions and recommendations addressing the research questions and suggested areas for future study.

CHAPTER 4

ANALYSIS

The previous three chapters laid the foundation for the qualitative analysis of several case studies. The primary research question is, how are US federal and state governments (Maryland and Virginia) taking the appropriate actions in order to mitigate the vulnerabilities of the bridges within the National Capital Region in order to support homeland security measures? The secondary research questions are as follows: Who is responsible for the upkeep, security, and resourcing of the bridges and roads that connect the District of Columbia to the rest of the continental United States? What historical difficulties have hindered the repair of NCR bridges? What are the most critical and vulnerable components of bridges in the NCR? Chapter 2 presented key transportation and infrastructure acts and policies that pertain to US bridges.

Assessment Factors

The author selected four assessment factors to use for the case study analysis. The first assessment factor is communication. Communication: How well did local/neighboring/Federal agencies or communities communicate with each other? Are their systems interoperable? Was there redundancy in deployed systems? The second assessment factor is integration. Was there positive or negative integration of responding agencies? Were there competing requirements that caused friction in the response? Was there any response from non-local civil authority jurisdiction? The third assessment factor is protection. This factor looks to evaluate how well the bridges in the scenario were utilized and safeguarded. Did terrorists specifically target bridges? Were there

mitigations in place to prevent catastrophic failure to bridges in the case study? The final assessment factor is applicability. How easily can the case study be applied to multiple areas of the nation? Is the information still relevant or is it outdated? The following figure illustrates the assessment factors applied to the four selected case studies.

Table 4. Analysis of Case Study Factors

| Assessment Factors | Case Study #1 NCR Post 9-11 Events | Case Study #2 2011 VA Earthquake Response | Case Study #3 I-40 Bridge Collapse | Case Study #4 Highway Evacuations of Metro Areas |
|---------------------------|---|--|---|---|
| Communication | | | (+) | |
| Integration | (+) | (+) | (+) | |
| Protection | (+) | (+) | (-) | (-) |
| Applicability | (+) | | | (+) |

Note: (+) designates a positive outcome of this factor in relation to the case study evaluated. (-) designates a negative outcome of this factor in relation to the case study evaluated. An absence of a mark identifies neither a positive or negative outcome observed with the factor in relation to the case study evaluated.

Source: Created by Author.

Analysis of Case Studies

The author analyzed the four case studies using the four assessment factors. This produced a rank order of the four case studies. The ranking is based upon the previous table. From most to least positive based upon the assessment factor the order of the case

studies are Case Study #1 (NCR response to 9-11), Case Study #2 (2011 VA Earthquake response), Case Study #3 (2002 I-40 bridge collapse), and Case Study #4 (emergency evacuation of 26 metropolitan areas).

Case Study #1 Analysis

Case study number one's assessment is three positive outcomes and zero negative outcomes. The Virginia Department of Transportation (VDOT) had good intelligence collection via the media and TRANSCOM. A pre-established formal agreement with the Pentagon and automatic mutual aid agreement with neighboring jurisdictions enabled the Arlington Fire Department to assume incident command and execute response efforts (Science Applications International Corporation 2002b, 14). The Maryland Department of Transportation (MDOT) prioritized infrastructure protection and support to NCR evacuation efforts. There was a substantial concern for bridge security. The Maryland Transportation Authority (MdTA) was directed that abandoned or stranded vehicles, especially under bridges, were to be moved with special emphasis away from bridges (Science Applications International Corporation 2002b, 15). The Maryland State Highway Administration (SHA) implemented surveillance under bridges and dispatched district engineers to high-risk bridges to provide visual confirmation that the piers and substructures were free of foreign objects (Science Applications International Corporation 2002b, 1). There was activation of video surveillance capability at major bridges and tunnels. In Washington, DC, there was a declared state of emergency in effect. While the District of Columbia Division of Transportation (DDOT) was working to change the traffic signal system, the Secret Service and Capitol Police were expanding the White House perimeter and closing streets. It was reported that there was significant

effort required to combat erroneous reports and rumors about the status of the transportation system (Science Applications International Corporation 2002b, 16). DDOT deployed portable signs and traffic cones to aid in the traffic movement around the closed streets. An analysis of travel data identified that compared to a typical commuter day, on 9-11 commuters experienced more than triple the risk of being late, a 26 percent reduction in just-in-time reliability, and an increase in stress by more than a third (Science Applications International Corporation 2002b, 20-21). It is important to note, “Each agency acted professionally, capably, and responsively, to perform its duties as it saw them. However, there was little if any coordination on decisions relating to management and operation of the transportation network among and between jurisdictions.” (Science Applications International Corporation 2002b, 23). There was also complications due to poor federal communication in regards to the release of employees and the unilateral actions of closing DC streets near key government facilities (Science Applications International Corporation 2002b, 23). There was a lack of redundancy for voice communications for the Virginia response effort. VDOT also had issues validating rumors. VDOT closed multiple bridges and roadways due to bomb rumors (Science Applications International Corporation 2002b, 24). Rumors similarly hindered MDOT. The media had reported terrorist threats against 11 Maryland locations, thus diverting needed State Police presence and evacuating civil leadership like the Governor. Leveraging updated technology, like advanced CCTV surveillance, computerized traffic signal systems, dynamic message signs, and internet broadcasting, were used to attempt a reduction in situational rumors. In terms of communication, it had both positive and negative aspects in terms of communication. At times, there was good

sharing of gathered information. VDOT had great internal communication. Arlington's Emergency Operations Center (EOC) had good communication with FEMA and Maryland. At other times, agencies took unilateral efforts versus concerted efforts. The secret service and capitol police took the initiative to close key streets and extend the White House perimeter. While these efforts meant to increase the safety of key government officials, they were not adequately communicated to other vital agencies and response organizations. Another lack of communication was that between VDOT and agencies within the NCR including the National Park Service and DDOT. This lack of communication resulted in an unwanted reactive mindset for VDOT (Science Applications International Corporation 2002b, 14). The integration in case study number 1 was more positive than negative. There were numerous critical mutual aid agreements in place that allowed for quick integration and response during the attack at the Pentagon. The ability for the Arlington Fire Department to respond and assume incident command (Science Applications International Corporation 2002b, 14). Protection has a positive outcome assessment. MDOT was very vigilant in their bridge protection and surveillance immediately after the 9-11 incidents. MDOT dispatched engineers to visually inspect and surveil the underside of bridges for potential dangers. Piers were examined for foreign objects and abandoned vehicles were cleared away. In DC, the Memorial Bridge was closed and the 14th Street Bridges was closed to northbound traffic. These decisions reduced the ability for follow-on attacks using ground transportation as the vehicle for delivery to the heart of DC. Applicability is assessed as a positive outcome for this case study. Numerous metropolitan areas around the US are adjacent to rivers and waterways

like the NCR. The NCR's multitude of agencies and government bodies operating within it serve as a model for other areas to learn from.

