

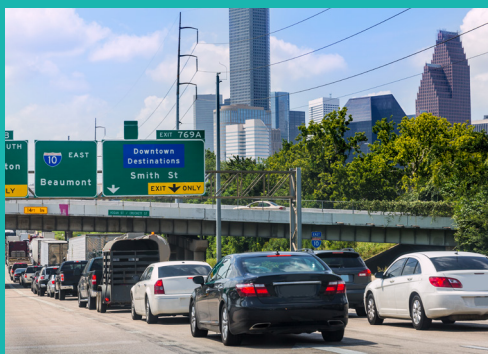


Houston-Galveston
Area Council

2045RTP

REGIONAL TRANSPORTATION PLAN

REVISED APRIL 10, 2019



2045RTP.com

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Chapter 1

INTRODUCTION

“In the year 2045, our region will have an integrated multimodal transportation system, achieved through coordinated public and private investments, that supports a desirable quality of life, enhanced economic vitality and increased safety, access and mobility.”

The Houston-Galveston Area Council (H-GAC) is the designated Metropolitan Planning Organization (MPO) for a diverse eight-county region that includes Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties. This area is concurrently recognized as the Transportation Management Area (TMA) for the upper Texas Gulf Coast region (Figure 1-1).

H-GAC’s mission is to plan for the orderly growth and development of the region, working in concert with multiple planning partners. This mission involves building region-wide consensus on improving transportation, promoting smart growth, protecting the environment, enhancing the economy, and fostering equity. As the MPO, H-GAC is responsible for developing the region's transportation policies and oversees the planning and programming of transportation infrastructure investments. In light of the expected growth of the region, this planning function will be critical to improving mobility, managing congestion, promoting regional development, and enhancing the quality of life of residents of the area.



Figure 1-1: Eight-County Planning Region

THE LONG RANGE PLAN

The Regional Transportation Plan (RTP) is a strategic planning document that articulates the MPO’s vision and goals for a desired future transportation network and the strategies to achieve them. Updated every four years, the plan outlines a financially constrained transportation investment program that is based on the unique needs and characteristics of the MPO region. The 2045 RTP is an update to its predecessor – 2040 RTP. The updated plan identifies multimodal transportation improvement strategies that further the region’s transportation vision and goals, which will be executed over a twenty five-year planning horizon.

The 2045 RTP is shaped primarily by federal legislation. Federal transportation authorizations establish the essential contours of the regional transportation plan and specify several planning factors that must be addressed by the MPO. The 2045 RTP is also shaped by the public input obtained through the public outreach events that were held throughout the planning region, as well as the public comments submitted by concerned citizens. The plan sets targets, incorporates performance measures, and monitors and

documents the progress made in several analytical areas that include asset management, congestion, system performance, safety, and environmental sustainability. The 2045 RTP will prioritize the major transportation investments that will be implemented through the year 2045. The recommended investments total approximately \$132 billion in 2018 dollars and include more than 950 individual projects.

FEDERAL LEGISLATIVE BACKGROUND

Since their creation by the Federal-Aid Highway Act of 1962, the role and relevance of the MPO in the transportation planning process has continued to evolve. Planning requirements and expectations are expressed in the successive surface transportation funding and authorization bills.

The “Moving Ahead for Progress in the 21st Century” (MAP-21) Act of 2012 focused on streamlining the country’s surface transportation programs and established performance-based metrics for many facets of the transportation system. Map-21 instituted the following transportation emphasis areas:

- **Safety**
To achieve a significant reduction in traffic fatalities and serious injuries on all public roads;
- **Infrastructure Condition**
To maintain the highway and bridge infrastructure asset system in a state of good repair;
- **System Reliability**
To improve the efficiency of the surface transportation system;
- **Congestion and Air Quality**
To achieve a significant reduction in congestion on the National Highway System and improve the quality of the air;
- **Economic Vitality**
To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development;
- **Environmental Sustainability**
To enhance the performance of the transportation system while protecting and enhancing the natural environment; and
- **Reduced Project Delivery Delays**
To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burden and improving work practices at the agencies.

In 2015, Congress passed the “Fixing America’s Surface Transportation Act” (FAST Act), which is the current surface transportation funding and authorization bill. The FAST Act funds surface transportation

Recent Federal Transportation Bills

- 1991 - Intermodal Surface Transportation Efficiency Act (ISTEA)
- 1998 - Transportation Equity Act for the 21st Century (TEA-21)
- 2005 - Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)
- 2012 – Moving Ahead for Progress in the 21st Century (MAP-21)
- 2015 – Fixing America’s Surface Transportation Act (FAST Act)

programs through 2020 and builds on the mandates of MAP-21 and other previous transportation authorization bills. The FAST Act provides funding for critical transportation projects that address congestion, freight movement, and the maintenance of transportation infrastructure. It also introduces programmatic changes designed to streamline the approval process and accelerate the delivery of transportation projects.

The FAST Act adds several new planning requirements for the MPO to address in their transportation plans. These include travel and tourism, resiliency and reliability of the transportation system, and reducing or mitigating stormwater impacts on surface transportation (See Table 1-1). These new planning factors are incorporated into 2045 RTP and discussed in later sections of the plan.

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FAST Act Requirement	FAST Act Provision	Issues Addressed in 2045 RTP	Where Addressed
Public Participation	23 CFR 450.316(a)	H-GAC's Public Participation Plan (PPP) was updated in 2017 to expand the list of stakeholders to be engaged in transportation planning process.	<ul style="list-style-type: none"> • PPP • Public Involvement
Consultation and Cooperation	23 CFR 450.316(b)	2045 RTP was developed with continued consultation and cooperation with state and local officials and takes into consideration the planning activities of other agencies and organizations within the MPO region.	<ul style="list-style-type: none"> • Public Involvement • Disaster Preparedness • Tourism
Resiliency and Reliability	23 CFR 450.206(a)(9)	2045 RTP incorporates an assessment of the vulnerability of transportation assets to extreme weather events and identifies initiatives to improve resiliency and increase the reliability of the regional transportation system.	<ul style="list-style-type: none"> • Resiliency • Resiliency (Appendix J) • Performance Measures
Stormwater Impacts	23 CFR 450.206(a)(9)	2045 RTP identifies roadways susceptible to impact by stormwater and includes a choice of projects and strategies aimed at mitigating these impacts.	<ul style="list-style-type: none"> • Resiliency • Resiliency (Appendix J)
Travel and Tourism	23 CFR 450.206(a)(10)	2045 RTP includes a review of opportunities to engage in recreational travel and tourism in the planning region and considers strategies to promote growth in this transportation sector.	<ul style="list-style-type: none"> • Travel and Tourism (Appendix M) • PPP
Disaster Preparedness	23 CFR 450.316(b)	2045 RTP identifies local emergency management operations serving the Houston-Galveston metropolitan region and details the designated hurricane evacuation routes and Zip-Zone Map.	<ul style="list-style-type: none"> • Disaster Preparedness
Intercity Buses	23 CFR 450.216(b) & 23 CFR 324(f)(2)	2045 RTP examines the existing intercity bus services in the region and identifies opportunities to expand these services and grow additional routes and operations.	<ul style="list-style-type: none"> • Intercity Buses (Appendix L)
Performance Measures	23 CFR 450.324(f)(3)	2045 RTP includes the federal performance measures linked to the vision, goals, and project prioritization of RTP 2045, and establishes targets for each performance measure applicable to the MPO region.	<ul style="list-style-type: none"> • PM System Evaluation Report (Appendix P)
System Evaluation Report	23 CFR 450.324(f)(4)	2045 RTP documents the condition and performance of the transportation system with respect to the federally required performance targets.	<ul style="list-style-type: none"> • PM System Evaluation Report (Appendix P)

Table 1-1: Major Requirements of the FAST Act Addressed in 2045 RTP

THE PLANNING PROCESS

2045 RTP is the product of a continuing, comprehensive, and cooperative planning effort, involving the state, local government entities, and private stakeholders. The plan must be approved and adopted by the Transportation Policy Council (TPC), a 28-member body composed of local elected officials, ranking officials of public agencies, and the state. The TPC is the policy board for the MPO and provides policy guidance and overall coordination for the multimodal transportation planning efforts of the MPO.

The TPC is advised by the Technical Advisory Committee (TAC), which is generally responsible for conducting any required programmatic analyses. The TAC reviews and evaluates H-GAC's transportation planning proposals and submits its recommendations to the TPC. A special 2045 RTP sub-committee was convened out of the TAC membership to assist H-GAC staff in the development of fundamental RTP assumptions and methodologies, and to ensure that recommended projects and activities supported the vision, goals, and objectives of the plan.

PUBLIC PARTICIPATION

Public participation is an essential part of the planning process and must engage all segments of the population to ensure that planning decisions reflect the range of regional values and desires. In developing the 2045 RTP, H-GAC followed the guidelines of its Public Participation Plan (PPP). In all, H-GAC hosted over 20 public meetings focused on the development of the plan and received over 1,200 public comments from interested citizens and stakeholders. The public participation program is more fully described in Chapter 7 of this document.

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Chapter 2

VISION, GOALS, PERFORMANCE MEASURES AND STRATEGIES

2045 RTP is a long-range plan centered around a shared regional vision: an aspirational statement about the desired future transportation system for the Houston-Galveston region. Five goals were chosen to actuate the vision, each of which were assigned performance measures that would indicate the progress made towards achieving the goal. 2045 RTP also identifies three strategies or investment tools which help local sponsors and decision-makers understand how their projects fit within the regional planning process, throughout the life of the plan. These items are discussed in the sections that follow.

VISION

In the year 2045, our region will have an integrated multimodal transportation system, achieved through coordinated public and private investments that support a desirable quality of life, enhanced economic vitality and increased safety, access and mobility.

GOALS

1. Improve Safety
2. Achieve and Maintain a State of Good Repair
3. Move People and Goods Efficiently
4. Strengthen Regional Economic Competitiveness
5. Conserve and Protect Natural and Cultural Resources

PERFORMANCE MEASURES

2045 RTP associates each goal with quantifiable performance measures that can indicate the progress made towards achieving the goals. Performance measures were first crafted in response to MAP-21. The FAST Act, which followed, reinforced the role of national performance measures in the planning process and the Federal Highway Administration (FHWA) has promulgated final rulings on the subject.

H-GAC has adopted several targets for the federally mandated performance measures and applied them to guide the goals, strategies, and ultimately the investment decisions recommended in the 2045 RTP. The performance measures cover a wide range of metrics that include highway safety, pavement and bridge condition, system reliability, congestion, air quality and transit asset management. Although the federally mandated performance measures are new, H-GAC has used performance measures to evaluate the investment decisions in its previous transportation plans. The reasoning behind the selection of each performance measure, recent trends, and their targets are available in Appendix P. Figure 2-1 shows the relationship between the 2045 RTP vision, goals and performance measures.

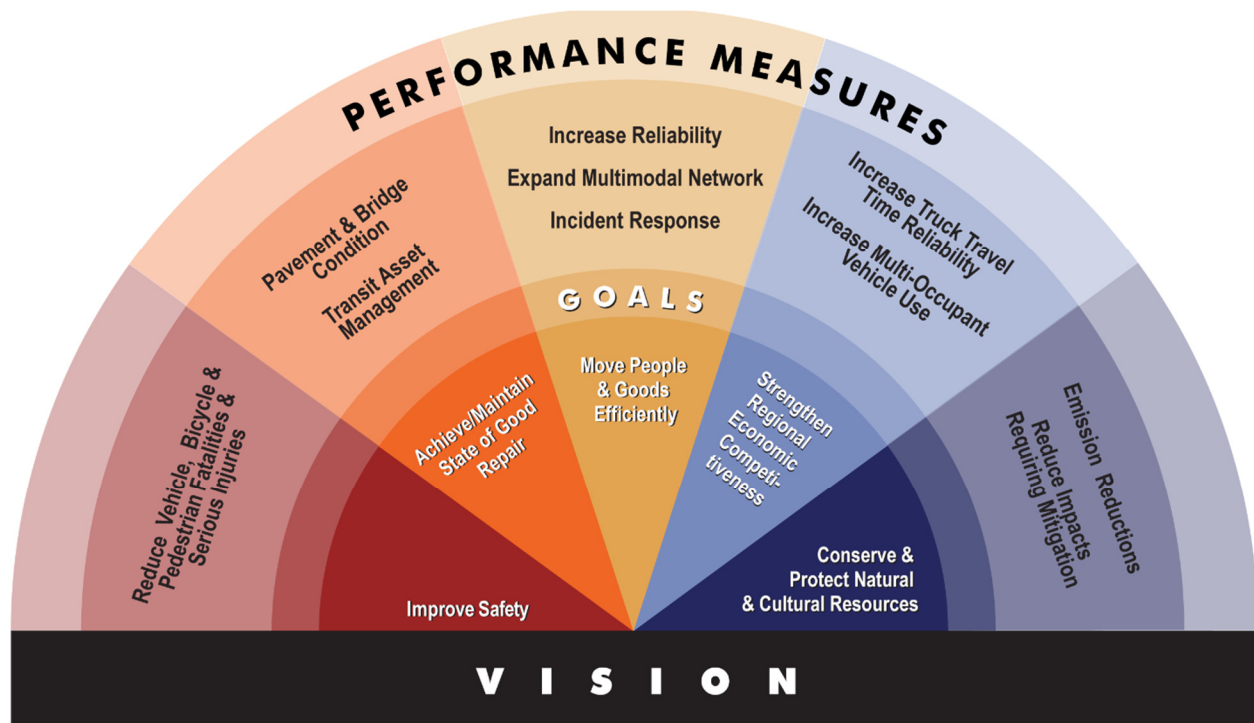


Figure 2-1: 2045 RTP Vision, Goals, and Performance Measures

STRATEGIES

The 2045 RTP employs three strategies as implementation tools to realize the plan goals:

MANAGE - [System Management and Operations]

- Maximize the efficiency and effectiveness of the transportation system through data, technology and policy solutions focused on reliability, continuity and the transparent dissemination of information.

MAINTAIN - [Asset Management]

- Improve and preserve the condition of the existing transportation infrastructure at the least practicable cost through the application of sound asset management techniques to ensure a state of good repair.

EXPAND - [Multimodal Network Capacity]

- Add capacity across all modes of travel with a focus on the interconnections between different networks and services that provide users with greater choices.

Table 2-1 illustrates the relationship between the goals, performance measures, and strategies of the 2045 RTP. Each strategy is evaluated by how effectively it addresses the associated goal and performance measures intended to quantify the outcome. The strategies to Manage (Improve System Management & Operations) and Maintain (Asset Management) both directly support all five of the 2045 RTP goals.

GOAL	STRATEGIES			PERFORMANCE MEASURE
	MANAGE [Improve System Management & Operations]	MAINTAIN [Asset Management]	EXPAND [Transportation Network Capacity]	
Improve Safety	●	●	○	Reduce Crash Rates of Fatalities and Serious Injuries
Achieve/Maintain State of Good Repair	●	●	●	Pavement & Bridge Conditions and Transit Asset Management
Move People and Goods Efficiently	●	●	○	Increase Reliability, Expand Multimodal Network and Improve Incident Response
Strengthen Regional Economic Competitiveness	●	●	●	Increase Truck Travel Time Reliability and Increase Multi-Occupant Vehicle Use
Conserve and Protect Natural and Cultural Resources	●	●	○	Emission Reductions and Reduce Impacts Requiring Mitigation

● Direct Impact ○ Related Impact

Table 2-1: Relationship between 2045 RTP Strategies, Goals and Performance Measures

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Many projects considered by the 2045 RTP apply to more than one strategy. For instance, road widening projects which would be considered “transportation and multimodal network expansion” include extensive “state of good repair” investments. The total expenditure for the three strategies combined is an estimated \$132 billion. Figure 2-3 illustrates the amounts of the 2045 RTP expenditure by strategy. These expenditure estimates include allocation of project costs across the strategies shown, when appropriate.

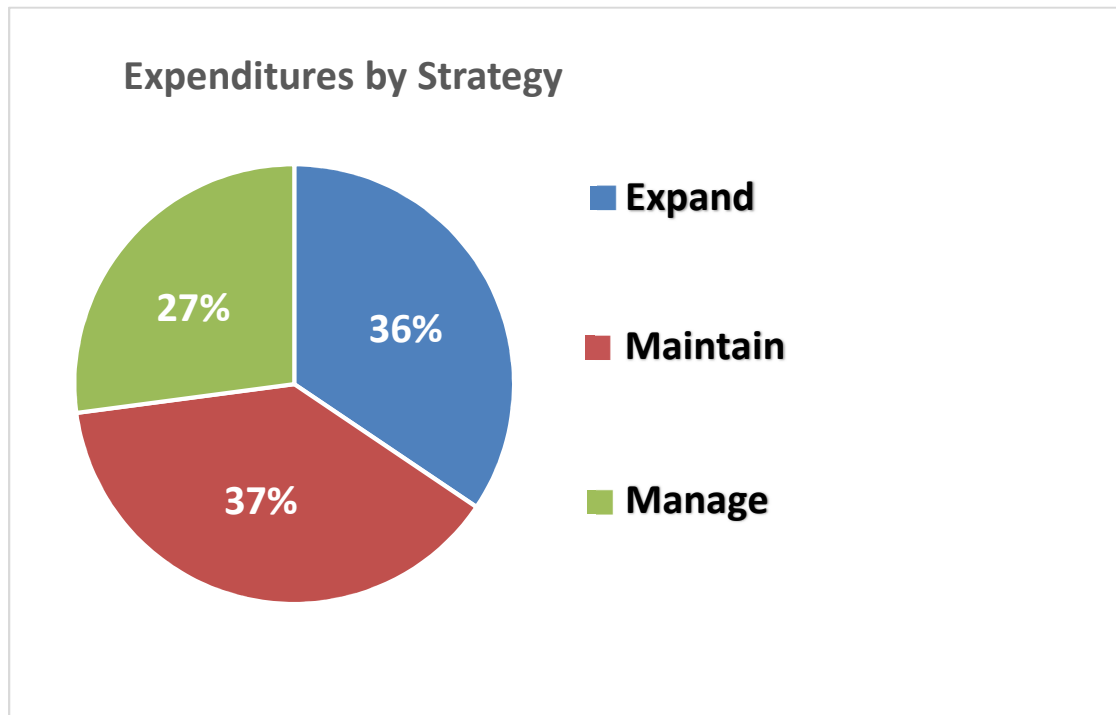


Figure 2-3: 2045 RTP Expenditure by Strategy

STRATEGY 1: MANAGE

The Manage strategy directly supports all five goals of the plan and accounts for about 27% of the total 2045 RTP expenditures (Table 2-2). This strategy will implement programs and projects that address congestion and safety through the reduction of vehicle crashes, quick and safe removal of stalled vehicles, improved intersection operations, bottleneck alleviation, and a reduction in vehicular travel demand through increased use of transit and other alternate commute solutions.

