

Federal Highway Administration

Assessing Criticality in Transportation Adaptation Planning

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INTRODUCTION

Federal, state, and local transportation planners are considering the range of impacts that climate variability and climate changes may have on assets. Federal Highway Administration (FHWA) put forth a draft conceptual model to assist transportation agencies in systematically assessing the vulnerability of transportation assets ([link](#)). FHWA is sponsoring pilots in 5 locations to test and refine the model. The draft model, illustrated in Figure 1, reflects considerable input from modal experts and is informed by literature reviews of climate-related risk and vulnerability analyses. However, the conceptual model is intended to be a starting point for the FHWA Climate Change Risk and Vulnerability Assessment pilots and other interested parties to begin a dialogue about the climate change vulnerability of the transportation sector.

The first step in the conceptual model focuses on narrowing the universe of transportation assets to facilitate a more in-depth assessment of climate change effects (e.g., changes in temperature, precipitation, sea level rise) on a smaller subset of assets.

“Criticality” in the sense of the FHWA conceptual model is not intended to reflect climate change risk; rather criticality in this context is a filter for screening the universe of assets in a particular geographic area so that the resulting list can be evaluated for exposure, sensitivity, and adaptive capacity (the three components of vulnerability). Due to resource constraints, the multitude of climate effects with the potential to impact transportation systems, and temporal complications related to asset design life, it is recommended that agencies limit the asset list at the outset in order to ensure adequate consideration of the assets that are deemed “critical” in subsequent steps. Appropriate methods for screening transportation assets are wide-ranging and reflect the specific circumstances of the study area, the organization leading the analysis, and a host of other issues, as discussed below. While there is no “one-size-fits-all” approach, this memorandum provides options and considerations for developing an appropriate criticality assessment strategy.

Figure 1: Assessing Criticality is the First Step in FHWA’s Conceptual Model

The FHWA pilots, currently in various stages of implementation, have grappled with some of the key issues surrounding criticality. Some of these same issues have been explored in the DOT-funded Gulf Coast Study, Phase 2 of which is being carried out in Mobile, AL. The remainder of this memorandum discusses the common challenges associated with assessing criticality; options for defining criticality and identifying scope; and applying criteria and ranking assets.

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COMMON CHALLENGES IN ASSESSING CRITICALITY

The following challenges are common when attempting to identify critical assets.

- Definitions of criticality are vague and can be difficult to implement. Who decides what is critical?

- It is difficult to define the boundaries and relationships of the system(s) in which the asset is embedded (e.g., a highway may have more importance to a multi-state region than to a particular county’s economic activity).
- It can be time-consuming, difficult, or impossible to gather certain types of data on assets in a study area, particularly privately owned assets (e.g., pipelines, ports, freight rail).
- Even when data are readily accessible from internal databases or elsewhere, it can be very difficult to integrate information on assets efficiently (e.g., spatial data may have incorrect or inconsistent reference information, making integration with other spatial data challenging).
- What defines “an asset”? Organizations must decide whether (and how) to include transportation-related services (e.g., ITS) and the appropriate level of disaggregation. For example, should the asset be defined as the airport complex, the service line from the airport to another destination, a specific runway, or the pavement on the runway?