Case Study #2 Analysis

Situation awareness was difficult for 30 minutes after the event due to the cellular telephone network congestion. Numerous facilities evacuated personnel throughout the region and began to assess impacts to infrastructure and personnel. Situation awareness improved among the governments and organizations when key stakeholders were able to participate in the conference calls established by the Metropolitan Washington Council of Governments. WashCOG set up the calls through the Regional Incident Communication and Coordination System (RICCS).

The primary initial concerns for Federal departments and agencies within the NCR were the assessment of the damage caused by the earthquake. The focus was on structures that house Federal personnel and on critical infrastructure. The Washington Metropolitan Area Transit Authority (WMATA) followed its established standard operating procedures. Along with the reduced maximum speed of Metrorail trains while its personnel conducted track inspections of the entire rail system, engineers from the FHWA and local agencies inspected bridges and highways in the impacted area (US Department of Homeland Security 2013, 7). Operations at Ronald Reagan National Airport saw a 90-minute suspension.

FEMA's National Preparedness Assessment Division (NPAD) and Office of National Capital Region Coordination (NCRC) conducted an analysis of the event along with the US Office of Personnel Management (OPM). The joint NPAD-NCRC team identified seven key findings related to Federal actions following the Virginia earthquake.

The findings are organized into three focuses: maintaining Federal operations; emergency communications; and information sharing (US Department of Homeland Security 2013, 5).

- Maintaining Federal Operations

Finding 1: Federal departments and agencies successfully maintained their essential functions after the earthquake.

Finding 2: Federal personnel evacuated from their workplaces while their department or agency assessed the damage caused by the earthquake.

Finding 3: Some Federal departments and agencies released their NCR personnel shortly after the earthquake while others waited for OPM guidance.

Finding 4: Some Federal personnel self-released prior to receiving department or agency or OPM guidance.

- Emergency Communications

Finding 5: Federal officials used NCR communications and information sharing systems to gain situational awareness due to cellular communications congestion.

- Information Sharing

Finding 6: Federal departments and agencies employed Twitter, Facebook, and other social media to push emergency information to Federal personnel after the earthquake.

Finding 7: Federal departments and agencies used multiple websites and systems to disseminate emergency information to their personnel following the earthquake. (US Department of Homeland Security 2013, 7).

On November 4, 2011, over two months after the incident, President Barack Obama issued a Major Disaster Declaration for areas in Virginia affected by the earthquake (FEMA-DR-4042). A second Major Disaster Declaration was issued on November 8, 2011, for the Washington, DC, area (FEMA-DR-4044). These declarations enabled a range of federal disaster assistance for the area.

Information dissemination being hindered by cellular tower congestion triggered Federal officials to utilize social media. The intention was well placed; however, the execution was flawed. The FEMA director does not have the Twitter following nor do Federal agency Facebook pages in order to make a substantial impact. Case Study #2 received one positive and zero negative assessments. Communication has neither a negative or positive outcome assessment for multiple reasons. Even though there was a fair amount of national news coverage, the severe initial cellular phone tower congestion that resulted in minimal ability for use for about 30 minutes. To combat the cellular disruption, Federal departments and agencies were able to leverage NCR communications and information sharing systems to gain situational awareness (US Department of Homeland Security 2013, 5). Agencies utilized social media, emails, and internet websites to bypass the telephonic communication issues. Building evacuation instructions were not clear and in some cases only added to area evacuation congestion. Integration for this case study has a positive outcome. This assessment was heavily influenced by the fact that the FEMA National Response Coordination Center (NRCC) was already activated and operational in anticipation of Hurricane Irene's impending landfall. The FEMA NCR Watch Desk monitored operations in areas affected by the earthquake, collected data from emergency responders and other entities, and disseminated this information to its stakeholders (US Department of Homeland Security 2013, 7). The FEMA National Continuity Programs (NCP) has responsibility for managing the Readiness Reporting System (RRS), which measures and reports the individual and aggregate ability of Federal departments and agencies to continue their Primary Mission Essential Functions (PMEFs) in support of the National Essential

Functions (NEFs). The near real-time assessments of the RRS enable FEMA NCP to determine needs and gaps in Federal continuity capabilities (US Department of Homeland Security 2013, 9). According to one assessor, “Despite the disruptions caused by the August 2011 Virginia earthquake, Federal departments and agencies successfully maintained their PMEFs without encountering any problems or gaps in operations” (US Department of Homeland Security 2013, 9). Protection for this case study received a positive outcome assessment. The case study discusses how engineers from the FHWA performed inspections on the bridges in the impacted area (US Department of Homeland Security 2013, 7). Applicability was neither positive nor negative. While there is a large part of the US that could feel earthquake effects from a major fault incident, not all areas of the US are subject to these effects.

Case Study #3 Analysis

The third case study, the I-40 bridge collapse, has the second most positive outcomes. This study’s research objective was to identify strategies and technologies to quickly restore highway bridges, a critical component of the nation’s transportation network, to their use in case they are damaged or destroyed by extreme events. A three-phase case study methodology was utilized to accomplish this objective (Yong Bai, Burkett, and Nash 2006, 338). The researchers performed a literature review, telephone interviews, and a survey.

The FHWA approved \$3 million in federal emergency relief funds to get the repair work started immediately. FHWA’s Emergency Relief (ER) Program provides funding for bridges damaged either in natural disasters or by outside sources that cause catastrophic failures. FHWA is budgeted for \$100 million per year for ER (Kirk and

Mallett 2013, 7). Through the repair process, FHWA provided technical expertise and assistance to ODOT, particularly in the areas of bidding and contract administration (Yong Bai, Burkett, and Nash 2006, 342).

During the five-day recovery effort, there were five major challenges. The challenges included the coordination of first responders, the establishment of access and staging areas, logistics of multiagency effects, establishing communications, and stabilization of the damaged structure (Yong Bai, Burkett, and Nash 2006, 340). ODOT implemented an extensive detour plan for ground traffic. One secondary result was an emergency need for enhancing the surfaces of many of the detour roads to prevent pavement failure in support of the increased traffic load. In addition, in support of the detour efforts, ODOT inspected 42 bridges on the detour routes and performed necessary maintenance work by replacing bearings under the bridge decks on two bridges (Yong Bai, Burkett, and Nash 2006, 339). There was good cross agency support during the rescue and recovery efforts. ODOT worked with multiple agencies including the US Army Corps of Engineers (USACE), the US Coast Guard, the National Transportation Safety Board, local police, the Oklahoma Army National Guard, and McClellan-Kerr Navigational Office (Yong Bai, Burkett, and Nash 2006, 340).