MANAGE		
2045 RTP GOAL	IMPACT	PERFORMANCE MEASURE
Improve Safety	●	Reduce Crash Rates of Fatalities and Serious Injuries
Achieve/Maintain State of Good Repair	●	Pavement & Bridge Conditions and Transit Asset Management
Move People and Goods Efficiently	●	Increase Reliability, Expand Multimodal Network and Improve Incident Response
Strengthen Regional Economic Competitiveness	●	Increase Truck Travel Time Reliability and Increase Multi-Occupant Vehicle Use
Conserve and Protect Natural and Cultural Resources	●	Emission Reductions and Reduce Impacts Requiring Mitigation

● Direct Impact ● Related Impact

Table 2-2: The Manage Strategy

System management is designed to make more efficient use of existing roadway facilities. A large amount of regional congestion is caused by roadway incidents that range from stalled vehicles and crashes to sports events and hurricane evacuations. Many of these circumstances can be addressed through the Manage strategy. H-GAC's Congestion Management Process (CMP) identifies effective tools which can be applied to meet the goals and performance measures of the RTP (See Appendix B). Examples of tools available and funded through the Manage strategy are listed in Table 2-3.

MANAGE	EXAMPLES
Safety	Traffic or facility improvements designed to improve safety
Intelligent Transportation Systems (ITS)	Technology-based improvements to data gathering or travel monitoring and reporting
Access Management	Improve access and efficiency of major roadways
Travel Demand Management	Programs such as new or improved transit services, car and vanpooling, telework and other strategies to reduce peak vehicular demand
Managed Lanes	Travel-time incentive for transit and other High-Occupancy Vehicles May include congestion or occupancy-based pricing

Table 2-3: Examples of Tools that Implement the Manage Strategy

An important benefit of the Manage strategy is that it achieves a reduction in overall vehicle usage, travel delay, and vehicle emissions detrimental to air quality without incurring the cost of constructing new transportation infrastructure. A reduction in vehicle use impacts would be realized by the more efficient use of the existing roadway and by travel demand management. The Manage strategy funds H-GAC's Commute Solutions program, which promotes alternate travel modes like transit, employer supported van and carpools, active transportation, and modified work schedules to decrease single occupant vehicle trips. More shared rides potentially reduce traffic congestion and improve air quality while providing cost and time savings for road users. Air quality is also improved through initiatives such as the Clean Cities/Clean Vehicles program which provides subsidies that promote the voluntary usage of cleaner burning fuels and engines.

The Manage strategy also enhances safety and travel reliability through projects that optimize signal timing and provide dynamic traffic alerts that can influence travel choices. This strategy would also reduce congestion costs and promote economic productivity by giving freight operators and other road users a more reliable sense of how long a certain route will take. Finally, the greater use of non-motorized transportation would decrease the wear on the transportation facilities and thereby increase their useable life.

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STRATEGY 2: MAINTAIN

Maintaining a state of good repair for the bridges, roadways, transit facilities, railroads, and port facilities is a basic need for our region's transportation system. The Maintain strategy directly supports all five 2045 RTP goals and accounts for about 37% of the total 2045 RTP expenditure (Table 2-4).

Keeping transportation facilities in good repair can be expected to bring several benefits. Better roads and bridges would mean less structural congestion and, therefore, reduced congestion costs for the road users. Proper maintenance also extends the usable life of the facilities and promotes safety for the travelling public at a fraction of the cost of constructing new infrastructure. Estimates for the 2045 RTP indicate an annual funding need of \$500 - \$700 million over the life of the plan to maintain the existing facilities.

MAINTAIN		
2045 RTP GOAL	IMPACT	PERFORMANCE MEASURE
Improve Safety	●	Reduce Crash Rates of Fatalities and Serious Injuries
Achieve/Maintain State of Good Repair	●	Pavement & Bridge Conditions and Transit Asset Management
Move People and Goods Efficiently	●	Increase Reliability, Expand Multimodal Network and Improve Incident Response
Strengthen Regional Economic Competitiveness	●	Increase Truck Travel Time Reliability and Increase Multi-Occupant Vehicle Use
Conserve and Protect Natural and Cultural Resources	●	Emission Reductions and Reduce Impacts Requiring Mitigation

● Direct Impact ● Related Impact

Table 2-4: The Maintain Strategy

A review of the pavement conditions in Texas suggest that the ratios of the facilities in good, fair, and poor condition will remain relatively even in the short-run but experience gradual improvement over time. For roads in the Houston-Galveston region, TxDOT data suggests baseline ratings of 48% of interstate pavements are in good condition, 52% fair, and 0% in poor condition. Non-interstate pavements in the region have lower ratings reflecting 47% of pavements in good condition, 42% in fair, and 11% in poor condition.¹ For transit, the 2045 RTP estimates an annual funding need of \$800 - \$900 million over the life of the plan. Examples of tools available and funded through the Maintain strategy are listed in Table 2-5.

¹ 2011 TxDOT Condition of Texas Pavements: Pavement Management Information System Annual Report. Chapter 2: Vision, Goals, Performance Measures & Strategies
Revised April 10, 2019

MAINTAIN	EXAMPLES
Roadway	Reconstruction, rehabilitation, or repaving of roadways and access facilities
Bridges	Upgrade facilities to new standards or rehabilitate for future use
Transit Facilities	Improve bus stops, transit centers, guideways, stations, or vehicle replacement or repair
Pedestrian Facilities	Upgrade to current design guidelines and ADA requirements

Table 2-5: Examples of Tools that Implement the Maintain Strategy

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STRATEGY 3: EXPAND

The Expand strategy is appropriated about 36% of total 2045 RTP estimated expenditures and directly supports two of the 2045 RTP goals (Table 2-6). The strategy includes adding travel capacity on all modes of transportation. Funding for this strategy is based on recommendation by the congestion management process and is driven by 2045 RTP goals and performance measures. The Expand strategy directly supports the system efficiency and economic competitiveness goals of the 2045 RTP and includes some of the most significant, visually obvious, and long-lasting investments in the plan. According to plan recommendations, the most intensive expansion corridors will be Beltway 8, the Grand Parkway, I-10 West, I-45 South, US 290, SH 35, SH 36, and SH 146.

EXPAND		
GOAL	IMPACT	PERFORMANCE MEASURE
Improve Safety	●	Reduce Crash Rates of Fatalities and Serious Injuries
Achieve/Maintain State of Good Repair	●	Pavement & Bridge Conditions and Transit Asset Management
Move People and Goods Efficiently	●	Increase Reliability, Expand Multimodal Network and Improve Incident Response
Strengthen Regional Economic Competitiveness	●	Increase Truck Travel Time Reliability and Increase Multi-Occupant Vehicle Use
Conserve and Protect Natural and Cultural Resources	●	Emission Reductions and Reduce Impacts Requiring Mitigation

● Direct Impact ● Related Impact

Table 2-6: The Expand Strategy

Transit system expansion would extend frequent high capacity service to the two busiest regional airports, as well as construct new commuter lines to northwest, west, and southwest suburban centers. New express bus service to Liberty and Chambers counties are also included. Bicycle and pedestrian system expansion would operate in line with the Draft Regional Active Transportation Plan (see Appendix H). Locally, many roadway expansion needs will be met by cities and counties, as well as private developers. Tolled roads have and will continue to provide critical additional roadway capacity. The 2045 RTP projects that involve major added capacity improvements are listed in Table 2-7.

MAJOR ADDED CAPACITY IMPROVEMENTS	
Beltway 8	\$ 92 Million
Grand Parkway	\$ 805 Million
I-10 West	\$ 661 Million
Thoroughfare Development	\$ 6.4 Billion
Light Rail and Bus Transit	\$ 11 Billion
Pedestrian/Bicycle Facilities	\$ 1.6 Billion

Table 2-7: Major Added Capacity Improvements

The 2045 RTP recommends additional travel lanes on or extension of some of the most-travelled toll roads: Sam Houston Tollway (South and East), Westpark, IH 10 E, and IH 45 Gulf HOV. The RTP also recommends the completion or construction of new toll corridors including US 290 (partial toll/ managed lanes), SH 249 Toll Road (Montgomery County), SH 35, IH 45 North, and the remaining segments of the Grand Parkway. It should be noted that some of these projects were identified in previous plans and are continued as part of the recommendations for the 2045 RTP update.

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Chapter 3

EXISTING CONDITIONS

The task of planning for the future multi-modal transportation system begins with analyzing the conditions of the key elements of the transportation system. The sections that follow describe the existing regional transportation network and highlight some of the challenges and needs that exist across different modes of transportation. Existing conditions provide a contextual basis for the investment recommendations of the 2045 RTP.

ROADWAY SYSTEM

H-GAC's transportation system contains a network of over 27,000 total miles of roadway, seen in Figure 3-1, which supports about 185 million miles of travel per weekday.¹ Arterial streets make up almost half of the roadway system and account for 37.5% of the daily vehicle miles travelled in the region.² These arterials bring local traffic to more regional destinations and freeways. In comparison, freeways represent only about 13% of road network but convey as much as 40% of the daily vehicle miles travelled. Lastly, local roads, or "collectors," comprise as much as one quarter of the road network but carry only about 7.5% of the daily vehicle miles travelled, most of which occur at trip origins and destinations.

To promote transit and high occupancy vehicle travel, designated "managed" lanes provide travel priority for transit buses, carpools, and vanpools during peak travel periods, and offer tolled access for single occupant vehicles during periods of lower traffic. Managed lanes are an operational

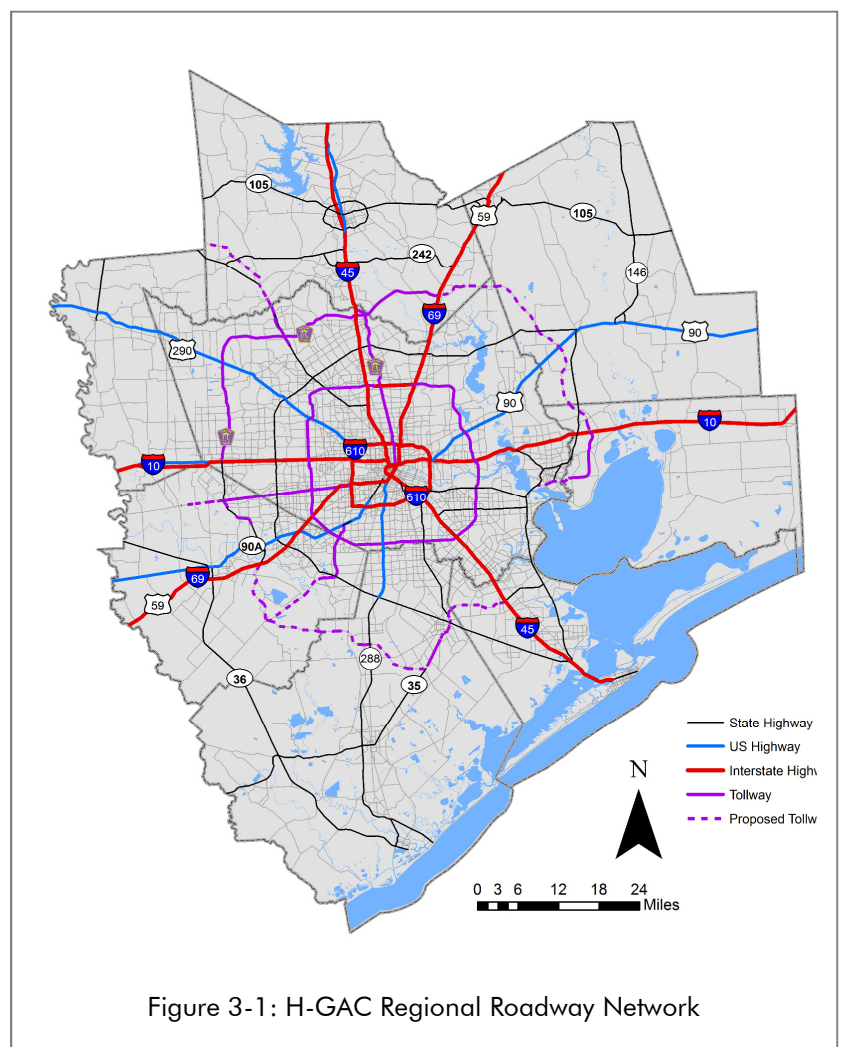


Figure 3-1: H-GAC Regional Roadway Network

¹ H-GAC Travel Demand Model, 2018

² Ibid.

strategy that use congestion pricing to encourage a more efficient use of highway capacity.

CHALLENGES

Safety

Safety is a serious concern for roadway travel in the region and is one of the goals of 2045 RTP. Between 2012 and 2016, motor vehicle crashes that occurred regionwide increased by more than 40%. Fatalities from motor vehicle accidents increased by over 20% during the same period. Vehicle crashes cost the region as much as \$6.4 billion in 2016 alone,³ and remain one of the leading causes of death among persons in their teens and twenties.

Congestion

Traffic congestion consistently ranks high in public opinion polls as a regional transportation concern. About 60% of the twenty most congested roads in Texas are in Harris County. So is half of the top ten.⁴ The West Loop Freeway (IH 610 W) and Southwest Freeway (IH 69 S/US 59 S) top the list as the most congested and second most congested road segments in the state, respectively. While congestion typically occurs during peak driving periods, IH 610 W experiences about 45% of its delay outside the peak periods.⁵



Connectivity

Connectivity across the region is an important but sometimes overlooked issue. Continuous routes that link the suburban population to the regional employment centers are an important mobility need and can aid orderly development. Area waterways constitute significant obstacles to roadway connectivity in several counties and directly impede north to south or east to west travel. Insightful thoroughfare planning is needed to enhance regional accessibility and provide convenient alternative routes that relieve traffic on congested corridors.

³ H-GAC Regional Safety Plan; TxDOT 2018.

⁴ Texas A&M Transportation Institute, Texas' Most Congested Roadways 2018.

⁵ Ibid.

FREIGHT SYSTEM

The Houston-Galveston region is served by an intermodal network of road, rail, water, air, and pipeline facilities through which imported goods are transported to regional distribution centers, raw materials are supplied to local manufacturers, petroleum products are shipped from the region's refineries to statewide, national, and global markets, and consumer goods are carried to local and regional markets. The H-GAC regional multimodal freight network is described in Figure 3-2.

COMMERCIAL TRUCKING

Commercial trucks account for most of the freight movement in the region. Trucks convey small volume loads and container shipments and are largely responsible for the first mile-last mile trips. More than 465 million tons of goods are shipped annually over the region's roadways. The top commercial truck freight commodities include food items, agricultural products, chemicals, plastic resin, building materials, iron and steel articles, machinery, motor vehicles, and consumer goods. It is projected that by 2045, the commercial trucking industry will handle 54% of all freight shipments by weight and 88% of the shipments by value.

RAILROADS

Three Class I railroads operate within the Houston-Galveston region: The Union Pacific Railroad (UP), Burlington Northern Santa Fe (BNSF), and Kansas City Southern (KCS)⁶ railroads.

Together, they operate more than 1,000 miles of track that include over 800 miles of mainlines, 120 miles of siding, and close to 50 miles within marshalling yards. Over long distances, railroads are the most efficient form of land transportation. Houston is a hub for the long haul UP Railroad lines that link the Louisiana gulf coast, the west coast, the upper mid-west and Mexico.

The Class I rail operators haul over 150 million tons of freight annually with chemical products being their main cargo. Over 450,000 carloads of chemicals or refined petroleum products were shipped from

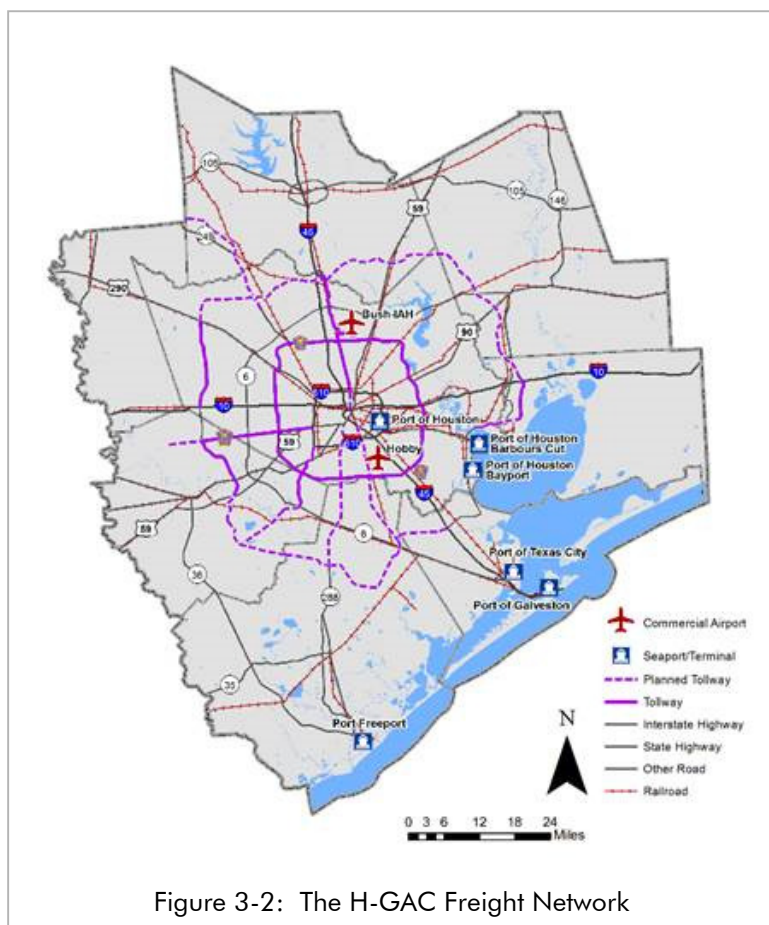


Figure 3-2: The H-GAC Freight Network

⁶ KCS does not own any track with the Houston Region but has trackage rights along with other railroads.

Houston on rails cars in 2016. The bulk of these shipments went to destinations within Texas, the Gulf Coast, and the West Coast.

MARINE FREIGHT

The Houston-Galveston region's marine freight network consists of four deep water ports – Port Houston, Port Freeport, the Port of Galveston, and the Port of Texas City. The Gulf Intracoastal Waterway (GIWW) links all the Gulf Coast ports and provides sheltered access to the nation's system of inland waterways. Water is the least costly freight transportation option available and the ports are the largest generators of freight in the region.

Port Houston is one of the largest ports in the world and holds several distinctions: ranked first among U.S. ports in foreign waterborne tonnage, second in total tonnage, and third in total foreign cargo value.⁷ It also leads the nation in exports of general resin products and is consistently the top performing breakbulk port in the nation. Port Houston handles 69% of the container traffic in the Gulf Coast and in 2018, was sixth nationally in total container volumes (import and export).

While the ports of Houston, Freeport, and Galveston all handle a variety of bulk and break-bulk commodities, container cargo, and cruise travel, the Port of Texas City almost exclusively handles liquid products related to the petrochemical industry. Petroleum products, crude oil, and chemicals make up over 85% of all trade flow in the region's ports and is projected to grow with the ongoing expansion of energy production nationally. The widening of the Panama Canal has prompted modernization and expansion efforts at area ports seeking to accommodate the larger vessels and increased cargo that is expected to come into the Gulf Coast market.

An ongoing Ports Area Mobility Study will consider options to improve the efficiency of freight movement through the ports while limiting their contribution to congestion in the surrounding urban core.

PIPELINE

The Houston-Galveston region has over 21,500 miles of pipelines which transport more than 445 million tons of liquid bulk annually. Pipelines are the predominant mode for moving crude oil, natural gas, and refined oil products from the oilfields to the refineries and on to regional markets or export terminals. In terms of market share, as much as 60% of the products moved by pipelines are bound for the export market while 40% are imported products bound for US markets. By 2045, the volume of goods shipped by pipeline is expected to increase by over 20% to about 540 million tons annually.

