Photo: National Oceanic and Atmospheric Administration

Baking Resilience into Freight Mobility Planning

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Above: A week after Hurricane Sandy tore through the Northeast in 2012, the *NOAAS Thomas Jefferson* launched a high-tech survey boat to check the waterways in the Port of New York–New Jersey. Resilience planning may have different meanings for different freight modes, but it is crucial to all of them.

By its very nature, freight infrastructure is a long-term investment, and its assets must serve the test of time. Time is not the real issue, however; it is how the facility responds to and recovers from the stress and shock of natural and manmade events that determines the resilience of the freight transportation system.

To ensure that resilience is incorporated into the freight planning process, freight planners must understand the following four aspects:

- The definition and meanings of resilience,
- How best to raise the awareness of the need for resilience,
- An approach to incorporate resilience in freight planning, and
- The areas where resilience best fits in the established freight planning process.

Defining Resilience

"Resilience" (and its variant, "resiliency") is a somewhat nebulous term. Derived from the Latin *resiliens*, meaning "to rebound or recoil," resilience is the capacity of a strained body to recover its form after experiencing shock or stress.

Depending upon one's experiences, needs, and modes, resilience can mean different things. To some, it may mean versatility and flexibility; for example, Minneapolis, Minnesota, converting roadway shoulders to bus lanes during peak traffic periods or Florida converting southbound Interstate lanes to northbound lanes to facilitate evacuation during hurricanes or tropical storms. Commercial airports may view resilience as the ability to recover quickly from severe weather and resume normal operations. Railroads have contingency plans to reopen rail lines that have experienced adverse weather or derailment and redundancy in their system to divert rail traffic to alternate routes as needed. A seaport may view resilience

Photo: Wikimedia Commons

The Minneapolis–St. Paul region widely deploys bus-on-shoulder travel—an example of resilience in dealing with traffic congestion.

in terms of infrastructure that is durable, tough, and always works.

Transportation system resilience often is linked to weather extremes and climate change, but this is only one of many reasons to develop a resilient freight system. Remember the old Timex wristwatch slogan “it takes a licking and keeps on ticking?” The message was that it is waterproof, dustproof, shatterproof, and shock-resistant; it works all the time (no pun intended). Transportation infrastructure needs to be resilient—a similar slogan to the old Timex ad might be “it takes a pounding but keeps on rebounding.”

But what is resilience, and have we defined it? Figure 1 illustrates the many different meanings of “freight resilience.” If we want to ensure the freight transportation system is ready and able to support the movement of goods, then we must plan for it and factor in the critical tenets that define resilience.

The Fixing America’s Surface Transportation Act of 2015 (FAST Act) requires the consideration of projects and strategies to “improve the resilience and reliability of the transportation system” in the planning process. Although the Federal Highway Administration (FHWA) does not offer guidance for incorporating resilience into transportation planning, it provides a white paper on how states and metropolitan planning organizations (MPOs) are integrating resilience. As noted in a RAND Corporation study, FHWA’s *Vulnerability Assessment and Adaption Framework* helps guide assessment of transportation infrastructure vulnerabilities but stops short of integrating resilience into planning.

FHWA incorporates resilience as a tenet of sustainability. For example, FHWA’s Infrastructure Voluntary Evaluation Sustainability Tool (INVEST) is a web-based collection of best practices and is available for planning agencies to evaluate and assess sustainability and resilience of projects and programs. INVEST notes that planning and designing for infrastructure resilience supports all the triple bottom-line (TBL) principles of sustainability—environmental, social, and economic—because it provides energy savings, improves transportation system and user safety and security, and reduces future spending on infrastructure replacement.

Like the sustainability TBL, resilience also can be viewed as a stool with three legs. First, resilience is a key characteristic of the freight transportation system; however, as the word-cloud graphic in Figure 1 demonstrates, resilience possesses many attributes. Second, resilience also should be an important element of the freight planning process. As the title of this article suggests, resilience, like safety and quality, must be inherent to freight transportation infrastructure. Third, resilience must become an outcome of the freight planning

FHWA’s INVEST tool, which helps agencies evaluate and assess project sustainability and resilience, was deployed in the rehabilitation of the Going-to-the-Sun Road in Glacier National Park, Montana.

process. Prioritizing projects should include criteria for reliance—infrastructure investment decisions are made for the long term.

These assets are built to support the economy for future generations. In reality, resilience exists on a continuum that may be present to differing degrees depending upon the external forces exerted on the system and across the asset’s lifespan. So although a particular bridge might be able to withstand heavy truck traffic today, it might not be resilient enough to withstand an earthquake tomorrow.