There were minimal but significant communication issues for this case. The biggest was that very few were aware that the replacement bridge project was ahead of schedule by nearly 10.5 days until the very end (Yong Bai, Burkett, and Nash 2006, 344). Communication is critical for a project involving multiple parties. A general guideline developed after this case is seen in the following figure. A key lesson learned was the use

of monetary incentive and disincentive clauses in the contracts to motivate a speedier project completion.

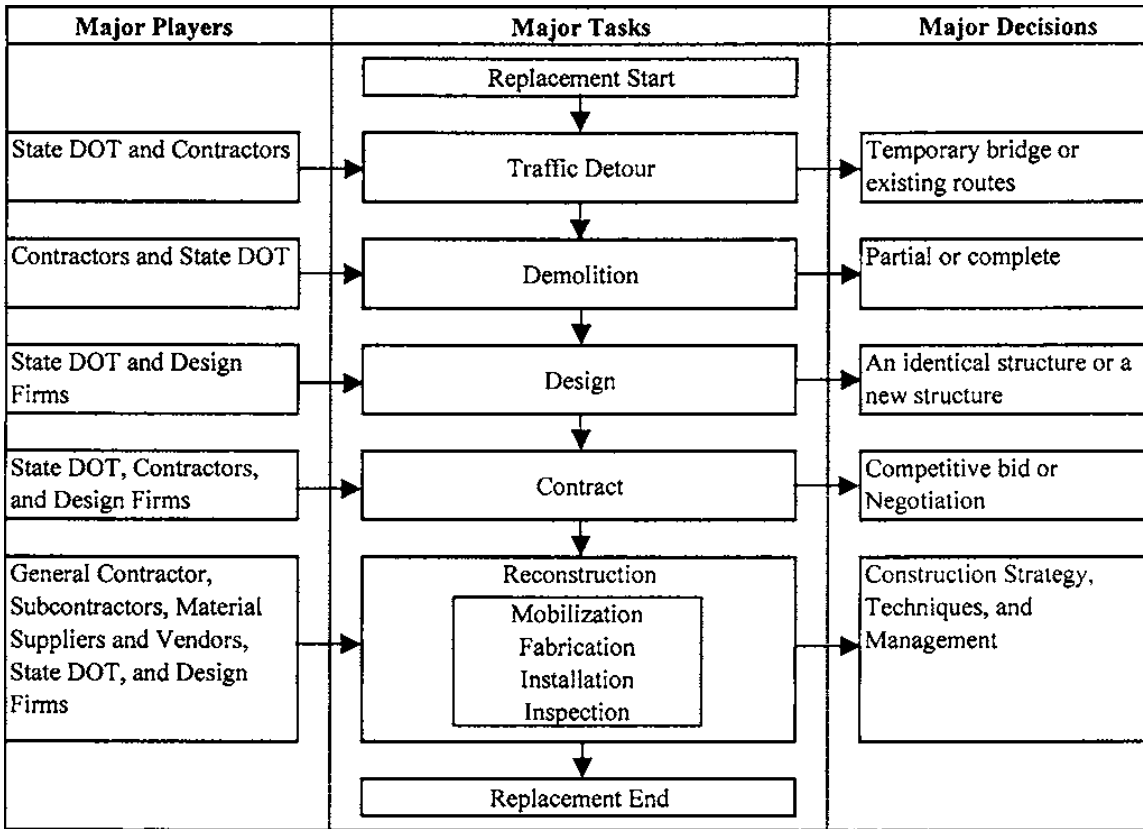


Figure 5. General Model for Bridge Replacement

Source: Yong Bai, William Burkett, and Phillip Nash, “Lessons Learned from an Emergency Bridge Replacement Project,” *Journal of Construction Engineering and Management* 132, no. 4 (April): 338-44, accessed May 11, 2016, <http://www2.ku.edu/~iri/publications/JCEM.pdf>.

Case study number three has two positive outcomes and one negative outcome. Communication has a positive outcome for several reasons. Immediately post incident, ODOT established an effective detour plan that rerouted traffic away from the failed Webbers Falls Bridge. In addition to notifying local drivers of the detour, ODOT also

communicated to long-range travelers from all corners of the state as well as the neighboring states of Kansas, Texas, and Arkansas (Yong Bai, Burkett, and Nash 2006, 339). Integration for this case study has a positive outcome. ODOT did a great job working with and integrating other agencies. There was close coordination with the U.S. Army Corps of Engineers, the U.S. Coast Guard, the National Transportation Safety Board, local police, the Oklahoma Army National Guard, and McClellan-Kerr Navigational Office for the rescue and recovery efforts. They also worked with FHWA for assistance with the emergency bridge replacement contract. Protection for case study number three has a negative outcome. While the piers of the flow of water side of the bridge had concrete blockers to protect the piers from impact on in the center of the waterway, the down water side had no protection for the piers. The pier that was struck and ultimately caused the catastrophic failure of the bridge had no protection on either side of it. There was nothing instructing approaching water transportation to only attempt to cross under the middle sections only. Applicability is neither positive or negative. Not all bridges have piers that are in waterways that are a risk from water transportation.

Case Study #4 Analysis

The fourth case study received one positive and one negative outcome assessment. The findings indicate that jurisdictions share several common perceptions of what might impede their mass evacuation plans (e.g., day-to-day congestion, infrastructure constraints, and communications equipment and frequencies) (Vasconez and Kehrli 2010, 6). Many of the personnel interviewed expressed that while reversal of the flow of traffic in highway lanes, may be practical for hurricane-prone States, it would not constitute a viable option to a quick-onset incident. Other interviewees also noted that

large-scale, mass evacuations would be very unlikely for their respective regions. In the case of certain “quick-onset” incidents (like a “dirty bomb”), and for many incidents it would be a superior decision for incident survivors to shelter-in-place rather than risk evacuation. The DDOT plan for incident evacuation relies heavily on bridges for southbound evacuation. Failure to execute precautions could leave many vulnerable to secondary attacks in a well-coordinated incident. The NCR currently benefits from a Homeland Security Grant to address evacuation planning as a part of catastrophic planning. The DHS/FEMA Regional Catastrophic Preparedness Grant Program (RCPGP) affords catastrophic events planning grants to the 10 highest risk Urban Areas and their surrounding regions. The 10 areas are Chicago, Los Angeles, Houston, New York, San Francisco, Washington, DC, Boston, Honolulu, Norfolk, and Seattle (Vasconez and Kehrli 2010, 73). Communication has neither a positive nor a negative assessment for this case study. Nearly half (12) of the 26 listed a communication issue as one of their top impediments for emergency highway evacuation from their metropolitan area (Vasconez and Kehrli 2010, 96). Some areas have positive discussion of communication practices. For example, in the New York City, New York study, Long Island authorities require approximately 3 to 6 hours prior to closing MTA or Port Authority bridges. This communication is critical to ensure that people using these bridges have enough time to evacuate or do not travel with to them with the intent to cross and find that bridges are closed, and they are stranded (Vasconez and Kehrli 2010, 53).