Energy pipelines provide a cost-effective means of transporting large volumes of freight that is consequently kept off the highway and rail network. For example, a pipeline that transports 150,000 barrels of oil per day conveys the equivalent of 750 tanker truckloads or 225 rail cars. By reducing the demand for trucks and rail cars, pipelines help to ease roadway congestion and contribute positively to regional air quality and transportation safety.

⁷ USACE Navigation Data Center.

AIR FREIGHT

Air cargo is a fast and very reliable mode for moving freight – but is also one of the most expensive. Air cargo is characteristically low weight and limited in bulk compared to truck or rail cargo. The Houston-Galveston region has three major airports: George Bush Intercontinental Airport (IAH), William P. Hobby Airport (HOU), and Ellington Field (EFD). IAH handles about 98% of the freight transported by the Houston Airport System. In 2017, over 420,000 metric tons of cargo passed through this airport, ranking 19th among the nation’s cargo-service airports. About 52% of this cargo is international, with Europe being the major trading partner.

HOU handles comparatively less air cargo than IAH while Ellington Field does not handle commercial traffic. From the airport, air cargo is distributed throughout the region by truck. Intermodal connectors linking air cargo facilities to the highways are important components of the region’s freight system.

CHALLENGIES

Perhaps the biggest challenge to the regional freight system is congestion. Because ports are such large generators of freight, it is critical that the freight corridors leading to and from these facilities have the capacity to accommodate the level of traffic generated. Region-wide, the increase in demand placed on the transportation freight network by a growing economy may exacerbate the effect of bottlenecks within the transportation system and lead to untenable and costly delay.

DISASTER PREPAREDNESS

EVACUATION PLAN

Evacuation routes are designated by the Texas Department of Public Safety (DPS) in coordination with local counties and municipalities. These routes are designated to evacuate part or all of the region in the event of natural or man-made emergencies or other threats to public safety. The Houston-Galveston region has 24 signed state roadways designated as evacuation routes (Figure 3-3). These evacuation routes are described in a Texas DPS Emergency Evacuation Traffic Management Plan. Houston TranStar serves as the regional emergency center and houses multi-agency operations that manage traffic incidents and respond to regional emergencies such as hurricanes and floods.

H-GAC coordinates with counties, municipalities, and the state to manage the database of regional evacuation routes and is responsible for periodic updates to the Emergency Evacuation Traffic Management Plan. H-GAC also administers the Regional Evacuation Viewer – a secure web application which provides near real-time updates of evacuation resource deployment and other related information. Users of the viewer can access current Evacuation Traffic Management Plans by county, city or corridor.

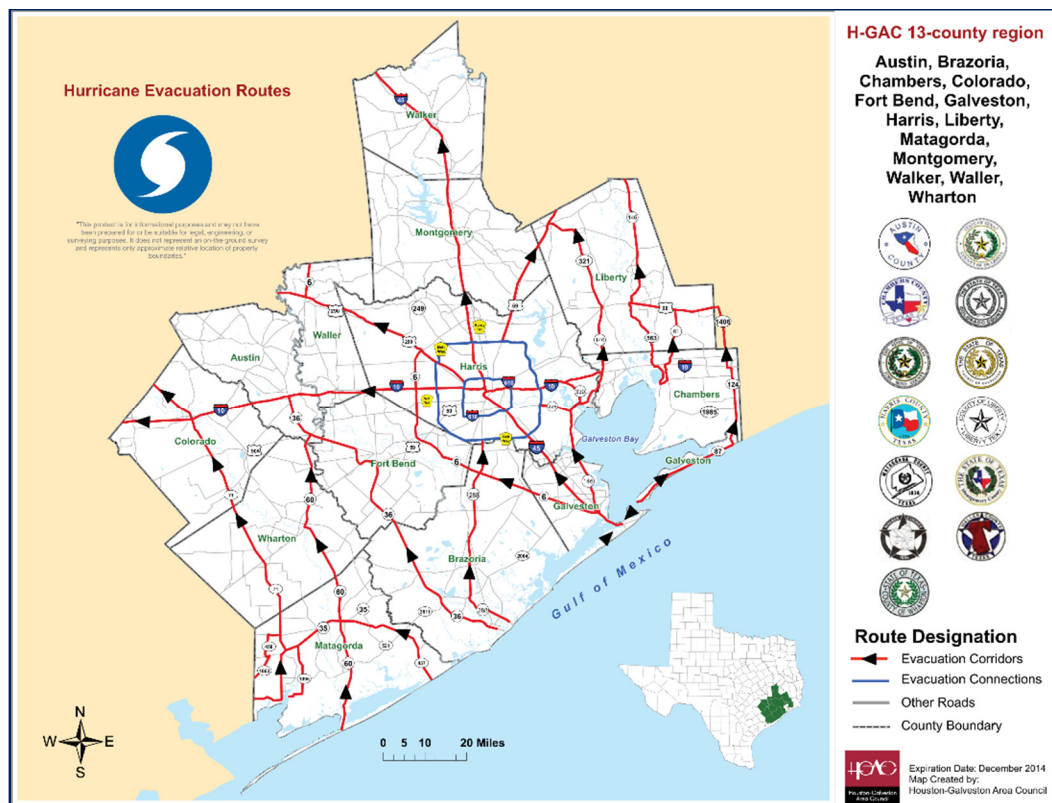
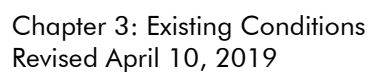


Figure 3-3: H-GAC Hurricane Evacuation Routes

Each year, H-GAC produces a Hurricane Surge Zone Map (“Zip-Zone Map”) for distribution to the public (Figure 3-4). The Zip-Zone Map is a public information tool which shows the parts of the region that are most at risk for hurricane-related storm surges over a basemap of postal zip codes. The Hurricane Surge Zone Map also indicates designated evacuation corridors and evacuation connections. Designation as an evacuation route is one criterion used in the RTP for prioritizing capital improvement projects. It is a critical safety issue that regional evacuation routes have adequate capacity to handle the high levels of traffic that often ensue in a regional emergency.

Figure 3-4: H-GAC Hurricane Evacuation Zip Zone Map



FAST Act Compliance

Houston TranStar serves as the regional emergency center and houses multi-agency operations that manage traffic incidents and respond to regional emergencies such as hurricanes and floods.

TOGETHER AGAINST THE WEATHER

The “Together Against the Weather” campaign was created to help individuals with disabilities and other special needs plan for disruptions caused by hurricanes, floods, and other weather-related emergencies. The program encourages the formation of supportive partnerships involving family members, community organizations, health care providers, and emergency management personnel, and suggests strategies for addressing challenges that commonly arise during periods of emergency evacuation.

Together Against the Weather offers several tool kits that include educational videos presented in English, Spanish, Vietnamese, and Chinese. Links are also provided to state, county, and municipal offices of emergency management. More information is available at:

<http://www.togetheragainstheweather.com/index.shtml>.

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REGIONAL TRANSIT SYSTEM

EXISTING SERVICE

The regional transit system consists of nine public transit providers which serve seven of the eight counties in the municipal planning area (Figure 3-5).⁸ The principal transit modes in the region include local bus, light rail, commuter bus or park and ride, demand response, and flexible route service. Urban transit service is concentrated in Harris County and is provided predominantly by the Metropolitan Transit Authority of Harris County (METRO).⁹

METRO provides about 90% of all commuter bus service. METRO also provides 23 miles of high capacity light rail service on three routes within Loop 610. Along with METRO, Fort Bend County Transit, Harris County Transit, Colorado Valley Transit, Brazos Transit District, and Connect Transit provide demand response service for disabled persons.

TRANSIT TRENDS

Transit ridership in the region decreased by about 2% in 2017 due to a fall in park-and-ride usage and the impacts of Hurricane Harvey. Regional transit service has, however, expanded in the suburban counties – Brazoria, Fort Bend, Galveston, and Montgomery Counties. The demand for rural transit service is growing in Liberty and Waller Counties, where regional commuter transit options will need to be established to complement existing local service. Bus vehicle reliability, which measures the average distance between mechanical breakdowns, improved 12% in 2017 to 10,800 miles.

NEW TRANSIT MODES

Flexible route service offered by METRO and Fort Bend Transit is a relatively new transit mode designed for areas of medium population density. Expanding this service within and outside of Harris County could create a more robust and better-connected regional transit system. Two other transit modes are in various stages of development. Bus Rapid Transit Service is scheduled to commence service in 2022 in the Uptown

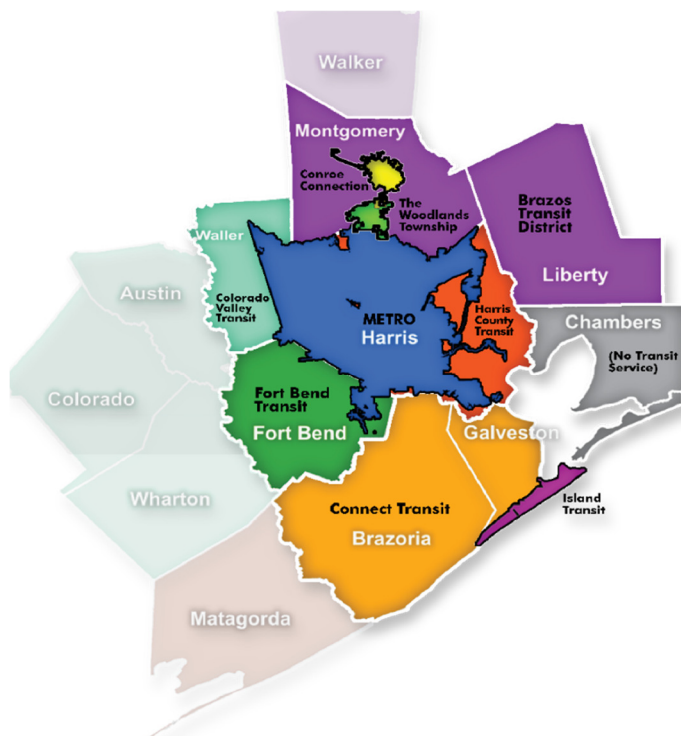


Figure 3-5: Transit Service Providers

⁸ Chambers County has no public transit service.

⁹ See Ridership and Miles Chart

Galleria area along Post Oak Boulevard and IH 610. Commuter Rail Service has long been envisioned for the region but has faltered over several issues – including funding.

HIGH CAPACITY TRANSIT EXPANSION

The High Capacity Transit Task Force (HCTTF) was created by the Transportation Policy Council in the spring of 2017 to research the need and opportunity for high capacity transit in the Houston-Galveston region. The Task Force's responsibility is to: "Coordinate with regional stakeholders to identify regional benefits, funding solutions and policy considerations to advance High Capacity Transit throughout the region."

As the result of a two-year planning process, the HCTTF Priority Network was created. The services indicated in the HCTTF Priority Network are mode-, technology- and alignment neutral. All recommendations in the HCTTF Priority Network are conceptual and are subject to further analysis and design. The Priority Network is shown in Figure 3-6.

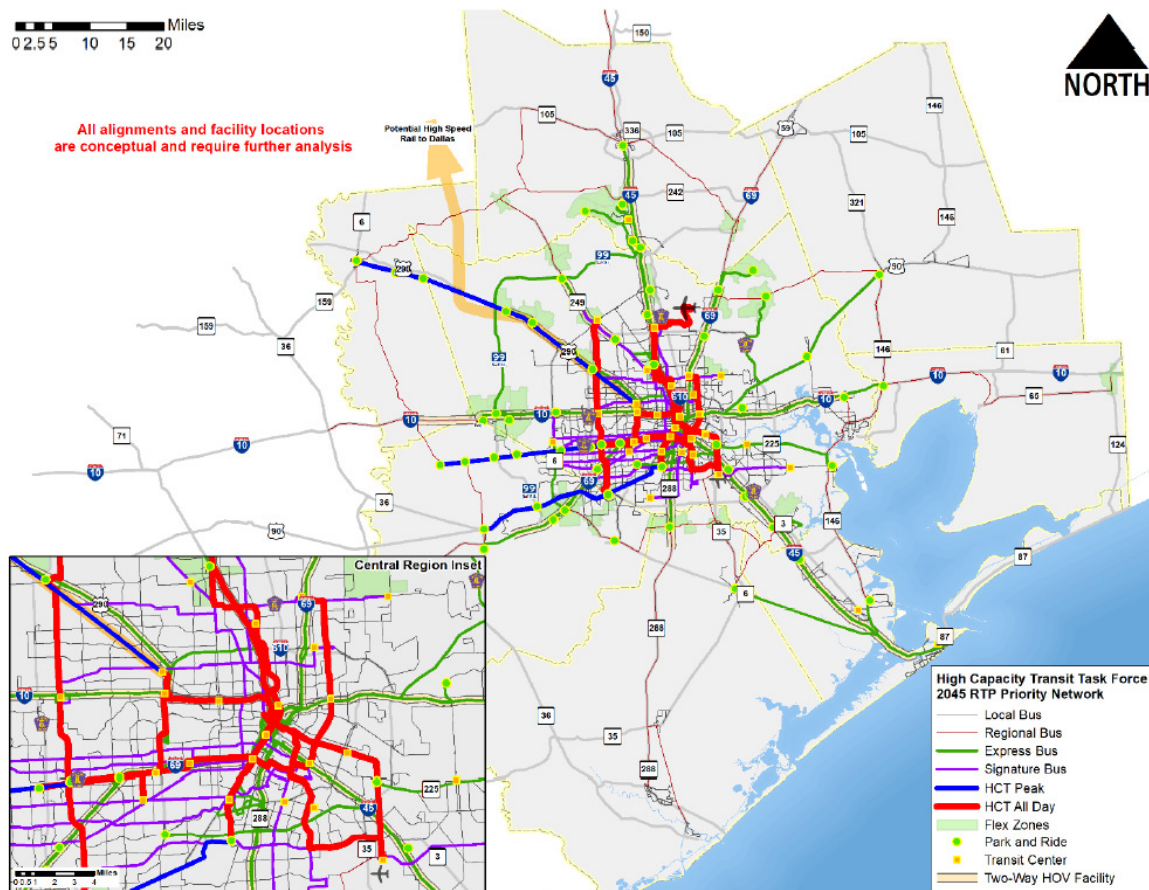


Figure 3-6: High Capacity Transit Task Force Priority Network

CHALLENGES

Funding

Funding for transit services is a challenge throughout the region. Although METRO receives local funding from a dedicated sales tax, its ability to grow existing service without additional revenue is severely constrained. For the other regional transit agencies that depend largely on federal and/or state revenue to cover their operating and capital costs, these funds have historically grown slower than operating and other transit costs. The lack of funding impacts the ability to provide a desirable level of service across the board for the transit dependent population and will probably continue to be a challenge in future years.

Coordination

Travelling around the region by transit is very difficult due to the fragmentation of available service. The lack of coordinated service, scheduling, and interoperability between the different regional providers means a high-quality seamless transit service is unavailable. This particularly impacts the ease of travel between counties. An opportunity to increase the market share for transit exists with better regional coordination and the development of seamless transit operations among regional providers. This would, however, require substantial commitment of fiscal and human resources and community vision.

Service Gaps

Chronic and emerging transit service gaps affect the vulnerable populations. Gaps include the lack of pedestrian friendly infrastructure such as accessible sidewalks, crosswalks, and pedestrian ramps at transit stops. Gaps also include the lack transit routes, non-existent stops, and inadequate service frequencies.

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ACTIVE TRANSPORTATION

Safe and well-connected active transportation infrastructure is an important component of the regional transportation system. Walking and biking as a mode of travel reduces roadway congestion and can contribute to community health and the quality of life of area residents. Over 120,000 people walk, bike, or take transit on their daily commute^{10, 11}. The H-GAC region currently has about 19,300 linear miles of sidewalks and 1,443 miles of bikeways (Figure 3-7).

INFRASTRUCTURE DENSITY

Sidewalk density is highest inside the Loop 610 area and in a few suburban communities. Bikeways show local concentrations in the Woodlands, Sugar Land, Kingwood, and a growing network in parts of Houston, Texas City, and Pearland. While more than 263 miles of bikeways have recently been constructed in various parts of the region, additional active infrastructure is needed especially in and around communities identified as sensitive for environmental justice.

FUTURE DEVELOPMENTS

Funding for walkways and bikeways comes primarily from Transportation Alternatives Set-Asides (TASA), but active transportation projects are also eligible for Congestion Mitigation/Air Quality (CMAQ) funding. The 2045 Active Transportation Plan provides more details on the existing conditions of our regional walkways and bikeways, identifies the places with a higher need for active transportation infrastructure, and outlines recommendations for improving the existing active transportation network (See Appendix H).

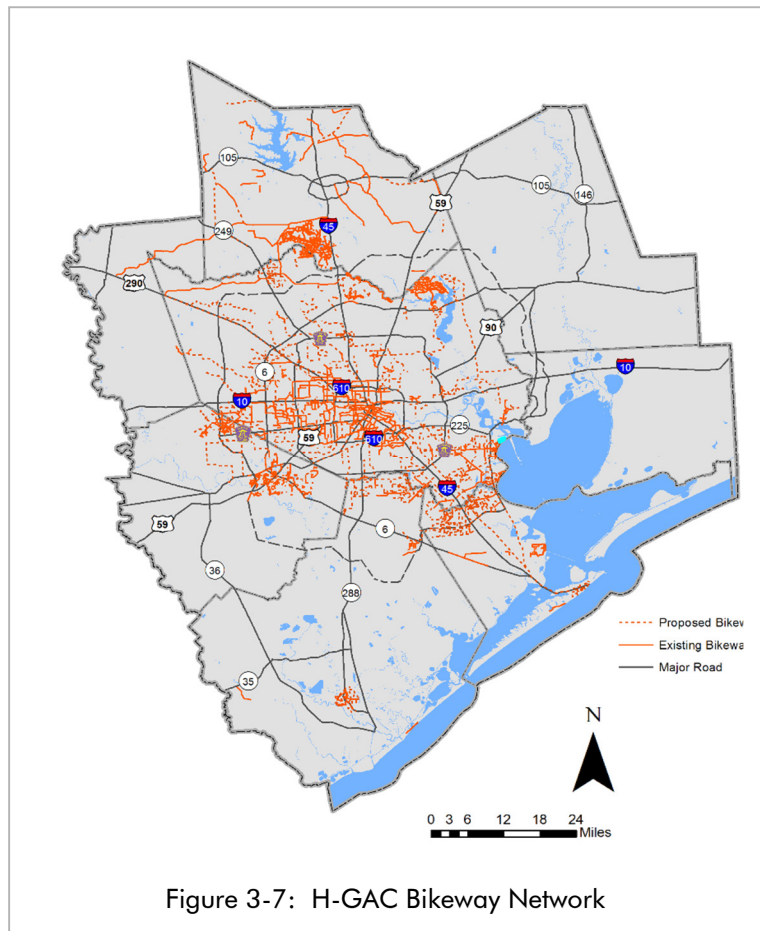


Figure 3-7: H-GAC Bikeway Network

¹⁰ We include transit riders because a 2018 H-GAC Transit Origin/Destination survey shows that around 80% of transit riders walk or bike to get to their transit stop and around 90% walk or bike from their transit stop to their final destination.

¹¹ According to the Bureau of Transportation Statistics, commutes only account for about 15% of all trips, meaning that many more people are using walkways and bikeway every day.

