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FINAL REPORT

TRANSPORTATION SYSTEMS HEALTH: CONCEPTS, APPLICATIONS & SIGNIFICANCE

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16. Abstract:
This report offers conceptual and analytical frameworks and application examples to address the question: how can broader statewide (or national) objectives be achieved while formally taking into consideration different regional priorities and constraints? -- a pertinent multi-scalar and multi-dimensional issue in performance-based planning under MAP-21: Moving Ahead for Progress in the 21st Century. The study defines health as the extent to which a transportation system meets the deficiency (i.e., basic) and growth (i.e., beyond basic) needs of the communities it serves, from various decision-making and stakeholder perspectives (e.g., state, regional, city, urban, rural, etc.). A conceptual framework for transportation system health is developed, using Maslow's Theory of Motivation, and applied to characterize regional transportation priorities in the state of Georgia. A supporting analytical framework is developed to analyze regional highway corridor health. The framework applies goal programming methods to develop corridor utility values that capture state and regional priorities in different corridors. Analysis results show that the relative priority rankings of corridors based on state versus regional priorities can differ, and can inform decisions to augment overall statewide and regional social and economic benefits. The study explores an expanded set of performance measures, using existing and available data for urban and rural areas. It explains how regional deficiency-growth profiles and statewide goals can inform the selection of performance measures and setting of performance targets. The report concludes with implementation guidelines to formally incorporate system health considerations in transportation planning and decision making in state transportation agencies.

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Transportation Systems Health

Final Report

Concepts, Applications & Significance

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Executive Summary

In the context of performance-based and risk-based decision making under MAP-21, transportation systems health concepts and analytical resources offer agencies both the knowledge base and tools to support the selection of performance measures and development of performance targets in a context-sensitive manner. This framework can strengthen the outcomes of transportation investment decisions to achieve statewide goals. This report provides guidance for addressing the multi-scalar and multi-dimensional issue of performance-based planning at multiple levels of decision making: namely, how to achieve broader statewide (or national) objectives while formally taking into consideration different regional priorities and constraints within the state. The study examines and applies the concept of health to transportation systems to provide support for a performance-based decision-making process, recognizing that achieving higher levels of context-sensitive performance at multiple scales of decision-making can result in a more robust system. Health is defined in this study as the extent to which a transportation system meets the deficiency (i.e., basic) and growth (i.e., beyond basic) needs of the communities it serves, from various decision-making and stakeholder perspectives (e.g., state, regional, city, urban, rural, etc.). Two key attributes of system health focused on are the balance between deficiency and growth needs, and the integration of decision-making priorities and stakeholder perspectives in multiple jurisdictions.

The 2012 national surface transportation legislation: Moving Ahead for Progress in the 21st Century (MAP-21) has articulated a performance-based approach to decision making, designating performance objectives in safety, infrastructure condition, congestion reduction, system reliability, freight movement, economic vitality, environmental sustainability, and reduced project delivery delays. A conceptual framework for contextualizing transportation system health is developed and presented here. The framework is derived from Maslow's Theory of Motivation, characterizing deficiency and growth needs of a transportation system and the community it serves. This framework is applied to characterize transportation priorities from regional perspectives in the state of Georgia using a content analysis of the comprehensive plans of Georgia's 12 regional commissions (RCs), with subsequent review and validation of the extracted priorities by agency officials. Cross-tabulations between the regional commissions and their stated transportation priorities reveal both similarities and differences in the priorities of the commissions that serve urban areas and those that serve largely rural communities. These differences suggest there is potential value in formally considering regional needs and opportunities in when working to achieve broader statewide objectives.

These concepts are applied to develop a quantitative analytical framework for transportation system health (TSH) analysis at the corridor level. The TSH analytical framework is applied to analyze the health of selected highway corridors in the state of Georgia, applying goal programming methods to develop corridor utility values that capture state and regional priorities. Results of the analysis show that the relative priority

rankings of corridors based on state versus regional priorities can differ, and both sets of information can be used to inform decisions to augment statewide and regional social and economic benefits.

The study offers an expanded set of performance measures using existing and available data for urban and rural areas recognizing that each has its own priorities that together support the overall goals of the state and the regional commissions. Aggregate measures of accessibility and economic development are derived from the available data and offered to demonstrate how evaluation of corridor health can formally incorporate contextual priorities when decisions are made to achieve statewide objectives. In addition, the study offers risk considerations for achieving statewide transportation system health. Results and findings of the study highlight how regional deficiency-growth profiles and statewide goals can inform the selection of performance measures and the setting performance targets with the objective of achieving statewide goals while formally addressing non-uniform transportation system priorities across jurisdictions. The report concludes with implementation guidelines for formally incorporating transportation system health considerations into existing planning procedures in state transportation agencies.

1 Introduction

In a performance-based decision-making environment, transportation agencies that understand system priorities and constraints at multiple levels of decision making, and can formally incorporate these into their planning and decision-making processes, are well positioned to develop more healthy transportation systems in the long run. "Healthy" is used here to refer to a system that can meet both basic and beyond-basic needs from various decision-making and stakeholder perspectives (e.g., regionally, statewide, in urban contexts, in rural contexts), and hence can be referred to as a more robust system. The 2012 national surface transportation legislation: Moving Ahead for Progress in the 21st Century (MAP-21) was the first piece of national legislation to articulate a performance-based process for decision making with designated performance objectives in safety, infrastructure condition, congestion reduction, system reliability, freight movement/economic vitality, environmental sustainability and reduced project delivery delays. As MAP-21 regulations are rolled out, an important consideration for performance-based planning is how best to manage transportation system performance in non-uniform regions to achieve uniform statewide and national objectives. While transportation agencies must report on all the designated performance measures, state transportation agencies that develop capabilities to reconcile the needs and opportunities in multiple geographic and economic regions and their local jurisdictions, as they make transportation investments to advance economies and enhance the quality of life in their states, will experience more robust transportation systems and communities across the state.

This report provides guidelines for conducting regionally-sensitive statewide transportation planning. The primary audience is state transportation agencies, although other transportation agencies could apply the framework and guidelines provided to their particular contexts, with some modifications. Specifically, the report addresses the issue of achieving statewide goals while taking into formal consideration regional priorities and constraints. It provides a body of knowledge, tools and data to formally incorporate regional priorities and constraints in analysis to achieve statewide objectives. The pluralistic concept of health is applied to characterize regional and corridor health, to demonstrate how priorities and constraints to health may change across different jurisdictions, and how these may be used in prioritizing to identify investment priorities to augment benefits at both state and regional levels.

Chapter 2 of the report discusses the concept of transportation systems health (TSH) from the literature and practice, and develops the concept of transportation system health addressing the hierarchy of needs that a transportation system can meet for the communities it serves. Chapter 3 reviews statewide, regional and local priorities in Georgia using planning documents for the state, required by the Georgia Planning Act. Chapter 4 analyzes regional transportation priorities in the state of Georgia using a content analysis of the Regional Commissions' comprehensive plans with a follow-up review and validation of the priorities extracted from the plans by agency officials; the validation exercise and results are presented in Chapter 5. Chapter 5 presents the development of an analytical framework, including the necessary tools and data, for evaluating transportation system health at the corridor level, and demonstrates an application to analyze the health of selected corridors as they traverse jurisdictions with different system priorities and constraints. As shown, a primary indicator of transportation system health and robustness is a system's ability to support different stakeholder values and needs from region to region. The results are analyzed to demonstrate how corridors may be prioritized simultaneously from the perspective of statewide and regional objectives to inform project selection and augment the robustness of the statewide and regional transportation system. Chapter 6 discusses how measures of accessibility and economic development may be developed to extend the performance measures used in evaluating system health, and offers risk considerations for transportation system health. Finally, Chapter 7 provides conclusions and recommendations for integrating transportation system health concepts within existing long-range transportation planning procedures to formally incorporate regional priorities in statewide transportation planning and project development.

2 Conceptual Framework for Transportation Systems Health

Whenever uniform overarching performance measures are offered to evaluate a system operating within and outside the boundaries of different geopolitical areas in a state/regional context, we can consider the question: what are the best investment decisions to achieve overarching statewide goals in a context-sensitive manner that also embraces the predominant regional values and priorities? The concept of health can be a useful construct for understanding and applying multi-dimensional views of performance for a transportation system, both from infrastructure-centered (i.e., function-based) and stakeholder-centered (i.e., value-based) perspectives. This chapter develops a conceptual framework for transportation system health, incorporating both functional-based and value-based dimensions of transportation systems and modes as they cross jurisdictional boundaries and face different stakeholder needs, aspirations and constraints.

2.1 Concepts of Health and the Built Environment

Traditional definitions view health as a state of being free from illness or injury. Various definitions focus on soundness, as in soundness of body; that condition in which its functions are duly and efficiently discharged (Oxford English Dictionary). There are slightly more expansive but similar definitions, e.g., the condition of being sound in body, mind or spirit, especially freedom from physical disease or pain (Merriam-Webster). The World Health Organization has offered a more comprehensive definition: "health is a state of complete physical, mental and social well-being; not merely the absence of disease or infirmity" -- signed on July 22, 1946 by the representatives of 60 states and entered into force on 7 April 1948 (WHO 1946). These definitions point to different views of health with the more basic views tending toward function -- revolving largely around the absence of dis-ease; while the more comprehensive views of health capture holistically the physical, mental and social dimensions of well-being. These concepts can be applied to a transportation system where less comprehensive views of system health fundamentally capture the state of the system relative to its basic functionality, and more comprehensive views include stakeholder preferences and priorities with respect to the system's broader impact on the social, economic and natural environments in which they live, work and play.

<u>System Health and Healthy Communities</u>

The transportation and built environment literature has multiple characterizations of health as applied to built systems. A primary characterization focuses on the extent to which the system contributes to a healthy population or community. For example, the U.S. Department of Transportation's *Statewide Transportation Planning for Healthy Communities* (2014) offers a flexible model for transportation planning to promote healthy communities. The model allows agencies to integrate public health considerations into their transportation planning and decision making, programs and interagency initiatives. Similarly, the City of Toronto describes a healthy transportation system for everyone as one that equals a healthy population – one that promotes healthy choices, reduces pollution, etc. (Toronto Public

Health ND). In the popular literature, a university Dean of the School of Public Health at University of Washington elaborates on "How to build a healthy transportation system in a major metropolitan area" suggesting that the best transportation system is not only efficient, affordable, flexible and convenient, but healthy (Frumkin 2012). He asserts that public health must be affirmed as a transportation priority or goal and included when objectives are set and performance is measured. These ideas are echoed in a primer for creating healthy regional transportation plans, developed by TransForm in collaboration with the California Department of Public Health (TransForm 2012). Developed in response to Senate Bill 375, which requires California's 18 largest regions to create a Sustainable Communities Strategy, the guide identifies ways to incorporate health-promoting strategies into regional transportation plans (RTPs) and showcases short case studies for improving community health through RTPs. Thus, one area of the practice-oriented literature on transportation health identifies a direct linkage between a transportation system's health or effectiveness and the extent to which the system promotes public health: healthy behaviors, choices or outcomes. This literature is closely related to the health impact assessment literature (Ross et al., 2014), which focuses on evaluating the health impacts of transportation policies, plans and projects prior to their implementation.

<u>Structural Condition and Health Monitoring</u>

Another characterization of health in the transportation literature has to do with structural condition. The literature on structural condition and health monitoring focuses on the functional health of the built environment. Health monitoring is defined as the measurement of the operating and loading environment and the critical responses of a structure. The purpose of health monitoring is to track and evaluate the symptoms of operational incidents, anomalies, and/or deterioration or damage indicators that may affect operation, serviceability, safety or reliability (Aktan et al. 2000). The health monitoring literature generally discusses issues relevant to the implementation of health monitoring applications for infrastructure such as bridges, buildings and aircraft as well as laboratory specimens such as beams and composite plates (Aktan et al., 2000; Aktan et al. 2002; Sohn et al. 2004), for the purpose of managing these systems as assets. Infrastructure condition indices may be used to characterize the health of structures, as with the California Bridge Health Index. Based on the National Bridge Inspection Standards and the National Bridge Inventory (NBI), the California Bridge Health Index uses a sufficiency rating, which combines and condenses functional and condition data from the NBI into a single rating number from zero to 100. This infrastructure health assessment approach is based on element-level inspection, characterizing bridge element health as a function of the current state of the element in comparison with its state following initial construction. In this particular characterization, the health index is measured in terms of asset value in dollars, and the value decreases as the system experiences use and deterioration over time (Shepard, 2001).

System Health as Multi-Dimensional Performance

A Federal Highway Administration (FHWA) report documents the results of a pilot study conducted to improve the FHWA's ability to assess highway infrastructure health. As part of the pilot study, a section of I-90 in South Dakota, Minnesota and Wisconsin was evaluated to provide a proof of concept for a methodology to assess and communicate the overall health of a corridor with respect to pavement and bridges. The study also developed a conceptual condition and health reporting tool. The health assessment was intended to provide a means for the FHWA to examine the overall health of specific corridors and to respond to requests for information. The analogy that was used for the health assessment was what occurs during a visit to the doctor's office. When one visits a doctor one does not receive a single health score, but rather an in-depth discussion of several health indicators that help to present a more comprehensive picture. Health in this context is based on factors that go beyond condition, such as age, remaining service life for pavements, traffic loads, traffic volumes, etc., and presents these data in a manner that enables users to apply expert judgment in order to assess the overall health of a corridor. The study developed a sample health report to serve as a management and communication tool. The overall corridor health for infrastructure is based on an average of the following four metrics: (1) Distribution of pavements in good/fair/poor condition; (2) Distribution of pavement remaining service life; (3) Distribution of bridges in good/fair/poor condition; and (4) Distribution of bridge age. The report can be used to assess the health of the national highway system, and to tell the story of infrastructure needs with all existing FHWA datasets (FHWA 2012).

Corridor Health as Multi-Dimensional Performance

Along similar lines of thought, Boadi and Amekudzi (2013) developed a multi-criteria framework for evaluating a more holistic measure of performance or health of a corridor based on multiple objectives. The model was developed to evaluate performance as a function of safety, mobility and preservation, enabling the identification of higher-risk corridors for prioritization for investment. The goal programming method, which is an extension of linear or nonlinear programming involving an objective function with multiple objectives, was applied to data from individual management systems at the Georgia Department of Transportation (pavement management, safety management and congestion management). Utility scores were developed for corridor segments reflecting a more comprehensive measure of health or performance from the combined standpoint of safety, mobility and preservation.

These approaches to evaluating system performance reflect a broadening understanding of built system health as including the simultaneous consideration of multiple dimensions of performance in decision making, including but not limited to the system's basic function.

Evolution of Transportation Performance

Arguably, the evolution of the use of performance measures in transportation agencies in the U.S. reflects an evolution in the desirable attributes of performance in a transportation system. Mobility-related metrics arose in the 2nd (1965) edition of the Highway Capacity Manual, which first introduced the grading concept for highway (automobile) level of service (LOS A-F) *(*Kittelson 2000*)*; measures of bridge health became widely used after Congress established the National Bridge Inspection Program in response to the deadly collapse of the Silver Bridge in 1967 *(*USGAO 2010*)*; and the pavement condition index (PCI) was formulated by the U.S. Army Corps of Engineers in 1978 *(*Shahin 1978*)*. Measures such as these, which deal with physical condition and traffic operations, are still critical for transportation performance management; however, the list of measures used by DOTs and MPOs has expanded rapidly as the transportation system has become understood as more complex and holistic. This is especially true since the 1990s, when Federal legislation such as ISTEA and TEA-21 began to promulgate concepts of multimodalism and transportation equity. For example, the 2010 version of the Highway Capacity Manual includes definitions of LOS for multiple modes, and "complete streets" policies are becoming more and more common across the country, in order to address more holistic community priorities such as access to multiple transportation choices, and for the promotion of physical activity. In this context, some transportation practitioners have started conceptualizing transportation system health as incorporating functional and broader-than-functional performance components; for example, an Arizona DOT official described a healthy transportation system as arising within the nexus of infrastructure, performance, and resources (Omer and Nehme 2014).

2.2 A Hierarchical View of Transportation System Health

An alternative view of transportation system health may be found through the lens of Maslow's Theory of Human Motivation. According to Maslow's Theory of Human Motivation, based in Human Psychology, human actions are motivated to achieve certain needs (1943). Maslow offers a hierarchy of needs suggesting that people are motivated to fulfill basic needs before moving on to other more complex needs. This hierarchy of needs, often depicted as a pyramid, begins with physiological needs, followed by needs for security, followed by social needs, followed by needs for esteem, and then self-actualizing needs (Figure 2.1). Maslow's theory suggests that people are often motivated to achieve a higher level of need when they have achieved more basic needs. The first four sets of needs in the hierarchy are usually referred to as deficiency needs (also known as D-Needs), i.e., needs that arise due to deprivation. The highest level of needs, i.e., self-actualization needs, are also referred to as growth needs or being needs (B-Needs),): they do not stem from a lack of something, but rather a desire to grow as a person. While a major limitation in this theory is that little research has been done to validate its claims, it remains widely relatable and has been applied both within and outside the field of psychology (Cherry ND). Applying this construct to frame transportation (and other built environment) system health offers a formal framework to structure the needs that a transportation system fulfills – some basic, others more growth-focused, and perhaps more likely to be considered as priorities only where basic needs have been fulfilled, especially in budget-constrained contexts.

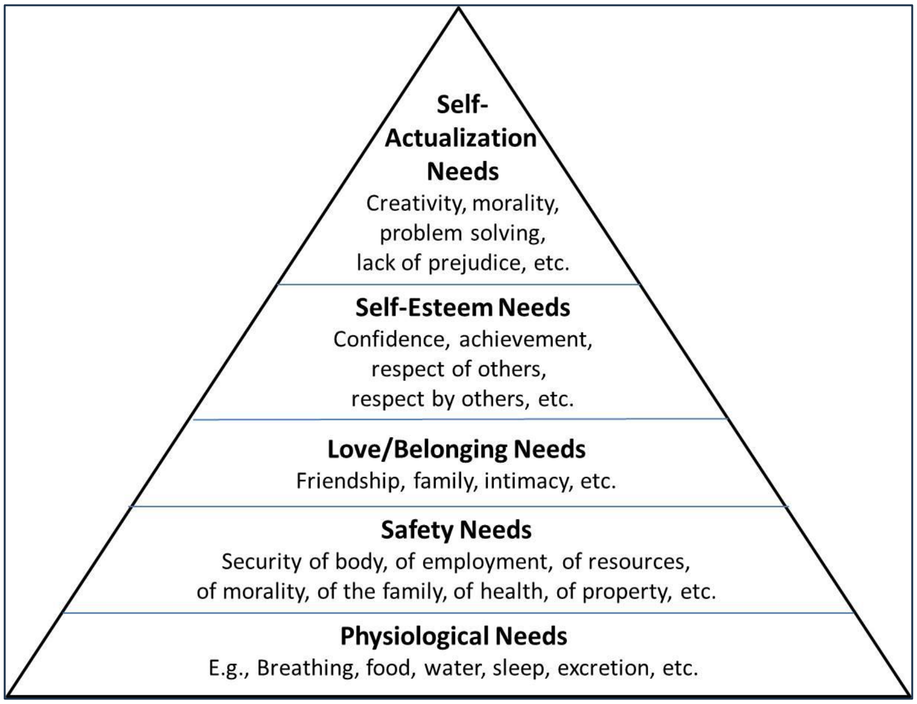

Figure 2.1 Maslow's Hierarchy of Needs

From both personal and business stakeholder perspectives, the most basic need fulfilled by a transportation system is mobility, as transportation is fundamentally about movement: movement of people, goods, ideas, and information. Once movement occurs, one may become concerned about moving with more safety and security; in other words, mobility must occur before we can consider the safety of mobility. Safety and security concerns are very likely to extend, either proactively or reactively, to include a system's resiliency to disaster in this era of increased natural and manmade disasters. Once one is able to move safely and securely, we may then become more concerned about how well we can use transportation to access various social and economic needs such as jobs, healthcare, education, shopping (i.e., essential needs), and recreation and leisure activities such as socializing with family and friends (i.e., non-essential needs). While we are here discussing transportation system characteristics and operations we do not mean to imply a sequential or hierarchical order is always dominant. For example, a stakeholder might place a higher preference on employment and the travel or modal preference becomes secondary or a negligible decision. Conversely, it is possible that communication systems replace the requirement for travel and the relationship between mobility and stakeholder preferences, satisfaction and the transport action or system are altered. From a business stakeholder's perspective, one may be concerned about the ease of access to raw materials, finished goods, labor and other markets – as necessary for the primary economic functions within a region. By transference, these community needs may be likened to the personal deficiency needs in Maslow's Hierarchy construct in the sense that they are generally considered deficiencies in communities where they are not available.