Table 5. Summary of Jurisdictional Perceptions of Impediments by Location

| Location | Top Impediments/Challenges |
|--|---|
| Atlanta, GA | Contraflow Constraints; Infrastructure Limitations; Arterial Road Systems with Overpasses Cannot Accommodate Trailer Heights; Bridge Weight Restrictions Impede Movements; and Traffic Data is Scattered Throughout the Region |
| Baltimore, MD | Evacuation Plan Needs Updating; Infrastructure Impediments-Roadways; and Region Lacks a Coordinated Signal Timing System |
| Boston, MA | Contraflow Constraints; Shoulders May Not be Able to Support Additional Evacuation Traffic; and No Place for Sheltering |
| Charleston, SC | Infrastructure Constraint I-26; East-West Evacuation Routes; Lane Restrictions; ITS Capabilities along Evacuation Routes; and Incident Responder Coverage Along I-26, Charleston to Columbia |
| Chicago | Traffic Congestion; Emergency Vehicle Access; Railroad Crossing/Street Blockage; Contraflow Operations Would Impede Evacuations; and Real-Time Highway Information for Responders and Public |
| Dallas/Ft. Worth, TX | Infrastructure Limitations; Lack of Cameras along Key Routes; and Evacuation Plans Do Not Exist |
| Denver, CO | No Evacuation Plan; No Evacuation Routes Identified; No Lane Assignments for Emergency Services; Infrastructure Limitations; Traffic Flow Analysis on Evacuation Routes; and Weather Hindrances |
| Detroit, MI | Infrastructure Conditions Impede Responder Operations; Congestion; and Bottlenecks on Freeways, including Narrow Freeway Lanes and Limited Shoulders |
| Hampton Roads, VA | Traffic Signal Timing; Number of Water Crossings; Limited ITS Deployment Along Key Evacuation Routes; Flood-Prone Infrastructure; and Human Resources to Manage Evacuation Operations and Tools |
| Houston, TX | Bottlenecks; Communications with the Public; Number/Type of Resources to Deploy; More CCTV Cameras; and Modeling Timeliness |
| Jacksonville, FL | Work Zones; Limited Fueling Stations; No DMSs on westbound I-10; and No ITS Deployment on Key Interstates |
| Las Vegas, NV | Insufficient Lanes and Daily Congestion; Coordination with Other States on Evacuation Routes; Communications Systems Would Not Support Evacuation Operations; Deployable Traffic Signs and Evacuation Route Signage; and Traffic Flow Monitoring |
| Los Angeles, CA | Congestion and Evacuation Route Capacity; Communications Capabilities; and Public Outreach and Understanding Evacuation Process |
| Miami, FL | Insufficient Road Capacity; Damage to Critical Infrastructure; Work Zones on Major Routes; Traffic Signal Timing; and Lack of ITS Devices on Major Arterial Roads |
| Minneapolis-St. Paul, MN | Infrastructure Capacity and Congestion; Lack of Coordinated Plan and Universal Agreement on the Benefits of Evacuation; Disconnected Transportation and Emergency Operations Centers; Need for More Signage and Public Education; Coordination of Signal Timing Plans; Address Equipment Gaps for Pedestrian Movements; and Develop Multiple Options for River Crossing |
| National Capital Region (DC, MD & northern VA) | Regional GIS Database; Traffic Signal Coordination on Arterials; Limited Roadway Capacity; Institutional Coordination; Communication Interoperability and Protocols; and VIP Movements and Security |
| New Orleans, LA | Highway Flooding; Additional ITS Capacity; Insufficient Capacity; and Lack of Emergency Lanes |
| New York City, NY | Infrastructure Condition and Limitations; Need Improved Coordination between State/Local Transportation Officials and Responders; Limited Deployment of ITS Impact on Sharing Situational Awareness Data; Weather Impacts; and Need for Public Information Campaign |
| Philadelphia, PA | Expressway Congestion; Need for Situational Awareness; Emergency Signal Timing Coordination; Operational Coordination; and Toll Waivers |
| Phoenix, AZ | Communication Capabilities; Community Outreach and Education Program; Rural Evacuation Route Signing and Information (public outreach) Strategy; Mass Evacuation Regional Command and Control Center; and Evacuation Route Signing |
| Portland, OR | Bridge Vulnerability; Capacity and Infrastructure Limitations; Communications and Coordination with Neighboring Jurisdictions and the Public; Communications and ITS Technology for Incident Operations; Improved Traffic Management and Safety; More Robust Planning for Evacuation Operations; and Identification and Use of Resources |
| San Diego, CA | Communication Capabilities; Evacuation Route Capacity; and Need Public Outreach Campaign |
| San Francisco, CA | Communication Capabilities if Damaged; and Infrastructure (Roads, Bridges and Overpasses) along Evacuation Routes |
| Seattle, WA | Congestion; Limited Infrastructure; and Insufficient Responder Resources to Manage an Evacuation |
| St. Louis, MO | Limited Capacity; and Highway Capacity and Bridges |
| Tampa-St. Petersburg, FL | Highway Infrastructure Capacity; Bridge Infrastructure Capacity; Bridge Vulnerability to Damage; Highway Vulnerability to Damage; and Limited Evacuation Routes due to Geographic Limitations |

Source: US Department of Transportation, *Highway Evacuations in Selected Metropolitan Regions: Assessment of Impediments* (Washington, DC: Federal Highway Administration, 2010), 7.

The integration and protection assessment factors for this case study was neither positive nor negative based upon the lack of discussion or evidence within the case study. Applicability for this case study received a positive assessment. This case study evaluated 26 metropolitan area throughout the US. The selected metropolitan areas are from 21 states or DC. Nearly any metropolitan area in the US can find data sets that apply to them as well. The only counter to this is that a mass evacuation would be determined viable after the type of incident was identified. Some large-scale, mass evacuations would be impractical for certain “quick-onset” incidents, and for many incidents, it would be preferable for citizens to shelter-in-place rather than evacuate (Vasconez and Kehrli 2010, 6).

Conclusion

This chapter recapped the previous three chapters and introduced the assessment factors used to analyze the selected case studies. The principle purpose of this chapter is to present the author’s analysis of the selected research methodology from chapter 3. The selected assessment factors are the use of communication, integration of responding agencies, protection of bridges, and applicability to other areas of the nation. The author analyzed four case studies, and discussed them according to strength. The four case studies ended up being strongest to weakest in increasing numerical order (Case Study 1 is strongest and Case Study 4 is weakest). Zero of the selected case studies gained a positive outcome in all four assessed factors. Chapter 5 will serve as the close of this thesis. The final chapter will present the author’s conclusions, recommendations, and proposed areas for future study in relation to this topic.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The previous four chapters sought to identify the answer to the primary and secondary research questions. Chapter 1 introduced the author's topic and research questions. Chapter 2 was the literature review. It presented key federal acts, local and federal government reports, and existing issues and challenges. Chapter 3 presented the research methodology used and explained the rationale for the selection of the four case studies. Chapter 4 described the analysis of the case studies by utilizing the four selected assessment factors. This chapter serves to present three areas. Chapter 5 consists of the author's conclusions, recommendations, and proposed areas for future study.