CHALLENGES

Although local governments are building more walkways and bikeways each year, many residents still lack safe infrastructure to walk or bike within and around their neighborhoods. Efforts are also needed to maintain and improve existing infrastructure to encourage area residents to walk and bike for more of their daily trips.

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CONGESTION MANAGEMENT

The federally required Congestion Management Process (CMP) is the systematic process of identifying congestion and its causes, applying congestion mitigation strategies to improve transportation system performance and reliability, and evaluating the effectiveness of the strategies implement.

The CMP is needed to maintain a safe and reliable transportation system that effectively supports economic development and enhances the quality of life of area residents. Congestion management is an integral part of the metropolitan transportation planning effort and provides a mechanism for funding and implementing congestion management strategies either independently, or as part of projects programmed in the RTP. The CMP advances the goals of the long-range plan. Consistent with 2045 RTP, the goals of H-GAC's CMP are to:

- Reduce the rate and severity of crashes for all system users;
- Improve transportation system reliability across all modes and systems of travel in the region;
- Reduce the impacts of incidents on traffic flow;
- Increase opportunities for travelers to use regional and local transit services and participate in Transportation Demand Management (TDM) programs to provide more travel choices;
- Improve system operational efficiency and accessibility to accommodate freight movement within the region; and
- Reduce emissions through congestion management.

TRANSPORTATION SYSTEM PERFORMANCE

Congestion has historically been a major transportation problem in the Houston-Galveston region. For the baseline year of 2014, the Planning Time Index (PTI) for the region was 1.58.¹² This means a trip that would normally take 30 minutes under free flow conditions would be completed in 47 minutes because of roadway congestion. The CMP identifies the region's congested corridors and identifies inexpensive strategies to minimize congestion and enhance the mobility of people and goods.

Harris County, which is the most populated county in the region, contains twelve of the twenty most congested roadways in the State of Texas (Table 3-1).

CMP ELEMENTS

1. Performance measures to monitor and evaluate recurring and non-recurring congestion;

2. Definition of congestion management objectives and performance measures;

3. Coordinated data collection and system performance monitoring efforts;

4. Implementation schedule, responsibilities, and potential funding for strategies; and

5. Implementation of a process for assessment of strategies, in terms of established performance measures.

¹² Texas A&M Transportation Institute, 2015.

2018 Rank	Road Name	From	To	Segment Length (miles)	Peak Period Avg. Speed (mph)	Free flow Speed (mph)
1	W. Loop Fwy/IH 610	Katy Fwy/IH10/US90	Southwest Fwy/US 59	3.62	30	62
2	Southwest Fwy/IH69/US59	W. Loop Fwy/IH 610	South Fwy/SH 288	5.44	39	62
5	Eastex Fwy/IH 69/US 59	SH 288	IH 10	3.03	34	61
7	Katy Fwy/IH 10/US 90	N Eldridge Pkwy	Sam Houston Tollway W	3.28	40	64
10	North Fwy/IH 45	Sam Houston Tollway N	N Loop Fwy/IH 610	9.26	42	63
11	Gulf Fwy/IH 45	IH 10/US 90	S Loop E Fwy/IH 610	7.89	37	59
12	South Fwy/SH 288	Gulf Fwy/IH 45	S Loop N Fwy/IH 610	4.80	40	60
13	Katy Fwy/IH 10/US 90	Sam Houston Tollway W	W Loop N Fwy/IH 610	6.62	45	63
16	IH 10/US 90	North Fwy/IH 45	Eastex Fwy/US 59	1.57	35	57
17	Katy Fwy/IH 10/US 90	Eastex Fwy/US	North Fwy/IH 10/US 90	5.65	42	62
18	N Loop W Fwy/IH 610	North Fwy/IH 45	Katy Fwy/IH 10/US 90	6.22	40	62
20	North Fwy/IH 45	N Loop Fwy/IH 610	IH 10/US 90	3.11	42	61

Table 3-1: Most Congested Texas Roadways in Harris County

FEDERAL REQUIREMENTS

MAP-21 and the FAST Act place an emphasis on performance-based planning. The Federal Highway Administration (FHWA) has identified two performance measures to assess congestion that are applicable to metropolitan planning organizations who receive Congestion Mitigation and Air Quality (CMAQ) funding. They are:

1. Annual hours of peak hour excessive delay per capita, and
2. Percent of non-single occupancy vehicle travel time.

These performance measures are incorporated into the 2045 RTP plan. The federal performance measures are discussed in more detail later in this document.

TRAFFIC SAFETY

The number of motor vehicles on area roadways increased substantially over the last several years. The region has, however, also experienced a corresponding increase in traffic-related injuries and deaths. Regionally, motor vehicle crashes increased more than 40% from 2012 to 2016. Fatalities resulting from these crash events increased more than 20% during the same period. Safety is a fundamental need in a transportation system. Just as our mobility is critically dependent on safety, the ability to travel and move goods safely is of great importance to the success of our regional economy and to sustaining our way of life.

H-GAC is involved in traffic safety in several ways: through planning and programming of capital improvements; through funding education and enforcement programs that promote traffic safety; and through the analysis and reporting of traffic safety data and information. These initiatives are represented in the Regional Safety Plan, which was developed to expand collaboration across regional safety stakeholders and provide a framework for development of an action plan to address the traffic safety issues experienced in the region.

CAPITAL IMPROVEMENTS

Safety is a major consideration in the RTP and the Transportation Improvement Program (TIP) development process. H-GAC uses a safety cost-benefit analysis as part of the project selection and prioritization process for both programs. In addition, traffic safety performance measures have been established to further characterize and quantify regional conditions.

EDUCATION AND ENFORCEMENT

Several regional traffic safety initiatives have been implemented to combat different crash types.

a. Teens in the Driver Seat

H-GAC partnered with the Texas A&M Transportation Institute (TTI) to provide traffic safety outreach assistance through its “Teens in the Driver Seat” program. This program prepares high school students to educate their peers on traffic safety, recognizing that teens tend to listen to their like-aged peers more than to adults and other authority figures. This program has expanded to 3 community colleges, 17 high schools, and 13 junior high schools in the region.

b. Child Passenger and Bicycle Safety

H-GAC partnered with Texas Children’s Hospital, operating through the Safe Kids Coalition, to promote the child passenger and bicycle safety outreach program. The program trained nearly 150 child passenger safety specialists, including Spanish-speaking associates, distributed 9,600 helmets and 550 child seats to economically disadvantaged families, and engaged the public through bike rodeo events and the distribution of child safety information.

c. DWI Task Force

H-GAC is overseeing a joint Driving While Intoxicated (DWI) task force organized to supplement regional enforcement efforts. The task force is funded through a Selective Traffic Enforcement Program (STEP) grant awarded by the Texas Department of Transportation (TxDOT). The effort includes small local government entities that would not individually qualify for the supporting grant funds. Since its inception in 2013, the task force has made over 1,100 DWI arrests.

TRAFFIC SAFETY DATA REPORTING

The State of Safety in the Region (SOSR) report provides an annual overview of the transportation safety situation in the Houston-Galveston region. The report chronicles trends in various crash types and provides analysis that includes the causes and patterns of different crash types, including age, gender, and ethnicity, time of day, day of week, month of year, and hotspot locations.

FEDERAL SAFETY PERFORMANCE MEASURES

The FHWA established five transportation safety performance measures in 2016. These safety performance measures will help to benchmark and assess regional progress towards safer roadways for all users. The federal safety performance measures are:

1. Number of fatalities
2. Rate of fatalities (per 100M Vehicle Miles Traveled)
3. Number of serious injuries
4. Rate of serious injuries (per 100M Vehicle Miles Traveled)
5. Number of non-motorized fatalities and serious injuries

These measures are part of a federal effort to introduce performance-driven, outcome-based approaches to key decisions. Safety performance measures are discussed in greater detail later in this chapter.

PAVEMENT CONDITIONS

The overall condition of the region's transportation infrastructure has remained stable over the past few years. As much as 81% of TxDOT roads were rated "good" or better in 2017 while as much as 82% of the bridges were assessed as being in "good" or better condition.

INFRASTRUCTURE MAINTENANCE AND PRESERVATION

The regional system of roads and bridges are one of the largest capital assets under the responsibility of the Texas Department of Transportation (TxDOT) and the area local governments. TxDOT currently maintains more miles of highway and more bridges than any other state in the US. The State of Texas has about 69,000 lane miles within the National Highway System (NHS), approximately 12% of which are inside the H-GAC metropolitan planning area. Ensuring the preservation of these roadway pavements and bridges is critical to safety, the efficient movement of people and goods, and regional economic development. With the gradual aging of this infrastructure, emphasis on maintenance and rehabilitation has become paramount. Decisions must be made about when, where, and how to allocate funding for their maintenance and preservation.

The purpose of a pavement management program is to encourage relatively small-scale repairs on roadway and bridge infrastructure before substantial damage occurs that would necessitate more expensive reconstruction. Timely pavement preservation treatments are a cost-effective approach to abate structural decline, safeguard the safety of the road users, improve traffic operations, and promote sustainability of the transportation system resources.

FEDERAL REQUIREMENTS

Federal Performance Asset Management prescribes pavement targets for all roadways on the interstate and non-interstate highway system, regardless of ownership. While the federal performance measures are focused on National Highway System, H-GAC applies these performance measures to all its pavements and bridges. The FHWA has identified four performance measures to assess pavement conditions applicable to metropolitan planning organizations. They are:

- International Roughness Index (IRI);
- Cracking;
- Rutting; and
- Faulting.

More details on the performance measures for pavement conditions are provided in the Performance Measures section of this document.

RESILIENCY

REGIONAL VULNERABILITIES AND RESILIENCE

Due to its low-lying coastal geography and semi-tropical climate, the Houston-Galveston region is vulnerable to extreme weather events like heat, drought, tropical storms, and flooding. The risk of these extreme events impacting the region's population, economy, and transportation infrastructure is expected to worsen because of the amplification of related stressors — land use changes, population growth, congested transportation systems, and climate change.

Federal Highway Administration RESILIENCE DEFINITION

“Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.”

Transportation systems and infrastructure are vulnerable to extreme weather. In fact, with sea level rise, temperature increases, and increasingly frequent and severe storms, it can be expected that transportation services and infrastructure will suffer more frequent disruptions or permanent damage which would seriously impede the movement of goods and people throughout the region. A summary of expected impacts to transportation infrastructure is shown in Table 3-2.

Understanding the region's risk to extreme weather, in 2010, H-GAC and local partners established resiliency as a regional priority in the “Our Great Region 2040” plan and adopted increasing the region's resiliency to disaster and a changing environment as a major goal.

FEDERAL REQUIREMENTS

Creating a more resilient transportation system has been identified as a national priority. The Fixing America's Surface Transportation (FAST) Act signed into law in 2015, requires MPOs to:

- Address resiliency in their transportation planning processes;
- Develop a Transportation Asset Management Plan (TAMP) that integrates climate change and extreme weather event resilience approaches into transportation asset management;
- Identify policies and design standards to reduce storm water impacts to surface transportation; and
- Coordinate resiliency planning efforts with organizations and agencies focused on natural disaster risk reduction.

REGIONAL RESPONSE TO FEDERAL REQUIREMENTS

To meet federal requirements, H-GAC staff is incorporating resilience into its transportation planning in the following ways:

a. Transportation Vulnerability Assessment Study

In 2018, the Houston-Galveston region was selected to participate in Federal Highways Administration's (FHWA) Resiliency and Durability Pilot Project. As part of this project, H-GAC will work with federal, state, and local partners to conduct a vulnerability assessment of transportation assets in the MPO region.

Expected Climate & Extreme Weather Impacts to Transportation Infrastructure		
Climate Variable	Projection	Impact on Transportation Infrastructure
Relative Sea Level	Over the last century, sea level at Galveston has risen more than 26 inches, which is significantly greater than the global average. In the next 50 years, Gulf Coast sea levels are expected to rise by 1 to 6 feet.	A 4-foot increase in relative sea levels would put a quarter of the region's interstates, 10 percent of rail lines, and nearly 75 percent of port facilities at risk.
Temperature	On average, the region already experiences more than 100 days above 90 °F per year. Average temperatures could increase 2° to 4°F by 2050. Temperature increases will be most severe in highly urbanized areas due to the heat island effect.	Higher temperatures will result in higher construction and maintenance costs. At temperatures above 90°F, highways, bridges, and rail lines deteriorate more quickly. Extreme heat can cause immediate damage such as buckling.
Hurricanes and Tropical Storms	Expected to become from frequent and powerful as the Atlantic Ocean and Gulf of Mexico warm.	Associated extreme rainfall, strong winds, and coastal flooding will damage infrastructure, cause road and evacuation route closures, and overwhelm storm drains.
Precipitation	Heavy rainfall events and droughts have increased; this trend is expected to continue with longer dry periods between extreme rain events.	Heavy precipitation can result in flash floods with impacts ranging from inconveniences (temporary road closures and transit service disruptions) to permanently destroyed infrastructure. Extreme rain events are also correlated to a higher incidence of crashes and delays.
Sources: <ul style="list-style-type: none"> • Transit and Climate Change Adaptation: Synthesis of FTA-Funded Pilot Projects, August 2014, FTA • The Gulf Coast Study Summary, Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study, Phase 1 Completed in 2008, FHWA • Gulf Coast Climate Change Adaptation Pilot Study, August 2013, FTA • Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I, March 2008, The Climate Change Science Program 		

Table 3-2: Impact of Extreme Weather Events on Transportation Infrastructure

The vulnerability assessment will use FHWA's Vulnerability Assessment Scoring Tool (VAST) and methodology and will include consideration of exposure, sensitivity, adaptive capacity, economic impact, and risk. Resiliency recommendations will be developed based on vulnerability assessment results. Results will also be used to help prioritize funding decisions for future transportation projects.

Work on the Resiliency and Durability Pilot Project commenced in Winter 2018 and should be completed by late Summer 2020. More information about the Transportation Vulnerability Assessment can be found at www.hgacmpo.com/resiliency.

b. Working Group

In 2019, H-GAC will form a transportation resiliency working group with the initial goal of developing a multi-year strategy to meet resiliency-related federal requirements and identify additional resiliency efforts that will reduce risk and improve safety in the region. Through the working group, H-GAC will host workshops, coordinate resiliency work with emergency management (preparedness and response) efforts, develop a plan to reduce and mitigate storm water impacts on surface transportation and more.

c. Texas Resiliency and Planning Workshops

H-GAC has participated in several resiliency workshops hosted by FHWA, TxDOT, the Texas A&M Transportation Institute (TTI), and other metropolitan planning organizations. The purpose of these workshops has been to exchange information, data sources, and resiliency strategies. As part of its transportation resiliency agenda, H-GAC plans to host further workshops focused on asset management and performance measures.

d. Cedar Bayou Initiative

The Cedar Bayou Initiative is a partnership of public and private sector stakeholders in the Cedar Bayou watershed. Its purpose is to identify and pursue priority projects to improve flood management, resiliency, and transportation goals throughout the Cedar Bayou watershed and the greater Chambers, Liberty, and Harris Tri-County area. Projects identified in 2018 can be grouped into three major categories:

- Dredging and other improvements to the main channel of Cedar Bayou, its tributaries and drainage channels.
- Stormwater infrastructure, detention, and runoff quality improvement.
- Improvements to transportation infrastructure to reduce flooding and improve evacuation capacity.

e. Designing for Impact

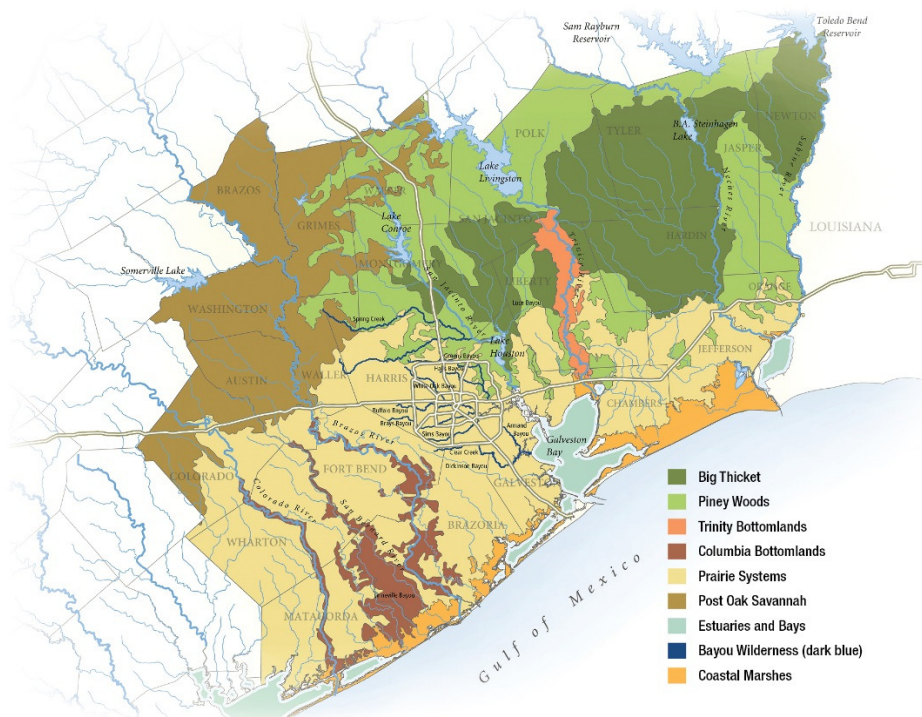
H-GAC is involved in the "Designing for Impact" study which is exploring strategies to reduce the impact of stormwater on the Houston-Galveston region's infrastructure. Working through a voluntary partnership of engineers, developers, architects, landscape architects, municipal and county representatives, the project identifies the Low Impact Development strategy as an effective and economically advantageous approach to addressing the regions' stormwater problems.

NATURAL ENVIRONMENT

For a rapidly growing region like the Houston-Galveston metropolitan area, the need exists for a workable and sustainable program to conserve and protect the region's high value natural resources. The parks, open spaces, natural areas, farmlands, and waterways are indispensable and contribute to the economy, and the health and quality of life of area residents. Almost 40% of the region's land cover is categorized as forest, wetland, or grassland (Figure 3-8). However, many of these resources are threatened by development.

As the Houston metropolitan region continues to grow, there will be need for additional housing and employment, and for an expansion of the transportation network. It is projected that about 71% of the 2045 population would be located beyond the Beltway – which is where much of the region's remaining undisturbed forest and grassland resources are. Except proactive action is taken, we stand to lose or significantly impair these resources and the important ecological services that they provide to the region. In addition, the ongoing disappearance of undeveloped land will have serious consequences for air and water quality, agricultural productivity, wildlife habitat, opportunities for recreation and pursuing healthy lifestyles, and keeping the region's character and cultural heritage. The challenge is how to plan for the projected urban growth and increased mobility while conserving our high priority natural resources and preserving the ecological diversity of our region.

Figure 3-8: Ecoregions in the Houston-Galveston Region



Source: *Houston Wilderness*

The subtropical climate of the Gulf Coast supports several distinct bioregions which perform beneficial functions that improve and protect the environment, improve resilience, and foster economic activity within the region. Table 3-3 lists some of the beneficial functions associated with the region's wetlands, grasslands, and forests.