Beyond deficiency needs, stakeholders may consider growth needs that are related to visibility and advancement at a higher scale (economic, social, and geographic, for example). Growth needs may include economic competitiveness within broader national or international contexts, or even in comparison to other regions or jurisdictions. Areas that have failed to grow sustainably with respect to the natural environment may include transportation-related smart growth goals to influence air quality, water quality and other ecosystem attributes. Growth needs may also come in the form of linkages between and among regions to foster enhanced inter-regional travel and trade, and regional economic development and competitiveness. Creative and iconic infrastructures that serve multiple jurisdictions and regions, and link together multiple communities and businesses across different regions; restorative infrastructures that improve upon the natural environment while supporting basic needs; and infrastructures intentionally designed to provide more equitable access to basic needs strengthening regions and jurisdictions socially and economically -- all of these may be viewed as infrastructure designed to fulfill growth needs or growth desires. Such infrastructures have also been referred to as strategic elements of the built environment that expand individual and community choices (Fischer and Amekudzi 2011).

Figure 2.2 illustrates such a hierarchy of needs that can be used to characterize transportation system health, showing how the condition and performance of a particular system can meet various levels of needs differently, simultaneously. Similar to the concept underlying Maslow's Hierarchy of Needs, tradeoffs between one class of deficiency needs and another become practicable as each need is addressed. The points M_1, M_2 and M_3 in Figure 2.2 may be viewed as points on a maturity scale at which communities through their appropriate agencies begin to consider priority tradeoffs in their investment decision making; for example, investing more in safety projects than mobility projects.

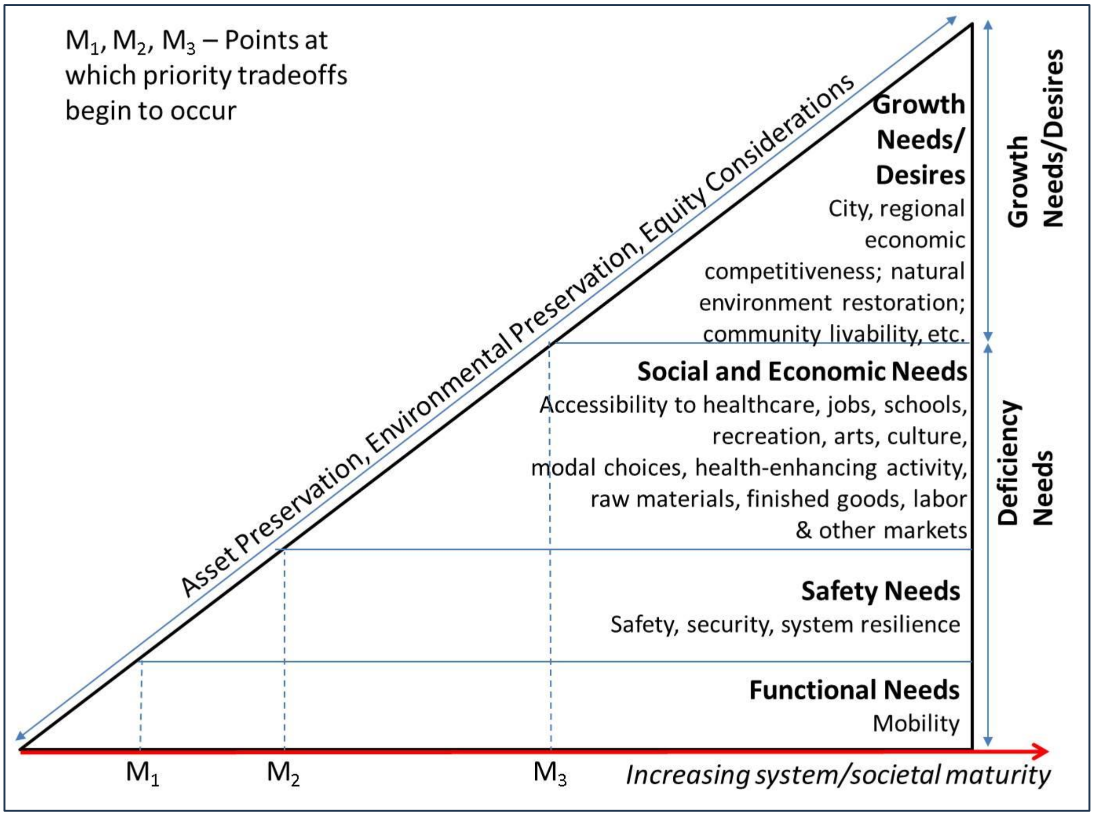

Figure 2.2 Hierarchy of Needs Characterizing Transportation System Health

From the standpoint of a state transportation agency concerned with fostering this broader concept of health across its different regions, the following questions are relevant:

1. To what extent is the statewide transportation system meeting *basic needs* across different regions within the state?
2. To what extent is the statewide transportation system meeting *growth desires* across the different regions?
3. Where do different regions within the state stand on their desire or ability to make priority investment tradeoffs?
4. To what extent is the state being intentional about identifying projects that offer co-benefits with respect to meeting statewide goals while addressing regional constraints and opportunities?

While the overarching goal remains to meet or advance uniform statewide objectives, candid attempts to answer these questions and invest to meet statewide goals while strengthening regions across the state can result in cumulative gains for a more robust system in the state and its regions. This statement is made while recognizing that in some cases, achieving statewide goals may run counter to strengthening regions; the emphasis here is on identifying potential co-benefits with respect to statewide and regional priorities.

Viewing the hierarchy of transportation needs, one observes in a very real sense that some minimum levels of mobility and access are at the core of a vibrant and healthy transportation system or a transportation system that contributes to vibrant and healthy communities -- affecting goals at all levels. In particular, a transportation system would be lacking in providing some basic needs and sustaining economic and social development if some minimal levels of mobility and accessibility were not achieved for communities to meet their most basic needs. Similarly, physical asset management and preservation, involving appropriate stewardship of the built environment -- including the timely retirement and replacement of obsolete assets -- is essential but not sufficient to maintain a healthy system. Understanding the relative mobility and accessibility afforded to various communities and businesses within and across various regions may therefore be a point of departure for understanding transportation system health. Understanding the relative safe and secure mobility and accessibility that are afforded to communities and their businesses would shed more light on the health of the system.

Beyond most basic needs related to healthcare, job, school and food access, one may address higher-level deficiency needs related to meeting less critical but nonetheless important social and economic needs such as recreation, the experience of arts and culture, and other forms of meaningful social activity. Beyond higher-level deficiency needs, understanding how a community envisions its growth (beyond deficiency needs), how the current transportation system can help achieve these growth desires, and what strategic investments will bridge the gap between the current and envisioned systems, will be yet another important step in the provision of comprehensive transportation system health, supporting community and stakeholder preferences. Efforts will move beyond addressing deficiencies and begin to influence and shape the built-natural-social environment with more strategic investments. These multiple layers of system health may be used in conducting more comprehensive evaluations, identifying data gaps and opportunities, and developing recommendations to enhance system health. It is important to note that many of the growth desires may be met through other regional and statewide infrastructures and systems that complement the transportation system or do not rely on it at all. The focus here is on how the transportation system can be used to promote or achieve higher-level community and stakeholder needs and desires.

As previously mentioned, M_1 and M_2 and M_3 (Figure 2.2) refer to various points of maturity within a system where tradeoffs can begin to occur between different deficiency needs or between a deficiency need and growth desire. In any system, a measure of system maturity can be viewed as the percent of the system in reactive versus proactive mode, where reactive status refers to a state in which the system is trying to recover from a deficiency, and proactive status refers to a state where the system has moved beyond deficiency needs to non-deficiency needs or growth desires. In which parts of the system are we maintaining health, recovering from having fallen into a non-health status; and in which parts of the system are we moving even to more robust states of health? Thus, it may be worth considering how much of an agency's decision making is focused on reducing system "illnesses", e.g. congestion reduction, air pollution reduction, versus achieving growth beyond system deficiencies, e.g., improving livability beyond some articulated minimum acceptable levels. *For competitiveness, there may be a healthy balance required between deficiency repair and the pursuit of growth desires beyond deficiency repair*.

To illustrate applications of the Hierarchy of Needs for measuring transportation system health – deficiency needs and growth desires, the next three chapters present TSH analysis, results and implications for selected cases in the state of Georgia. Chapters 3 and 4 identify statewide and regional transportation priorities for Georgia's 12 regional commissions, and view those priorities through a lens of the deficiency/growth balance. Chapter 5 presents a quantitative analysis of the health of selected corridors as they traverse different regions, using available data, from statewide and regional priority perspectives, respectively. Chapter 6 presents a discussion on how additional performance measures may be considered and incorporated to capture a more comprehensive view of system health. And finally, Chapter 7 provides guidelines for incorporating TSH concepts into existing planning and project development procedures.

3 Understanding How Regional Priorities Align with Statewide Goals

3.1 Geographic and Political Scales in Georgia

In the post-Map-21 era, it is expected that states and regions will report on similar goals. However, even in the case where there are uniform goals, it will be necessary for these goals to be expressed using locally-relevant, regionally-relevant or state-relevant performance measures for various contexts. As was demonstrated during the development of Georgia's Transportation Investment Act (TIA) project list and the subsequent vote, transportation priorities can vary across geopolitical boundaries and over various geographic scales. Localities and regions of localities may sometimes have different priorities in comparison with statewide goals. Additionally, several localities may have different priorities but find synergistic goals at the regional level. And even where there are similar priorities, the most appropriate performance measures may change from locality to locality or from region to region.

The state of Georgia has 159 counties and over 500 incorporated municipalities. Numerous state agencies have consolidated these entities into various representative regions for planning, implementation, service provision and oversight. For instance, the Department of Transportation has seven districts that oversee and support field services. Under each District Office, there are also Area Offices that support between two to seven counties each. One Area Office serves the city of Atlanta, for example (dot.ga.gov). Additionally, the Georgia Environmental Protection Division (EPD) of the Department of Natural Resources (DNR) has seven districts that oversee implementation of state and federal environmental laws (EPD). The Georgia Department of Public Health (DPH) has 18 service districts and the Office of Highway Safety has 16 networks of counties for traffic enforcement services (DPH, OHWS). In addition, the Department of Community Affairs (DCA) identifies 12 regional commissions for comprehensive planning (DCA). All of these divisions follow county boundaries but do not necessarily align with one another with respect to their highest priorities for transportation investment.

These various divisions suggest that state departments may approach local implementation and planning at different scales and within different boundaries. Given the regional commissions' responsibilities for comprehensive planning, this study formally incorporates the perspectives of the regional divisions. Regional commissions connected with MPOs may have influence on transportation investment decisions. In addition, regional commissions have a direct correlation to the transportation councils used for the TIA, and reflect transportation priorities within their planning documents.

3.1.1 Statewide Strategic Goals

The State of Georgia's Office of Planning and Budget (OPB) implemented a planning process in 2008 to enhance the coordination of strategic planning from the Governor to the State's different agencies, including the Department of Transportation (DOT). With a vision for "a lean and responsive state government that allows communities, individuals and businesses to prosper," the Governor's strategic goal areas for Georgia are education, mobility, economic growth, health, safety, and a responsible and efficient government. Table 3.1 below provides additional information for the goal areas.

Table 3.1 Governor's Strategic Goals

Educated	Developing life-, college-, and work-ready students
Mobile	Transporting people and products in a 21^{st} century Georgia
Growing	Creating jobs and growing businesses
Healthy	Accessible care and active lifestyles
Safe	Protecting the public's safety and security
Responsible & Efficient Government	Fiscally sound, principled, conservative

The OPB provides specific guidelines to help agencies understand how to align their priorities with the Governor's goals and provides training and worksheets to assist with agency strategic planning. Figure 3.1 shows the framework introduced by the OPB for FY2015 strategic planning. As shown, each state agency is expected to align their four-year strategic plan with the State's 5-year strategic plan, with regular progress reports to ensure accountability.

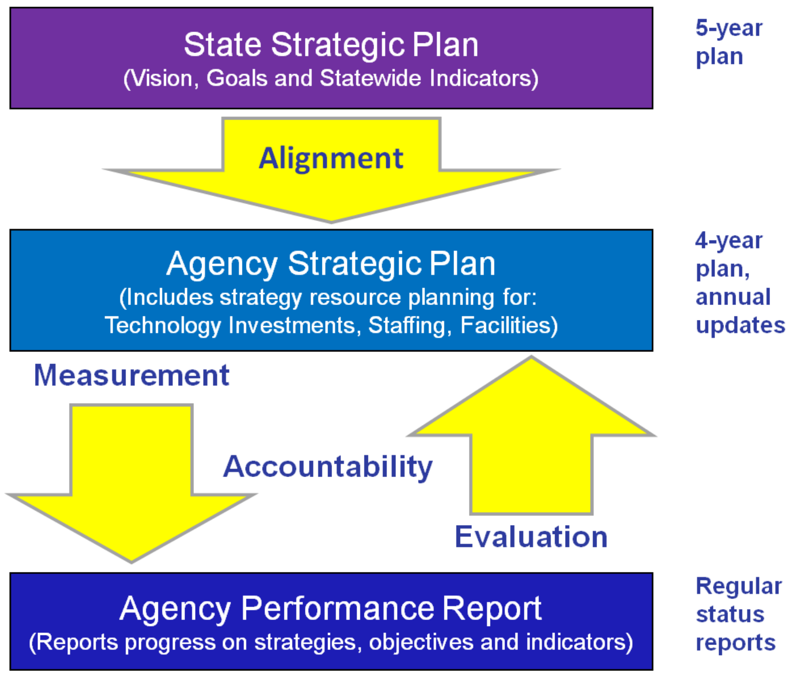

Figure 3.1 Georgia State Strategic Planning Framework (OPB)

GDOT's goals for the 2013-2017 Strategic Plan, represent a second set of transportation priorities, and are focused on "planning and constructing the best set of mobility-focused projects", "making safety investments and improvements where the traveling public is most at risk", "taking care of the transportation infrastructure to ensure mobility and safety", and making GDOT work better (GDOT 2013). GDOT's strategy map, shown in Figure 3.2, is particularly linked to the Governor's strategic goal areas of mobility, safety, and responsible and efficient government.

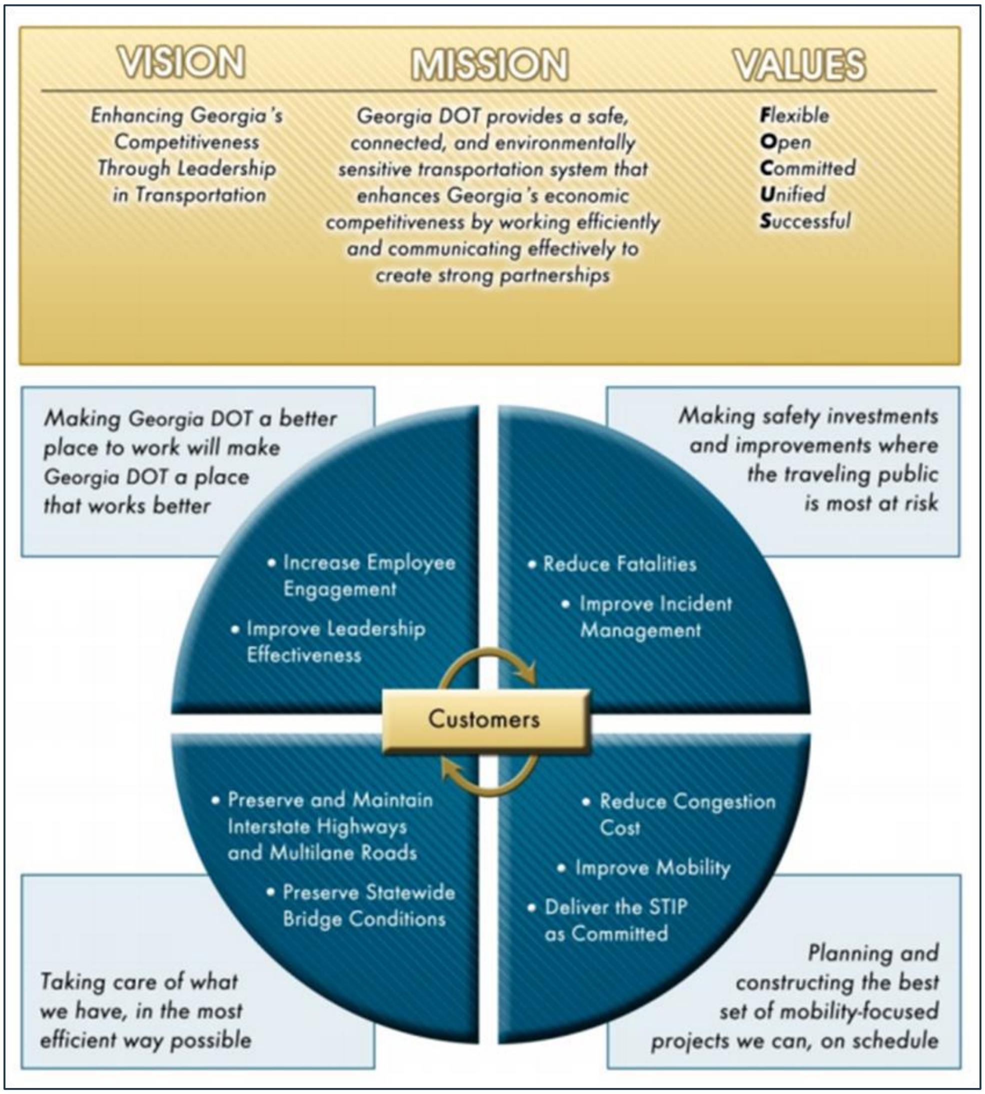

Figure 3.2 GDOT Strategy Map

Transportation priorities in the state of Georgia are further influenced by a third set of statewide goals documented in the Statewide Strategic Transportation Plan (SSTP). The SSTP is an intermodal, comprehensive, fiscally-constrained transportation plan required by Georgia State law to set the strategic direction for transportation in the state. In Georgia, the SSTP has been combined with the Federally-required Statewide Transportation Plan (SWTP) which includes an analysis of future transportation needs. Developed by GDOT, the SSTP has four goals established by combining best practices, understanding customer needs, and stakeholder interviews. Figure 3.3 shows Georgia's strategic goals, objectives and performance metrics as documented in the SSTP.

Goal	Objective	Performance Metric(s)
1 Supporting Georgia's economic growth and competitiveness	Improved access to jobs, encouraging growth in private-sector employment, workforce	• Average number of workers that can reach a major employment center by auto in 45 minutes in the AM peak period* • Average number of workers that can reach a major employment center by transit in 45 minutes in the AM peak period*
	Reduction in traffic congestion costs	• Annual congestion cost per peak auto commuter*
	Improved efficiency, reliability of commutes in major metropolitan areas	• Average work commute time* • Daily average number of people traveling in HOT/express lanes during the weekday AM and PM peak periods* • Daily average number of people taking rail trips during the weekday AM and PM peak periods*
	Efficiency and reliability of freight, cargo, and goods movement	• Daily hours of truck delay on Georgia Interstates
	Border to border and interregional connectivity	• % of population within 10 miles of a 4-lane state or US route
	Support for local connectivity to statewide transportation network	• % of state and federal transportation funds spent on local roads
2 Ensuring safety and security	Reduction in crashes resulting in injury and loss of life	• Reduction in annual highway fatalities
3 Maximizing the value of Georgia's assets, getting the most out of the existing network	Optimized capital asset management	• % of Interstates meeting maintenance standards • % of state-owned non-Interstate roads meeting maintenance standards • % of state-owned bridges meeting GDOT standards
	Optimized throughput of people and goods through network assets throughout the day	• Metro Atlanta highway morning peak hour speeds* • Metro Atlanta highway evening peak hour speeds* • Average HERO response time* • % of commute trips to major employment centers on transit* • Average transit operating cost per passenger*
4 Minimize impact on the environment	Reduce emissions, improve air quality statewide, limit footprint	• To be determined

* This metric is obtained for metropolitan Atlanta only.