Conclusions

The primary research question for this thesis is how are US federal and state governments (Maryland and Virginia) taking the appropriate actions in order to mitigate the vulnerabilities of the bridges within the National Capital Region in order to support homeland security measures? This was a difficult question to answer directly. The author was unsuccessful in contact attempts to key subject matter experts within the US DOT or DC. It appears, based upon literature research, that the primary actions that NCR governments are performing are an increase of interagency coordination and communication. There are also training scenarios conducted to identify weaknesses in the NCR's interagency incident response capability.

Secondary research question number two asked, who is responsible for the upkeep, security, and resourcing of the bridges and roads that connect the District of

Columbia to the rest of the continental United States? This was a difficult question to answer. In the NCR, numerous entities, departments, and agencies have a responsibility for some of the bridges. The author found a breakdown of ownership based upon percentages (see figure 2). Four percent of the bridges are under Federal responsibility, such as the National Park Service (NPS) for the region's parkways and the Arlington Memorial Bridge. Seventy percent of the NCR's bridges are under the control of state governments and their agencies with responsibility for the major highways in the region. This includes the Maryland Department of Transportation (MDOT), the District of Columbia Department of Public Works (Transportation Division) (DCDPW), and the Virginia Department of Transportation (VDOT) (Science Applications International Corporation 2002b, 5). The rest of the 26 percent of the bridges fall under local control.

The second secondary research question looked to answer the historical difficulties have hindered the repair of NCR bridges. The author did not find much information pertaining to this question. Based upon the literature review from chapter 2, the historical difficulties have been competing budgetary priorities coupled with loopholes allowing bridge repair funds to be used for other projects.

The third and final secondary research question asked, what are the most critical and vulnerable components of bridges in the NCR? The answer to this is similar to all bridges. As seen in the I-40 bridge collapse case study, the substructure to include piers are catastrophically vulnerable. Significant damage to one pier can cause sectional collapse and render the bridge useless. The NCR should take note of this case study due to the number of important bridges spanning waterways within the NCR.

Recommendations

The first recommendation is the installation of pre-screening sites on all major highway bridge entrances to the NCR. The layout should follow the FHWA's Smart Highway Vision components illustrated in the following figure. This passive system allows for the alerting of authorities to several key bridge or population dangers. The Weigh-in-motion sensor would detect vehicles that exceed the gross weight restrictions for aging bridges. The over-height detector is useful to prevent damage to overpasses on the route. The radiation detection system could be used to alert an active response to vehicles that are carrying radioactive materials for nefarious purposes within the NCR.

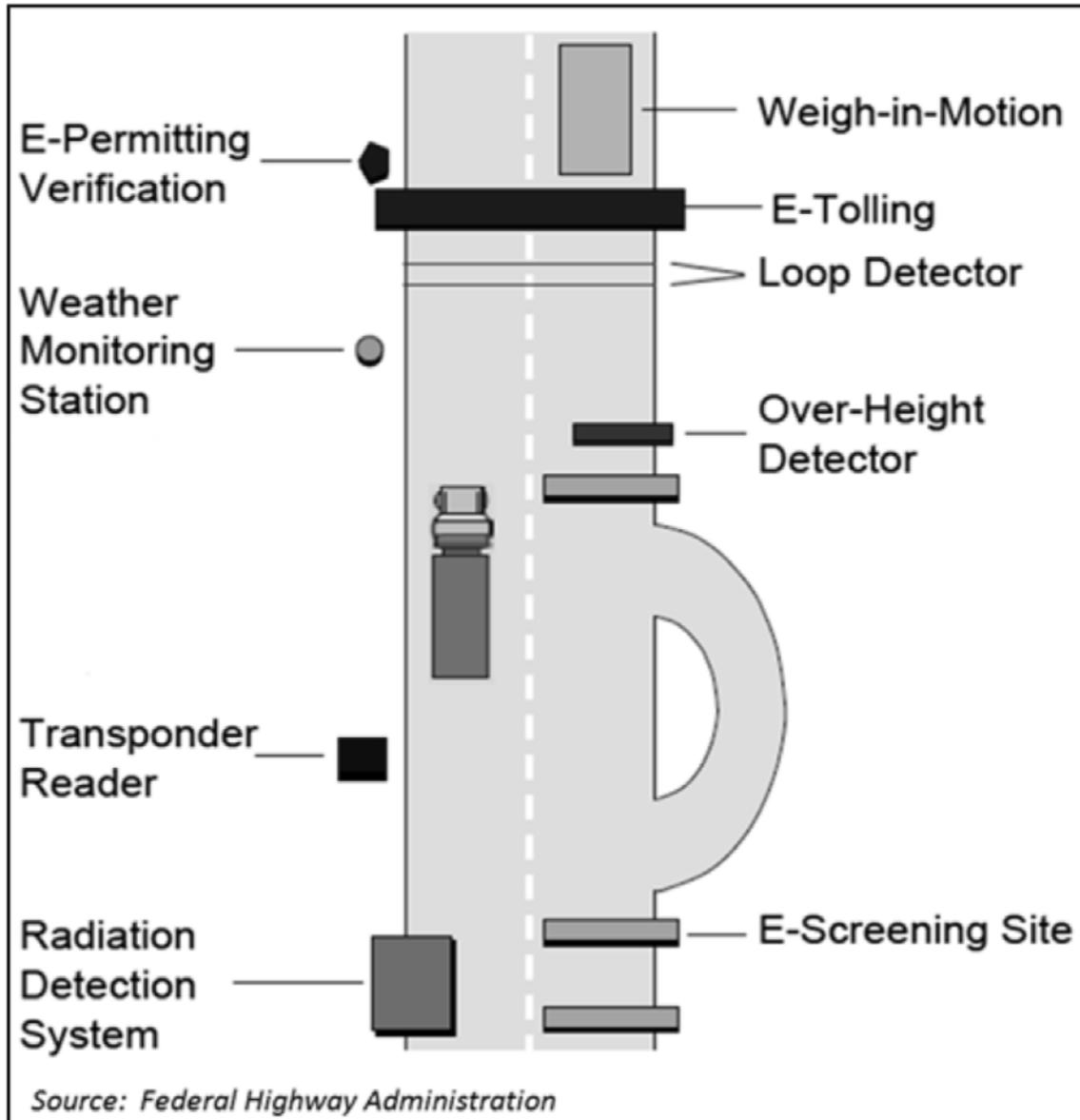


Figure 6. Illustrated Description of FHWA’s Smart Roadside Vision Components

Source: CDM Smith, *District of Columbia Freight Plan*, prepared for District of Columbia Department of Transportation (DDOT) (Washington, DC: District of Columbia Department of Transportation, 2014), 94.