OPTIONS FOR DEFINING CRITICALITY AND LIMITING STUDY SCOPE

GOALS AND AUDIENCE FOR VULNERABILITY INFORMATION

The New Jersey Pilot Approach

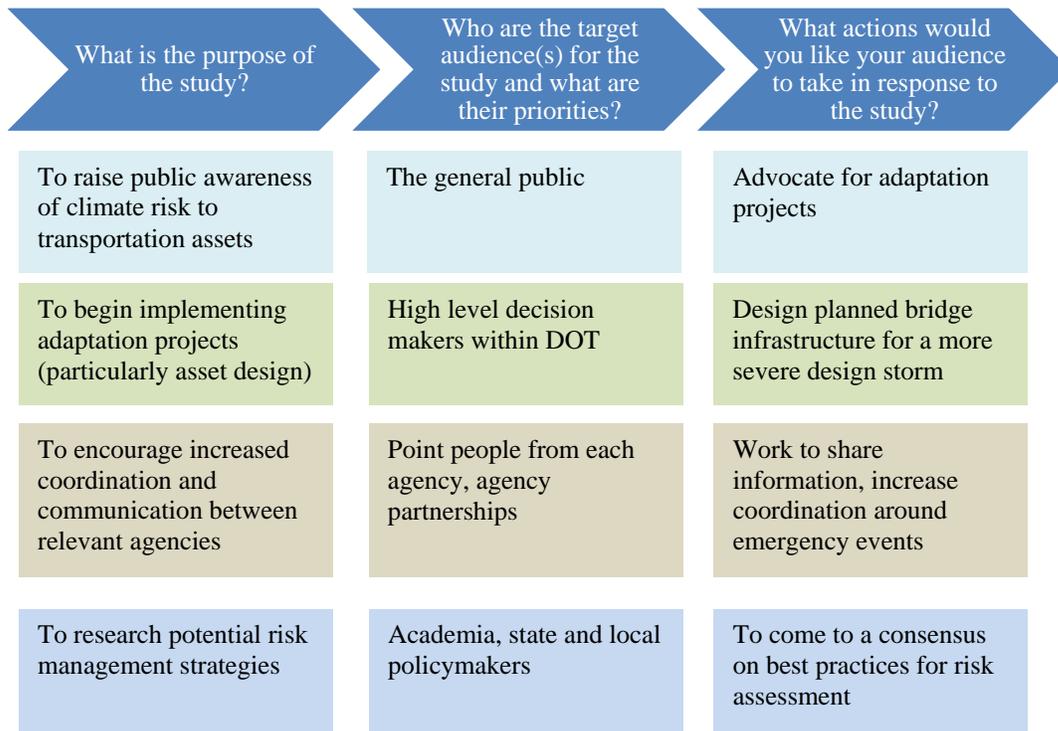
The New Jersey pilot aims to improve coordination among agencies and also to educate upper management in state agencies about the vulnerabilities of the key transportation systems to changes in climate. The pilot partnership recognizes that effective adaptation will require coordination from state and local transportation agencies, as well as state environmental, emergency planning, and other offices. In recognition of these goals and the importance of creating buy-in early in the process, the leadership team for the study includes staff from multiple levels of government and representation from practitioners in emergency management, transportation, and environmental issues.

Several of the key challenges that have vexed practitioners at the forefront of adaptation planning are related to what is meant by the term “critical” and which assets are in/out of the boundaries of the vulnerability assessment. For this reason, it is necessary to clearly define the purpose and intended audience for the overall vulnerability assessment, which includes the criticality assessment. For example, the analysis may be intended to communicate the risks of climate change, justify specific projects, inform design decisions on projects in the pipeline, or a host of other outcomes. Recognizing the intended use of this vulnerability information and the intended audience (e.g., state legislators, transportation officials, planners) should drive

the design of the criticality assessment method. Figure 2 outlines three initial steps that can help agencies formulate their vulnerability assessment. First, define the purpose of the study. Second, identify the primary and secondary audiences for the study. Third, articulate the actions you would like the target audience to take in response to the study. Even though the criticality assessment process may be similar between the four example projects listed in the figure, the details of the assessment will differ in order to reflect the intended goals of the project. In particular:

- Should your assessment include many assets or only a few? (Is the intent to go deeply into a few key assets or to focus broadly, but with less depth?)
- Should your assessment include a range of modes, or only one mode?
- How should you define “critical”? Should the focus be on economic drivers, health and safety concerns, replacement cost, or other criteria?
- Who are your stakeholders? When should you involve them in the process?

Figure 2: Vulnerability Assessment: Purpose, Target Audiences, and Intended Results