Figure 3.3 GDOT goals, objectives and metrics from SSTP

Among these three strategic planning visions that define the state of Georgia's transportation priorities, there are some common themes that surface as overall priorities. Much of the commonality is evident in the objectives associated with each goal. The three themes that are common in each vision include: **mobility**, **safety**, and **preservation**, with safety being the only priority called out explicitly in each instance. **Economic**

growth/development and **accessibility** (to jobs, healthcare and education) are priorities commonly defined in two of the strategic plans.

MAP-21 encourages performance-based prioritization, which presents a unique set of opportunities and challenges in dealing with different priorities within multiple geopolitical contexts. In addition to diversifying funding streams, project prioritization becomes increasingly important as resources tighten.

3.2.2 Regional Planning Priorities in Georgia

The Georgia Planning Act, signed in 1989, expresses the state's commitment to coordinated and comprehensive planning at all levels of government. The Act created Georgia's 12 regional commissions (RCs) to assist local governments on a regional basis and to develop, promote and assist in establishing coordinated and comprehensive planning in the state. The Act established requirements for regional-level planning throughout the state. Additionally, the legislature created the 12 regional commissions, each representing a collection of counties and their local interests. Figure 3.4 shows Georgia's 12 RCs.

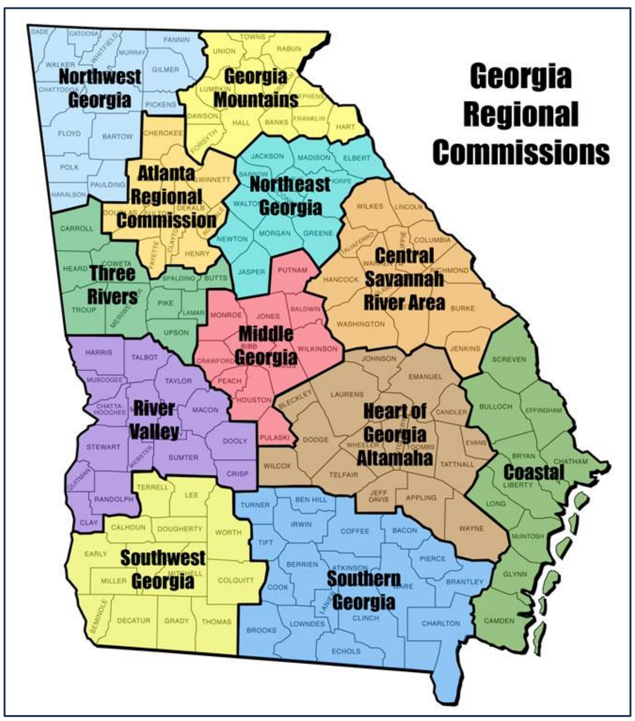

Figure 3.4 Regional Commissions of Georgia

[Source: Carl Vinson Institute of Government, University of Georgia]
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Through the Planning Act, each regional commission is required to produce a regional plan that includes a regional assessment, stakeholder involvement program and a regional agenda. The regional agenda is completed after the assessment and with continued stakeholder input. Each agenda contains a regional vision, an outline of issues and opportunities to be addressed, an implementation program with guiding principles for decision making aligned with the vision, and an evaluation and monitoring plan. These elements provide a road map for the region's future and outline the priorities for the region. These priorities are not limited to transportation but include all aspects of development.

The requirements for regional planning are aligned with statewide planning goals and objectives. Six statewide planning goals are outlined in the regional planning requirements as identified by the Department of Community Affairs (DCA). The DCA is a state agency. The goals as established by the DCA coordinate with some of the statewide goals discussed previously. The economic development goal clearly aligns and several other goals correlate with the Governor's goals. For example, "community facilities and services" expresses the need for efficient growth and development patterns which relates to the Governor's goal of strategic growth. Additionally, intergovernmental coordination is aligned with responsible and efficient government. The goals identified in the DCA's list can be found in Table 3.2.

Table 3.2 Six Goal Areas for Regional Planning (DCA)

Goal	Description
Economic Development	To achieve a growing and balanced economy, consistent with the prudent management of the state's resources, that equitably benefits all segments of the population.
Natural and Cultural Resources	To conserve and protect the environmental, natural and cultural resources of Georgia's communities, regions and the state.
Community Facilities and Services	To ensure the provision of community facilities and services throughout the state to support efficient growth and development patterns that will protect and enhance the quality of life of Georgia's residents.
Housing	To ensure that all residents of the state have access to adequate and affordable housing.
Land Use and Transportation	To ensure the coordination of land use planning and transportation planning throughout the state in support of efficient growth and development patterns that will promote sustainable economic development, protection of natural and cultural resources and provision of adequate and affordable housing.
Intergovernmental Coordination	To ensure the coordination of local planning efforts with other local service providers and authorities, with neighboring communities and with state and regional plans and programs.

Supporting the six goals are 25 quality community objectives. The DCA uses the objectives to guide its support of regional planning by providing best practices for achieving these objectives and structuring local assessment review around the quality community objectives. The regional agendas are also often structured around some set of applicable quality community objectives that support the six statewide goals in the context of the region. Regional commissions may include additional areas of interest that support the local priorities outside of the statewide goals. In this way, the regional agendas reveal the priorities of the regional commissions.

One of the DCA goals is specifically related to transportation. This goal is to ensure the coordination of land use and transportation planning to support efficient and sustainable development and growth patterns. The transportation-related priorities were identified for each region by reviewing the regional agendas and a diverse set of interests were identified from the 12 regional commissions. The range of priorities can be found in **Table 3.3**.

Table 3.3 Regional Transportation Priorities from Regional Comprehensive Plans

Regional Transportation Priorities	
Non-SOV transportation choices	Safe and efficient movement of people and goods
Complete Streets/bicycle and pedestrian infrastructure	Freight rail
Transportation to support development (residential and economic) patterns	Airports
Transportation facility demand improvements	Presence of logistic strategic hub
Transit access to community facilities and services	Increase of import/export capabilities
Optimization and management of existing assets in the current transportation system	Pre-disaster mitigation/resiliency
Connectivity	Sustainable infrastructure
Reduction of sprawl development/Smart Growth	Air Quality
Greenways and trails	Commute length
Access to housing and community facilities and service	Income spent on transportation
Port access and connectivity	Access control
Reduction of impervious surfaces	Parking requirement reductions
Scenic corridors important for tourism	Signage for controlling and managing traffic flows
Strategic expansion/restriction of regional system	Transportation facility design
Unpaved roadways	High speed rail

3.1.3 Local Influence in Planning and Decision-Making

Incorporated municipalities and other localities also have transportation-related goals and priorities. These goals are reflected in the transportation projects that are locally financed and those that receive state or federal funding. In the cases where state or federal funding is received, there is direct communication between GDOT and local governments to identify local projects that will be included in the State Transportation Improvement Plan (STIP). In Georgia, local planning is also supported by the regional commissions; however, local priorities may vary from regional priorities in the same way that regional goals may differ from state goals.

3.2 Consolidating Priorities

Although there are some similarities, to understand how priorities at different geographic scales relate to and differ from each other, each of the priorities in **Table 3.3** was categorized under one or more of the statewide goals from GDOT's SSTP: Economic Development, Safety, Assets, and Environment. All of the priorities that did not relate to one of these goals were categorized as "other." Upon review of the priorities in "other," many related to the primary function of the transportation network and thus an additional category was defined: Mobility and Accessibility, which aligns with the Governor's goal of a mobile state. **Table 3.4** shows the regional priorities aligned with the statewide goals. Each regional priority is placed under one statewide goal area (i.e., the predominant goal area for the priority), although such priorities may influence more than one goal area.

Table 3.4 Regional Priorities Aligned with Statewide Goals

Economic and Regional Development	**Environment**
Transportation to support development (residential and economic) patterns	Non-SOV transportation choices
Transportation facility demand improvements	Complete Streets/bicycle and pedestrian infrastructure
Transit access to community facilities and services	Transportation facility demand improvements
Connectivity	Reduce sprawl development/Smart Growth
Reduce sprawl development/Smart Growth	Greenways and trails
Greenways and trails	Reduce impervious surfaces
Access to housing and community facilities and service	Sustainable infrastructure
Scenic corridors and tourism	Air Quality
Strategically expand/restrict regional system	
Unpaved roadways	**Mobility and Accessibility**
Safe and efficient movement of people and foods	Non-SOV transportation choices
Presence of logistic strategic hub	Complete Streets/bicycle and pedestrian infrastructure
Increase import/export capabilities (including freight rail, airports and ports)	Transportation facility demand improvements
Access control	Transit access to community facilities and services
Parking requirement reductions	Connectivity

High speed rail	Reduce sprawl development/Smart Growth
	Greenways and trails
Safety	Access to housing and community facilities and service
Complete Streets/bicycle and pedestrian infrastructure	Port, rail and airport access and connectivity
Safe and efficient movement of people and foods	Strategically expand/restrict regional system
Pre-disaster mitigation/resiliency	Safe and efficient movement of people and foods
Signage for controlling and managing traffic flows	Pre-disaster mitigation/resiliency
	Income spent on transportation
Assets	Commute length
Complete Streets/bicycle and pedestrian infrastructure	High speed rail
Optimize and manage existing assets in the current transportation system	
Unpaved roadways	
Transportation facility design	
Signage for controlling and managing traffic flows	

It can be deduced from this table that there is indeed overlap in the priorities across geographic scales; however, the level of emphasis or specificity of objectives may differ. In addition, the nature of the measures used to track progress toward particular objectives may differ in the attempt to meet statewide objectives in a more regionally-relevant manner.

4 Analysis of Georgia's Regional Transportation Priorities

As discussed in Chapter 2, transportation system health focuses on understanding more comprehensively how the transportation system is meeting deficiency needs and growth desires in different yet contiguous geopolitical and spatial contexts. As discussed in Chapter 3, transportation priorities may differ across geopolitical contexts and thus present opportunities to exploit co-benefits. In considering simultaneously the priorities of different transportation planning entities, conflicting and consistent objectives may be identified. This can help both with consensus development as well as decision making that results in more robust outcomes. Understanding priorities in such a multi-level (i.e., decision making/stakeholder preferences) and multi-geographical (i.e., spatial) manner can set the stage for more nuanced decision making to achieve goals at multiple decision-making levels and in multiple spatial domains, and thus exploit co-benefits. The Transportation System Health conceptual framework can provide formal support for planning and decision-making activities that are sensitive to various contexts, as in regionally-sensitive statewide planning and decision making or locally-sensitive regional planning and decision making, for example.

A qualitative system health analysis was conducted to characterize regional priorities in Georgia using information from the regional comprehensive plans, and validating this information through follow-up interviews with planning officials in Georgia's 12 RCs. Georgia's RCs were classified into urban, transitional (i.e., moving from rural to urban) and rural regions using data from the 2010 Census. The county was used as the spatial unit of analysis and the contiguous area formed by the counties within a regional commission were considered as regions within the broader statewide planning framework. Percentages of population within Georgia's 159 counties, from the "Population by Urban and Rural: 2010" tables were reviewed and counties designated as urban or rural depending on the total percentages of urban and rural populations within the county boundaries. Counties where 50% or more of the population was urban were designated as urban counties and vice versa. The split between urban and non-urban counties within the RC boundary was then used to classify regional commissions as urban, transitional or rural. Regional commissions with 50% or more counties of a particular type (i.e., urban, rural) were classified as such. Regional commissions where between a third to half of the counties were urban were designated as transitional regions or 'regions in transition' from rural to urban. And regions where more than two-thirds the counties were rural were designated as rural. Thus, the Atlanta Regional Commission was classified as urban, the NW Georgia Regional Commission was classified as a region in transition, and the Central Savannah River Area Regional Commission was classified as rural.

Table 4.1 Urban/Rural Classification of Georgia's Regional Commissions shows the rural/urban classification of the RCs.

The total population in the state of Georgia was about 9.7 million in 2010, with about 75% of this population living in urban areas (USDC, 2010). This urban/rural population split (Table 4.1) and Georgia's demographics (i.e., the Atlanta Metro Region contains roughly half of Georgia's population) indicate that Georgia is largely an urban state from a population standpoint. In a stated preference approach, comprehensive plans for Georgia's 12 regional commissions were reviewed to gather regional priorities identified in the plans. The priorities were extracted from the Regional Commissions' comprehensive plans and categorized under Georgia's statewide strategic goals:

- Safety
- Mobility and accessibility
- Assets (maintenance and construction)
- Economic and regional development
- Environment

Table 4.2 summarizes the categorical transportation and transportation-related priorities extracted from the 12 comprehensive plans. Subsequently, cross tabulation analyses were conducted to extract urban/transitional and rural transportation priorities as articulated in the comprehensive plans. These priorities were mapped to provide additional information on the spatial and regional distribution of these priorities within the state, and considered through the lens of the deficiency/growth balance of system health.

Table 4.1 Urban/Rural Classification of Georgia's Regional Commissions

RC	Rural/Urban Classification
NW GA (NWGRC)	Region in Transition
GA Mountains (GMRC)	Rural
NE GA (NEGRC)	Region in Transition
Atlanta (ARC)	Urban
Three Rivers (TRRC)	Region in Transition
Central Savannah River Area (CSRA)	Rural
Middle GA (MGRC)	Region in Transition
River Valley (RVRC)	Rural
Heart of GA (HoGa)	Rural
SW GA (SWGRC)	Rural
Southern GA (SGRC)	Rural
Coastal GA (CGRC)	Rural

Table 4.2 Summary of Transportation Priorities from RC Comprehensive Plans

	ARC	NWGRC	MGRC	NEGRC	SGRC	GMRC	HOGA	RVRC	CGRC	TRRC	CSRA	SWGRC	Subtotals
Mobility and Accessibility													
Non-SOV transportation choices	x	x	x	x	x			x	x	x		x	8
Complete Streets/Bike and pedestrian infrastructure			x	x	x	x		x	x	x	x	x	9
Transportation facility demand improvements	x		x			x			x				3
Transit access to community facilities and services		x	x	x	x	x		x				x	7
Connectivity				x	x	x		x	x	x			6
Reduce sprawl development/Smart Growth		x	x	x			x	x		x			6
Greenways and trails		x		x		x			x	x		x	6
Access to housing and community facilities and service					x	x		x					3
Port, rail and airport access and connectivity		x		x		x	x	x					5
Strategically expand/restrict regional system	x							x					1
Safe and efficient movement of people and goods		x		x									2
Pre-disaster mitigation/resiliency						x							1
Income spent on transportation	x												0
Commute length	x												0
High speed rail													0
Subtotals	5	6	5	8	5	8	2	8	5	5	1	4	
Safety													
Complete Streets/Bike and pedestrian infrastructure			x	x	x	x		x	x	x	x	x	9
Safe and efficient movement of people and goods		x		x									2
Pre-disaster mitigation/resiliency						x							1
Signage for controlling and managing traffic flows								x					1
Subtotals	0	1	1	2	1	2	0	2	1	1	1	1	
Assets													
Complete Streets/Bike and pedestrian infrastructure			x	x	x	x		x	x	x	x	x	9
Optimize and manage existing assets in the current transportation system	x		x				x	x	x		x	x	6
Unpaved roadways			x				x			x			3
Transportation facility design								x					1
Signage for controlling and managing traffic flows								x					1
Subtotals	1	0	3	1	1	1	2	4	2	2	2	2	
Economic and Regional Development													
Transportation to support development (residential and economic) patterns		x	x		x	x	x	x	x	x	x		9
Transportation facility demand improvements	x		x			x			x				3
Transit access to community facilities and services		x	x	x	x	x		x				x	7
Connectivity				x	x	x		x	x	x			6
Reduce sprawl development/Smart Growth		x	x	x			x	x		x			6
Greenways and trails		x		x		x			x	x		x	6
Access to housing and community facilities and service					x	x		x					3
Scenic corridors and tourism							x			x			2
Strategically expand/restrict regional system	x							x					1
Unpaved roadways			x				x			x			3
Safe and efficient movement of people and goods		x		x									2
Presence of logistic strategic hub	x						x						1
Increase import/export capabilities (including freight rail, airports and ports)		x		x		x	x	x					5
Access control				x									1
Parking requirement reductions				x									1
High speed rail								x					1
Subtotals	3	6	5	8	4	7	6	8	4	6	1	2	
Environment													
Non-SOV transportation choices	x	x	x	x	x			x	x	x		x	8
Complete Streets/Bike and pedestrian infrastructure			x	x	x	x		x	x	x	x	x	9
Transportation facility demand improvements	x		x			x			x				3
Reduce sprawl development/Smart Growth		x	x	x			x	x		x			6
Greenways and trails		x		x		x			x	x		x	6
Reduce impervious surfaces		x		x				x					3
Sustainable infrastructure						x							1
Air Quality	x												0
Subtotals	3	4	4	5	2	4	1	4	4	4	1	3	

4.1 Analysis of Georgia's Transportation Regional Priorities - Results

Assuming that the regional comprehensive plans articulate the priorities that the RCs consider most important, the following inferences were made from the summary of priorities in Table 4.2. While all regions are concerned with issues of mobility and accessibility, safety, asset provision and preservation, economic and regional development and environmental management and preservation, across the 12 RCs, there are clearly differences in priorities.

1. With reference to mobility and accessibility, the priorities considered most important by the largest number of RCs relate to enhancing the infrastructure to support multiple modes and improve non-SOV transportation choices; improve transit access to community facilities and services, and expand the complete streets network and enhance the bicycle and pedestrian infrastructure. Enhanced bicycle and pedestrian infrastructure also has potential impacts on safety and asset provision. Approximately 60% or more of the RCs had articulated at least one of these priorities within their comprehensive plans. In addition, half of the RCs had articulated priorities related to improving connectivity, reducing sprawl development and enhancing the quality of greenways and trails.

2. With reference to safety, issues related to complete streets and bicycle/pedestrian infrastructure were the most articulated priority. One RC (Georgia Mountains) identified priorities related to pre-disaster mitigation/resiliency.

3. With reference to assets provision and management, complete streets and bicycle/pedestrian infrastructure were the most articulated priorities, also with safety implications. In addition, half of the RCs identified priorities related to optimizing and managing existing assets in the system.

4. With respect to economic and regional development, priorities related to transportation to support (residential and economic) patterns were identified by the largest number of RCs. The other priority most related to economic development identified by the majority of RCs was transit access to community facilities and services. Connectivity, identified by half of the RCs, would also have implications for economic and regional development.

5. With respect to the environment, the priorities identified by the most number of RCs were related to the development of complete streets and bicycle/pedestrian infrastructure, and expansion of non-SOV transportation choices. Sprawl reduction and the development of greenways and trails, identified in half of the RC comprehensive plans, would also have impacts on the environment.

In essence, from a regional perspective, the transportation priorities that were most articulated in the regional commissions' comprehensive plans include improving modal choices and connectivity, particularly improving transit access to community facilities and services, enhancing multimodal and intermodal infrastructure, enhancing bicycle/pedestrian infrastructure; and enhancing transportation to better support desired residential and economic patterns. The priorities extracted from the comprehensive plans were sent to agency officials for review and validation. Table 5.4 (Chapter 5) shows the weights assigned to a list of priorities by each of the 12 Regional Commissions.

It is important to note some caveats for this exercise. The categories identified to organize priorities may be changed. These were selected to align with the needs hierarchy (Figure 2.2) and the reporting found in the comprehensive plans. Secondly, the comprehensive planning priorities and the DCA requirements for comprehensive plans, in order to be eligible for federal funds, largely explain regional priorities. The definitions of some of these priorities may be the same although they are presented here as mutually-exclusive and non-overlapping. Thirdly, under the Georgia Planning Act, the state is prescriptive about Developments of Regional Impact (DRIs) and all projects must conform to required goals and metrics; this explains some of the similarities in goals especially in urban areas where common objectives may be narrowly prescribed and not always reflect regional or local deficiencies. Finally, it is also important to note that the political process (local and state) may explain priorities and may not in fact reflect local preferences. Extracting priorities directly from expert panels at the local level may address some of these limitations created by extracting priorities from comprehensive plans.