Another recommendation is to garner federal or state government support and funding for retrofitting current critical bridges within the NCR with potential

countermeasures. Some countermeasures identified to deter, detect, and/or defend bridges are listed in the following figure that was developed by The American Association of State Highway and Transportation Officials' Security Task Force 2002.

Table 6. Potential Security Countermeasures for Bridges

| POTENTIAL COUNTERMEASURES | DETER | DETECT | DEFEND |
|---|--------------|---------------|---------------|
| Increase inspection efforts aimed at identifying potential explosive devices as well as increased or suspicious potential criminal activity. | ✓ | | |
| Institute full-time surveillance at the most critical assets where alternate routes are limited or have not been identified. | ✓ | ✓ | |
| Eliminate parking under any of the most critical type bridges. Elimination of the parking can be accomplished through the use of concrete barriers. | ✓ | | |
| Place barriers in such a way as to eliminate ease of access where a vehicle could be driven right up to the asset. | ✓ | | ✓ |
| Install security systems with video capability at all DOT facilities. | ✓ | ✓ | |
| Protect ventilation intakes with barriers. | ✓ | | ✓ |
| Install and protect ventilation emergency shut off systems. | | | ✓ |
| Install Mylar sheeting on inside of windows to protect employees from flying glass in the case of an explosion. | ✓ | | ✓ |
| Place a full-time security officer in a guard shack to control access. | ✓ | ✓ | ✓ |
| Lock all access gates and install remote controlled gates where necessary. | ✓ | | ✓ |
| Develop and implement a department-wide security policy. | ✓ | | |
| Limit access to all buildings through the issuance of a security badge with specific accesses identified and controlled through the card. | ✓ | ✓ | |
| Train all DOT personnel to be more observant of their surroundings and potentially dangerous packages, boxes, people, etc. | ✓ | ✓ | |
| Improve lighting | ✓ | ✓ | |
| Increase surveillance at tunnels by installing cameras linked to the Traffic Operations Center (TOC). | ✓ | ✓ | |
| Add motion sensors to fences. | ✓ | ✓ | |

Source: Science Applications International Corporation (SAIC), National Cooperative Highway Research Program Project 20-07/Task 151B, *A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection*, prepared for American Association of State Highway and Transportation Officials' Security Task Force (Vienna, VA: Science Applications International Corporation), 26.

Areas for Future Study

This section is divided into three topics. They are active mitigations, passive mitigations, and recommended developments. In order to actively mitigate homeland security threats to the NCR bridges, there needs to be an increased presence on NCR bridges. This can be accomplished by increased presence patrols (with varied frequency) or by closed circuit television (CCTV) cameras. Passive mitigations that are currently available include vehicle arrestors (radio frequency, wire cable based, and spike strip based), deployable barriers, and increasing the blast protectiveness of current bridges. Recently developed is the technology for shutting down a vehicle with the use of targeted radio frequencies. I recommend adding this capability to unmanned aerial systems (UAS) or drone platforms. This development would provide non-lethal vehicle stopping capability combined with the surveillance and stand-off that UAS provide.

The sheer number of bridges in the NCR make it fiscally irresponsible to retrofit all bridges with terrorist mitigating features. The question then becomes, is it possible to protect the most probable bridge targets with mitigations? A future study to identify the most likely, most vulnerable, or bridges with the largest financial or death toll impact would be beneficial. It would also be beneficial to mandate security vulnerability mitigations (building materials, sensors, CCTV, etc.) to all new highway bridge construction. There are other questions that the author developed in concert with this research that would benefit from future study. Is the best option preparing for the worst to minimize casualties? This includes pre-staging equipment (i.e. buses for pedestrian foot traffic across bridges and thru tunnels. How cost effective is it to try to combat worst case

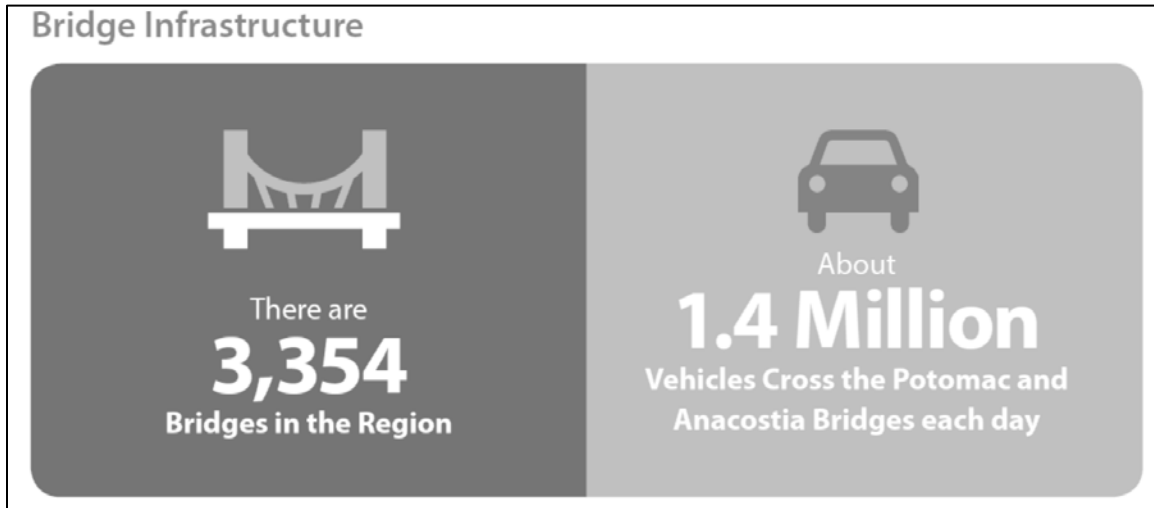
scenarios? Can resources better be served installing smart monitoring systems (with redundant or backup capability) at key locations?

Closing Remarks

Chapter 1 introduced the topic of vulnerable bridges in the NCR. Chapter 2 presented the author's literature review. This included key legislation and reports. Chapter 3 identified qualitative study with a multiple case study design as the research methodology used. Chapter 4 thoroughly analyzed four case studies against the assessment factors of communication, integration, protection, and applicability. This final chapter contained the author's conclusions, recommendations, and identified areas of future study. The conclusions answered the primary and secondary research questions. The recommendations centered on leveraging existing technology and FHWA plans to help mitigate bridge vulnerabilities. The author proposed non-lethal weapon capabilities as both active and passive areas for future research.