DEFINING CRITICALITY

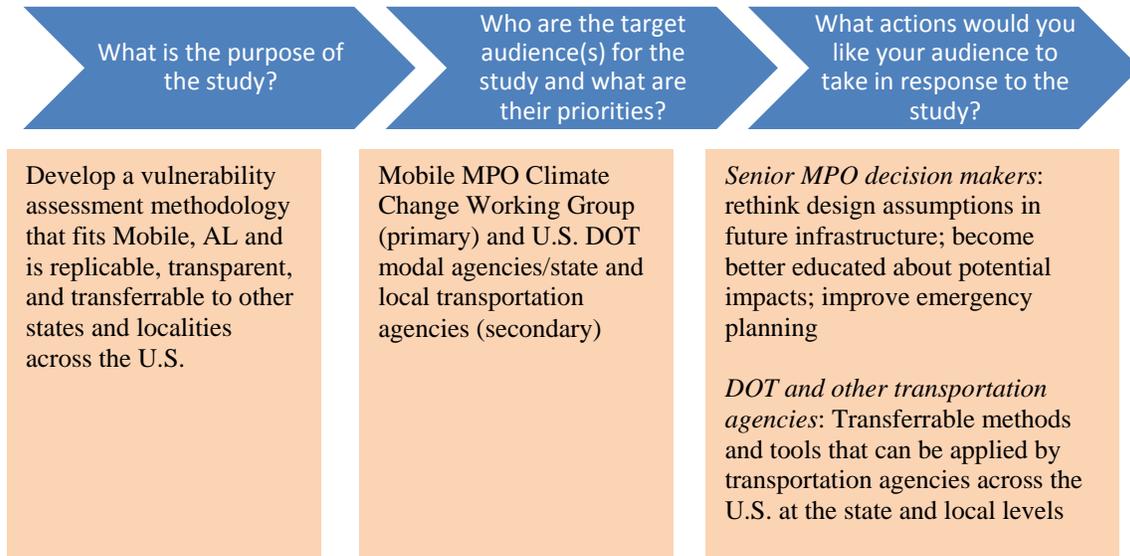
For many, the definition of a critical asset as an asset that is so important to the study area that its removal would result in significant losses.¹ However, this definition does not resolve three important questions: what is an asset, what is the study area, and who defines significant losses? If we assume that our definition of critical should align with the profile of our target audience, we can make the definition of criticality more specific. For example, the local decisionmakers are likely to care about high profile, high-use assets across all modes, while senior management within a single agency is likely to prioritize assets that they own or operate.

The Oahu MPO Pilot Approach

The Oahu MPO pilot is hoping to influence three main target audiences: the public, the engineers and planners from the City & County of Honolulu and Hawaii Department of Transportation, and the MPO legislator and council members. The pilot is targeting the general public audience since one of the most recent, long-range planning-related surveys indicated a need for more education on climate change, particularly among the Title VI/Environmental Justice populations. The pilot is also aiming to create a “feedback loop” to encourage planners and engineers at the City & County of Honolulu and Hawaii Department of Transportation to consider the long-term impacts of design decisions that are being made on an ongoing basis. Finally, the pilot has found a wide range of thought on climate change among local decision makers. The pilot is therefore aiming to educate these legislators and council members with the hope that they will make informed decisions on adaptation. To facilitate communication to the target audiences, the pilot project has chosen to focus on a few high-profile, easily recognizable asset “complexes.”

¹ For example, see DHS (2007). Transportation Systems: Critical Infrastructure and Key Resources Sector-Specific Plan as input to the National Infrastructure Protection Plan. Department of Homeland Security. Arlington, VA. <<http://www.dhs.gov/xlibrary/assets/nipp-ssp-transportation.pdf>>

Defining Criticality in the Gulf Coast Phase 2 Study



Because of the far-reaching goals of the study, the assessment of critical assets for Gulf Coast Phase 2 covered all modes. The emphasis on replicability and transferrable lessons drove the study team to focus the initial assessment on transparent, quantitative (wherever possible) criteria; these criteria were then equally weighted to reflect socio-economic importance, operational/use and health & safety concerns. Because Mobile, AL is centrally located among multiple regional intermodal connections, accessibility to the ports and pipelines were also factored into criticality.

DEFINING SCOPE

Defining the scope of the project involves determining how many critical assets to identify and how to draw the spatial (e.g., county, state), temporal (e.g., existing, planned, existing and planned assets), modal (e.g., highways, ports, freight rail, transit), ownership (e.g., state-owned, county-owned, privately owned), and other parameters of the study. The sections below provides a discussion of several kinds of boundaries and the types of considerations that may go into decisions regarding boundaries; in practice, the scope of a vulnerability analysis should reflect the objectives and constraints of the target decision maker and key stakeholders.

The San Francisco/MTC Pilot Approach

The purpose of the SF/MTC pilot is to develop a risk assessment methodology which will inform planning decisions around existing and planned infrastructure on the shoreline. The SF/MTC pilot is considering a range of criteria, many of which focus on identifying assets likely to be affected during an emergency or by flooding/sea level rise.