FIGURE 1 “Resiliency” word cloud.

Photo: Jacob W. Frank, National Park Service

Freight moves 24 hours a day, seven days a week, 365 days a year, and the multimodal freight system that provides that conveyance must always be available to perform consistently and facilitate the unimpeded movement of goods and commodities.

When freight moves freely, customer service is maximized and logistics costs are minimized—and everyone wins. Moving freight requires tough, strong infrastructure. A typical Class 8 commercial truck with a loaded trailer weighs 80,000 pounds. Forty tons of mass moving at 65 mph every day has a significant impact on roadway infrastructure. A loaded rail hopper car weighs 286,000 pounds, and although loaded tri-level auto racks and loaded double-stacked intermodal well railcars vary in weight, 170,000 pounds is typical.

Over time, the mass (by weight and volumes), speed, and frequency of goods movement exerts wear and tear on the infrastructure. The laws of physics are inescapable. As a result, even before considering climate impacts and other events, infrastructure already needs to be resilient and these factors must be incorporated into the freight planning exercise.

Planning to incorporate resilience factors into the freight transportation system is the proactive approach. Although we cannot predict the future, we can plan for it. Resilience planning must plan not only for how a facility recovers from an event but also how such an event can be avoided. Arguably, there is no such thing as being "reactive to resilience." Failing to plan is planning to fail. Events on nonresilient infrastructure lead to an overburdened, costly reaction and recovery effort.

Developing Resilient Freight Infrastructure

Understanding resilience is the first step to incorporating it into transportation system planning. Eight tenets provide the foundation for resilient infrastructure: availability, reliability, durability, redundancy, adaptability, demand, recoverability, and vulnerability. Although each tenet is an important factor, some may be more important than others (Figure 2). For day-to-day freight mobility needs, the first four tenets align with the immediate mandate for supply chains to function. Being available, reliable, durable, and redundant supports today's need for mobility to be immediately responsiveness to maximizing customer needs while minimizing transportation costs. As supply-chain needs fluctuate over time or as disruptive events occur, the other four tenets—adaptability, demand, recoverability, and vulnerability—rise in importance.

System Shocks

As 2020 has proven, supply chain disruptions do occur; suppressing the importance of any tenets is shortsighted. All tenets are important, but their relevance varies in different geographies and operational situations.

The freight transportation system reels from the effects of shock and stress every day. These factors are omnipresent and must be considered during infrastructure inspections, risk assessments, and when conducting strengths-weaknesses-opportunities-threats (SWOT) analysis. The underlying

Photo: Birmingham Photographer J.g., Flickr

A BNSF train returns to a Birmingham, Alabama, railyard after dropping off auto racks. Moving heavy freight loads requires durable infrastructure.

FIGURE 2 Resilience in the context of the overall multimodal freight transportation system rather than a single aspect or portion of the system.

causes of shocks and stress can be natural as the physical environment is dynamic and powerful. Similarly, human factors both intended and unintended manifest as shocks or stress, or both. Equally important are institutional factors and economics, which drive the demand for freight transportation infrastructure (Figure 3).

The adage "a chain is only as strong as its weakest link" may be appropriate for some supply chains that are lean or lack options and alternatives, but the multimodal freight system supports every supply chain in the nation. Therefore, it should be a goal to ensure that the freight transportation system incorporates multiple links to overcome expected stresses and shocks. Given the expansiveness of the freight transportation system, resilience failures will occur.

In today's parlance, freight movement is a contact sport. To be proactive, we need a strong defense: planning and preparation. Equally important, we need a robust offense: policies, programs, and projects to maintain the freight transportation system. Incorporation of resilience into the planning process and preparations for contingencies sets the conditions to establish effective polices and selection of programs and projects to develop a resilient freight transportation system.

Photo: SoulRider.222, Flickr

St. John's Bridge looms behind University Park, Oregon. Resilience considerations for mountainous regions are different from those in areas with flatter terrain and more roadway connections.

Proactive Measures

A process to assess and measure resilience needs to be developed. One way to approach this task is to develop assessment criteria to underscore each of the tenets presented above. For example, reliability factors could include consistency of peak traffic volumes and unpredictable but frequent adverse weather, such as ice or fog. Criteria for durability may include the ability of pavement to support large quantities of truck traffic or susceptibility to frequent potholes. Redundancy could include the existence of parallel or alternative roadways, inland waterway and rail options, and the like.