4.2 Cross Tabulation Analysis – Results

Cross-tabulations were developed to investigate the similarities and differences in the transportation priorities of the urban/transitional and rural regions, as revealed though the stated regional priorities documented in the comprehensive plans for 12 RCs.

Table 4.3 and Table 4.4 show cross tabulation analysis results for safety and asset preservation, and Table 4.5 and Table 4.6 show cross tabulation analysis results for accessibility to social and economic needs, economic and regional development, and environmental preservation. These profiles reveal both similarities and differences between the urban/ transitional regions and rural regions, with respect to the priorities considered important enough to be articulated in their comprehensive plans.

Table 4.3 Cross Tabulation Analysis for Urban/Transitional RCs: Safety and Asset Provision/Preservation

	ARC	NWGA	NEGA	Three Rivers	Middle GA
Safety					
Complete Streets/Bicycle and Pedestrian Infrastructure			X	X	X
Pre-disaster mitigation/resiliency					
Asset Provision and Preservation					
Complete Streets/Bicycle and Pedestrian Infrastructure			X	X	X
Assets optimization and management	X			X	X

Table 4.4 Cross Tabulation Analysis for Rural RCs: Safety and Asset Provision/Preservation

	GA Mtns	CSRA	River Valley	Heart of GA	SW GA	Southern GA	Coastal GA
Safety							
Complete Streets/Bicycle and Pedestrian Infrastructure	X	X	X		X	X	X
Pre-disaster mitigation/resiliency	X						
Asset Provision and Preservation							
Complete Streets/Bicycle and Pedestrian Infrastructure	X	X	X		X	X	X
Assets optimization and management		X	X	X	X		X

Tables 4.3 and 4.4 indicate that rural RCs were more likely to identify complete streets/bicycle pedestrian infrastructure issues as priority issues. Also, rural regions were more likely to identify assets optimization and management as a priority than urban or transitional regions. Only one regional commission (GA Mtns) had identified pre-disaster mitigation and resiliency issues as a priority in their comprehensive plan.

Tables 4.5 and 4.6 indicate that the enhancement of non-SOV transportation choices is a broadly articulated need for urban and transitional regions, and an important priority also for rural regions. All but one of the rural regional commissions identified as a priority the need for transportation to support residential and economic patterns. Rural RCs were more likely to identify transit access as a priority than urban and transitional RCs.

Table 4.5 Cross Tabulation Analysis for Urban/Transitional RCs: Accessibility to Social and Economic Needs, Economic and Regional Development and Environmental Preservation

	ARC	NWGA	NEGA	Three Rivers	Middle GA
Accessibility/Environmental Preservation					
Non-SOV transportation choices	X	X	X	X	X
Complete Streets/Bicycle and Pedestrian Infrastructure			X	X	X
Transit access to community facilities and services		X	X		X
Economic and Regional Development					
Transportation to support (residential and economic) patterns		X		X	X
Transit access to community facilities and services		X	X		X

Table 4.6 Cross Tabulation Analysis for Rural RCs: Accessibility to Social and Economic Needs, Economic and Regional Development and Environmental Preservation

	GA Mtns	CSRA	River Valley	Heart of GA	SW GA	Southern GA	Coastal GA
Accessibility/Environmental Preservation							
Non-SOV transportation choices	X	X	X	X		X	X
Complete Streets/Bicycle and Pedestrian Infrastructure	X	X	X		X	X	X
Transit access to community facilities and services	X		X		X	X	

Economic and Regional Development							
Transportation to support (residential and economic) patterns	X	X	X	X		X	X
Transit access to community facilities and services	X		X		X	X	

Summary of Cross Tabulation Analysis Results

The stated transportation priorities of Georgia's 12 regional commissions indicate that one of the main issues of concern in all the RCs (urban/transitional and rural) is increased choices for options beyond single occupant vehicle travel. Urban/transitional RCs were unanimous in identifying non-SOV transportation choices as a priority in their comprehensive plans, and all but one rural RC identified issues related to non-SOV transportation choices as a priority within their plans. The stated priorities emphasized transit access, as well as bicycle/pedestrian transportation, with rural RCs more likely to identify both of these alternative modes as priorities. While the majority of urban/transitional and rural RCs identified transportation to support economic development as a priority, rural RCs were more likely to address this as a priority than urban/transitional RCs. In addition, the majority of RCs in both urban/transitional and rural regions identified asset provision and preservation as a priority; however rural RCs were more likely to articulate asset provision and preservation as a priority than urban/ transitional RCs. Little was found addressing pre-disaster mitigation and resiliency needs as well as the equity of access across the 12 RCs. The articulation of asset provision/preservation, transit/non-motorized modal access, and transportation for economic development as priorities by relatively more of the rural RCs points to potential areas of deficiency. Data on the system condition and performance may be collected for further evaluation, and the results used as inputs in project development to achieve some minimum standards in the provision of deficiency needs.

4.3 Spatial Views of Georgia's Regional Priorities

The results of the analysis of Georgia's regional transportation priorities were mapped to extract spatial information. Figures 4.1 through 4.5 show the relative variations in the priorities of different goals across the regional commissions as extracted from their comprehensive plans using content analysis. The scores in the legends reflect the number of times regional commissions mentioned initiatives related to the particular performance objectives in their comprehensive plans.

Comparison of these maps provides insight on how regions throughout the state prioritize issues related to the state's priorities. Each map reflects one of the statewide goals and can be used to understand the relative emphasis each RC placed on said goal in their regional plan. For instance, based on Figure 4.1, one can conclude that Georgia Mtns has more priorities aligned with safety than the Heart of GA. Similarly, each map is a visual depiction of the level to which regional priorities echo state goals. This can be used at the state level to identify projects and other initiatives that support the regional priorities across the state in order to produce co-benefits and achieve both regional and statewide goals.

The maps are not intended to be compared to offer insight across different categories of goals; rather each map can offer insights on the relative priority of a particular goal across the different regions. If the safety map and the accessibility map are compared, it would not be accurate to say that the Heart of Georgia's results value mobility and accessibility above safety; such comparisons may be made only within a particular map (i.e., within the context of a particular goal, e.g., safety). However, one can look across the set of maps and make general statements such as River Valley RC has priorities highly aligned with the statewide goals based on the high scores in each map.

For each of Georgia's 12 regional commissions, Figure 4.6 shows the relative levels of importance assigned to all the goal areas under consideration. It is important to note the relative differences in the priorities assigned to the same goal areas, resulting from explicit efforts to conduct regionally-sensitive statewide planning, may be used to develop regionally-sensitive investments that achieve statewide goals.

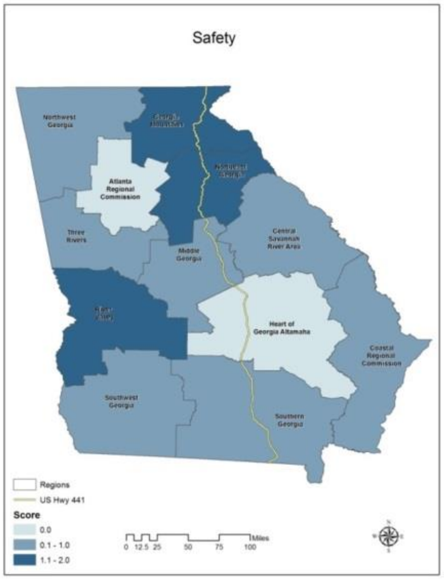

Figure 4.1 Stated Priority of Safety across Georgia's Regional Commissions

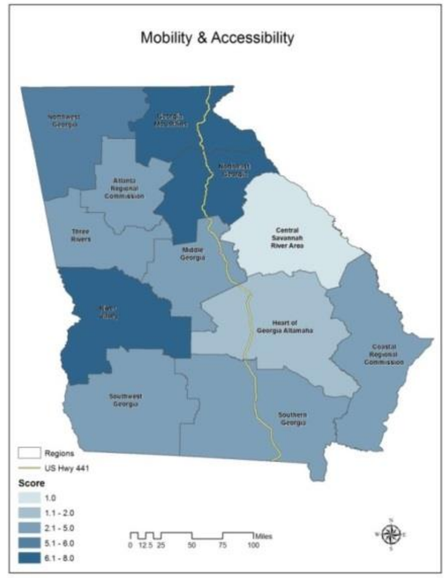

Figure 4.2 Stated Priority for Mobility and Accessibility across Georgia's Regional Commissions

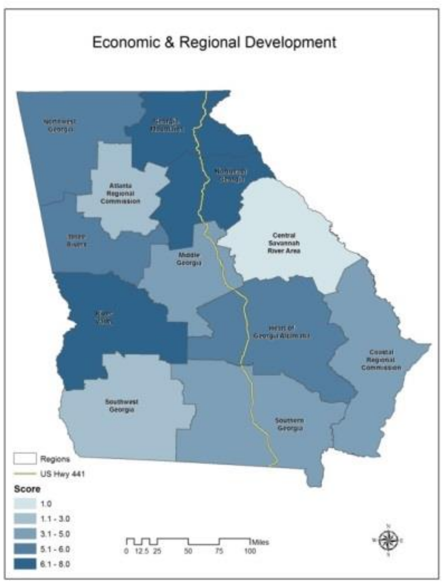

Figure 4.3 Stated Priority of Economic and Regional Development across Georgia's Regional Commissions

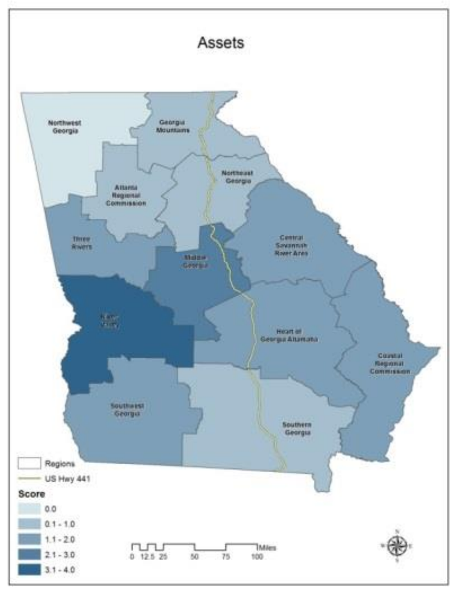

Figure 4.4 Stated Priority for Asset Construction and Maintenance across Georgia's Regional Commissions

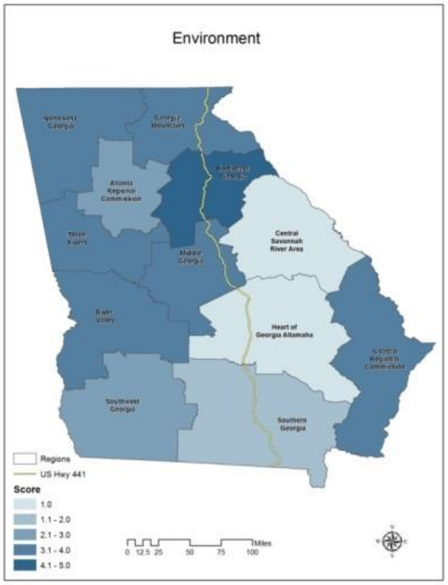

Figure 4.5 Stated Priority for Natural Environment across Georgia's Regional Commissions

As stated previously, the maps above are not intended for comparison across the different goal areas. Rather, they offer some insights on the relative importance placed by each regional commission on each goal area. Figure 4.6 shows distributions of the relative levels of importance placed by each regional commission on the five goal areas: safety, preservation, mobility/accessibility, economic and regional development, and the environment. With additional data on the status of the transportation system in these regions, deficiency-growth profiles can be developed to characterize how well the regions are meeting basic and growth needs.

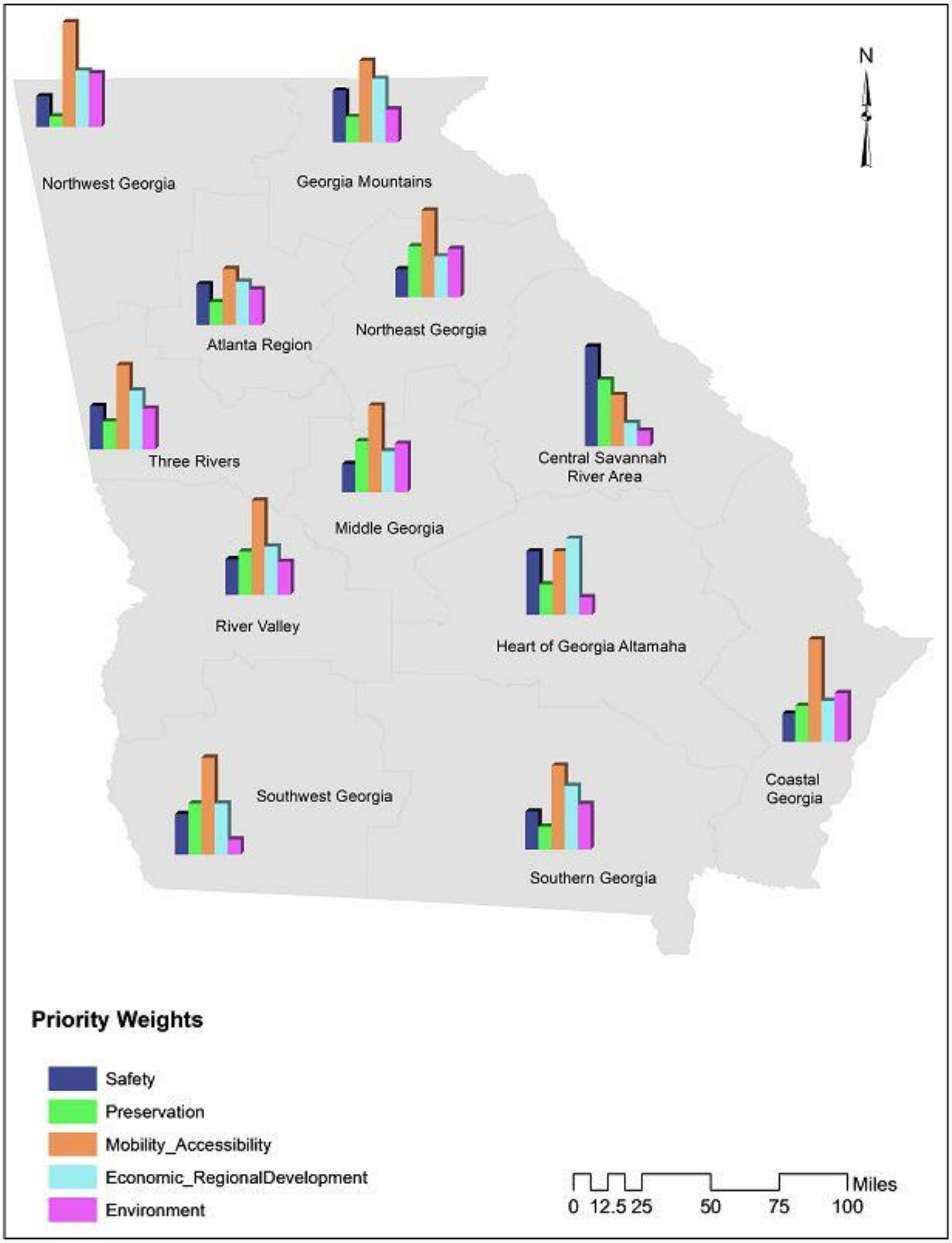

Figure 4.6 Priority Weights for Georgia's 12 Regional Commissions

Regional priorities are an important input in determining the overall health – status, deficiencies, opportunities and constraints – of the system. The articulated needs in the regional comprehensive plans indicate that most regions are concerned with deficiency needs, largely related to mobility, different kinds of accessibility, and asset management. The general absence of resiliency priorities (with the exception of the Georgia Mountains RC) indicates that if there are significant natural disaster risks in any of the regions, resiliency planning will add value in transportation and other investment decision making.

From the results above, some of the system's vulnerabilities may lie in growth opportunities to better support regional economic development, especially in rural areas, a backlog of infrastructure preservation needs, and an opportunity to understand better the disaster risks to the system and the most cost-effective ways to manage them.

That several urban/transitional and rural regions articulate priorities at multiple levels of deficiency needs (i.e., functional, safety, social and economic, and growth/desires needs) reflects a relatively mature system in which implicit or explicit investment tradeoffs have been made to address simultaneously lower-level and higher-level deficiency needs (Figure 2.2).

The results indicate that there is value in exploring how investments made to promote statewide goals (i.e., mobility, safety and asset preservation) can be explicitly tailored and leveraged to enhance economic development, particularly in the rural regions, and to address pre-disaster mitigation and system resiliency issues where needed. The findings also indicate that it could be a worthwhile exercise to assess whether regions are underperforming in any particular areas in ways that could undermine the state's overall transportation system performance, or whether the transport system operations and characteristics and performance in specific locations explain or serve to shape deficiencies for certain regions and commissions thereby creating or contributing significantly to the priorities extracted from the comprehensive plans. Vulnerabilities may also exist in the absence of intentional efforts to address any existing disparities within the system, particularly as this relates to conditions that can be improved through transportation, e.g. poverty.

While statewide expenditures should primarily support statewide objectives, intentional efforts to find ways to leverage funds to achieve statewide objectives while advancing regional priorities could help develop a statewide transportation system with stronger regional sub-systems, resulting in a more robust statewide system and communities in the long run. Intentional efforts could be made to identify synergistic collaborative activity between or among regions that leaves each region better off and contributes effectively to statewide goals. For example, funding structures that incentivize multijurisdictional cooperation and projects that leverage regional strengths and deficiencies could be viewed as mechanisms for achieving statewide mobility goals while strengthening regional interconnectivity.

The 2012 national surface transportation legislation, MAP-21, has offered a risk-based performance-based framework for transportation investment decision making. In the context of MAP-21, the TSH conceptual framework could be used to support the development of regionally-relevant performance measures that contribute effectively to statewide goals while addressing regional differences to capitalize on co-benefits and mitigate risks – identifying a minimum level of provision for deficiency needs across the state. The TSH framework in particular would identify potential areas of risk as areas with lower deficiency needs in so far as these affect the ability of statewide system to perform at the expected levels of service.

To highlight some of these concepts and their applicability, the next chapter presents an analytical framework for conducting Transportation System Health Analysis at the corridor level, with an application to selected state routes in the state of Georgia.

5 An Analytical Framework for Transportation System Health at the Corridor Level

The following analytical framework was developed to apply the Transportation System Health concept to evaluate system health at the corridor level and demonstrated in case studies of selected routes in the state of Georgia. The first study corridor is a section of U.S. Route 27 also known as the Martha Berry Highway or State Route 1 (presented in this chapter), and the second and third are sections of State Route 20 and U.S. 84 also known as State Route 38 (presented in the Appendix).

5.1 Framework Structure

The Corridor Health Analysis Framework (CHAF), shown in Figure 5.1, allows agencies, decision makers, and practitioners to align their assessment of transportation system health with different transportation indicators. The CHAF provides flexibility that allows users to perform analyses at different geographic scales. A particular analysis can use state or regional priorities to assess the health of a corridor at a macro-level. In contrast, a micro-level analysis can analyze a corridor by aligning the functional classes of its constituent segments to the priorities of the locality, (e.g., a county). The micro-level analysis, however, requires multi-granular data, which can be difficult to obtain. Thus, agencies or practitioners interested in conducting this level of analysis need to identify practical and affordable means of gathering useful, high-quality data to augment the framework's benefits.