GEOGRAPHIC SCOPE

Each of the five FHWA pilot projects has already determined a geographic scope for the project. In some cases (such as the Oahu MPO), this geography was more obvious than in others (such as the Newark, NJ pilot partnership). For state and local transportation agencies, geographic boundaries will be one of the most important determinants of scope. For the pilots, like Newark, where the region is an integral part of significant transportation-related activities in the larger region (i.e., the NY-DC corridor), the importance of

a particular asset may need to be considered in two contexts: the importance of the asset to parties involved in the vulnerability assessment, as well as the importance of the asset in the context of broader regional or national systems which include the asset (e.g., interstate commerce on I-95).

TEMPORAL SCOPE (FUTURE ASSETS)

The study goals and audience may drive the temporal scope of the assets being assessed for criticality. If the target audience includes maintenance staff, then the assets (and the associated effects) should focus on near-term, seasonal effects rather than long-term changes in climate (e.g., temperature trends). Alternatively, if the goal of the assessment is to help a metropolitan planning organization consider climate change effects in their long-term planning efforts, then it may be useful to include the assets in the long-range transportation plan in the “universe” of assets to be screened against criticality criteria and ultimately reviewed for vulnerability. In general, if the audience for the study has a purview for assets with long design lives (and planned upgrades) or assets envisioned for the future, it is important to include these assets in the analysis.

MODAL SCOPE

The position of the decision maker and the perspectives of the stakeholders should determine the initial list of modes to include in the analysis. In many cases, the study may only include modes that the target decision maker or ultimate audience has influence over. Potential transportation modes to include in the analysis include: highways, public transit, aviation, maritime, pipelines, bicycle and pedestrian facilities, and railroads.

OWNERSHIP

The agency assessing criticality may want to limit the scope of assets considered in the criticality assessment based on ownership of the assets. Smaller, more focused analyses may limit the scope to assets owned and/or operated by the agency itself. For example, the WSDOT pilot is focusing its analysis on the State Highway System assets since the agency is responsible for the planning, design, construction, and maintenance of this system. This system includes assets such as roads, wetland mitigation sites, stormwater treatment facilities, rest areas, park and ride lots, transit facilities, maintenance facilities, air field assets, and the Washington State Ferry system.

APPLYING CRITERIA AND RANKING ASSETS

After articulating the project’s scope, purpose, and intended audience, the next step is to assess the criticality of assets.

DEFINING ASSETS AND SYSTEMS

The criticality of an asset depends both on its physical characteristics (e.g., replacement value) and on its function in multiple systems (e.g., emergency evacuation route, key commercial route, level of activity, value of freight carried). One of the challenges that agencies face during the criticality assessment is defining assets and determining which auxiliary systems to include in the analysis. For example, a study aimed at educating the general public or local decisionmakers might prefer to aggregate assets into highly recognizable “complexes.” A study aimed at increasing agency cooperation will want a higher level of detail with a particular focus on asset function across systems. Finally, a study with the objective of

implementing adaptation strategies (e.g., asset management systems considering changes to design/retrofits) will require a level of detail high enough to inform quantitative assessments of

The WSDOT Approach

The objective of the WSDOT pilot study is to develop a methodology for evaluating transportation assets vulnerable to climate change related impacts and to prioritize those assets for pro-active response actions. The pilot is aiming to provide results that enable decisionmakers to better protect critical and vulnerable transportation assets from climate impacts. The pilot has focused only on the assets it owns and operates and has deeply involved O&M and engineering stakeholders. The pilot defined assets broadly, but according to engineering and technical considerations. For example, the asset list specifically includes ramps as distinct from roadways.

vulnerability and risk and analyses of possible adaptation strategies specific to that asset.

Along with asset definitions, the study will define which supporting system to include. Electricity transmission and distribution systems and intelligent transportation systems (ITS) are examples of auxiliary systems that might be considered “critical.” The extent to which these systems are included in the criticality assessment depends on the purpose and intended audience of the study. If emergency management is a primary or secondary goal, the agency may want to include ITS systems. If power outages are a primary concern, the vulnerability assessment may need to address electricity assets.

THREE APPROACHES TO CRITICALITY ASSESSMENT

In practice, the five FHWA pilot projects have used three approaches to narrow the universe of transportation assets based on their individual interpretation of criticality: the desk review approach, the stakeholder solicitation approach, and the hybrid approach. Each of these approaches is described in more detail below.