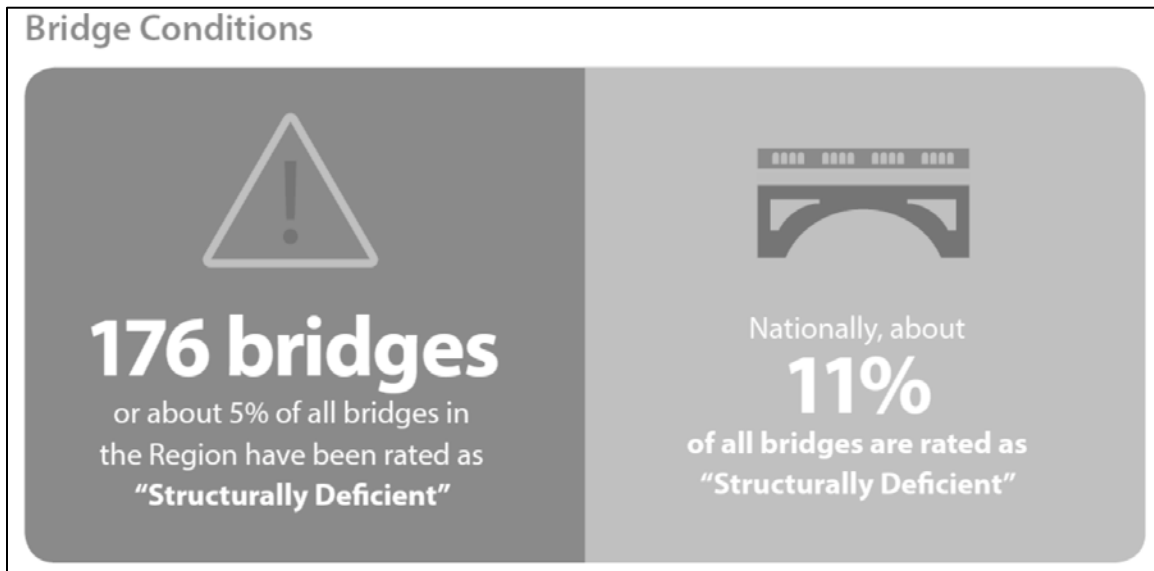
This thesis set out to answer one primary question and three secondary research questions. The author learned a lot about this topic over the eight-month process of completing this thesis. The hope is that others continue to address this pressing issue and take the additional questions generated by the author's research and make them their own.

ILLUSTRATIONS



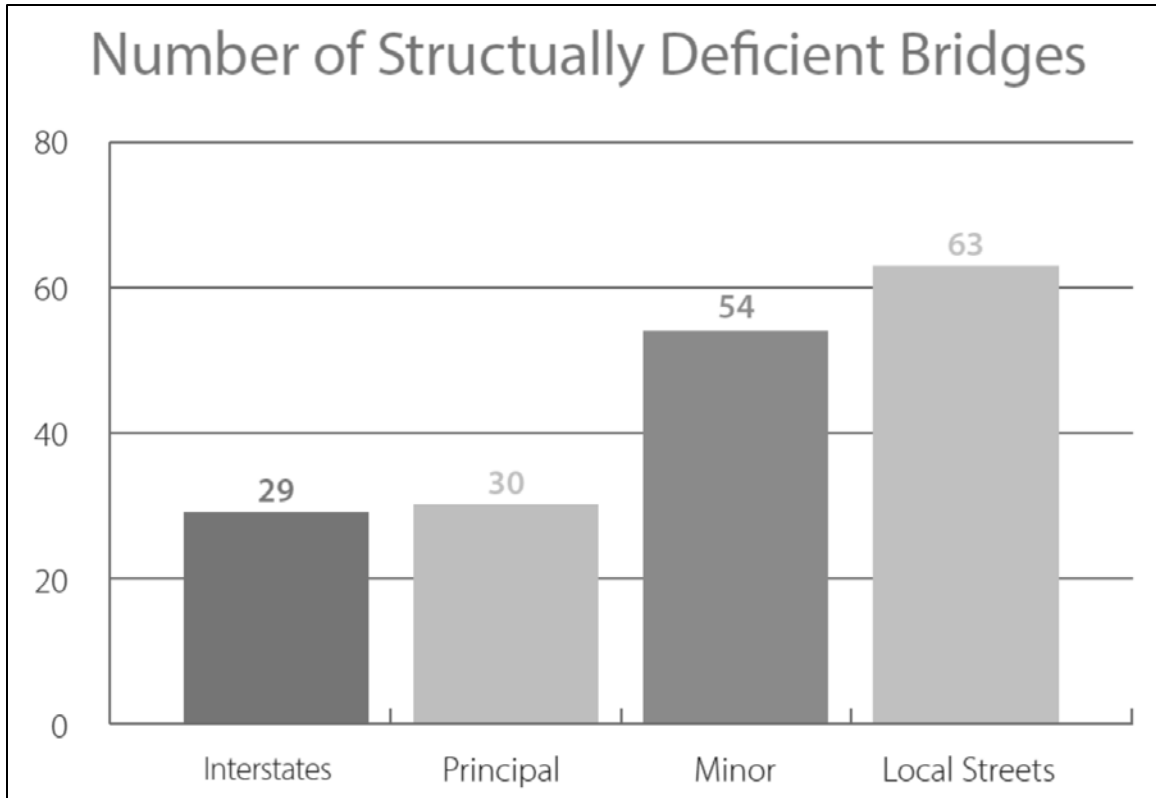
DC Bridge Infrastructure Statistics

Source: Metropolitan Washington Council of Governments, *2015 State of the Region: Infrastructure Report* (Washington, DC: The Metropolitan Washington Council of Governments, January 14, 2015).