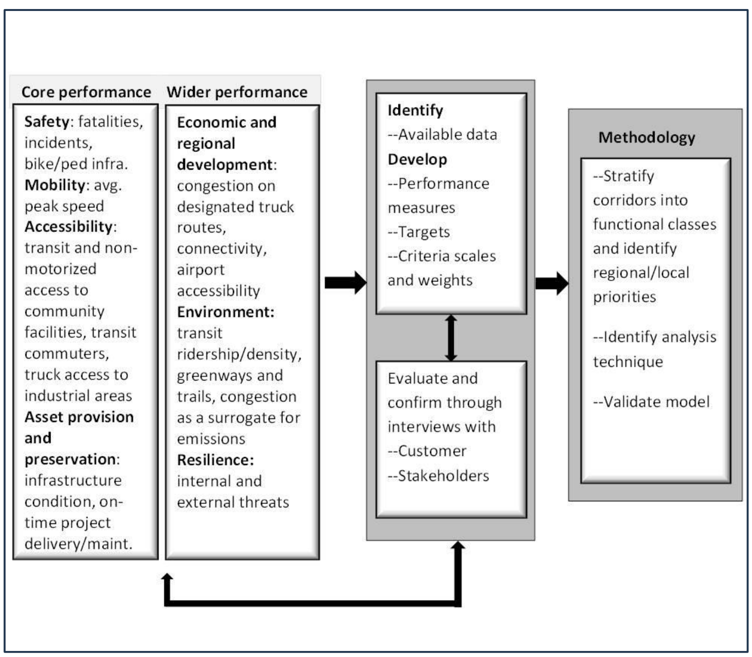

Figure 5.1 Corridor Health Analysis Framework

The first stage of the corridor health analysis procedure involves identifying the priorities and the criteria on which the system's health will be assessed. The framework allows analysts to define the priorities in two dimensions: core and wider performance. The core performance areas involve all of the basic functions required of transportation systems, such as safety, mobility, accessibility, etc. The wider performance areas involve benefits of a transportation system beyond its basic requirements. For example, a healthy system also helps to improve the economic productivity of a region by offering efficient movement of goods and services, diverse mode choices to employment centers, and efficient access to industries, airports, and ports. Thus, the framework addresses deficiency needs in the core performance dimension and growth desires in the wider performance dimension (i.e., deficiency and growth needs, respectively, as defined in the Hierarchy of Needs for measuring Transportation System Health [see Figure 2.2]). The ability of the CHAF to combine all of these dimensions in assessing a transportation system's health makes the framework more comprehensive and flexible, as well as able to offer insights into the health of the system relative to the nature of its needs.

After priorities are determined, the next stage is to identify available data, develop performance measures, and establish performance targets, criteria scales, and weights. Most of these tasks are better accomplished by involving all or a representative sample of stakeholders (including users) in the process. This helps to ensure the development of performance metrics that reflect their needs, and thus are more widely accepted. Since decision makers, stakeholders, and system users have diverse perspectives on performance, collaborating with them on these issues will provide a more robust set of metrics that captures all their perspectives. The final stage of the framework is focused on methodology selection, application and validation. In this process, the analytical technique and the appropriate level of assessment are selected. While the type of technique depends on different factors such as analytical experience, monetary resources, and data, it is important to select a technique that is applicable and replicable across a wider range of analysis levels (i.e., macro- and micro-levels).

5.2 Applying the Framework: Corridor Analysis of Transportation System Health

This section of the report provides a demonstration showing how one can apply the CHAF to determine transportation system health. It first gives a brief description of the case study corridor and then goes through the framework on a step-by-step basis, showing the different methods that can be applied at different stages of the framework. To demonstrate the efficacy of the proposed framework and algorithm, the health of three separate sections of the Georgia highway network was evaluated.

5.2.1 Description of Case Study Corridors

The first study corridor is a section of U.S. Route 27 corridor, also known as the Martha Berry Highway or S.R.1. This route traverses Georgia from north to south. This highway corridor is designated as part of the Governor's Road Improvement Program (GRIP), a program aimed at improving a system of corridors identified to be essential in bringing economic development to the surrounding regions and the state. The US27/SR1corridor, when fully constructed, will be the longest (approximately 350 miles) corridor within the GRIP network. The corridor runs through four regions: Northwest Georgia, Three Rivers, River Valley, and Southwest Georgia (see Figure 5.2). This particular corridor was selected because of its economic importance to the regions and state, the availability of corridor data (due to the presence of a large number of MPOs along this corridor), and the potential to transfer and apply the method and results to other GRIP routes.

The second corridor used in this study is S.R.20. It has an approximate length of 165 miles and wraps around the Atlanta region from Rome in the northwestern part of the state. State Route 20 has connection points with U.S. 27, U.S. 411, I-75 and I-575. These connection points make S.R. 20 an important route for diversions from the interstates. The corridor passes through Northwest Georgia, Northeast Georgia, Atlanta and Georgia Mountains regions.

The third corridor U.S. 84, also known as S.R. 38, is about 280 miles long and spans the southern part of the state passing through Southwest Georgia, Southern Georgia, Heart of Georgia Altamaha and Coastal Georgia from west to east. Similar to U.S. 27/S.R. 1, U.S. 84 is also listed as part Georgia's GRIP corridors, which are proposed to help improve economic development in Georgia. Section 5.3 presents the results and findings of the first case study (SR1), and the case study results for SR20 and SR38 are presented in the Appendix.

The data disparities observed among the evaluated corridors throughout the study suggests that although the method is replicable for all corridors including GRIP corridors, achieving meaningful results will require additional efforts to gather non-existing data. That is, without a central database or standards for gathering data for these corridors, replicating the analysis for all other corridors can be extremely demanding with respect to data collection and may not produce very meaningful results depending on data availability. The data utilized in these illustrations are attainable through various transportation, planning, and local agencies. Until a common data source is established that maintains such data, stakeholders can identify meaningful surrogate data to accomplish their objectives.

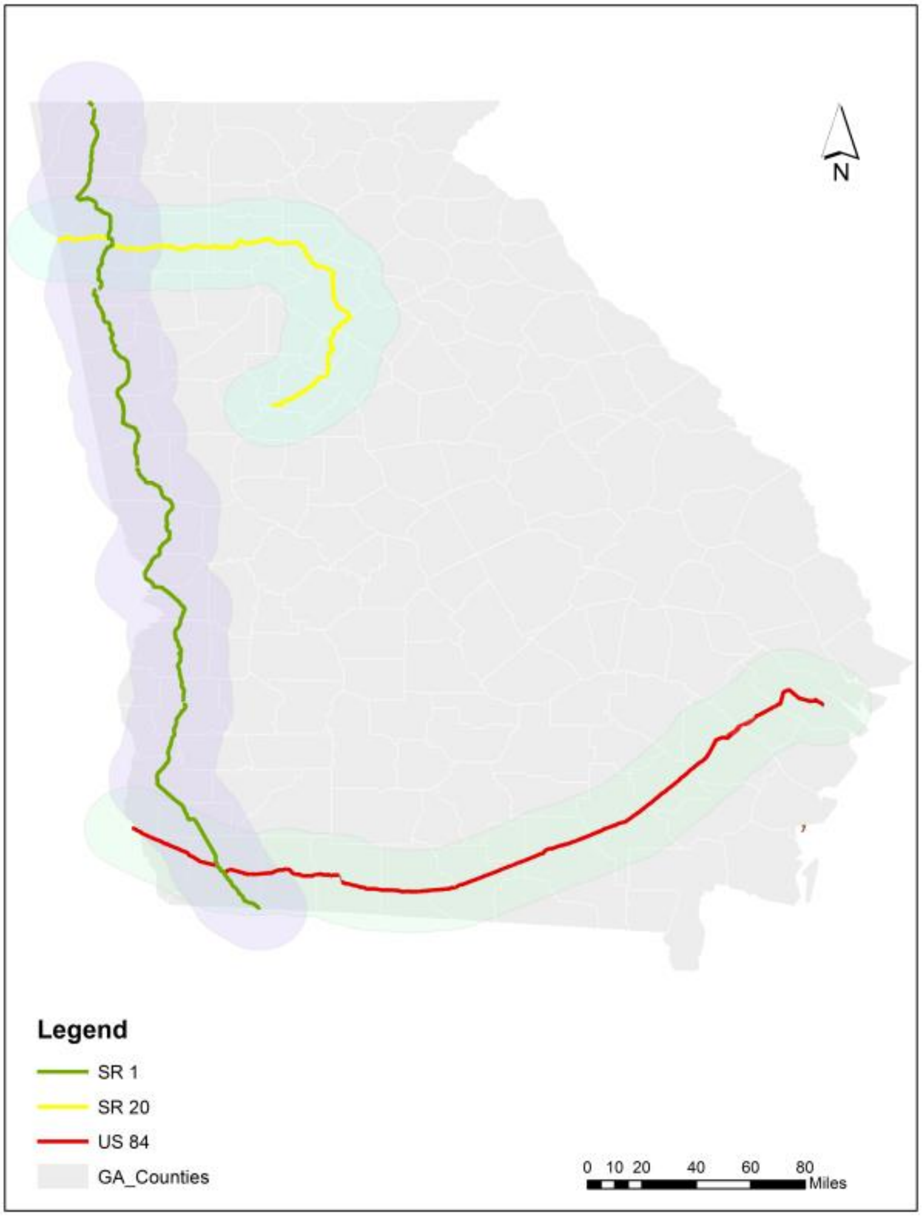

Figure 5.2 Location of case study corridors

5.2.1.1 Defining Corridor Boundaries

The definition of a transportation corridor boundary is an important issue in integrated transportation investment decision making. The boundaries and characteristics of a transportation corridor can be defined narrowly or broadly depending on the context, scope, and objective of the study being conducted. Essentially, the limits of a corridor are defined by contextual perceptions, a practice that has led to diverse definitions of a corridor in the literature. In freight transport analysis for the long haul of goods, one can define a corridor as a railway line, waterway, or a highway, or a combination of these three. A narrower definition of a corridor revolves around a section of an arterial that has economic development potential (e.g., a shopping center). Other contextual definitions of a corridor include land use management, access management, right-of-way identification, recreational needs, trade facilitation, and operational improvements (Reiss et al. 2006).

Comprehensively, a corridor can be described as "a largely linear geographic band defined by existing and forecasted travel patterns involving both people and goods". The corridor serves a particular travel market or markets that are affected by similar transportation needs and mobility issues. It includes various networks (e.g., limited access facility, surface arterial(s), transit, bicycle, pedestrian pathway, and waterway) that provide similar or complementary transportation functions (Reiss et al. 2006). For the objectives and scope of this study, a corridor is defined to include a limited-access facility, surface arterial(s), transit, bicycle, and pedestrian pathway(s).

5.2.2 Aligning Priorities

As discussed in the Chapter 3, transportation priorities were extracted from various planning documents at the regional level and aligned with statewide transportation priorities. Drawing from this information, the performance criteria used in this case study were safety, mobility, accessibility, asset preservation, economic and regional development and the environment. Table 5.1 shows the five statewide goal areas aligned with various regional transportation priorities.

Table 5.1 Regional Priorities Aligned with Statewide Goals

Economic and Regional Development		Mobility and Accessibility
Transportation to support development (residential and economic) patterns		Non-SOV transportation choices
Transportation facility demand improvements		Complete streets/bicycle and pedestrian infrastructure
Transit access to community facilities and services		Transportation facility demand improvements
Connectivity		Transit access to community facilities and services
Smart Growth and reduction of sprawl		Connectivity
Greenways and trails		Smart Growth and reduction of sprawl
Access to housing and community facilities and services		Greenways and trails
Scenic corridors and tourism		Access to housing and community facilities and services

Strategic expansion/restriction of regional system	Port, rail, and airport access and connectivity
Unpaved roadways	Strategic expansion/restriction of regional system
Safe and efficient movement of people and foods	Safe and efficient movement of people and foods
Presence of logistic strategic hub	Pre-disaster mitigation/resiliency
Increased import/export capabilities (including freight rail, airports and ports)	Income spent on transportation
Access control	Commute length
Parking requirements reductions	High speed rail
High speed rail	**Safety**
Environment	Complete streets/bicycle and pedestrian infrastructure
Non-SOV transportation choices	Safe and efficient movement of people and foods
Complete streets/bicycle and pedestrian infrastructure	Pre-disaster mitigation/resiliency
Transportation facility demand improvements	Signage for controlling and managing traffic flows
Smart Growth and reduction of sprawl	**Preservation**
Greenways and trails	Complete streets/bicycle and pedestrian infrastructure
Reduction in impervious surfaces	Optimize and manage existing assets in the current transportation system
Sustainable infrastructure	Unpaved roadways
Air quality	Transportation facility design
	Signage for controlling and managing traffic flows

5.2.3 Data and Performance Measures

The next step in the framework involves identifying the necessary data required to assess attainment of the stated goals and priorities. To do this, the performance measures for each goal must be determined; this step is highly dependent both on regional priorities and limited by available data.

For this case study, regional commissions within the study area were contacted to ascertain the data they had available as well as any performance measures currently used to track transportation system performance. This process yielded minimal results in terms of data; therefore, the regional MPOs, some local city governments, and the state DOT were contacted for additional data. The resulting data came from various sources including the Computerized Pavement Condition Evaluation System (COPACES), the Bridge Information Management System (BIMS), the National Bridge Inventory, the Georgia GIS Data Clearinghouse, and the FHWA Freight Analysis Framework. The data from the scan, as well as various online data sources enabled selection of appropriate measures that could reflect each region's performance priorities (Table 5.2). For example, the COPACES ratings were used as a measure of the condition of road pavements. In some cases, proxy measures were developed; for example, the length in miles of major roads was used as a proxy for the corridor's contribution to economic and regional development as this measure can reflect the ease of freight movement within a county or region.

Table 5.2 Performance Measures Selected for Analysis

Priority Area	Measure	Data Source
Safety	Number of traffic incidents per 100,000 people	GDOT safety data U.S. Census Bureau
Mobility	Average travel speed (mph)	Freight Analysis Framework (FAF)
Accessibility	Link to node ratio of number of transit, pedestrian (sidewalks, trails and greenways) and bicycle facilities within 0.3 miles of community facility (school, hospital, library, emergency shelter, police station & fire dept.)	GDOT-GIS data Tiger/line GIS files Regional commission & city developed GIS data Georgia GIS Data Clearinghouse
Preservation	% bridges with sufficiency rating >/=50; % road pavements with COPACES rating >/=70	National Bridge Inventory Bridge Information Management System (BIMS) Computerized Pavement Condition Evaluation System (COPACES
Economic Development	Length in miles of major roads relative to the analysis area; Number of counties with transit services to employment centers	NAICS Data (Census.gov) American Public Transportation Association (APTA)

5.2.4 Case Study Corridor Evaluation

The analysis model proposed in this work enables assessment of the overall health of a transportation corridor in a consistent, transparent, and replicable manner, which takes into consideration different modes of transportation. The model assesses the health of a transportation corridor focusing on the overarching priorities and objectives of a regional commission and the State DOT. In this analysis, each variable represents a specific health element of the corridor. The model generates a composite score combining the selected individual health characteristics of the corridor. The results can also be reported as a vector of health elements to communicate more detailed information on different elements of corridor health.

This framework provides the flexibility to alter performance targets, priority weights, and performance scales for sensitivity analyses. Depending on the granularity of the data available, the algorithm can be used to perform contextual health analysis of urban, suburban, and rural transportation corridors. The analysis method employs the principles of **goal programming**: the algorithm compares the performance data for each corridor to a previously established target, and a score between 0 and 1 is assigned to the performance criterion based on the proximity of the performance data to the target. For example, performance data that achieves or exceeds the target is assigned a score of 1. Similarly, performance data that falls below the target is assigned different scores depending on extent of deviation from the target or goal. Equation 5.1 shows the formulation of the goal programming model.

$$\begin{bmatrix} H_{c_1} & H_{c_2} & \cdots & H_{c_n} \end{bmatrix} = \begin{bmatrix} w_1 & w_2 & \cdots & w_m \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots \text{(eqn 5.1)}$$

Where:

H_{c_n} = the health score for each corridor
n = the number of corridor segments
m = the number of priority areas
w_m = the weight assigned to each priority area
a_{mn} = the individual health indicator for a given priority area

5.2.5 Estimating Individual Health Indicators, Priority Weights, and Overall Health Score

In medicine, a person's overall health is based on a combination of factors. Similarly, the overall health of a transportation corridor is based on a combination of the corridor's performance in all areas prioritized by decision makers and analysts. For instance, a corridor's health may include a combination of the corridor's contributions to the economic development of the region and/or state, the provision of diverse modes, and the accessibility level of the corridor (i.e., the accessibility of the corridor to different facilities or for various populations). While the composite health score may only offer a general view of the performance of the corridor, the ability to examine a corridor's health using goal-area-specific indicators offers transparency in the processes. In other words, the ability to identify health areas that may be overshadowed by higher-priority areas (more heavily weighted) in computing the overall score provides decision makers with information useful in policy development. This transparency in analysis reduces the risks associated with a black-box decision analysis and decision support exercise.

5.2.6 Individual Health Indices ($\boldsymbol{a_{mn}}$)

Individual health indices for priority areas in each corridor are estimated using constructed scales typically developed by decision makers and practitioners. The flexibility afforded by

Federal law to agencies allows them to determine their own targets. This means that constructed scales can vary (in terms of the number of grade points and ranges) from one agency to another. For example, using expert opinion, an agency may select four grade points (e.g., Excellent, Good, Fair, and Poor) with corresponding grade values (1, 0.5, 0.3, and 0). There is subjectivity in developing scales for the health indicators. This subjectivity in scaling makes it difficult to make universal comparisons of system health. However, it allows an individual agency to assess its own system health on a defined scale, using its own established targets, and manage the system toward desired outcomes. Table 5.3 shows the constructed scales for the health variables used in this case study. One can similarly construct other scales for the other health indicators. Using these established scales, each variable can be analyzed to assess the health of a transportation corridor. Using similar concepts, appropriate scales can be developed to measure other attributes of interest.

Table 5.3 Constructed attribute scales

Safety

Performance Level (# of state average accidents per 100,000 residents = X, and # of accidents per 100,000 residents of buffer area= Y)	**Scale**
$Y \geq 80\%$ of X	1.0
50% of $X \leq Y < 80\%$ of X	0.5
10% of $X \leq Y < 50\%$ of X	0.3
$Y < 10\%$ of X (Goal)	0

Mobility

Performance Level (segment targeted average speed, e.g., posted speed limit = Xmph, actual segment speed= Ymph)	**Scale**
$Y \leq$ 15mph below X	1.0
15mph below $X < Y <$ 10mph below X	0.5
10mph below $X \leq Y \leq X$	0.3
$Y \geq X$	0

Asset Preservation: Bridges

Performance Level (% of bridges with sufficiency rating > 50= Y)	**Scale**
$Y < 30\%$	1.0
$30\% \leq Y < 60\%$	0.5
$60\% \leq Y < 90\%$	0.3
$Y \geq 90\%$	0

Asset Preservation: Pavements

Performance Level (% of pavement with Copaces rating >= 70= Y)	**Scale**
$Y < 30\%$	1.0
$30\% \leq Y < 60\%$	0.5
$60\% \leq Y < 90\%$	0.3
$Y \geq 90\%$	0

Economic Development (employment access and freight movement [productivity])

Performance Level (X =target % of industries within k miles of exit(s), Y = actual % of industries within k miles of exit(s))	**Scale**
$Y < 50\%$	1.0
$50\% \leq Y < 80\%$	0.5
$80\% \leq Y < X$	0.3
$Y \geq X$	0

Accessibility

Performance Level (link-node ratio target* = $X = 1.2$ *and* $Z =$ *actual computed link – node ratio*, target % of counties with commuter or transit services to major employment centers, Y =% of counties within k miles of employment centers with commuter or transit services)	**Scale**
$Z < 20\%$ *of* X	1.0
20% of $X \leq Z <$ 50% of X	0.5
$Z \geq$ 50% of X	0.3
$Z \geq X$	0

*Link-node ratio (target=X) = $\frac{number\ of\ links\ (bicycle, transit, or\ sidewalks)}{number\ of\ accessible\ nodes\ (community\ facilities)}$, $accessible\ nodes \neq 0$.

5.2.7 Priority Weights (w_m)

Generally, weight assignment signifies the relative importance a decision maker or stakeholder assigns to a priority area (or decision variable). It can also represent the emphasis that a regional commission places on a decision variable because of current issues or the need to improve performance in that particular area. Arriving at these weights can be accomplished using different methods. It is important to note that weighting schemes can be determined in a variety of ways from simple conversations with primary decision makers to more robust methods involving historical analyses. For this study, two weighting schemes were used. The first scheme assigns different weights to the decision variables for each corridor reflecting the relative priorities of the regions (i.e., regional-level analysis). The second weighting scheme assigns equal weights to all the decision variables (i.e., the State-level analysis), indicating that State-level decision makers are equally interested in achieving each priority goal.

For this case study, weights for each regional commission were determined based on the number of times elements related to a particular decision variable were mentioned in the region's comprehensive plan. This data was collected by scoring the number of initiatives, priorities or goal areas set out in each regional commission's comprehensive plan under the respective decision variable (Table 5.1). The assumption driving the scores is that the articulated activity in a particular area correlates with the importance assigned to a decision variable, or priority area. For instance, mobility initiatives were mentioned 6 times by the Northwest GA Regional Commission, 5 times by Three Rivers, 8 times by River Valley, and 4 times by Southwest GA; the approach used in this study assumes that River Valley Regional Commission assigns a higher weight to mobility relative to the other Regional Commissions in the timeframe of this study.