Different levels of vulnerability depend upon the location and situation of the asset—for example, one in a flood zone—as well as upon the criticality of the asset—for example, one that is part of the primary multimodal freight network. Once criteria are identified for each tenet, each criterion can be assigned a weight to align with its relevant importance in different geographical areas. Mountainous states with challenging terrain may not have the same redundancy of roadway routes as a state with flat topography. Some states are not connected to the inland waterway system, while others are located in climate zones that experience frequent freezing and thawing, and some states are located where major shocks occur, such as earthquakes and hurricanes.

Although all tenets of resilience must be considered, different criteria and weighting these criteria allow freight

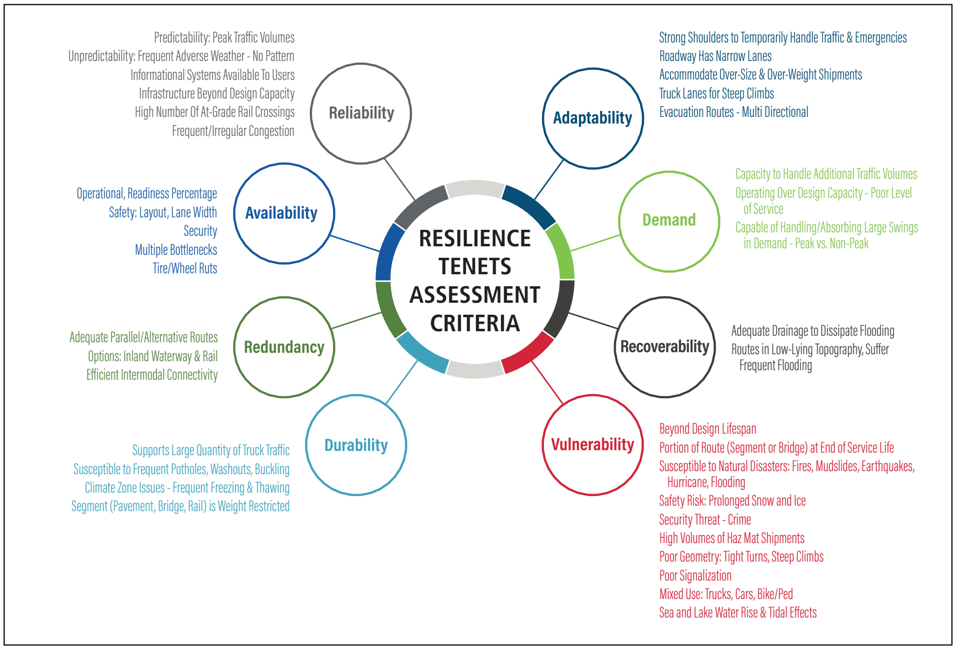

FIGURE 3 Resilience tenets assessment criteria.

planners to tailor the resilience process to fit the needs of states, regions, MPOs, and other planning agencies. Some plausible examples are shown in Figure 4.

Managing resilience for freight transportation infrastructure can be challenging and daunting, but sustainment of the economy requires it. To be effective, resilience should be considered within the current process for freight planning.

Multistep Process

Freight planning requires the development of goals and objectives first, which then provide a framework for the other elements of the freight-planning process. Therefore, it is important that resilience be integrated into the goal-setting effort. As components of the freight plan are developed, resilience is inherent in many tasks. The first four steps shown in Figure 5—assessment, determining needs, developing solutions, and selecting and prioritizing projects—are integral to the freight-planning process.

ASSESSMENT

As a first step, freight planners should focus on system resilience, which includes how well the system is performing. This process begins with the identification of the multimodal freight system and its operation. The lack of redundancy, inability to support growing demand, or a lack of reliability should trigger a warning that the freight system lacks resilience for current and future situations.

Similar to private-sector supply chains, the freight system possesses key nodes and links. These include interchanges, bridges, locks and dams, airports, pipeline junctions, intermodal facilities, seaports, and border crossings. A SWOT analysis by freight mode or by corridor may be a way to undertake a systematic approach to a SWOT analysis for the multimodal freight system. If portions of the system are unavailable or vulnerable, then there exists a resilience risk.

DETERMINING NEEDS

Next, a resilience assessment can be helpful as a component of identifying and validating needs and issues. Determining needs involves the use of data and consultation with freight stakeholders to capture

FIGURE 4 Forces affecting freight transportation resilience.