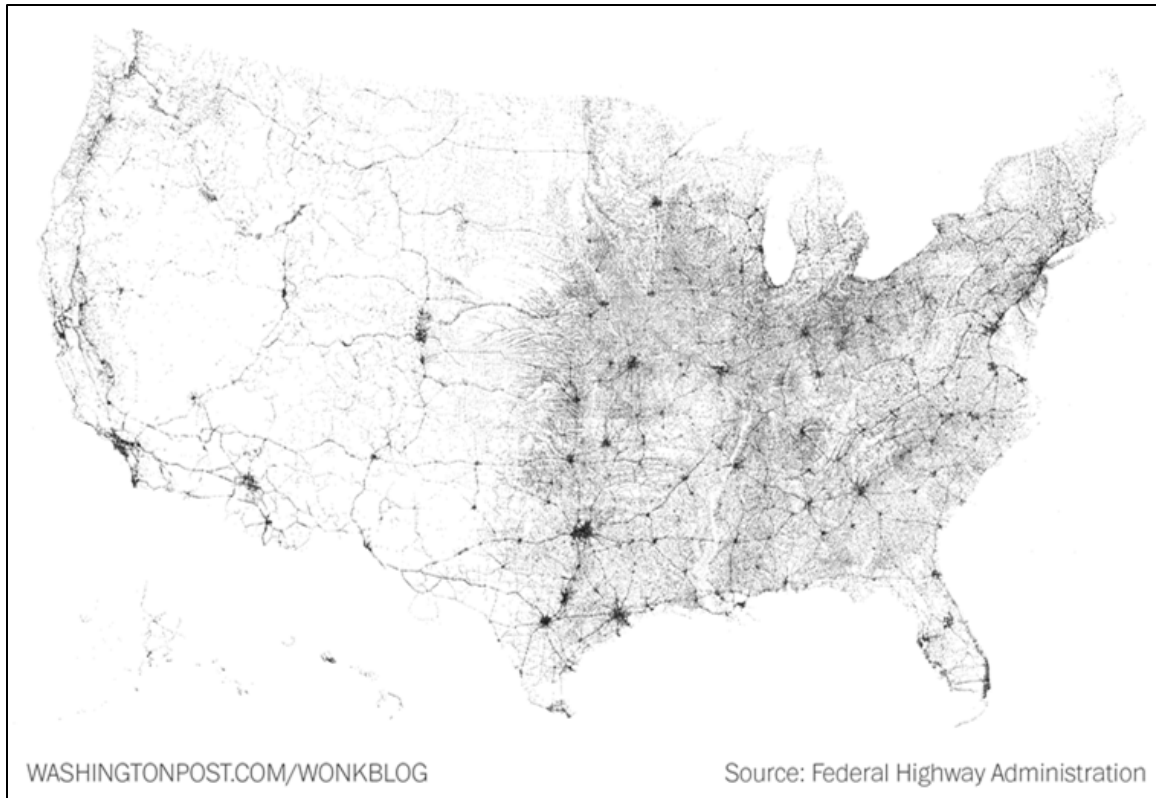
DC Bridge Condition Statistics

Source: Metropolitan Washington Council of Governments, *2015 State of the Region: Infrastructure Report* (Washington, DC: The Metropolitan Washington Council of Governments, January 14, 2015).



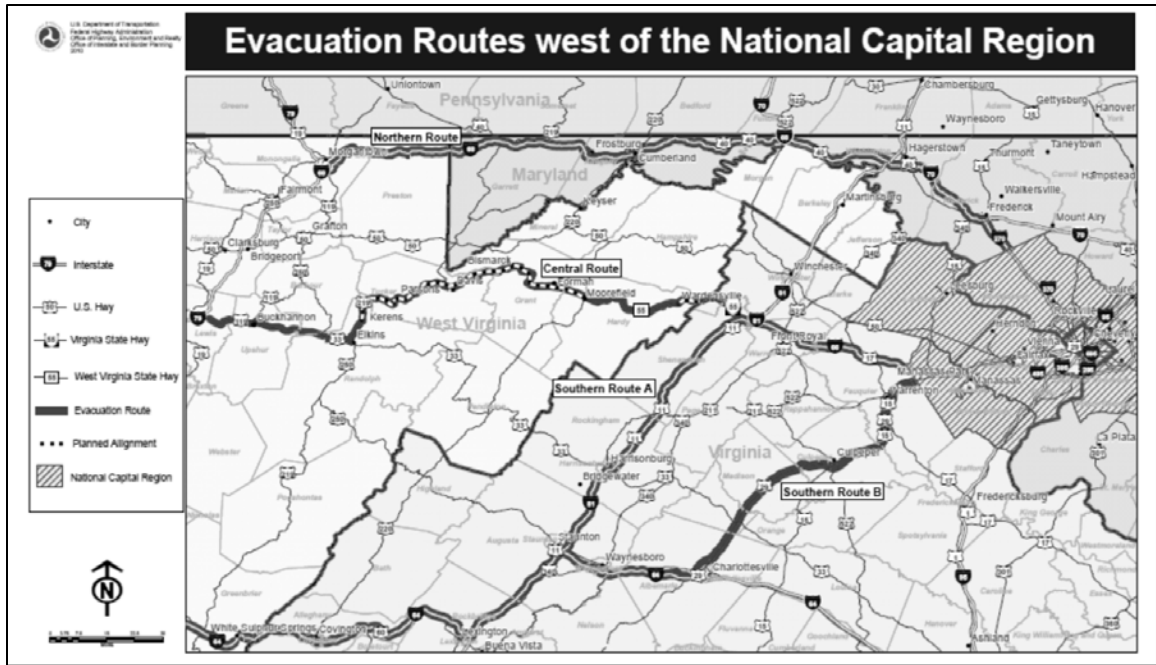
DC Bridges Rated Structurally Deficient

Source: Metropolitan Washington Council of Governments, 2015 State of the Region: Infrastructure Report (Washington, DC: The Metropolitan Washington Council of Governments, January 14, 2015)



A Map of the Continental US Made of Only Plotted Bridges

Source: Christopher Ingraham, “A Surprisingly Accurate Map of the U.S. Made With 600,000 Bridges—and Nothing Else,” *Washington Post*, February 3, 2015, accessed October 23, 2015, <https://www.washingtonpost.com/news/wonk/wp/2015/02/03/a-surprisingly-accurate-map-of-the-u-s-made-with-600000-bridges-and-nothing-else/>.



Highway Evacuation Routes West of the NCR

Source: US Department of Transportation, *Highway Evacuations in Selected Metropolitan Regions: Assessment of Impediments* (Washington, DC: Federal Highway Administration, 2010), 10.

GLOSSARY

Catastrophic Event. Any natural or man-made incident, including terrorism, which results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, national morale, and/or government functions.

CCTV. Closed Circuit Television used for live video monitoring of the roads, bridges, tunnels, etc.

Critical Infrastructure and Key Resources. The infrastructure and assets vital to a nation's security, governance, public health and safety, economy, and public confidence.

Critical Infrastructure Protection. Actions taken to prevent, remediate, or mitigate the risks resulting from vulnerabilities of critical infrastructure assets.

Homeland Defense. The protection of United States sovereignty, territory, domestic population, and critical infrastructure against external threats and aggression or other threats as directed by the President.

Homeland Security. A concerted national effort to prevent terrorist attacks within the United States; reduce America's vulnerability to terrorism, major disasters, and other emergencies; and minimize the damage and recover from attacks, major disasters, and other emergencies that occur.

Incident. An occurrence, caused by either human action or natural phenomena that requires action to prevent or minimize loss of life or damage to property and/or natural resources.

Incident Management. A comprehensive approach to preventing, preparing for, responding to, and recovering from terrorist attacks, major disasters, and other emergencies. Incident management includes measures and activities performed at the local, state, and national levels and includes both crisis and consequence management activities.

National Capital Region. The District of Columbia; Montgomery and Prince Georges Counties in Maryland; Arlington, Fairfax, Loudoun, and Prince William Counties in Virginia. The Metropolitan Washington Council of Governments expands the definition of the NCR to include Frederick County in Maryland.

TRANSCOM. An inter-agency consortium that provides information-sharing and other services to transportation agencies in the New York metropolitan region.

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