The weight assignments were determined for all decision variables using Equations 5.2 and 5.3. First, Equation 2 computes a weight scale for the decision variable using the element subtotals and, subsequently, Equation 5.3 uses the scaled score to estimate the expected priority weight for the corresponding health decision variable. The weight scale captures the relative number of times an element related to a particular decision variable (e.g., mobility) is mentioned in the regional comprehensive plan, relative to the maximum number of times elements related to that same variable are mentioned when considering all of the regions being studied. These elements are referred to as evaluative elements in equations 5.2 and 5.3. Similarly, the priority weight captures the relative importance a region assigns to the individual priority areas, assigning points for each priority area that altogether add up to 100.

$$Weight\ Scale\ (WS_i) = \frac{x_i - x_{min}}{x_{max} - x_{min}} \ldots\ldots\ldots\ldots\ldots \text{(eqn 5.2)}$$

$$Priority\ Weight\ (PW_i) = \frac{WS_i}{\sum_1^m WS_i} \ldots\ldots\ldots\ldots\ldots\ldots \text{(eqn 5.3)}$$

where:

$x_i = Number\ of\ individual\ evaluation\ elements\ for\ priority\ x$

$x_{min}, x_{max} = Minimum\ and\ maximum\ evaluation\ elements\ for\ priority\ x$

$m = number\ of\ priority\ areas.$

Weights computed using this method were subsequently sent to the respective regional commissions for validation and feedback. This was first done by email and followed later by brief phone interviews to ensure all the concerns and comments from the regional commissions were appropriately addressed. In each case, the contact at the regional commission was either the Planning Director or the Regional Planner for the area. Table 5.4 shows the weights generated using the scaling method described and the final weights used in the analysis after validation by the regional commissions. In some instances during the validation process, the regional commissions agreed with the weights assigned and thus, had no revisions or additions to make (shown in bold format in Table 4.4). However, in other instances, the regional commissions provided more information which resulted in changes to the priority weights. It is important to note that these weights are not static but time-dependent representations of the relative priority levels that the RCs assign to the goal areas under consideration at a particular time. These priorities can change at any time. For such weights to be useful, they must be current – reflecting the most current consensus on relative priorities from regional perspectives.

Table 5.4 Priority Weights for Regional Commissions

	Initial estimated weights					Validated weights				
Region	Safety	Preservation	Mobility & Accessibility	Economic & Regional Development	Environment	Safety	Preservation	Mobility & Accessibility	Economic & Regional Development	Environment
NW GA	**12**	**4**	**41**	**22**	**21**	**12**	**4**	**41**	**22**	**21**
GA Mountains	17	5	44	19	15	20	10	32	25	13
ARC	6	11	49	12	22	16	9	22	17	14
Three Rivers	11	14	34	21	20	17	11	33	23	16
NE GA	**11**	**20**	**34**	**16**	**19**	**11**	**20**	**34**	**16**	**19**
CSRA	39	26	20	9	6	39	26	20	9	6
River Valley	**14**	**17**	**37**	**19**	**13**	**14**	**17**	**37**	**19**	**13**
Middle GA	**11**	**20**	**34**	**16**	**19**	**11**	**20**	**34**	**16**	**19**
SW GA.	16	20	38	6	20	16	20	38	20	6
Southern GA	16	10	46	18	10	15	9	33	25	18
HOGA	9	28	20	39	4	25	12	25	30	7
Coastal GA	12	15	38	13	22	11	14	40	16	19

5.2.7.1 Overall Health Score (H_{c_n})

The overall health score of a corridor is computed using Equation 1 to combine all health indicator variables suggested by decision makers or analysts with the corresponding priority weights above. The number of variables used in determining the overall health score will depend on the goals and objectives of the agency and data availability. Similarly, the method of aggregation can also be determined using different criteria. As stated earlier, this model uses the goal programming approach, which is a multi-utility assessment methodology that uses a weighted sum to evaluate the performance of alternatives. The method allows analysts to assign weights to decision variables. Generally, high-priority decision variables receive larger weights while decision variables with lower priority receive smaller weights.

5.3 Analysis and Discussion of Results

For this demonstration, the study corridor, U.S. Route 27, was defined using a 15-mile buffer along the route. It was also segmented based on the regions that it traversed. Thus, the analysis was categorized into (1) Northwest Georgia, (2) Three Rivers, (3) River Valley, and (4) Southwest Georgia. Targets used in this analysis were based on GDOT performance targets where they were previously established; and engineering judgment where no clear thresholds were found. Table 5.5 shows a sample of the input data used in the analysis. This table only identifies corridor characteristics and input data used in the analysis. The goal areas are in the constructed attribute scaling and results tables (Table 5.4 and Table 5.6).

Table 5.5 Selected characteristics of study segments

Regional Commission	Corridor_ ID	Length of corridor (miles)	Buffer area population	Total Number of bridges	Number of bridges with SR>50	Total number of Incidents	Average travel speed along corridor (mph)	Total number of nodes (comm. facilities)	Total number of links within 0.3miles of facilities
Northwest	GA_27_C1	115.14	740435	241	212	21617	45	1192	97
Three Rivers	GA_27_C2	76.67	338830	116	100	11096	44	617	25
River Valley	GA_27_C3	109.89	272528	152	125	13284	40	821	4442
Southwest GA	GA_27_C4	75.16	121659	51	48	1837	50	267	15

Regional Commission	Total length of pavement above CoPaces of 70 (miles)	Annual CO2 equivalent (in metric tons)	Annual CO2 emission per mile (in metric tons)	Ratio of regional to statewide emission	Annual CO2 emission per capita	Total number of industries & warehouses within buffer	Total counties within study corridor	Total counties with transit services to employment centers
Northwest Rivers	115	221771	1926	4.02	0.003	64	11	11
Three Rivers	59	112379	1466	3.06	0.332	31	5	2
River Valley	104	195558	1466	3.06	0.718	66	10	5
Southwest GA	50	58841	783	1.63	0.484	84	9	3

Table 5.6 summarizes how the health indicators of the segments of the study corridor compare in achieving regional and statewide goals. The individual health indicators shown in Table 5.6 have been scaled using the predefined scales presented in Table 5.3. After applying the scaling and weighting process at both the regional and state level, an overall health score was computed for each region. The individual health indicators represent the extent to which each priority area's target has been met. A health indicator rating of 0, such as the accessibility measure for the Northwest Georgia Region, indicates that the region did not meet the required performance target. Likewise, a health indicator rating of 1 indicates that the region either met or exceeded the set performance target. The results show that the corridor segments within the Three Rivers and River Valley regions failed to meet three of the seven performance targets. However, three regions out of the four either met or exceeded their performance targets in at least one priority area.

The component scores, on the other hand, show the impacts of the regional and state level weighting on the performance scores. In this case, component scores were achieved by multiplying performance scores with the computed regional weights and assumed state weights respectively. The state weights were assumed to be of equal importance across the priority categories. From a regional perspective, these scores also reflect how a region achieves its goals while contributing to the statewide goals. For example, in the Northwest Georgia Region, component scores for asset preservation vary significantly between the regional and state scores despite very high performance scores for the corridor. This shows that a lower priority is placed on the asset preservation relative to the region's other priorities; bridge and pavement condition contributes less to the overall health of the corridor from the regional perspective. This score differential could indicate that the region currently has high-performing physical assets (bridges and pavements) or is relatively less concerned with asset preservation in comparison with other priorities. Among the seven regional component scores for Northwest Georgia, employment access and mobility were the highest.

Regional variations in system health are also revealed by comparing the component scores of the four regions. For example, Northwest Georgia shows a regional component score for asset preservation (bridges) of 0.001; whereas Three Rivers shows a component score of 0.026, although both RCs perform similarly (0.5) in their score for asset preservation (i.e., bridges). This variation further illustrates differing priorities along a single corridor. High component scores may indicate either high individual health scores or high weights or both.

Lastly, the Overall Health Ratings (OHR) are composite indices from which regional level and state level assessment outcomes (and differences between them) can be inferred at a glance. The OHR scores are essentially a reflection of the health of each corridor segment as measured based on regional and statewide priorities, respectively. The results shown in Table 5.6 show that generally, these corridor segments are viewed at a higher level of health from a statewide perspective than from a regional perspective. The OHR will not always be the same from state and regional-level perspectives. The more different the values, the more important it will be to identify projects that address the particular deficiency needs or growth desires driving the differences. Based on the scaling, normalization and weighting, the highest and lowest values the OHR measure could take are 0 and 1, respectively.

Table 5.6 Output table showing results of analysis

Corridor	Priority Area	Health Indicator			Overall Health Rating (H_{c_n})	
		Individual Health Index[1] (a_{mn})	Component Score[2]		Regional Level	State Level
			Regional	State		
Northwest	**Mobility**	0.3	0.067	0.06	0.25	0.40
	Safety	0.3	0.035	0.06		
	Accessibility	0	0.000	0		

	Asset Preservation	0.5	0.001	0.05		
	Bridges					
	Pavements	1	0.002	0.1		
	Economic Development	1	0.111	0.1		
	Employment Access					
	Freight Access	0.3	0.033	0.03		
	Mobility	0.3	0.049	0.06		
	Safety	0	0.000	0		
	Accessibility	0	0.000	0		
	Asset Preservation	0.5	0.026	0.05		
Three Rivers	Bridges				0.13	0.17
	Pavements	0.3	0.016	0.03		
	Economic Development	0	0.000	0		
	Employment Access					
	Freight Access	0.3	0.035	0.03		
	Mobility	0	0.000	0		
	Safety	0	0.000	0		
	Accessibility	1	0.187	0.2		
	Asset Preservation					
River Valley	Bridges	0.5	0.043	0.05	0.34	0.38
	Pavements	1	0.085	0.1		
	Economic Development	0				
	Employment Access		0.000	0		
	Freight Access	0.3	0.028	0.03		
	Mobility	0.5	0.093	0.1		
	Safety	0.5	0.083	0.1		
	Accessibility	0	0.000	0		
	Asset Preservation					
Southwest GA	Bridges	1	0.100	0.1	0.32	0.36
	Pavements	0.3	0.030	0.03		
	Economic Development					
	Employment Access	0	0.000	0		
	Freight Access	0.3	0.009	0.03		

[1]Estimated using Table 5.3
[2]Component score=$W_m * a_{mn}$ (reference section 5.2.4)

The results of the analysis also show different scores across the three indicator levels (individual, component, and overall) from region to region. For example, segment of the corridor in River Valley obtained the highest OHR based on their regional priorities but was rated second when statewide priorities were used. Similarly, based on statewide priorities, the Northwest Georgia segment obtained the highest OHR but still not as high when the health was assessed using the region's stated priorities. Thus, by looking at the individual component scores for each priority area, as well as the corresponding performance scores, decision makers can determine areas that fall short of predefined goals and targets at both levels of analysis, and thus prioritize those areas for improvement. From a strategic investment perspective, this enables intentional project development efforts to achieve regional goals and broader statewide goals simultaneously, in order to realize co-benefits.

It is thus necessary to take both disaggregate and aggregate views of the results of this TSH analysis in order to develop a comprehensive story about health. The disaggregate indicators and OHR values together provide a comprehensive set of measures on system, health. The disaggregate information may shed light on how differences in priorities influence corridor health from regional and state perspectives. The disaggregate views of the results also allow the analyst to identify segments that have low individual health indices and high weights as priority segments. The aggregate views of the results show the analyst how each segment is performing in its overall health from a statewide perspective and from a regional perspective. For example, the OHR results for the corridor section in Northwest Georgia indicate that this corridor is operating at 25% of its full health capacity from a regional perspective, but at 40%of its full health capacity from a statewide perspective. A drill down into the more disaggregate data will help articulate the potential areas for investment at the regional level to augment this OHR value. These areas can be considered in the context of statewide priorities to identify projects that offer co-benefits from regional and statewide perspectives.

5.4 Summary

Transportation system health (TSH) can provide insight and tell a broader story of how regional transportation systems potentially help to achieve statewide goals while contributing to context (i.e., regional or local) goals as well. Transportation system health, as defined in this study, encompasses more than the functional purposes of the system to include other aspirational objectives held by stakeholders of the system, with particular reference to deficiency needs and growth desires of the system. The concept involves addressing geopolitical and stakeholder views of system performance such that decision makers can augment or maximize value in multiple contexts (i.e., statewide or regional, urban or rural). The Corridor Health Analysis Framework provides an algorithm that assesses a diverse array of stakeholder-identified variables to define the health of a transportation system. Ideally, this list of variables will include the primary transportation system health risks and opportunities in a region, and incentivize appropriate data collection where this kind of analysis is limited by such data availability. The model provides sufficient flexibility for practitioners with adequate and high-quality data to perform extensive and context-sensitive system health assessments of their transportation systems, for example, regionally-sensitive statewide assessments. The greater value of TSH may be in the development of more explicit locally-derived weighting frameworks using less aggregate data tied to places and projects in regions that reflect their highest priorities. Regions may decide they value secondary needs over primary ones in some cases, for example. Some of these secondary needs may offer opportunities for defining projects with cobenefits at the statewide and regional levels.

This case study has demonstrated the systematic process of applying the TSH framework in a corridor-level evaluation. In the case study, the algorithm utilizes four main system health variables [safety, mobility, asset preservation (includes bridges and pavements), and economic development (includes freight and employment access)], each individually illustrating an aspect of system performance, and contributing to overall system health. In addition, these individual health indicators are used to generate a composite score that offers a summary of the overall health measure of the corridor from two perspectives: statewide and regional. The overall health measure gives an indication of the physical, operational efficiencies and economic development potential of the corridor. In the case study, four different regional commissions along the study corridor were treated as independent jurisdictions and each region's section of the corridor was assessed based on its contextual priorities as well as its contributions to achieving statewide goals. The individual health indicators of each decision variable for a given region offer contextual information to decision makers for achieving established regional targets, which can support resource allocation to achieve such targets. Similarly, the overall health ratings of corridors in each region can point to opportunities for collaboration to strengthen regional systems. As economic development priorities typically get evaluated based on the number of jobs, wage increases, dollar of added value, and other fine grained measures, the results of this exercise will increase in value with data availability and quality improvements.

Although this application of the framework demonstrates analysis at a high level, the concept is equally applicable to lower-level analyses. This evaluation is heavily dependent on the selected performance measures and constrained by data availability; the data granularity will dictate the level of analysis that can be performed using the algorithm. TSH holds much promise for providing decision makers with a means by which to examine, and strategically manage, transportation infrastructure investments considering goals and objectives at multiple levels of government decision making, and from multiple stakeholder perspectives. As decision makers and agencies seek to expand their performance management practices, better alignment of performance measures and targets with multi-level goals and priorities will enable even stronger transportation system health outcomes in the long term.

6 Additional Measures of Performance

6.1 Addressing Accessibility, Regional Economic Development and Risk in System Health Analysis

The application of the TSH analytical framework is heavily dependent on and constrained by data availability. Ideally, a TSH analysis should capture the most significant priorities - risks and opportunities - for the decision makers and stakeholders whose perspectives are being used in the analysis. In the example application presented in Chapter 5, five measures were used based on the data identified. In some cases, measures were computed based on the original data files identified to provide a more comprehensive set of measures for communicating system health. To apply this method more effectively, it will be important to identify opportunities for more comprehensive performance measurement and reporting, related to the most significant risks and opportunities that are not currently being measured. To this end, this chapter presents an extended set of measures for assessing transportation system health. These measures capture both basic needs and growth desires for the stakeholders of a transportation system (Figure 2.2), and address accessibility and regional economic development. Several of the measures may be viewed as surrogates. Less aggregate data is ultimately necessary for economic analysis to characterize the local economic environment better across a large scale of indicators, e.g., wages, unemployment, value of economic goods and services.

6.1.1 Accessibility

Accessibility of the transportation system refers to the ability of people to reach goods, services, and activities using the system. This section provides an interrelated set of measures that offer a holistic approach to addressing accessibility (Equation 6.1). Here, accessibility is characterized as a function of cumulative opportunity, travel impedance, and network connectivity or density.

$A_k = f\{C_k, N_k, \sum_i^n I_{pk}\}$ …………….. eqn 6.1

where:

A_k = accessibility of corridor k

C_k = cumulative opportunity of corridor k

N_k = network connectivity of corridor k

I_{pk}= travel impedance, I, from facility p to corridor k

Cumulative opportunity refers to the number of facilities and services that can be reached within a certain distance of a corridor. These are community facilities necessary for both passers-through and populations living in communities close to the corridor. Examples include schools, libraries, hospitals, emergency shelters, police departments and fire departments. The number and types of facilities to include is at the discretion of the analyst.

Network connectivity refers to the number of available connection points (including intermodal connection points) to the route under study; and may be influenced by the density of the network around the route. These two components enable an assessment of the ease of connection to the main route, as well as the redundancy of the network along the corridor being studied.

Travel impedance, as captured by this measure, refers to the cost of travel between community facilities and the route under study, which affects the utility of travel between those facilities. Travel impedance can be measured by either travel time or distance.

Demonstration

State Route 20 is used in this proof of concept for the accessibility measure. This route passes through Northwest Georgia, Northeast Georgia, Georgia Mountains and the Atlanta Region.

Cumulative Opportunity

In calculating the cumulative opportunity for this measure, six types of facilities were considered. However, as previously stated, the numbers and types of facilities to be considered are at the analyst's discretion. The main tools used in this section were the clip and join tools in ESRI's ArcGIS. The facilities used were emergency shelters, hospitals, police stations, fire departments, libraries, and schools. Only facilities within the 15-mile buffer of SR20 were considered. All geospatial data for these facilities were Office of Regulatory Services (ORS) GIS shapefiles obtainable from the Georgia GIS Clearinghouse or from the U.S. Census website under Tiger/Line products. Figure 6.1 shows a sample of the data used in this portion of the study.

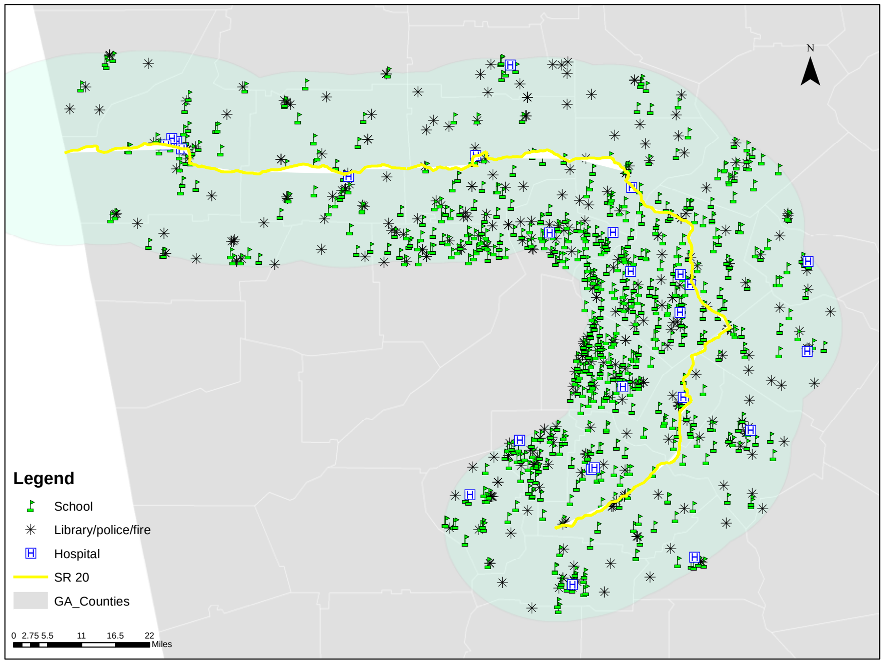

Figure 6.1 Community facilities found within the SR20 buffer area

By joining of the total number of facilities and the counties, the total number of facilities within the buffer area for each region was determined. The results are shown in Table 6.1. These values, standardized by the corridor lengths or coverage areas in the different regions, would offer some measure of the relative accessibility of the corridors to these basic services.