Benefits from Region's Most Common Ecosystem Types	Coastal Wetland Marshes	Prairies	Forests
Recreation & Ecotourism	X	X	X
Aquifer & Groundwater Recharge	X	X	X
Flood Prevention	X	X	X
Wildlife Habitat	X	X	X
Carbon Sequestration	X	X	X
Erosion Control	X	X	X
Water & Air Purification	X	X	X
Seed Bank		X	
Provides Storm Drainage		X	
Reduces Runoff & Pollution			X
Blocks Noise			X
Reduces Building Energy Costs			X

Table 3-3: Beneficial Functions of Ecosystem Resources

CONSERVING THE NATURAL RESOURCES

One of the goals of 2045 RTP is to conserve and protect the region's natural and cultural resources. This can be achieved by greater integration of resource conservation in the transportation planning process. Transportation regulations require the MPOs to consult with environmental resource agencies, and to incorporate environmental stewardship in the long-range transportation planning process.

Several federal and state resource agencies are tasked with protecting the quality of the human and natural environments through their rule-making responsibilities and the enforcement of federal and state environmental statutes and regulations. H-GAC and its transportation partners consult with these agencies as well with universities, research institutes, and private natural resource conservation organizations in the effort to protect and enhance the environment. The outcomes of these collaborative efforts include

protection and conservation plans for area watersheds, riparian corridors, and the Galveston Bay system; surface water quality monitoring; air quality improvement programs; and the establishment of nature trails, conservation easements, and ecosystem restoration initiatives.

H-GAC is updating its “Eco-Logical” web tool which identifies the high-quality ecotype resources within the metropolitan planning area. Eco-Logical is designed to alert planners of situations where project investments coincide with sensitive habitats, and encourage actions to avoid, minimize, or mitigate the impact of transportation planning on these important environmental resources. The web tool may be viewed at: <http://arcgis02.h-gac.com/EcologicalGIS/>.

INDIRECT ENVIRONMENTAL IMPACTS

While positive outcomes result from the MPO region’s economic development and continued population growth, residents are periodically reminded of externalities associated with this growth – particularly the risk of flooding. Flood risk increases as forests, grasslands, and wetlands in the flat and low-lying metropolitan region are replaced with rooftops and pavement. The results include swifter and greater amounts of runoff to the rivers and streams and prolonged flood stages that disrupt travel, displace thousands of residents, and cause billions of dollars of damage to homes, businesses and civil infrastructure.

The region’s vulnerability to inland and coastal flooding was underscored in recent years during the 2015 “Memorial Day Flood,” the 2016 “Tax Day Flood,” and the 2017 “Hurricane Harvey.” H-GAC is keenly involved in regional efforts by the state, local governments, and research institutions to understand the Houston flood problem and to find solutions to mitigate regional flood losses, minimize travel disruptions, increase resiliency, and minimize stormwater impact on transportation infrastructure.

H-GAC also recognizes that transportation infrastructure projects can have foreseeable consequences that occur later in time but not necessarily near the project site. Through its policies, impacts must be considered during the transportation planning process. Strategies for mitigating these impacts include using spatial environmental data tools to evaluate the impact of potential projects; promoting low-impact developmental practices in transportation projects and subsequent development; and coordinating with other air and water quality and land conservation efforts in project areas.

EMERGING TRANSPORTATION TECHNOLOGY

The region's transportation system is nearing its capacity limits with traffic congestion levels remaining high despite billions of dollars of investments in new or expanded highways. To sustain regional mobility, new options for travel must be developed that are convenient and accessible. Future transportation must be able to react quickly to the demand placed upon it. This section focuses on emerging technologies such as autonomous and connected vehicles, and their potential to affect and influence the regional transportation system.

AUTONOMOUS AND CONNECTED VEHICLES

Among emerging transportation technologies, two concepts that have gained prominence are "Autonomous Vehicles" (AVs) and "Connected Vehicles" (CVs). Connected and Autonomous Vehicles (CAVs) employ both technologies simultaneously; the concurrent development of both technologies is anticipated to provide reinforcing and synergistic benefits.

Autonomous vehicles (often referred to as "driverless cars") utilize mapping software, radar, sensors, and other equipment to survey, respond and navigate through their surroundings with little to no human input. Autonomous Vehicle technology is most easily conceptualized using a five-level continuum suggested by the National Highway Traffic Safety Administration (NHTSA), ranging from Level 0 (the human driver is in complete control), to Level 5 (the vehicle is responsible for all driving functions in any environment).¹³

Figure 3-9 shows an example of one of the earliest demonstrations of automated vehicle technology operating at low speeds in a pilot project within pedestrian and urban street environments. This type of vehicle typically accommodates about 10 passengers, travels at up to 25 miles per hour, and has a service range of roughly two miles.



Figure 3-9: Example of an Automated Vehicle

Connected vehicles communicate wirelessly with each other and/or with roadside infrastructure and operate cooperatively to reduce congestion, decrease fuel consumption, and promote safety. Connected vehicle technology allows communications between vehicles ("Vehicle to Vehicle" or V2V); traffic signals and other stationary infrastructure components ("Vehicle to Infrastructure" or V2I); pedestrians and bicyclists ("Vehicle to Pedestrian" or V2P); and any or all entities that may interact with or affect the vehicle ("Vehicle to Everything" or V2X). Figure 3-10 provides conceptual examples of this technology.

1 <http://www.nhtsa.gov/About+NHTSA/Press+Releases/2015/nhtsa-will-accelerate-v2v-efforts>



Figure 3-10: Examples of Connected Vehicle Technology

There is currently a significant amount of university and private sector research and investment focused on developing, testing and advancing automated and connected vehicles. Although there are inherent risks in predicting future trends, it is currently envisioned that fully-autonomous vehicles could replace conventional cars with autonomous cars by 2025. It also is projected that autonomous vehicles will reach 50 percent market share by 2035.

BENEFITS AND DRAWBACKS

The deployment of emerging vehicle technology could provide benefits such as reduced roadway crashes and fatalities due to the elimination of human driver error or impairment, which has been found to cause 94% of all crashes,¹⁴ through faster computer-based reaction times as well as greater reliability. Other potential benefits include smarter driving and navigation, reduced urban parking needs due to autonomous parking capabilities, and increased access to travel by persons who face obstacles due to age or physical impairment. Driverless taxis could enable users to request a ride using smartphone applications, without having to search for and walk to access a vehicle. Such autonomous vehicles enable carsharing companies to seamlessly reposition vehicles to better match demand.

Connected vehicle technology will enable transportation agencies to access vehicle data related to speed, location, and traffic management to address specific problems in real-time. In addition to sending information to drivers, CVs will send information to transportation agencies to enhance their knowledge of road conditions, as well as generate historic data that will help agencies better plan and allocate future resources.

Autonomous vehicles could potentially make congestion worse. Fleets deployed by taxi or rideshare companies could clog the streets of major activity centers as they search for riders. Retail companies could hire entire fleets of automated vehicles to serve as “mobile showrooms” that circulate around city streets waiting to be dispatched to potential customers, and personal automated vehicles could loop around city blocks while they wait for their owners to get coffee or pick up dry cleaning. As with any technology, there is also the potential for malfunction, whether it be the vehicle’s on-board navigation system or the communication system that connects it to other infrastructure. The potential, however slight, for automated vehicles to be “hacked” by criminal or terrorist elements is a concern.

¹⁴ <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115>

CURRENT AND FUTURE APPLICATIONS

Automated and connected vehicles have the potential to improve public transportation by increasing transit productivity, efficiency, and accessibility; mitigating congestion in an integrated transportation environment; and providing travelers with better transportation information and transit services. Transit-oriented connected vehicle mobility applications support dynamic system operations and management, enable a convenient and quality travel experience, and provide an information-rich environment to meet the needs of travelers and system operators across all modes.

One potential way to enhance public transportation would be by providing first-mile/last-mile (FM/LM) connections, by which autonomous vehicles may be operated more cost effectively without an operator onboard every vehicle. These smaller and smarter vehicles will be able to offer not only fixed route connections between high demand trip generators, but also offer a new type of service customized by each user. Platooning buses is another solution that is being researched by METRO that will allow multiple vehicles to travel in close proximity to one another, much like a train, by utilizing vehicle to vehicle connectivity.

A potential for early deployment of AV technology exists along the region's HOV network, where automated buses could operate in barrier-separated HOV lanes that do not require interaction with general traffic (NHTSA Level 4 Automation). This is supported by a Transportation Research Board (TRB) study for AV technology readiness¹⁵, which has identified protected operating environments such as HOV lanes as ideal for early deployment of automated buses, including platooning operations. Figure 3 -11 shows the region's HOV connected transit centers and their associated park-and ride lots, which are typically spaced along the region's freeway corridors length about five to ten miles apart.

Vehicle platooning has the potential to increase capacity of roads within existing right-of way. This application of connected vehicle technology also reaches into freight transportation within the Houston-Galveston region. With its heavy reliance on truck movement from container terminals, the region's ports could greatly benefit from truck platooning to, from, and between various port terminals to reduce the impact of truck congestion on the region's roadways.

¹⁵ Functionality of Level 4 transit operations, AV technology readiness and the probable timeline for early deployment are discussed on pp. 18-22 in the research report titled "Impacts of Laws and Regulations on CV and AV Technology Introduction I Transit Operations"; TSU's CTTR served as the Principal Investigator for this study.



Figure 3-11: - HOV Lane Direct Connector Lanes to Transit Center Bus Only Facilities

CHALLENGES

While there is much discussion about these emerging technologies, there is also much uncertainty as to when the technology be widely manufactured and deployed. Many questions regarding the development and deployment of emerging transportation technology remain unanswered. Will people adopt new technologies, and how quickly? Will new technologies be implemented along with electrification of vehicles? Will we see a shared vehicle ownership model emerge or will private ownership models remain? These are questions for which we can only hypothesize the outcomes.

Key challenges that could potentially slow down widespread use of autonomous vehicles include: testing and approval; development of a regulatory framework; affirmative demonstrations of reliability, security and safety; affordability; and public acceptance. AVs also stand to disrupt the norms of both transportation and land use planning, including parking minimums, street design, right-of-way, signage and signalization, access management and integration and accommodation of bicycle and pedestrian infrastructure

PERFORMANCE MEASURES SYSTEM EVALUATION

MAP-21 and the FAST Act legislations introduced Transportation Performance Management (TPM) into the Federal Highway Program, establishing a performance and outcome-based planning system designed to improve policy decision-making, increase accountability and transparency, and to promote the efficient investment of federal transportation funds. The federal performance measures relate to the goals of:

- Improving safety
- Maintaining infrastructure condition
- Reducing traffic congestion
- Improving the efficiency of the system and freight movement
- Protecting the environment

A performance measure (PM) is an indicator of the progress made towards attaining desired goals or targets. The performance measures incorporated in the 2045 RTP were chosen mainly because they are understandable, sensitive to several transportation modes, and have a nexus to the established regional goals. H-GAC's performance categories include Highway Safety (PM 1), Pavement and Bridge Conditions (PM 2), Highway System Performance (PM3), and Transit Asset Management. These performance measures and how they apply are detailed in Table 3-4.

NATIONAL HIGHWAY SYSTEM

The federal performance measures are linked to the National Highway System (NHS) – a network of critical highways that are deemed to be most important to the nation's economy, defense, and mobility. The Houston metropolitan planning area has about 8,784 lane miles of roadway on the NHS. The H-GAC 2045 RTP is, however, focused on all major roads in the metropolitan planning area and not just those listed on the NHS system.

PERFORMANCE TARGET NUMBERS

FHWA final rules require State DOTs and MPOs to establish and report target numbers for each of the federal performance measures. H-GAC adopted the target numbers established by TxDOT. Overall, performance management is a powerful analytical tool for tracking regional performance over time and permits a comparison between planning regions nationwide. Furthermore, target setting, tracking, and reporting are conducted within a relatively short timeframe – from one to four years – which give transportation planners the opportunity to link short-term performance to long-range priorities for the region. H-GAC's performance measures and their target numbers are discussed in detail in Appendix P.

Category	Performance Measure	Applicability	Reporting Frequency
Highway Safety	Number of fatalities	All public roads	Annually
	Rate of fatalities		
	Number of serious injuries		
	Rate of serious injuries		
	Number of non-motorized fatalities and serious injuries		
Pavement and Bridge Condition	Percentage of pavements of the Interstate System in Good condition	Interstate System	Biennially with four-year performance periods
	Percentage of pavements of the Interstate System in Poor condition		
	Percentage of pavements of the non-Interstate NHS in Good condition	Non-Interstate NHS	
	Percentage of pavements of the non-Interstate NHS in Poor condition		
	Percentage of NHS bridges classified as in Good condition	National Highway System (NHS)	
	Percentage of NHS bridges classified as in Poor condition		
Highway System Performance	Percent of the person-miles traveled on the Interstate that are reliable	Interstate System	Biennially with four-year performance periods
	Percent of the person-miles traveled on the non-Interstate NHS that are reliable	Non-Interstate NHS	
	Truck Travel Time Reliability (TTTR) Index	Interstate System	
	Annual Hours of Peak Hour Excessive Delay Per Capita	National Highway System (NHS)	
	Total Emissions Reduction	Urbanized area	
Transit Asset Management	Rolling Stock	The percentage of revenue vehicles that exceed the Useful Life Benchmark (ULB)	Annually
	Equipment	The percentage of non-revenue service vehicles that exceed the ULB	
	Facilities	The percentage of facilities that are rated less than 3.0 on the Transit Economic Requirements Model (TERM) Scale	
	Infrastructure	The percentage of track segments (by mode) that have performance restrictions	

Table 3-4: FHWA Performance Measures

Chapter 4

REGIONAL GROWTH AND TRAVEL PATTERNS

Long-range transportation plans are informed by estimates of the future population, employment, and regional landuse. These elements help to assess the future mobility needs and regional travel patterns and enable the planner to evaluate the transportation investments needed to create and maintain an effective regional transportation system for the future.

POPULATION FORECAST

The Houston-Galveston area consistently ranks as one of the fastest growing metropolitan regions in the nation; fueled by a positive net migration and a relatively high rate of natural increase. The region's population grew from about 3.1 million residents in 1980 to about 6.8 million residents in 2018 – an increase of well over 100%. This averages to the addition of nearly one million residents per decade. The strong population growth trend is expected to continue well into the future and the region is projected to have up to 10.7 million residents by the year 2045 (Figure 4-1).

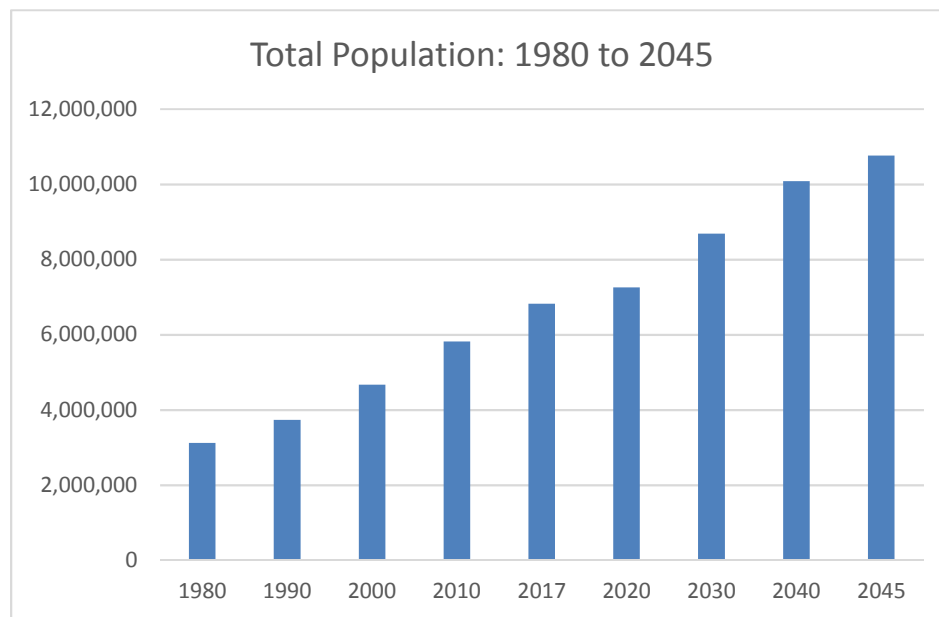


Figure 4-1: Regional Population Growth Forecast

While more residents move back to the rejuvenated inner city, the region will continue to expand towards the suburbs outside the Beltway (Figure 4-2 and Figure 4-3).

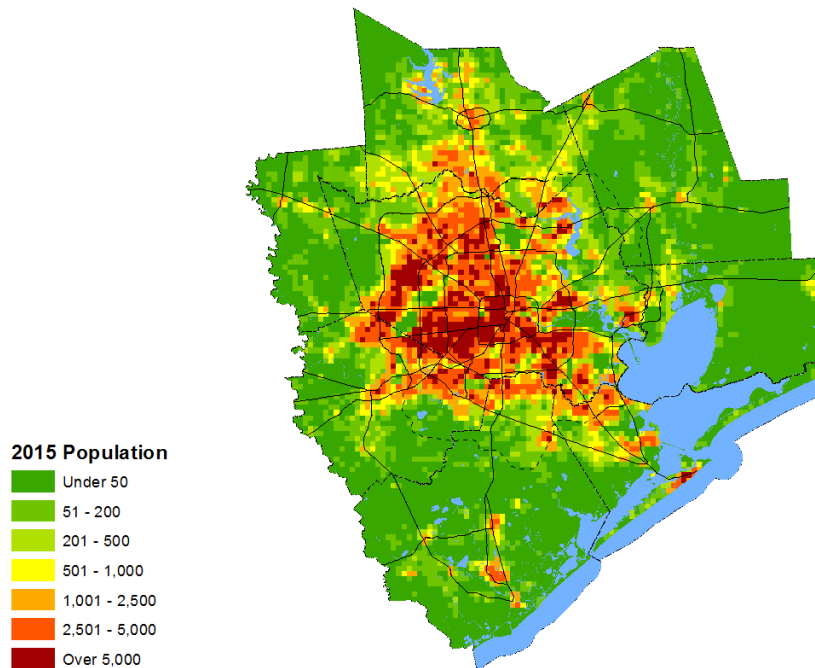


Figure 4-2: Regional Population (2015)

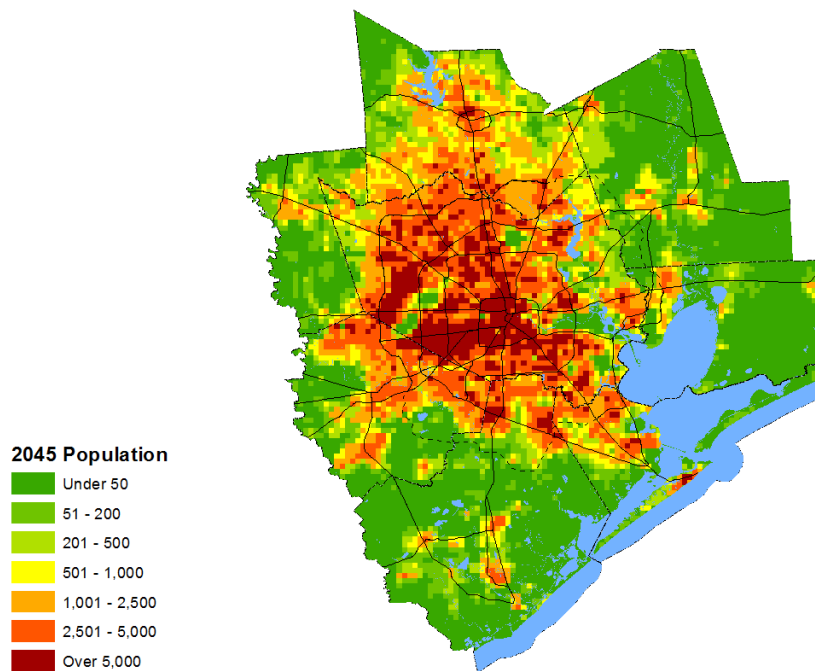


Figure 4-3: Regional Population Forecast (2045)

HOUSEHOLDS FORECAST

The number, size, composition, geographical location, and the density of households in the region all influence the demand for transportation services and infrastructure. Understanding the trends related to households will inform plans to accommodate the future transportation needs. Like the population, the number of households in the region increased from 1.1 million in 1980 to about 2.5 million in 2018. It is projected that the region will have about 4.1 million households by 2045. While the number of households are increasing, however, the household sizes are decreasing. Compared to 2.82 residents in 1980, household size currently averages 2.78 and is expected to decrease to 2.61 by the year 2045 (Figure 4-4). Finally, household density is expected to increase as more people move into the region. The current density of 247 households per square mile is projected to grow to up to 469.5 households per square mile in 2045.