APPROACH 1: DESK REVIEW

One approach to formulating criticality criteria is to identify a broad range of criteria that capture use and access across a range of modes and systems. The desk review emphasizes objectivity and quantitative information based upon readily available data sources and that require little local knowledge to apply in asset ranking. In the desk review approach, modal experts or modelers use prioritization schemes already in place and rank assets based on data such as average daily traffic, functional classification, and expert judgment.

This approach may or may not weight individual factors in an attempt to rank and classify the assets. This method may lend itself to studies intended to further research on appropriate decision support tools in this area and/or academic audiences. Advantages of the approach include its transparency and replicability. However, lack of data on important elements of criticality, many of which are qualitative and locally specific, or not available from the private sector, could undermine results of the desk review in the eyes of the local stakeholders and decision makers.

The VDOT/Hampton Roads Pilot Approach

The VDOT/HR pilot is aiming to identify a short list of assets for the Multi-Criteria Decision Analysis (MCDA) model. The VDOT/HR pilot is relying on the existing prioritization schemes of different agencies in order to identify critical assets. In particular, the pilot program has prioritized assets by examining hurricane evacuations routes, traffic volume, and maintenance priorities (e.g., which areas are prioritized for snow removal following winter storms).

APPROACH 2: STAKEHOLDER ELICITATION

Determining asset criticality based on input from select stakeholders and local experts is a second approach to assessing criticality. With a stakeholder elicitation approach, the project leaders will identify a group of stakeholders in the region with expert knowledge of specific interests (e.g., commercial activity, public safety, or road maintenance). The project leaders will then organize a workshop or series of workshops designed to elicit feedback from these stakeholders on which assets are critical.

Advantages of the stakeholder approach include getting buy-in from relevant stakeholders early in the process, encouraging collaboration and communication among stakeholders and actors likely to implement any adaptation strategies, accessing information that is not readily available in publicly-available datasets, and quickly assessing criticality without a lengthy research process. However, the results of the stakeholder-driven process are highly subjective. The outcomes are highly dependent on the quality of the workshop facilitation, the composition of workshop attendees, and the participation of key experts.

APPROACH 3: HYBRID APPROACH

The hybrid approach includes aspects of both the desk review approach and the stakeholder elicitation approach. Hybrid approaches often begin the process with a desk review which identifies a long list of critical assets based on commonly available data such as average daily traffic or economic information for the region (e.g., data on imports/exports from a particular port). The project team will then use the results of the desk review to inform and structure feedback from stakeholders and local experts.

Lessons Learned from the Gulf Coast Phase 2 Criticality Assessment

During the Gulf Coast Phase 2 project, criticality was defined as a function of socioeconomic considerations, use/operations, and health/safety priorities. Since the project looked across a number of modes, these overarching categories of criteria were chosen to maximize consistency across modes; however, specific criteria chosen in each category for the various modes were subsequently identified. The audience for this project includes transportation agencies *across the country* as well as decision makers in Mobile, AL; thus, objectivity, inclusivity, and transparency were key. This is why the Gulf Coast Phase II project utilized a hybrid approach with a strong desk review element augmented with periodic input from a local working group. The working group weighed in on the initial approach, the categories of criteria, and the mode-specific criteria. Transportation experts evaluated all available data and scored assets from 1 to 5 (low to high). Assets were then binned into high, medium, and low categories based on the distribution of asset scores. The project team presented the results from this desk review at a stakeholder meeting and adjusted the list of critical assets based on stakeholder feedback.

Criticality = f(Socioeconomic, Use/Operations, Health & Safety)