Table 6.1 Cumulative opportunity for different sections of SR 20

SR 20	Emergency Centers	Hospitals	Library+Police+Fire	Schools	Total
Northwest	90	7	75	77	249
Northeast	38	3	43	49	133
GA Mountains	37	1	25	53	116
ARC	139	14	206	441	800

Network Connectivity

Network connectivity measures roadway connections. In a broader context, the quality of connections between modes (i.e., ease of walking and cycling to public transport) is considered in assessing the quality of a network's connectivity (Litman, 2014).

Primary and secondary roads were used to demonstrate how one would determine the network connectivity of the corridor. In a more detailed analysis, lower-level roads may be included, as well as any rail, transit, bicycle and pedestrian facilities that are at grade with the main route being studied. Network connectivity values, as stated earlier, are the number of connection points to the main routes. For this demonstration, this measure was considered to be the number of connection points that SR 20 has with the primary and secondary routes (Figure 6.2 and Table 6.2).

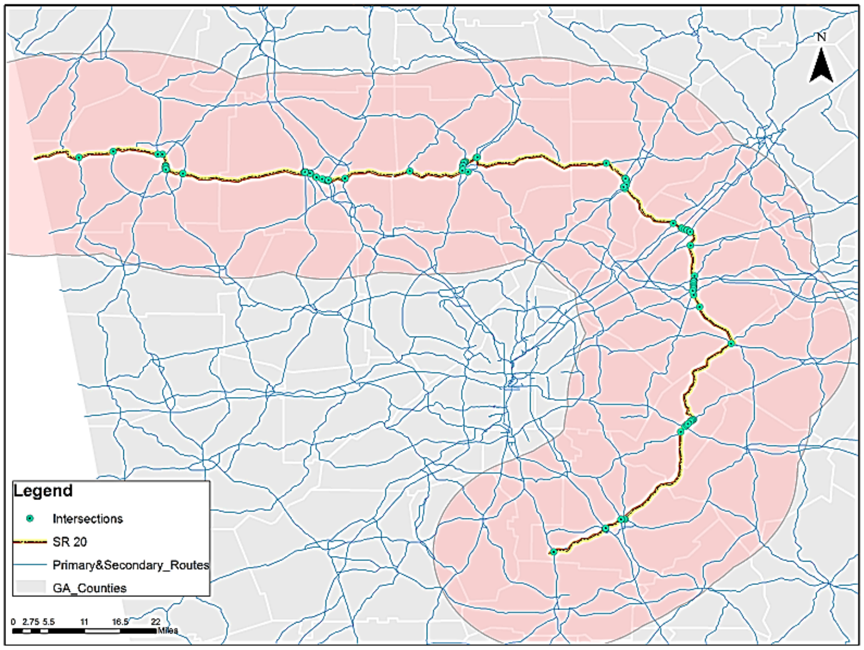

Figure 6.2 SR20 Connectivity to Primary and Secondary Road Network

Table 6.2 Number of SR20 Connection Points by Region

Region	Points of Connection	Number of Connections/Mile
Northwest	25	0.5
Northeast	1	0.1
GA. Mountains	8	0.5
ARC	39	0.5

Travel Impedance

Distance was used as the travel impedance measure for this section. It was assumed that community activities were concentrated at the population centroids of each census tract. Thus, population weighted centroids for each tract were calculated using census block-level population data. GIS "near distances" were then calculated between the centroids and the SR20 point connections (intersections between primary/secondary roads and SR20).

Table 6.3 shows the average distances calculated for each region. Distances shown in the table are Euclidean distances. For a more detailed analysis, network distances may be calculated by using the network analyst to calculate an OD Cost Matrix (with distance as the cost) by setting the tract centroids as origins and point intersections as destinations.

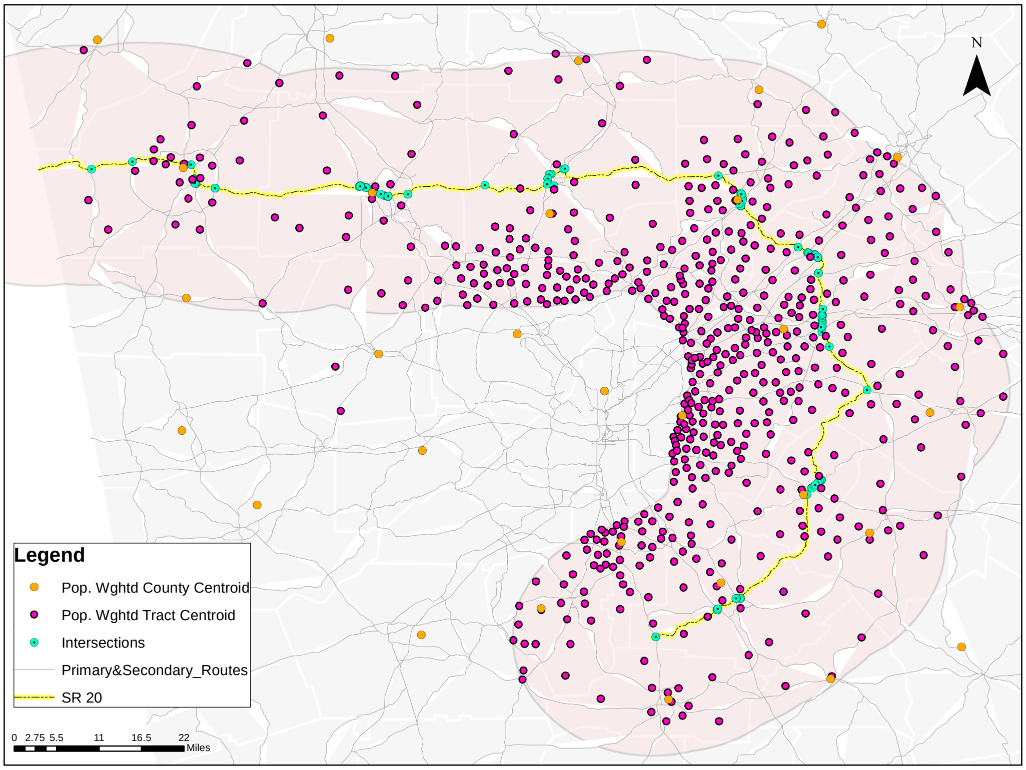

Figure 6.3 Map showing census tract centroids and SR20 connections used in analysis

Table 6.3 Mean distance between activity centers and SR20

Region	Mean Distance
Northwest	7.16
Northeast	9.94
GA. Mountains	6.76
ARC	9.81

Summary of Results

Table 6.4 and Figure 6.4 show a summary of the accessibility metrics used to assess the accessibility of SR20. Figure 6.4 shows relatively high values for all the measures across the Atlanta region. This observation implies a relatively high accessibility for the section of the corridor within the Atlanta region. With the exception of the Northeast region, all the other regions show similar connectivity to the mainline route. Consequently, one can conclude that each of these three regions contributes relatively equally to the health of this corridor in their respective regions (with respect to network connectivity), as well as to the state.

Ultimately, a corridor is said to be healthy if the corridor performs reasonably well in all of the measures used in estimating its accessibility. That is, a region performing well in all of these measures, or achieving its targets (both at the regional and statewide levels), is considered to offer the community better access to the section of the corridor within the region. However, some measures may not be regionally sensitive but may contribute to achieving statewide goals, and vice versa. In such scenarios, regions may elect to work toward achieving regionally-relevant targets. As such, a corridor may be classified as being highly accessible regionally, but not as accessible from a statewide perspective. For example, if one considers a segment of a corridor, within a given region, with a high level of performance in cumulative opportunity (better access to community facilities), but with relatively poor performance in points of connection or connectivity (poor access for manufactured or industrial goods and services leaving the region) to the corridor, such a corridor can be said to be in good health, at least in reference to regional accessibility, but not doing so well in contributing to statewide goals.

Table 6.4 Summary of Accessibility Metrics

Region	Cumulative Opportunity	Network Connectivity (connections/mile)	Points of Connection	Mean Distance
Northwest	249	0.5	25	7.16
Northeast	133	0.1	1	9.94
GA. Mountains	116	0.5	8	6.76
ARC	800	0.5	39	9.81

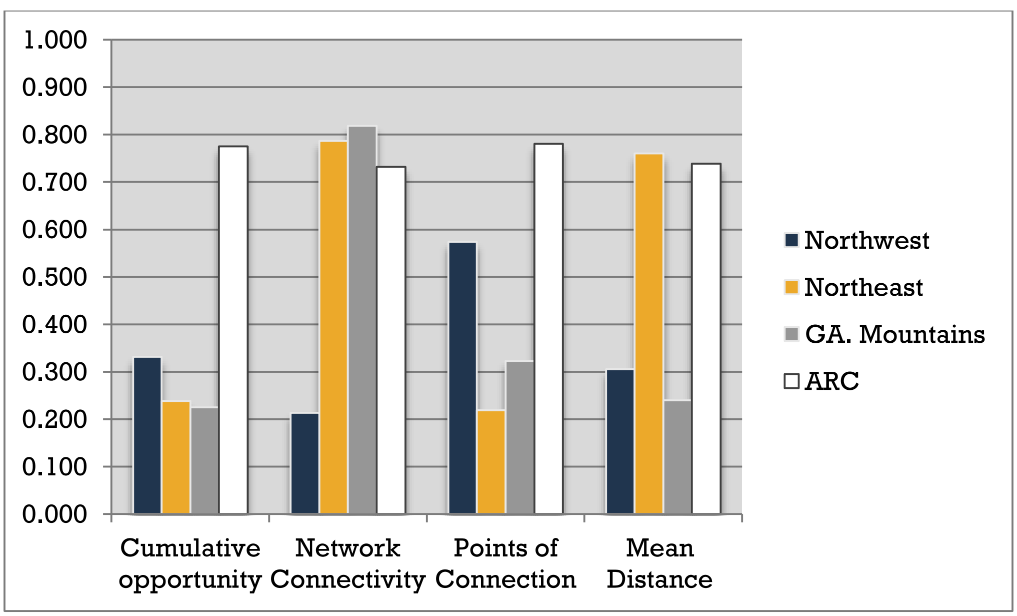

Figure 6.4 Regional Variation in Accessibility

6.1.2 Regional Economic Development

The regional economic development measure assesses the extent to which the transportation system or in this case, the corridor under study contributes to the achievement of economic progress within the region. Improvement of this measure requires input, and in some cases collaboration between, both state and local/regional agencies.

This measure also comprises a number of interrelated subunits which generally fall into two categories as shown in equation 6.2: (1) workforce-centric metrics which include the workforce's marginal accessibility to jobs, travel time index of the journey to work, and cumulative opportunity of jobs within the study corridor; and (2) freight-centric metrics: truck throughput efficiency and truck route density.

$ER_k = f\{ W_k, T_k , E_k, TTE_k, D_k\}$ ....eqn 6.2

where:

ER_k = regional economic development of corridor k

W_k = workforce accessibility within corridor k

T_k = average travel time to locations of employment from study corridor k

E_k = employment opportunities available within a certain distance from main route of corridor k

TTE_k = truck throughput efficiency of main route within corridor k

D_k = density of routes available for truck movement within corridor k

Workforce accessibility in this measure is assessed in terms of the marginal accessibility provided by an alternative mode of transportation such as transit to employment centers. In this way, the extent to which alternative modes support the entire system within the corridor area can be determined.

The travel time metric refers to the average time it takes for employees to get to employment locations after exiting the study route by auto. This captures the relative proximity of jobs to the physical corridor of study. It is closely related to the cumulative number of employment opportunities within the study corridor from the main route. A travel time index may also be used for this measure to provide the ratio of peak hour travel time to free-flow travel time. This will measure congestion levels on the route, which is correlated to the employment in the surrounding areas.

The two freight measures are truck throughput efficiency and density of routes. The former measures the efficiency of freight movement through the region, which is a measure of system productivity, while the latter measures system redundancy and reliability as well as route connectivity for truck freight movement.

Demonstration

Workforce Accessibility, W_k

For this measure, the percentage of counties with transit access (i.e., any service within the county) was used to determine the marginal accessibility provided by alternative modes to employment centers. Data here were obtained from the American Public Transportation Association (APTA) database. Both large and small transit agencies and services were included in the count, as well as, paratransit services. Similar to the rest of the analysis, only counties within the buffer area of SR20 were included. Table 6.5 provides a summary of the results. For a more accurate representation, the number of counties with transit services shown in the third column may be replaced with the actual number of people within the transit agency's service area. This data may be obtained from the individual transit agencies.

Table 6.5 Number of Counties with Transit Access

Regional Commission	Total No. of Counties within Study Corridor	Total No. of Counties with Transit Services to Employment Centers	% of Counties with Transit Service
Northwest	7	7	100
Northeast	5	2	40
GA. Mountains	3	3	100
ARC	9	7	78

Average Travel Time

The travel time value calculated in this step provides the average travel time from an employment establishment (shown in Figure 6.5) to the nearest point of connection on SR20. Here, the Euclidean distance was used; however, the network distance may also be used for a more accurate value. The geocoded employment establishments were clipped to retain only those within the buffer area. The layer was then projected into a State Plane Coordinate System in order to produce output distances in feet.

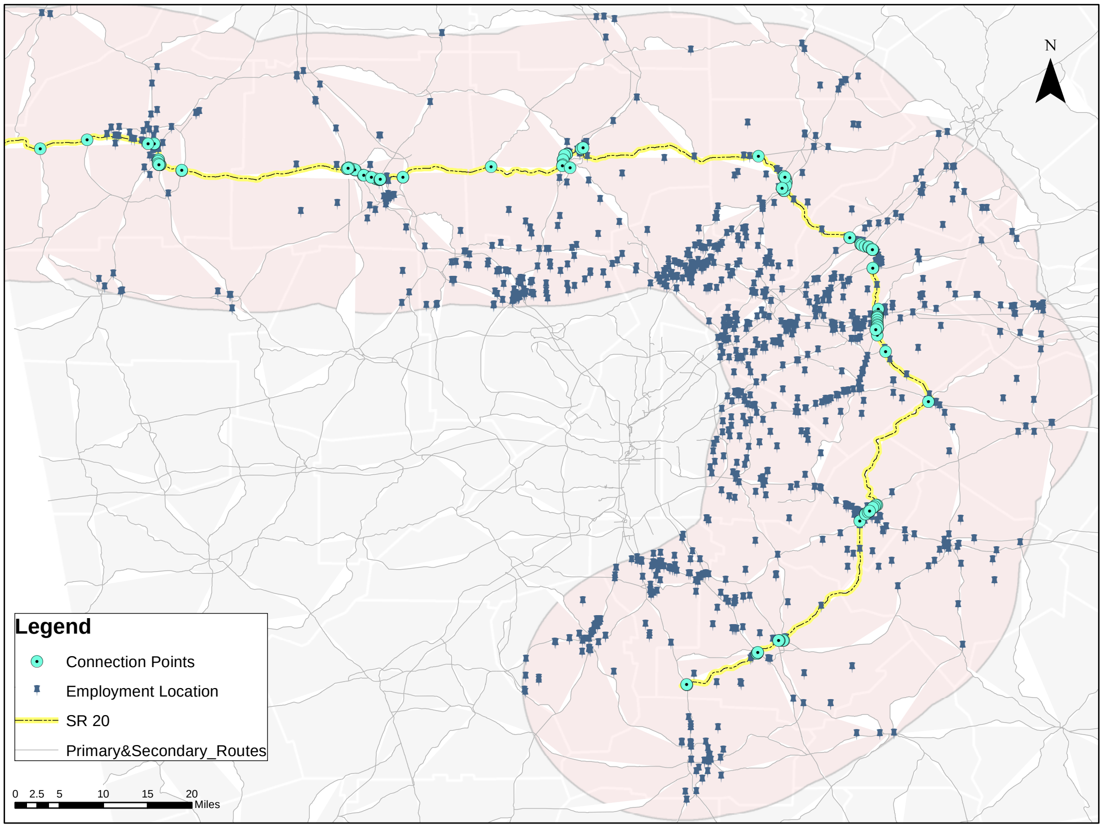

Figure 6.5 Nearness of Employment Locations to Points of Connection on SR20

These distances were then combined with the average speeds on the primary and secondary routes within the corridor to calculate the travel times shown in Table 6.6.

Table 6.6 Average Travel times from employment establishments to SR20

Region	Distance (mi)	Avg. Speed (mi/hr)	Avg. Travel Time (mins)
Northwest	5.08	41	7
Northeast	9.97	41	14
GA. Mountains	5.73	38	9
ARC	8.64	38	14

Employment opportunities, E_k

The third metric used is to assess the employment opportunities easily accessed within the corridor boundaries. To demonstrate this, the top four industries with the highest number of employees within the four counties were used – to scope down the data: retail, educational establishments, healthcare facilities and social services. The industries, with their respective addresses, were obtained from a private company (referenceusa.com); however, this data may also be obtained through other means (that may be more readily available to public agencies). The data was then geocoded using GIS to find their locations on a map. Table 6.7 below provides a summary of the results from the analysis.

Table 6.7 Number of Employment Opportunities within Corridor

Region	Number of Employment Opportunities
Northwest	120
Northeast	79
GA. Mountains	111
ARC	826

Truck Throughput Efficiency, TTE_K

The Truck Throughput Efficiency measure is estimated as the rate of flow, i.e., annual average daily truck traffic (AADTT) per mile in a unit of time on the corridor. The output produced offers a measure of productivity of SR20 by showing the number of trucks moved over a mile per unit of time. It also shows how well particular sections of SR20 are performing in the context of the entire freight network by providing information on areas with high freight movement and bottlenecks. The truck traffic and speed data were obtained from the Freight Analysis Framework (FAF) data. The FAF 2007 data gives the estimated peak period link speed, estimated using procedures outlined in the 2000 Highway Capacity Manual (HCM) and the arc geometry provided in the 2008 HPMS database. Table 6.8 shows the results of the analysis.

Table 6.8 Regional Truck Throughput Efficiency

Region	AADTT	Speed (mi/hr)	TTE
Northwest	49,974	40	0.0008
Northeast	15,158	34	0.0022
GA. Mountains	19,114	29	0.0015
ARC	78,972	33	0.0004

Summary

Table 6.9 provides a summary of the metrics used to assess regional economic development. Looking at Figure 6.6, comparisons can be made across regions using the five metrics. Figure 6.6 shows that within the 15-mile buffer of SR20 (both ways), the Atlanta region's section has higher rates for the number of employment opportunities and truck throughput efficiency; however, it also has a high average travel time to SR20. This observation implies that within the corridor, there exist a greater number of employment opportunities; however, the workforce with access to cars has to travel longer times to access the corridor. Consequently, addressing such a deficiency requires decision makers and planners to consider initiatives that will improve accessibility to these jobs from the main corridor thereby improving the overall health of the corridor. Similarly, the Northwest Georgia region has some form of transit service in all its counties and also has the lowest average travel time along the corridor. The combination of all these measures offers a more holistic view of how a corridor contributes to the economic development of the region and the state as a whole. Figure 6.6 shows that no single region dominates in all the measures used. Essentially, some of the measures may be more appropriate for regional level assessments, and others may be more appropriate for state level assessments, even though the measures collectively tell a story of overall corridor health. The different performance distributions also indicate that jurisdictions may require flexibility to focus on different types of measures to achieve similar goals, e.g. accessibility. Hence, the health of a corridor in terms of economic development can be examined for its respective contribution to both regional and statewide economic development, and projects developed to address existing deficiencies and growth opportunities.