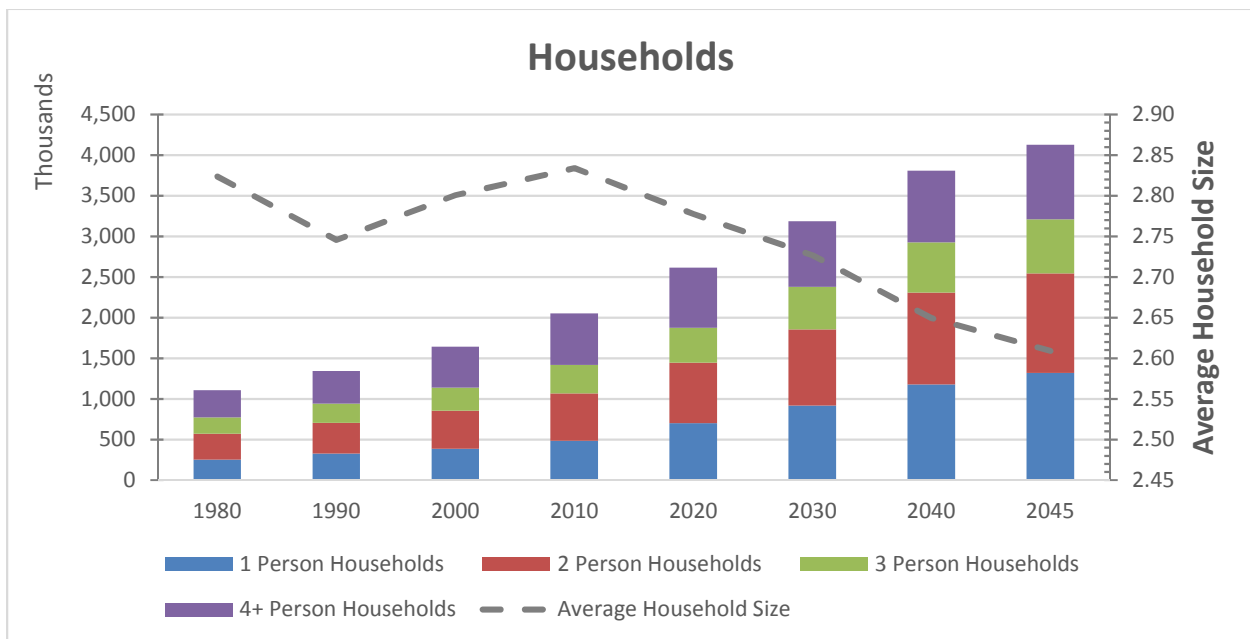


Figure 4-4: Regional Household Change (1980 – 2045)

AGE DISTRIBUTION

One of the key factors that contributes to the region's vibrant and growing economy is its youthful population. The median age of the population of the Houston-Galveston region is currently 34 years. About 51% of the population is less than 35 years old while only 10% of the population are over 65. By 2045, however, it is projected that up to 18% of the population will be 65 years or over, and that the median age will be 38 years.

EMPLOYMENT FORECAST

The Houston-Galveston region is one of the largest employment hubs in the nation. The region has been described as the top metropolitan region in the nation for economic growth potential and ranks second in manufacturing GDP.¹ Moreover, up to 20 Fortune 500 companies make the region their home.² Job growth continues to flourish in the region. From 2010 to 2015, jobs in the region increased from about 2.7 million to almost 3.2 million jobs. Employment is projected to increase to about 4.8 million by 2045 (Figure 4-5). The projected job growth is expected to be greatest in the urban core within the beltway region (Figure 4-6 and Figure 4-7).

Although the regional economy still depends heavily on the energy industry, the development of other economic sectors is diminishing the impact of vagaries in oil and gas jobs on regional employment. Over the next three decades, however, the job-to-household ratio is projected to decline. Due to ongoing changes in household structure, the aging of the population, and changes in technology, it is projected that the region will have only 1.16 jobs per household in 2045 – down from 1.4 in 2017.

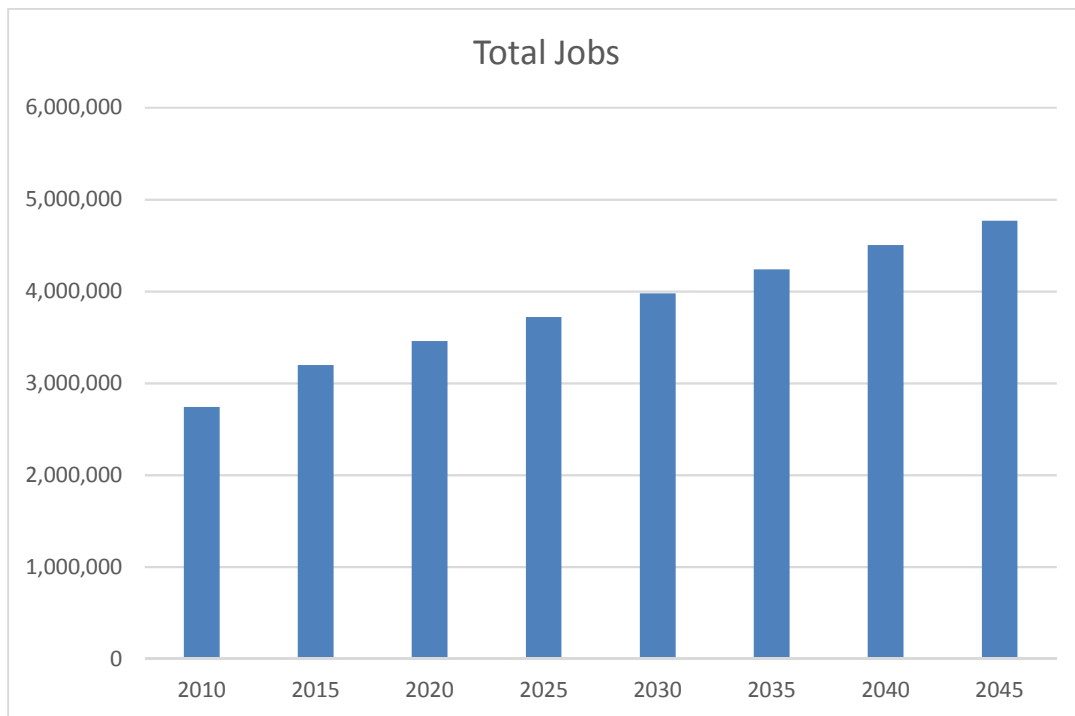
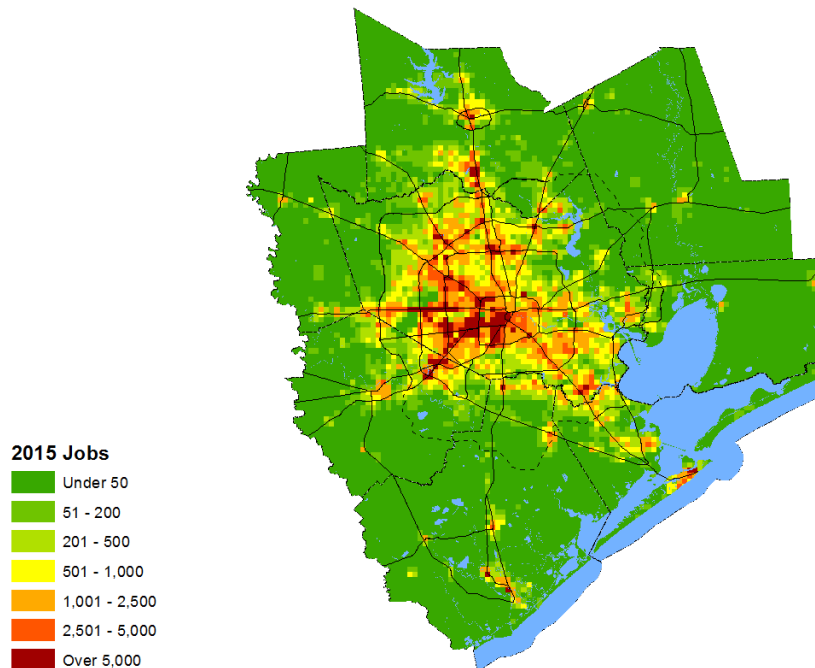


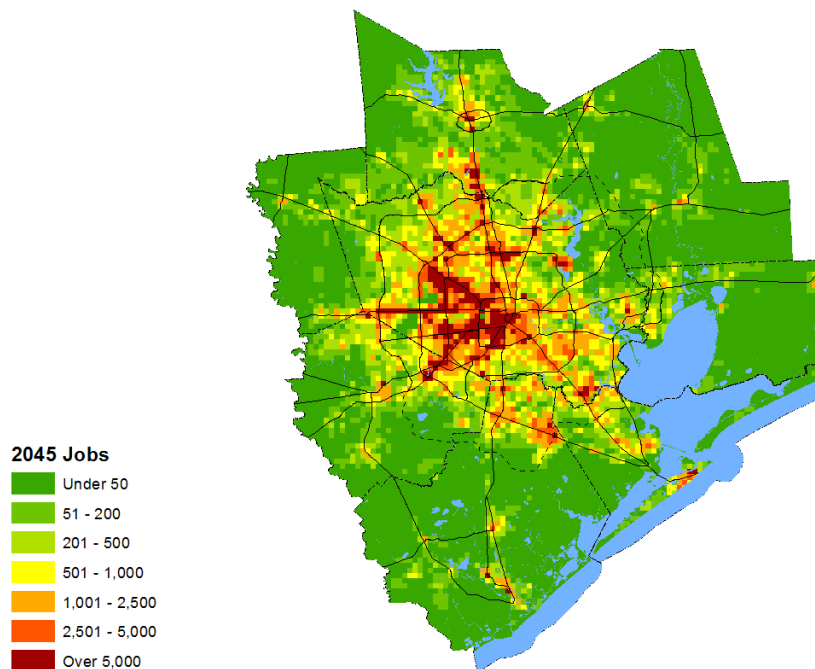
Figure 4-5: Regional Employment Growth (2010 – 2045)

¹ *Business Facilities* (2018, July,) 14th Annual Metro Rankings Report. Retrieved from <https://businessfacilities.com/2018/07/business-facilities-2018-metro-rankings-report/>.

² *Ibid.*



Map 4-6: Regional Employment (2015)



Map 4-7: Regional Employment Forecast (2045)

TRAVEL PATTERNS

The transportation system exists to serve the mobility needs of the people who live and work in the Houston-Galveston metropolitan region. Forecasting future travel patterns helps to reveal the adequacy of planned investments for meeting future needs. As discussed earlier in this document, the H-GAC region is expected to experience a significant growth in its population, households, and in the number of local jobs through the year 2045. These increases are expected to lead to a considerable rise in vehicular travel within the region (Figure 4-8). Regional travel is measured by the total miles traveled by all the residents in the region daily – also known as vehicle miles traveled (VMT).

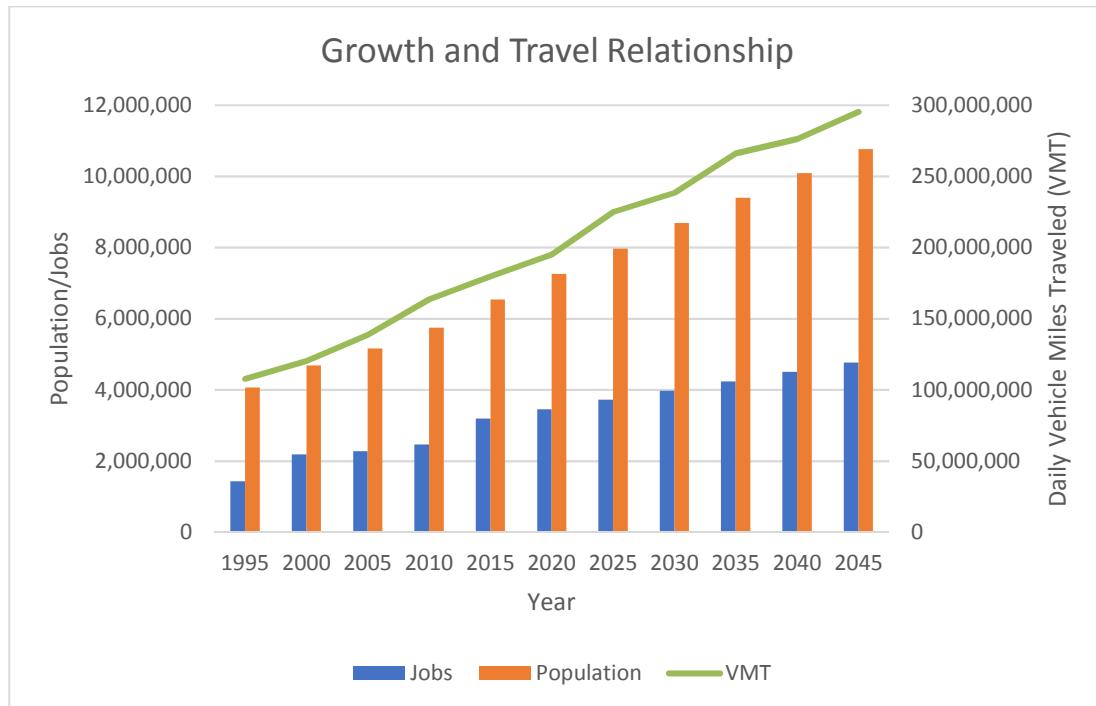


Figure 4-8: Impact of Forecast Growth on Amount of Daily Regional Travel

All areas of the H-GAC region will experience increased travel over the next 25 years. Driven by the location of jobs and residents, vehicular travel will increase from 179 million vehicle miles of travel to 295 million in 2045, an increase of almost 40 percent. Travel patterns will also continue to change during the plan horizon. As growth in suburban Harris County and adjacent counties continues, travel to, from or within the area outside Beltway 8 will represent 70% of all trips. The largest increase in travel will be trips that both begin and have their destination in the area outside the Grand Parkway, forecasted to double by 2045.

The growth of employment beyond the IH 610 loop has led to significant commuting in traditionally non-peak directions on many of the region's freeways and toll roads. This trend will continue as the peak travel direction reverses in some major travel corridors such as parts of IH 69 (US 59) South, IH 10 West

and IH 45 North. Although the development of major employment centers in formerly suburban (or rural) areas leads to greater use of major road capacity, it presents new challenges for efficiently serving suburban destined commuters with competitive transit alternatives.

CONGESTION

Travel forecasts suggest that traffic congestion will be a significant problem for the H-GAC region if adequate mitigation steps are not taken. When regional travel increases faster than the transportation system can be improved to accommodate the increased demand, congestion related delays can be expected to grow worse with time. Expressed in other terms, as the regional VMT grows, daily vehicle hours traveled (VHT) will increase at an even higher rate. This relationship can be seen in Figure 4-9.

H-GAC's travel model also projects that the amount of travel delay that road users regionwide will experience will grow from nearly 700,000 hours per day in 2020 to over 1.4 million hours by the year 2045 (Figure 4-10). Delay is measured as the difference between time spent traveling on an uncongested network and the time spent traveling on a congested one. Average travel speed on the other hand is projected to decline from 36.4 miles per hour in 2020 to 34.6 miles per hour in 2045.

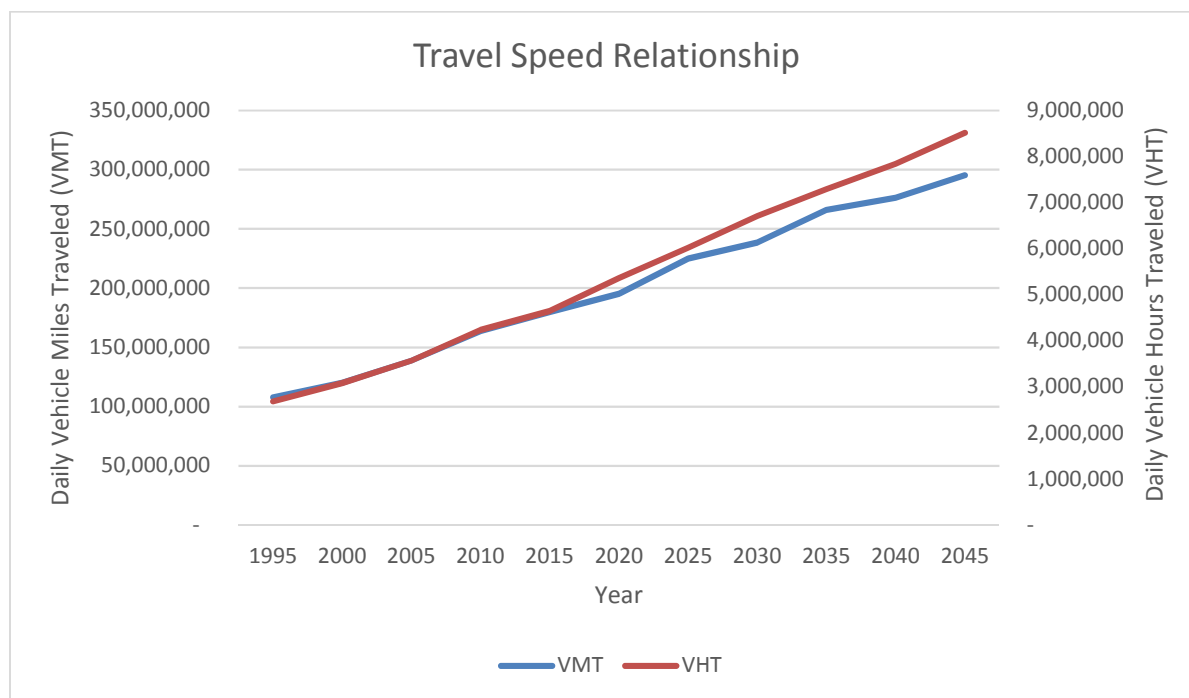


Figure 4-9: Impact of Forecast Growth on Distance and Time Spent Traveling

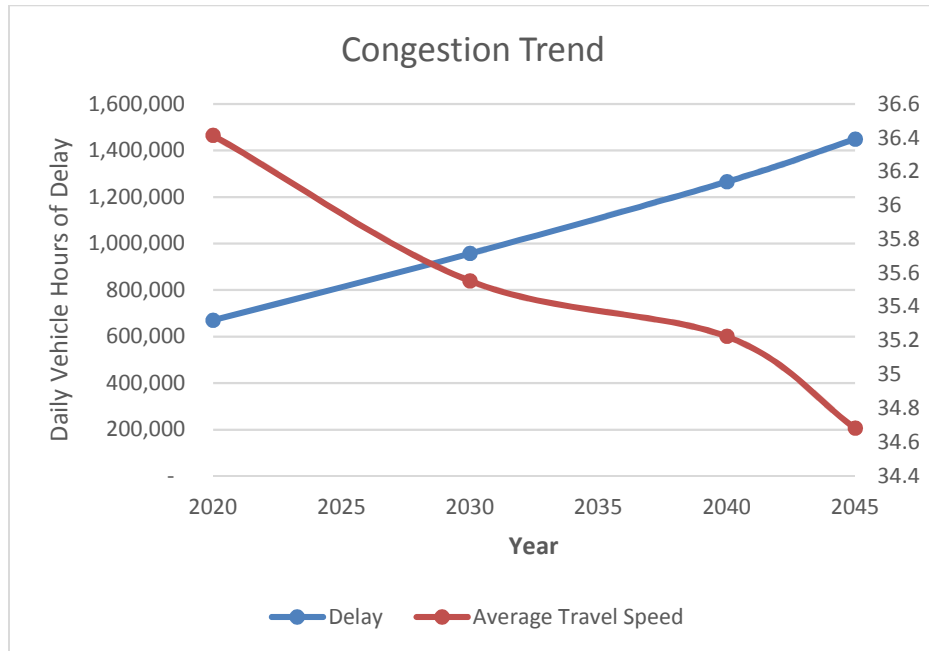


Figure 4-10: Impact of Forecast Growth on Delays and Travel Speeds

Figures 4-11 and 4-12 compare the severity of congestion estimated for the years 2020 and 2045, with the assumption that all the projected population and employment increases occurred but no improvements were made to the transportation system. The figures indicate that serious and severe congestion would be prevalent on area roadways in 2045 if the projects recommended in the 2045 RTP were not implemented. This is described as the “no-build” scenario. The total vehicle hours in the region is anticipated to more than double and the portion of time spent traveling in serious and severe congestion would increase from a combined 15% of all daily travel in 2020 to over 50% in 2045.