E.g., access to major employment centers

E.g., average daily traffic, ridership, freight tonnage

E.g., access to hospitals, evacuation routes

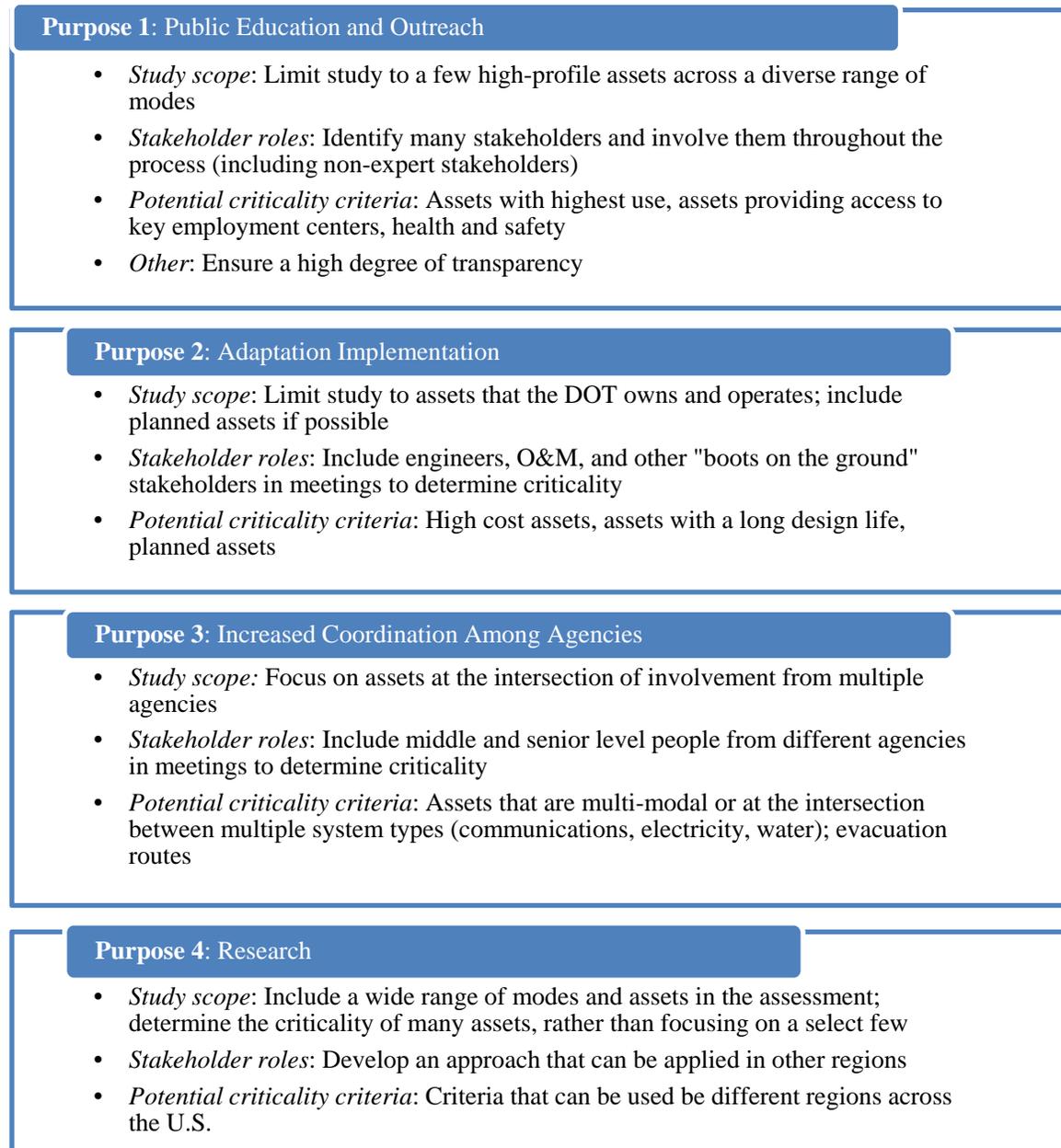
CONCLUSIONS

There is no single right way to assess criticality as the first step in an overall vulnerability assessment. Figure 3 provides some hypothetical examples of how different target audiences and purposes might shape the details of a criticality assessment, drawing upon some of the points raised previously in the memorandum. The approaches in the figure build on the illustrative examples in Figure 2, aligning project purpose with study scope, audience, and criteria that might be used in the ranking of assets.

In the experience of FHWA sponsored projects to date, successful criticality assessments generally:

- Identify assets that align with the priorities and values of the target audience.
- Create buy-in from important stakeholder groups (stakeholders who comprise or influence the target audience).
- Develop and organize relationships, contact information, data sources (spatial, financial, engineering), and other resources that will be useful during the subsequent vulnerability and risk analysis.
- Involve some sort of qualitative or quantitative ranking scheme based on identified criteria.

Figure 3: Illustrative Approaches to Criticality Assessment, Depending on Project Purpose and Intended Audience, Building on the Hypothetical Examples in Figure 2



REFERENCES

DHS (2007). Transportation Systems: Critical Infrastructure and Key Resources Sector-Specific Plan as input to the National Infrastructure Protection Plan. Department of Homeland Security. Arlington, VA. <<http://www.dhs.gov/xlibrary/assets/nipp-ssp-transportation.pdf>>