Table 6.9 Summary of Regional Economic Development Metrics

Region	% of Counties with Transit Service	No. of Counties With Transit Services	Number of Employment Opportunities	Truck Throughput Efficiency, TTE	Avg. Travel Time (mins)
Northwest	100	7	120	0.0008	8
Northeast	40	5	79	0.0022	14
GA. Mountains	100	3	111	0.0015	9
ARC	78	9	826	0.0004	14

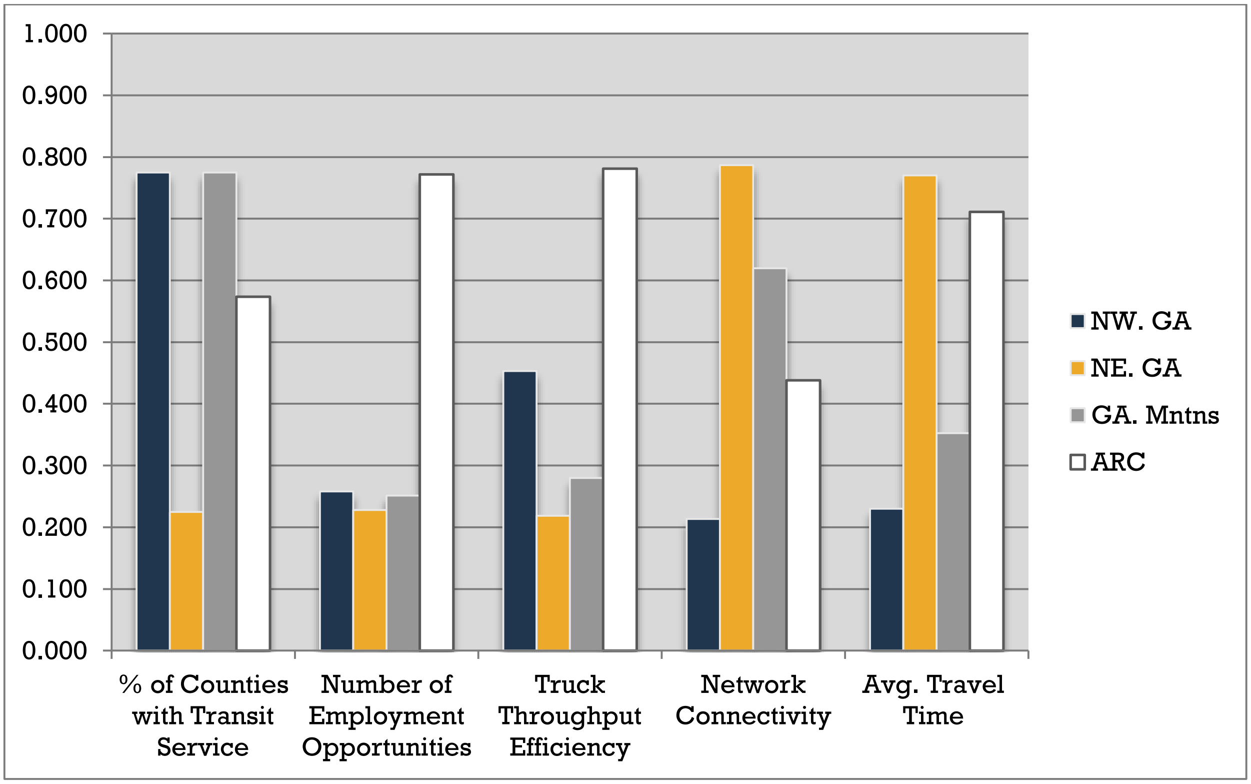

Figure 6.6 Variation in Regional Economic Development Metrics

6.1.3 Transportation System Health and Risk

Traditional definitions of risk focus on the chance of loss. Broader definitions of risk may include the chance of gain alongside with that of loss. As noted by the Federal Highway Administration, the New Zealand Transportation Agency, which is considered an international leader in risk and asset management, defines risk as the chance of something happening that will have an impact on (an entity's ability to achieve) objectives. This expansive definition of risk includes both negative threats and positive opportunities. It can also apply to the enterprise level of an agency, embracing a more expansive framework for setting priorities, allocating resources and ensuring organizational success (FHWA 2009). On the premise that stronger regional systems allow for the development of a more robust statewide system, all else being equal, TSH analysis can help with identifying areas of potential risk – both positive and negative – that an agency may use as strategic input in project investment decision making. Figure 6.7 summarizes various situations that may occur in a TSH analysis of a system at the statewide and regional levels and their implications for risk decision making relative to achieving a more robust statewide transportation system (i.e., one that is meeting both statewide and regional priorities).

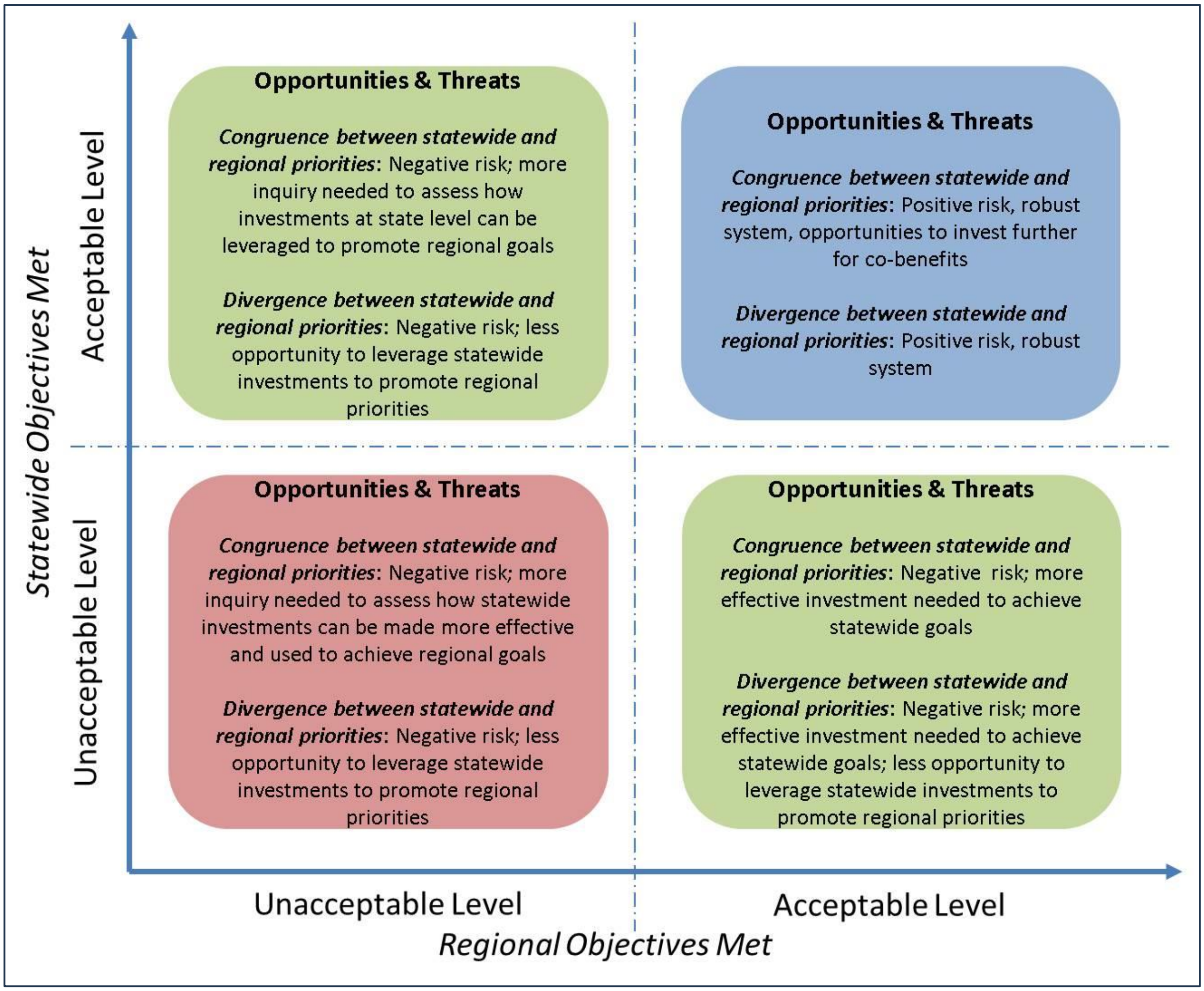

Figure 6.7 Transportation System Health Risks - Statewide and Regional Perspectives

6.2 Significance for Performance Measures Selection and Targets Setting

Good information on the balance between deficiency needs and growth desires from statewide and regional perspectives can be part of the basis of informed discussions to select performance measures and develop targets. Such targets would be appropriate with respect to achieving common statewide goals while formally incorporating the deficiency needs and growth aspirations of different regions.

Selection of Performance Measures: Results of the content analysis of transportation priorities articulated in the comprehensive plans of Georgia's 12 regions shows that different regions can be characterized by different transportation deficiency-growth profiles. The implementation of MAP-21 may offer opportunities for data development to characterize the status of state and regional deficiency-growth profiles and how these are change over time.

These deficiency-growth profiles can be used to inform the selection of appropriate performance measures to evaluate progress toward statewide goals while formally considering the particular deficiency needs and growth aspirations in various regions. Such activity may assist in the development of performance measures that address statewide deficiency needs and growth aspirations while formally considering regional deficiency needs and growth aspirations. The availability of such performance data can help inform the development of regionally context-sensitive projects that are designed to contribute to statewide goals.

Development of Performance Targets: Regional deficiency-growth profiles can inform the development of feasible and appropriate targets that are tailored to move regions forward with respect to achieving statewide goals while setting achievable interim targets with respect to augmenting existing regional deficiency-growth profiles. This target setting exercise will be sensitive to how regions lean with respect to achieving their basic needs. Thus, for example, regions that have stronger deficiency needs may use these as a basis for proposing dissimilar targets to regions that have achieved deficiency needs at a higher level. In addition, better data characterizing regional deficiency-growth profiles can be used to extract information on the tradeoffs that different regions are making with respect to various deficiency needs and growth aspirations. Such data can be used as a basis for setting interim performance targets that contribute to achieving statewide goals while being sensitive to the different regional deficiency-growth profiles.

7 Conclusions and Implementation Guidance

The Transportation Systems Health (TSH) conceptual and analytical frameworks offer resources to support the implementation of a performance-based, risk-opportunity based framework for transportation planning and decision making. The TSH concept includes understanding transportation deficiency needs and growth aspirations from multiple decision-making and stakeholder perspectives (e.g., state, regional, urban, rural), and using this information to augment co-benefits as project investment decisions are made. It offers a formal approach to conduct regionally-sensitive statewide planning and decision making. The flowchart below (Figure 7.1) offers guidance for implementing TSH concepts in existing transportation planning and decision-making processes. Application of these concepts in transportation planning and decision making can help agencies achieve statewide goals in a more regionally-sensitive manner, providing robust and healthy transportation systems and communities.

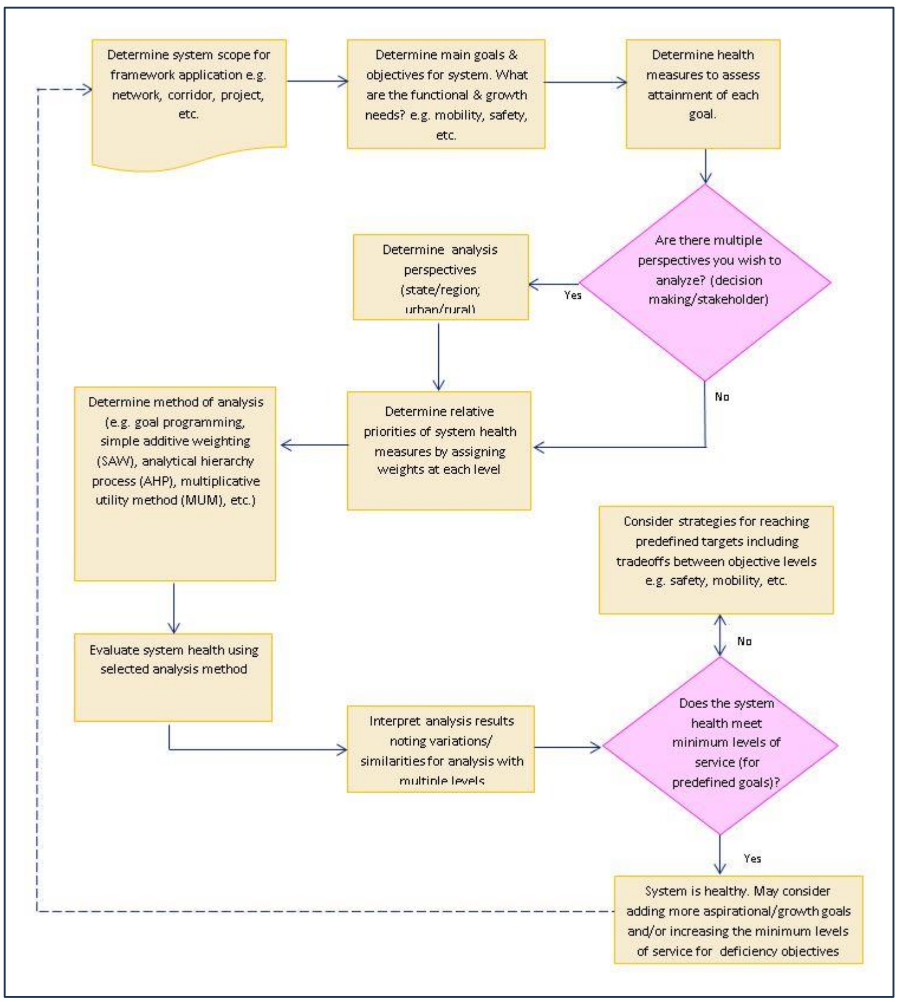

Figure 7.1 Implementation Guidance for Incorporating TSH Concepts in Transportation Planning

8 Appendix

Results and Discussion of Framework Application to State Route 20

The table below summarizes how the health indicators of the segments of the State Route 20 (SR20) compare in achieving regional and statewide goals. As stated in Chapter 5, the health indicator comprises of two main elements; the performance score and component score. The performance scores are scaled scores which represent the extent to which each priority area has been met. Thus, a performance score of 0 indicates that none of the targets for that particular priority area has been met. Similarly, a performance score of 1 represents a target that has been fully achieved or exceeded. The results from the second case study show that the Northwest Georgia segment of the study corridor met or exceeded the set targets in four out of the seven individual priority areas assessed giving that corridor segment the highest average performance score.

The component score shows the impact of the regional and state level weighting on performance scores. Also, as stated earlier, equal weights were assigned to each priority area in calculating the state level component scores. The methods used in obtaining regional level components have also been discussed in chapter 5. Referring to the SR 20 results table, the variations in bi-level weightings are revealed. For example, in the Northeast Georgia segment of SR20, bridge preservation has a performance score of 0.5, but the respective regional and state component scores are 0.017 and 0.05. This suggests that while the equal weights assigned at the state level indicate a higher contribution to statewide goals, at the regional level, bridge preservation contributes a relatively lesser amount to achieving regional goals.

The component scores are also an indication of how a region achieves its goals while contributing to the statewide goals. For example, in the Northwest Georgia segment of the corridor safety, accessibility, pavement preservation, and employment access each has a performance score of 1, which indicates that targets in those areas have either been met or exceeded. However, despite having the same performance scores, the regional component scores vary across those four priority areas. Among the four areas, accessibility has the highest regional component score of 0.271 followed by safety and employment access, leaving pavement preservation with the lowest regional component score of 0.003. This score differential reveals the inherent relative priority levels assigned to each of these areas. That is, accessibility and safety are prioritized as needing relatively more improvement than pavement preservation or employment access.

Regional variations in system health may also be deduced from the Overall Health Rating (OHR) which range from 0 to 1. The state level OHR shows that, generally, the performance scores of the primary five priority areas contribute more towards attaining statewide goals. However, across all four regions, the regional OHRs are relatively lower than the state level OHRs, indicating there is relative less satisfaction current performance of the study corridors from a regional perspective than from a statewide perspective. These ratings also indicate that on the whole, the Northwest Georgia segment of the study corridor had achieved the highest health rating and also reveal the opportunities for improvement in the Northeast Georgia segment.

Appendix Table 1: Summary Table for State Route 20 CHAF Application Results

Corridor	Priority Area	Health Indicator			Overall Health Score (H_{c_n})	
		Individual Health Index (a_{mn})	Component Score		Regional Level	State Level
			Regional	State		
Northwest	**Mobility**	0	0.000	0	0.63	0.68
	Safety	1	0.181	0.2		
	Accessibility	1	0.271	0.2		
	Asset Preservation	0.5	0.001	0.05		
	Bridges					
	Pavements	1	0.003	0.1		
	Economic Development	1	0.136	0.1		
	Employment Access					
	Freight Access	0.3	0.041	0.03		
Northeast	**Mobility**	0	0.000	0	0.37	0.58
	Safety	1	0.225	0.2		
	Accessibility	0	0.000	0		
	Asset Preservation	0.5	0.017	0.05		
	Bridges					
	Pavements	0.3	0.010	0.03		
	Economic Development	0	0.000	0		
	Employment Access					
	Freight Access	1	0.118	0.1		
GA. Mountains	**Mobility**	0	0.000	0	0.47	0.68
	Safety	1	0.233	0.2		
	Accessibility	0	0.000	0		
	Asset Preservation					
	Bridges	0.5	0.017	0.05		
	Pavements	0.3	0.010	0.03		
	Economic Development	1				
	Employment Access		0.105	0.1		

	Freight Access	1	0.105	0.1		
ARC	**Mobility**	0	0.000	0	0.36	0.61
	Safety	1	0.187	0.2		
	Accessibility	0	0.000	0		
	Asset Preservation					
	Bridges	0.5	0.028	0.05		
	Pavements	0.3	0.017	0.03		
	Economic Development					
	Employment Access	0.3	0.029	0.03		
	Freight Access	1	0.098	0.1		

Results and Discussion of Framework Application to State Route 38

The third case study corridor used to demonstrate the application of the CHAF analysis is State Route 38, which lies in the lower southern part of the state spanning four regions. For this corridor, the same five primary priority areas were assessed to produce health indicators (performance and component scores), as well as the overall health rating. Across the four segments, performance scores met predefined targets in at least one priority area with safety and freight access being the top two priority areas with a performance score of 1. The segment of the corridor which traverses Coastal Georgia had the highest number of priority areas which either met or exceeded targets. These performance scores provide a quick assessment of each corridor segment's ability to meet set targets. Thus, investment decisions may be guided by performance scores, and based on the relative regional or state priorities, different priority areas such as mobility or safety may be targeted for performance score improvement.

Regional variations in system health are also revealed by comparing the component scores of the different regions. Such variations are observed in the regional component safety scores for Southern Georgia and Heart of Georgia Altamaha. Although both segments have a performance score of 0.5 for safety, the regional component scores for the two segments are 0.120 and 0.161, respectively. This variation illustrates the effects of the weights varying from region to region. Thus, it may be inferred that the Heart of Georgia segment of the corridor weighs safety relatively higher than the other priority areas compared to Southern Georgia.

For the OHRs, the state level scores are relatively higher than the regional level scores in three of the four corridor segments. Thus, for the Southwest Georgia Region, SR38's contribution to the attainment of regional goals is at a slightly higher level than its contribution to state level goals. These further illustrate the differences in achieving regional and statewide goals.

Appendix Table 2 Summary Table for SR 38 CHAF Application Results

Corridor	Priority Area	Health Indicator			Overall Health Score (H_{c_n})	
		Individual Health Index (a_{mn})	Component Score		Regional Level	State Level
			Regional	State		
Southwest GA	**Mobility**	0.3	0.063	0.06	0.63	0.57
	Safety	1	0.233	0.2		
	Accessibility	1	0.209	0.2		
	Asset Preservation	0.5	0.070	0.05		
	Bridges					
	Pavements	0.3	0.042	0.03		
	Economic Development	0	0.000	0		
	Employment Access					
	Freight Access	0.3	0.010	0.03		
Southern Georgia	**Mobility**	0.3	0.057	0.06	0.35	0.44
	Safety	0.5	0.120	0.1		
	Accessibility	0	0.000	0		
	Asset Preservation	0.5	0.032	0.05		
	Bridges					
	Pavements	0.3	0.019	0.03		
	Economic Development	0	0.000	0		
	Employment Access					
	Freight Access	1	0.142	0.1		
HOGA	**Mobility**	0.3	0.039	0.06	0.40	0.44
	Safety	0.5	0.161	0.1		
	Accessibility	0	0.000	0		
	Asset Preservation					
	Bridges	0.5	0.032	0.05		
	Pavements	0.3	0.019	0.03		
	Economic Development	0				
	Employment Access		0.000	0		
	Freight Access	1	0.145	0.1		
CGRC	**Mobility**	0	0.000	0	0.40	0.56
	Safety	1	0.156	0.2		
	Accessibility	0	0.000	0		

	Asset Preservation					
	Bridges	1	0.094	0.1		
	Pavements	0.3	0.028	0.03		
	Economic Development					
	Employment Access	0.3	0.028	0.03		
	Freight Access	1	0.094	0.1		

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