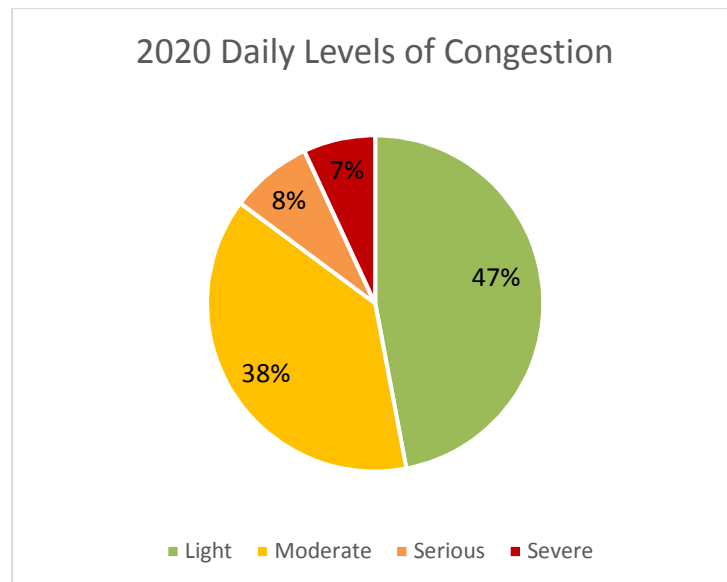


Figure 4-11: 2020 Daily Congestion Levels

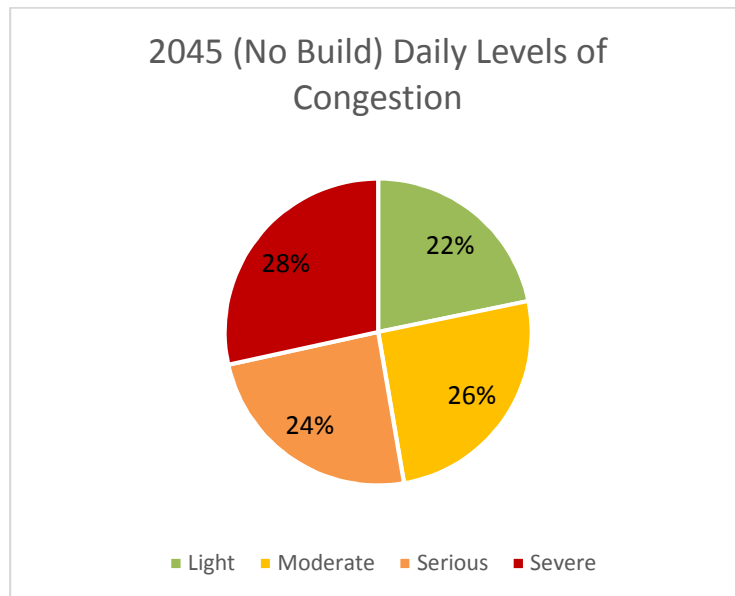


Figure 4-12: 2045 Daily Congestion Levels without Improving the Transportation System

Figure 4-13 through 4-15 give a spatial representation of the predicted levels of congestion discussed above. Current demand on the region's transportation network already results in major corridors becoming seriously or severely congested during peak hours. Under the growth forecasts for population and employment discussed above, the congestion levels on the existing transportation network intensify and spread through most of the core of the region. If the roadway projects recommended in 2045 RTP are implemented ("build" scenario), the impact of the growth expected in the regional congestion levels is somewhat reduced but are still noticeably worse than current levels. This underscores the importance of recommended strategies to invest in transit, active transportation, and intelligent transportation systems, that better utilize the existing roadway infrastructure to manage the impacts of this region's growth on congestion.

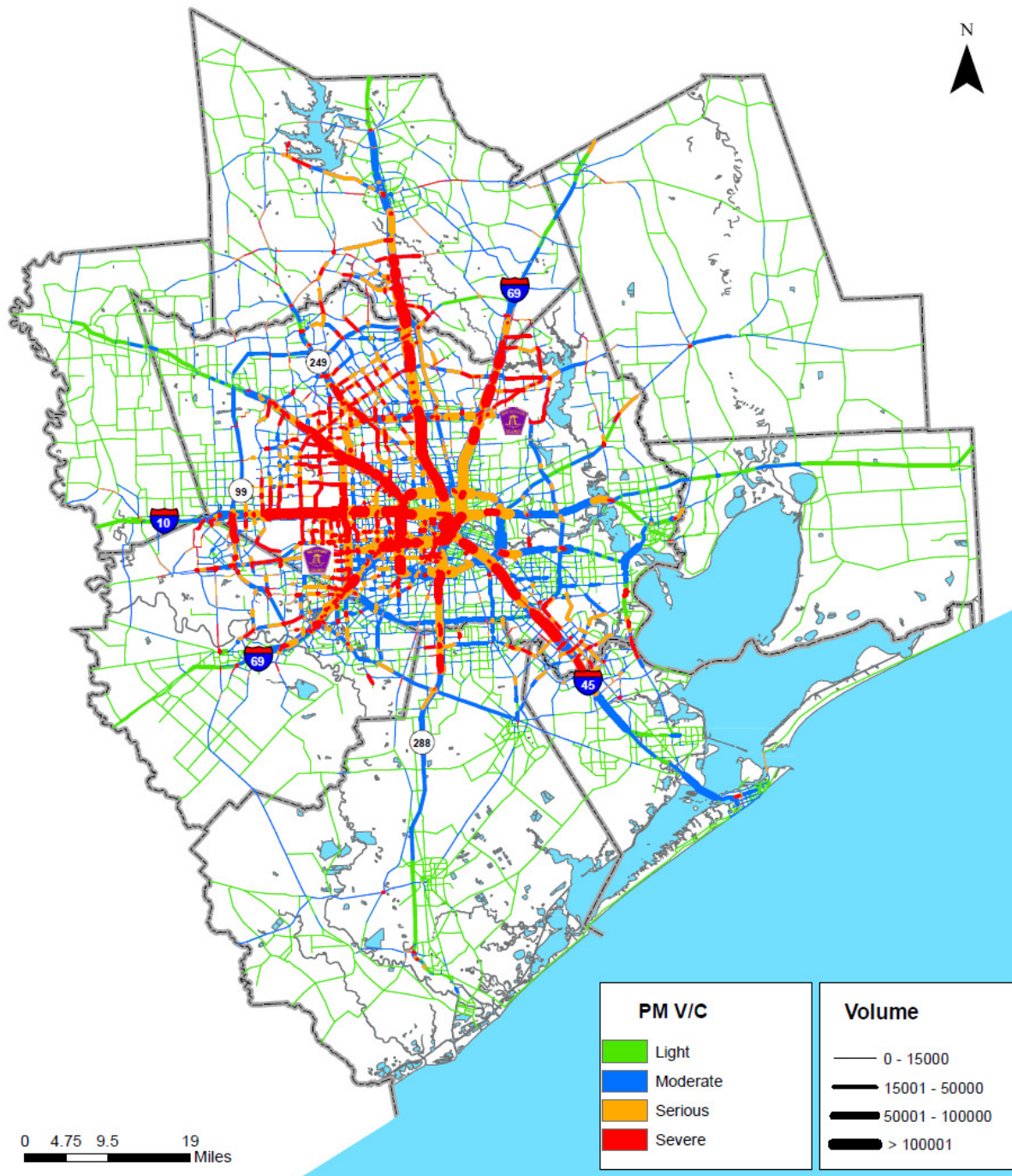


Figure 4-13: 2020 Peak Congestion

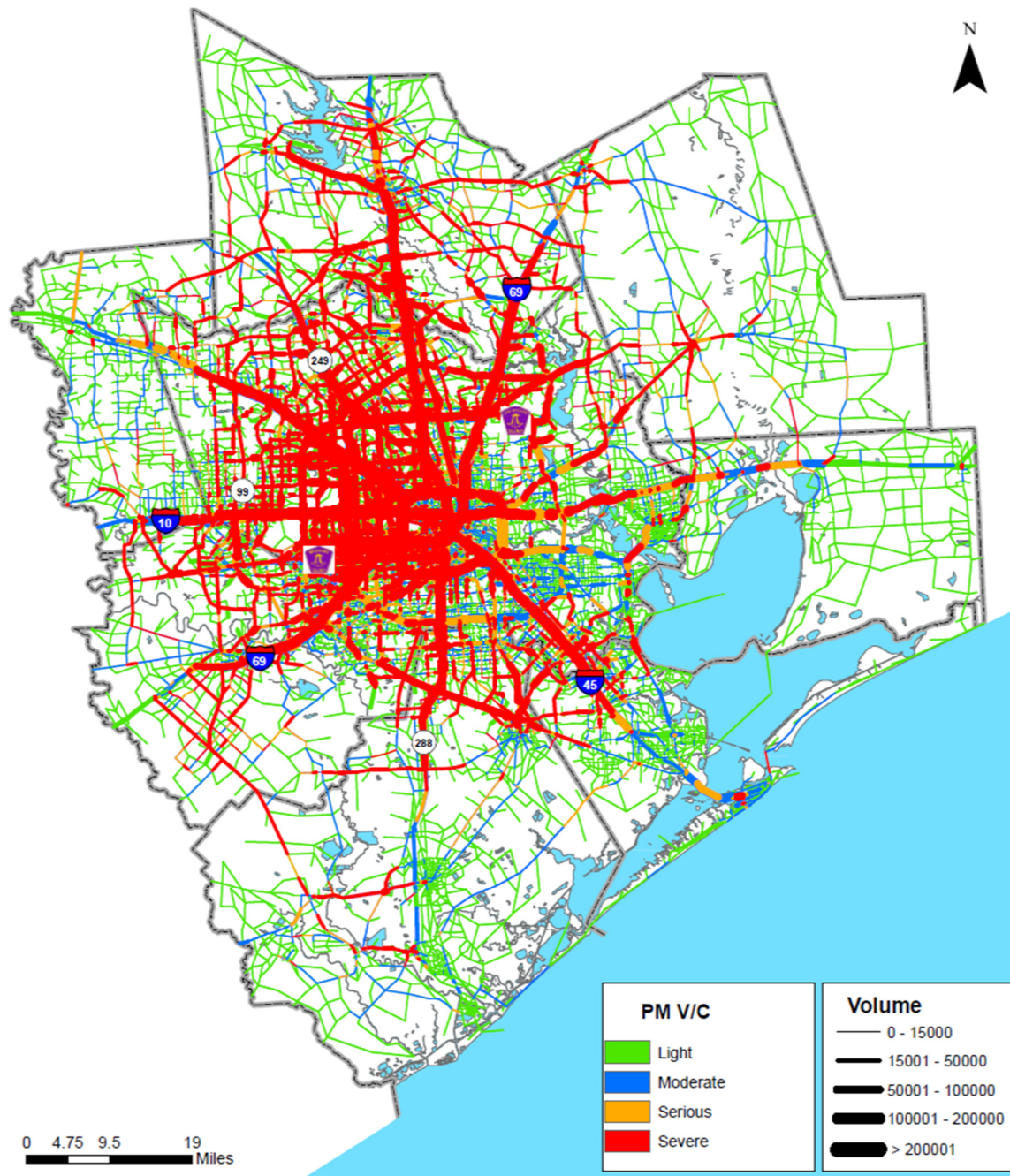


Figure 4-14: 2045 Peak Congestion without Improving the Transportation System

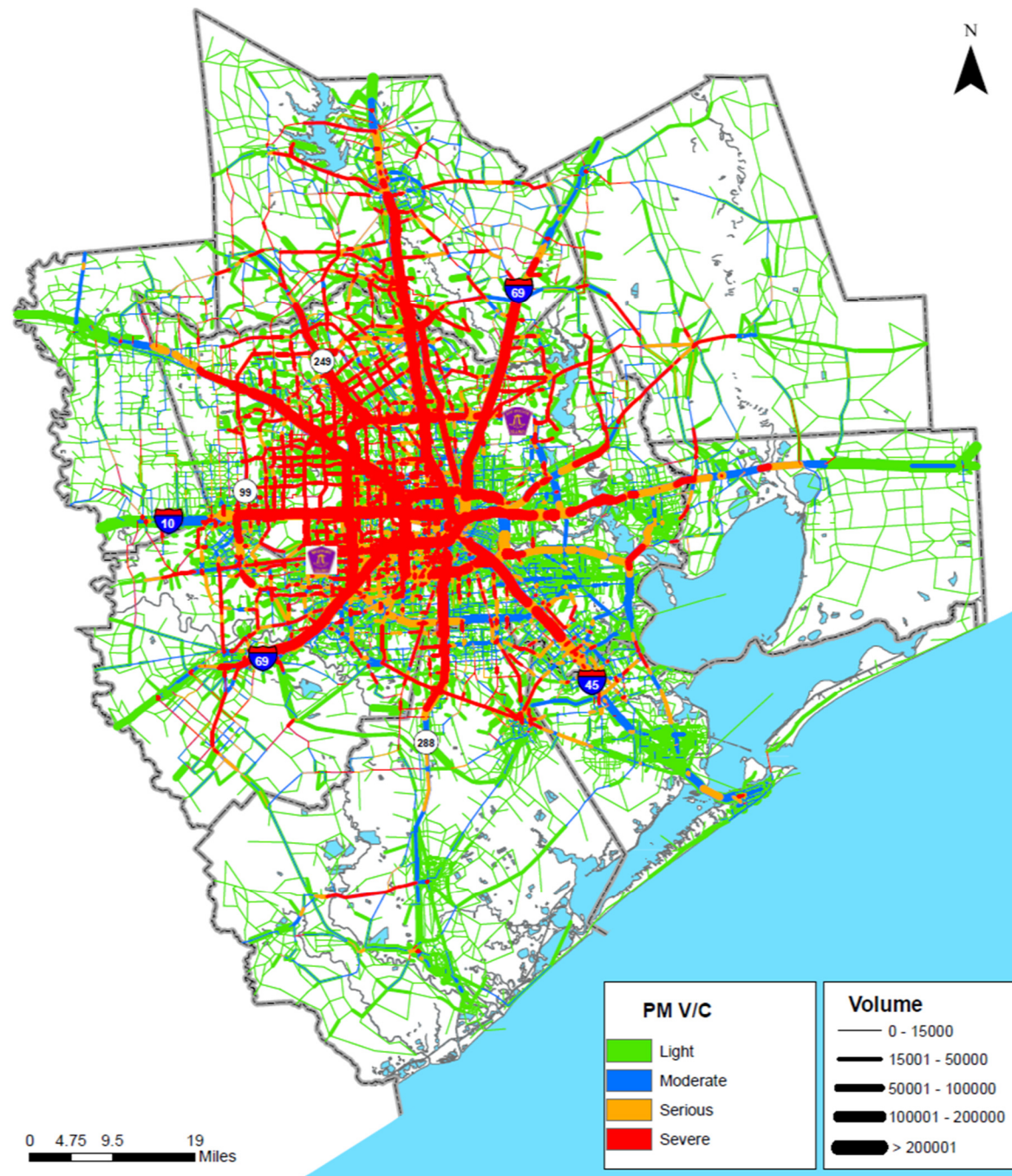


Figure 4-15: 2045 Peak Congestion with Roadway Capacity Improvements only

Chapter 5

RECOMMENDATIONS AND FISCAL CONSTRAINT

A cost-feasible set of prioritized transportation improvements is essential to satisfy the Houston metropolitan region's growing travel demand and to provide a reliable transportation network for all road users. The 2045 RTP was developed to guide transportation investments for the region through the next twenty-five years.

H-GAC incorporates federal performance measures and planning factors into its programming activities by integrating them into the five foundational goals of the Regional Transportation Plan. Based on the performance measures, the 2045 RTP goals provide a context for guiding transportation project development and investments. The five 2045 RTP Goals were developed to:

- Improve Safety
- Achieve and Maintain a State of Good Repair
- Move People and Goods Efficiently
- Strengthen Regional Economic Competitiveness
- Conserve and Protect Natural and Cultural Resources

The primary method for the programming of projects is the "Call for Projects" issued by H-GAC. In order to evaluate transportation projects submitted, the goals from the 2045 RTP were translated into three major strategies:

- ❖ **MANAGE** [System Management and Operations]
- ❖ **MAINTAIN** [Asset Management]
- ❖ **EXPAND** [Multimodal Network Capacity]

These three RTP strategies and the related twenty-one investment categories were developed in consultation with regional partners and utilized to evaluate candidate projects. Evaluation criteria for the investment categories consisted of a safety, delay and emissions benefit cost analysis and an assessment of the planning factors. The criteria were designed to demonstrate linkages to the RTP's goals and strategies. The evaluation criteria and planning factors are detailed in Chapter 2 and are referenced in federal regulations 23 CFR §450.306, 23 CFR §409 and 490, and 49 CFR §625.