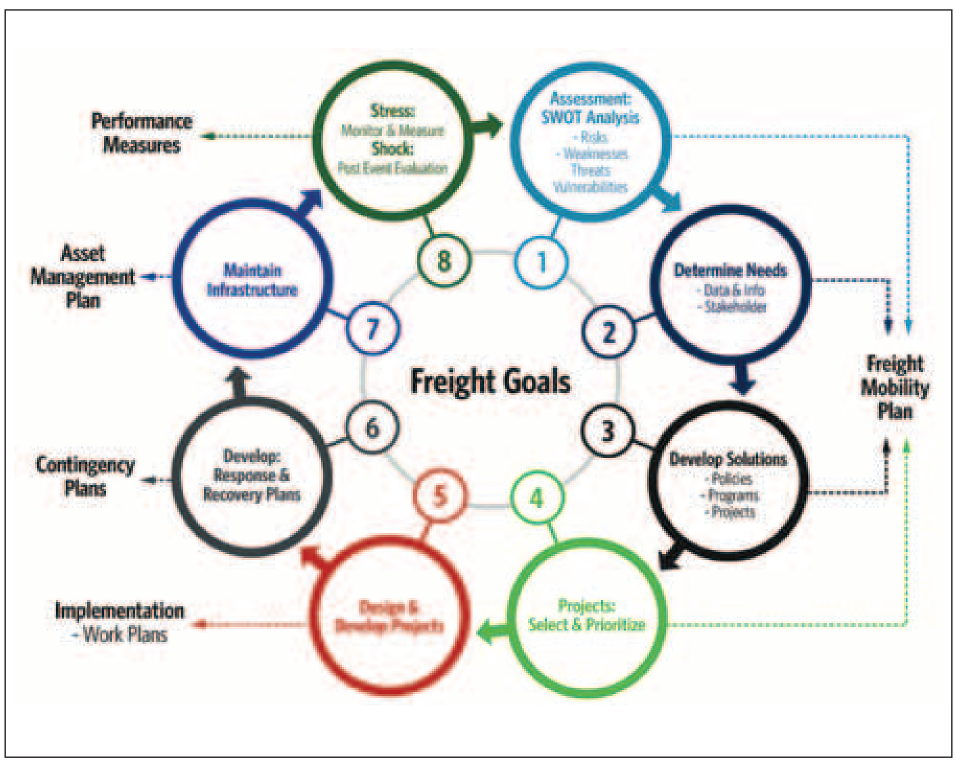

FIGURE 5 Continuous resiliency cyclic process for freight transportation planning.

Photo: Todd Kimery, U.S. Army Corps of Engineers

Lock and Dam 52 in Illinois impounds water in 2018, one year before the Ohio River dam was demolished to make way for the new Olmsted Locks and Dam. Many major components of the inland waterway system—like Lock and Dam 52—were built in the early 20th century, and their age can cause resilience risks.

objective and accurate information. One method of analysis considers the particular need in light of the eight resilience tenets. For example, a rural state highway bridge that provides a critical linkage for transporting agricultural products often may not support trucks at the maximum gross vehicle weight limit, so that bridge and the associated route would not be resilient for durability and vulnerability reasons. Similarly, a particular lock and dam on the inland waterway system may not be reliable and may need frequent maintenance and repairs. Understanding and identifying the potential risks and threats of lack of resilience can be part of identifying needs and issues.

DEVELOPING SOLUTIONS

Next, recommendations of policies, programs, and projects should be based upon objective data and information analysis and validated by stakeholders and should support the freight goals. These recommended solutions can be system enhancements or can be project-based. The solutions should have recommendations for when the project is needed—immediately, mid-term, or long-term, and should have recommended funding sources.

SELECTING AND PRIORITIZING PROJECTS

Finally, project selection and prioritization should be predicated on the greatest needs, including those that support resilience. In many cases, policies, programs, and projects are not supported by the need for resilience. In turn, if resilience is not addressed as a freight goal, then the freight plan is missing a key aspect on which the freight mobility system and choice of priority freight projects should be based.

Resilience should be factored into the project development process (shown in Step 5 of Figure 5) and then continuously assessed throughout the infrastructure's lifespan.

When plans have been assembled, the transition to implementation begins. Some post-planning actions are shown in Steps 6 to 8 (Figure 5). If the planning process is effective in articulating the need for resilience in freight infrastructure and the freight system, then it falls on agency leadership to enact policies and programs to support resilience and to prioritize projects that support resilience goals. Planners should clearly communicate the freight mobility needs and issues and provide recommendations that can be implemented.

Every day, we utilize freight transportation infrastructure that was built by the previous generation. The phrase "we are building it for the next generation" can be the lens through which we view the long-term benefits for freight transportation and then incorporate resilience into freight infrastructure and freight system performance. We need a resilient mindset to build a resilient freight transportation system.

RESOURCES

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