Individual projects for capital investments exceeding \$100 million were considered under the Major Investments strategy. These projects enhance regional economic competitiveness by improving the transportation network—especially the region's freight network—through the construction of new roadways and/or the large-scale expansion of existing critical facilities. They improve safety and enhance roadway network efficiency through design and operational improvements, incident management programs, and new or expanded facilities. Additionally, major investment projects were required to support all RTP goals to be eligible for funding.

In addition to purported safety and delay benefits, Major Investment projects were evaluated based on the following planning factors:

- Enhancing or providing intra/inter-regional mobility and/or enhancing or providing direct connections to the freight networks or evacuation routes;
- Improving multimodal levels of service for automobile, transit, bicycle, and pedestrian travel modes;
- Improving transportation resiliency or includes flood mitigation strategies, such as elevating facility above flood level, additional storm water detention, flood warning devices, or other control measures;
- Asset management strategies that will ensure the facility's state of good repair and reduce maintenance and operations costs; and
- Anticipated tangible economic benefits including increased property values, or job creation or retention, etc.

MANAGE [SYSTEM MANAGEMENT AND OPERATIONS]

- ❖ **A strategy to maximize the efficiency and effectiveness of the transportation system through data, technology and policy solutions focused on reliability, continuity and the transparent dissemination of information.**

The Manage strategy focuses on programs and projects aimed at improving system management and enhancing transportation operations. Projects that implement this strategy would, for example, address congestion and safety through the reduction of vehicle crashes, quick and safe removal of stalled vehicles, improved intersection operations, bottleneck removal, and the reduction in regional vehicular travel through increased use of transit and other alternate commute solutions. System management strategies are expected to reduce crash rates by enabling the more efficient use of existing roadway facilities and improving travel reliability. It will increase reliability by utilizing more available facilities through projects such as signal timing and dynamic traffic alerts. Less congestion and more reliable travel will limit the damage to current facilities and extend their useful life.

Access management techniques and safety treatments improve thoroughfare safety and operational efficiency through driveway consolidation, installation raised medians, dedicated turn lanes, roundabouts and innovative intersections, road diet/reconfiguration, associated bicycle and pedestrian accommodations, and improvements to circulation and connectivity between land uses along major thoroughfares among other improvements. Pedestrian safety treatments, such as midblock crossings and First Mile/Last Mile improvements greatly enhance safer access to fixed route transit, bike share and employment. Grade separations substantially reduce motor vehicle crashes by eliminating congestion and conflicting vehicle movement through physical separation of roadway facilities and/or construction of direct connectors.

The deployment or enhancement of intelligent transportation systems (ITS) is another investment category of the Manage strategy. ITS improves transportation network operational efficiency using traveler information systems such as dynamic message signs, warning systems, real-time transit vehicle location and next-bus arrival information, active parking management, and automated ramp/gate operations, signage.

Transit Priority Infrastructure projects improve operational efficiency of transit services within H-GAC's eight-county planning area by implementing a regional fare collection and transit priority infrastructure. The various project types for this investment category include, but are not limited to, transit bus pullouts, queue jump lanes, stop consolidation, transit-related ITS systems, and signage.

Autonomous and Connected Vehicle Infrastructure is another category of projects that are beginning to show promise for improve travel efficiency. The equipment and systems for this technology are constantly evolving as greater knowledge is gained about how this technology can improve public and private travel choices. It is likely that future calls for projects will include proposals to deploy this type of infrastructure in the region. Examples of project recommendations that support the Manage strategy are listed in Table 5-1.

Manage Recommendation Examples	
Roadway	
Improve access management on roadways (Project Listing - FM 2920 Access Management Project)	
Manage congestion through the construction of grade separations (Project Listing - SH 288/Rodeo Palms Pkwy Grade Separation Project)	
Freight	
Develop a Concept of Operations for a Freight ITS Program (Regional Goods Movement Study)	
Improve flow of containers through a virtual container yard to reduce truck trips (Ports Area Mobility study - underway)	
Transit	
Universal Accessibility of safe, barrier-free access to transit services for all users, regardless of ability (High-Capacity Transit Taskforce Report)	
Build Regional Fare Collection System (Regionally Coordinated Transportation Plan)	
Active Transportation	
Collect, analyze, and share data on crashes involving people walking, biking, and rolling (2045 Active Transportation Plan)	
ITS/Operations	
Conduct regional incident management (Tow and Go Program)	
Improve traffic signal operations (Regional ITS Plan)	
Safety	
Conduct safety audits at high frequency intersection crash locations (Regional Safety Plan)	

Table 5-1: Examples of Projects that Support the Manage Strategy

The Congestion Management Process

The Congestion Management Process (CMP) is the systematic process of identifying congestion and its causes, applying congestion mitigation strategies to improve transportation system performance and reliability, and evaluating the effectiveness of the strategies implemented. The goals of the H-GAC CMP are to:

- Reduce the rate and severity of crashes for all system users;
- Improve transportation system reliability across all modes and systems of travel in the region;
- Reduce the impacts of incidents on traffic flow;
- Increase opportunities for travelers to use regional and local transit services and participate in Transportation Demand Management (TDM) programs to provide more travel choices;
- Improve system operational efficiency and accessibility to accommodate freight movement within the region: and
- Reduce emissions through congestion management.

MAINTAIN [ASSET MANAGEMENT]

- ❖ **A strategy to improve and preserve the condition of existing transportation infrastructure at the least practicable cost through the application of sound asset management techniques.**

Maintaining high quality and updated roadways and transportation facilities will ensure the basic safety needs of the traveling public by deploying the most current technology and construction practices. The Maintain strategy includes project types that ensure the existing roadway network is kept in good operational condition. These strategies also ensure that timely maintenance and rehabilitation are performed on critical infrastructure, such as principal arterials, National Highway System roadways, and the First Mile/Last Mile of intermodal connectors. There are three investment categories under the Maintain strategy.

The first, and perhaps most critical category, is rehabilitation and reconstruction of roadway pavements and structures, including bridges, to ensure state of good repair and operational efficiency of the network. Asset management extends the life and ensures the safety of current facilities at a fraction of the cost of constructing new ones. Maintaining the ADA compliance of sidewalks and ramps is critical to both pedestrian network and transit access.

Infrastructure Resiliency addresses the vulnerabilities of highways and regional thoroughfares to extreme weather, sea level change and changes in environmental conditions through the implementation of eligible construction investments. Such projects will elevate or harden roadways on corridors that have required multiple emergency repairs, experience regular inundation, and are critical to evacuation plans. Projects in this category also include construction of roadways that serve as alternate routes for roadways impacts by extreme weather events.

Finally, keeping transit systems in good condition is very important for maintaining a true multimodal transportation network. Accordingly, Transit Facility State of Good Repair is an investment category under the Maintain strategy. These projects seek to improve the safety and operational efficiency of transit services within H-GAC's eight-county planning area by supporting the replacement or overhaul of transit passenger and vehicle maintenance facilities that have exceeded their Useful Life Benchmark, and the construction of

new transit maintenance facilities, consistent with each transit provider's adopted Transit Asset Management Plan and performance targets. Typical projects in this category include vehicle replacement and overhaul; improvements of warning beacons, real time passenger information system, and Electric charging stations; and reconstruction of transit passenger facilities including Park & Ride lots, multi-route transfer locations, bus stops and passenger shelters. For METRO Rail, the asset management of rail track segments, signals and the systems will protect the transportation investments and ensure a State of Good Repair. Examples of project recommendations that support the Maintain strategy are listed in Table 5-2.

Maintain Recommendation Examples	
Roadway	
	Maintain and improve roadways (Project Listing -IH 45/SH 242 Intersection Improvements Project)
	Maintain and improve roadways (Project Listing -SH 105/SH 321 Intersection Improvements Project)
Freight	
	Work with partners to mitigate short-term deficiencies on the freight-significant network (Regional Goods Movement Study)
Transit	
	Store and maintain vehicles of multiple providers at a single operations and maintenance facility with providers sharing the capital cost of a passenger facility at a location where transfers between multiple providers will occur (High-Capacity Transit Taskforce Report)
Active Transportation	
	Maintain and improve the existing network of walkways and bikeways in the region and coordinate regional data collection for active transportation infrastructure (2045 Active Transportation Plan)
ITS/Operations	
	Maintain and coordinate on rural and urban ITS deployments (Regional ITS Plan)
Safety	
	Conduct intersection improvements at high crash locations (Regional Safety Plan)

Table 5-2: Examples of Projects that Support the Maintain Strategy

EXPAND [MULTIMODAL NETWORK CAPACITY]

- ❖ **A strategy designed to add capacity across all modes of travel with a focus on the interconnections between different networks and services that provide users with greater choices.**

The regional demographic and growth trends forecasted in the 2045 RTP clearly show the transportation network will need to grow to accommodate more people and vehicles in the future. The primary purpose of the RTP is to ensure that transportation network growth adequately addresses future needs. The Expand strategy's investment categories address transportation network growth in a multimodal fashion. The categories include expansion of not only roadways, but transit services and facilities as well. This multimodal approach ensures the regional residents have viable choices for their travel needs.

The first investment category under this strategy seeks to improve accessibility and mobility of people and goods on the regional thoroughfare network through the addition of roadway capacity. Network expansion could reduce crashes and improve incident response providing travel alternatives to currently congested facilities. Projects include roadway widenings, new roadway construction, with pedestrian/bicycle/transit accommodations, and drainage improvements related to the roadway. Projects must be consistent with H-GAC's congestion management process.

Innovative Freight Movement is another investment category of the Expand strategy to improve transportation safety and operational efficiency of the regional freight network through the deployment of innovative intermodal freight transfer technologies. Vital to the region's economic competitiveness, heavy cargo movement projects include capital equipment, and the construction and installation costs, and intermodal transfer equipment.

Unlike the Transit Facility State of Good Repair category under the Maintain strategy, the Transit Passenger Facilities investment category seeks to increase transit usage within H-GAC's 8-county planning area by supporting the construction of new or expanded passenger facilities, such as Park & Ride, transfer points, super stops, and transit vehicle purchases. The same types of transit facilities are eligible under this investment category.

Likewise, the Transit Expansion investment category is intended to increase transit usage by supporting the purchase of additional revenue vehicles for transit providers demonstrating ridership growth, as documented in reporting to FTA's National Transit Database (NTD).

The High Capacity Transit Task Force (HCTTF) was created by the Transportation Policy Council in the spring of 2017 charged with investigating the need and opportunity for high capacity transit in the Houston-Galveston region. The Task Force's charge is to: *"Coordinate with regional stakeholders to identify regional benefits, funding solutions and policy considerations to advance High Capacity Transit throughout the region."* As the result of a two-year planning process, the HCTTF Priority Network was created. The services indicated in the HCTTF Priority Network are mode-, technology- and alignment neutral. All recommendations in the HCTTF Priority Network are conceptual and are subject to further analysis and design. Examples of project recommendations that support the Expand strategy are listed in Table 5-3.

Expand Recommendation Examples	
Roadway	
	Expand roadway network to improve capacity and connectivity (Project Listing - State Highway 99 Widening Project)
	Expand roadway network to improve capacity and connectivity (Project Listing - US 90 Grade Separations Project)
Freight	
	Provide access to growing economic centers outside of the urban core (Regional Goods Movement Study)
Transit	
	Expand local bus services in areas indicating high transit need that do not currently have service (High-Capacity Transit Taskforce Report)
Active Transportation	
	Build interconnected networks of walkways and bikeways in Focus Areas and between regional hubs like employment and population centers and tourist destinations (2045 Active Transportation Plan)
ITS/Operations	
	Provide redundancy to the ITS systems and build Regional ITS network (Regional ITS Plan)
Safety	
	Promote design practices to improve safety and reduce speeds on new roadways (Regional Safety Plan)

Table 5-3: Examples of Projects that Support the Expand Strategy

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FISCALLY CONSTRAINED 2045 RTP

Fiscal constraint analysis is performed to exercise caution in planning for the future transportation network. Revenues for future investments are not limitless and proper governance requires a conservative fiscal approach when considering which improvements are necessary and in what timeframe. Federal and state regulations require every RTP be fiscally constrained. H-GAC estimated revenues and expenditures through the year 2045, including federal, state, and local revenue sources.

Estimating Revenue and Expenditure

Reasonably available revenue is estimated by annual financial reports from local agencies, relevant TxDOT data and projections, and trends related to debt financing and regional revenues. Federally, the main source of funding is provided by the Highway Trust Fund—supported primarily by the federal gas tax, currently set at fixed rate of 18.4 cents per gallon of gasoline and diesel fuel sold. At the state level, revenues are derived from the State Highway Fund supported by a fixed-rate tax of 20 cents per gallon, and two voter-approved constitutional amendments—Proposition 1 and Proposition 7. Locally, revenues are estimated based on future capacity of local municipalities, counties, transit agencies, toll road authorities, and other qualified public entities to invest in regional transportation by providing a local match, or share thereof, in sponsorship of the recommended projects and transportation programs presented in the 2045 RTP.

Over the time frame of the 2045 RTP, the total estimated revenues are forecasted to be \$147 billion, as expressed in year of expenditure dollars (Figure 5-1). In terms of transportation investment expenditures, the 2045 RTP recommends \$132 billion in year of expenditure dollars (Figure 5-2). The anticipated revenues are more than is needed to cover the expenditures of the 2045 RTP. Year-of-expenditure dollars are included in Appendix D to conform to more official expectations and certain regulatory requirements.

2045 RTP Revenue by Source
Total: \$147 Billion

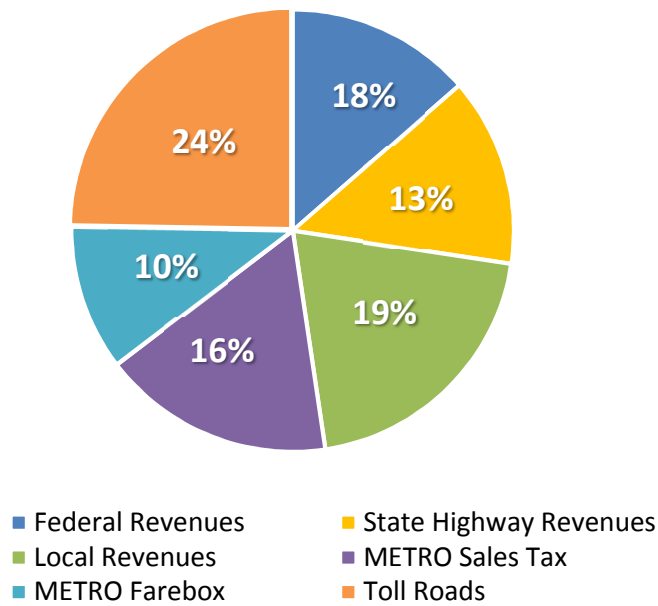


Figure 5-1: Revenue by Source

2045 RTP Expenditures by Strategy
Total: \$132 Billion

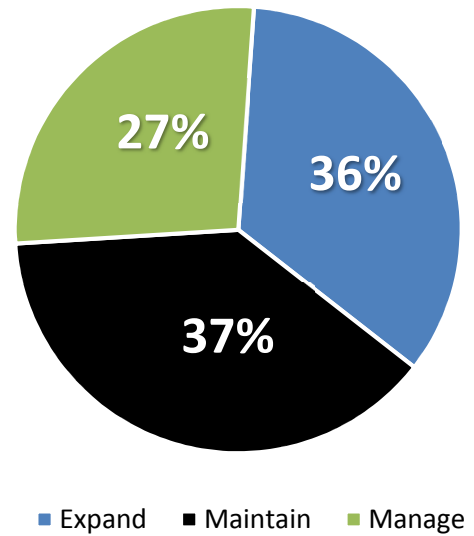


Figure 5-2: Expenditures by Strategy

The 2045 RTP strategies: Maintain, Manage, and Expand recommend an overall total of \$132 billion in transportation investments encompassing more than 950 individual projects and programs. Figure 5-3 shows the major transportation corridors assigned with investments. To summarize the total investments of the 2045 RTP, Table 5-4 identifies the corridor-based major investments and the regional investment programs along with their project descriptions. The summarized costs shown have been estimated on the previous history and total project estimates submitted by project sponsors.

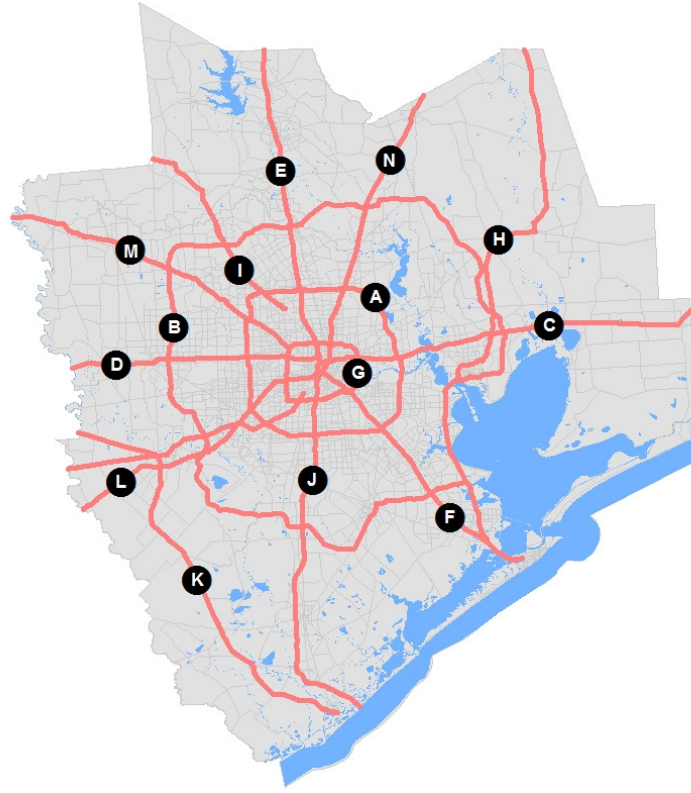


Figure 5-3: Corridor-Based Major Investments

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	STRATEGY 1 MANAGE [System Management and Operations]	STRATEGY 2 MAINTAIN [Asset Management]	STRATEGY 3 EXPAND [Transportation Network Capacity]	TOTAL
CORRIDOR - BASED MAJOR INVESTMENTS				
A. BW 8	\$171,060,455	NA	\$92,210,650	\$263,271,105
B. GPW	\$3,039,631,514	\$17,358,361	\$804,832,838	\$3,861,822,713
C. IH 10E	\$480,448,759	\$17,961,814	NA	\$498,410,573
D. IH 10W	\$350,305,370	\$96,450,000	\$661,472,604	\$1,108,227,974
E. IH 45 North of IH 10	\$425,207,762	NA	NA	\$425,207,762
F. IH 45S	\$93,658,303	\$122,000,000	\$747,950,000	\$963,608,303
G. IH 610	\$297,405,625	\$96,545,811	NA	\$393,951,436
H. SH 146	\$13,915,000	\$15,787,734	\$595,409,960	\$625,112,694
I. SH 249	\$3,295,380	NA	\$290,528,541	\$293,823,921
J. SH 288	\$261,000,000	NA	\$372,371,428	\$633,371,428
K. SH 36	\$17,167,217	NA	\$764,510,618	\$781,677,835
L. SOUTHWEST CORRIDOR	\$110,900,000	NA	\$286,053,077	\$396,953,077
M. US 290	\$3,485,844,309	\$53,100,000	\$707,533,709	\$4,246,478,018
N. US 59N	NA	NA	\$211,765,982	\$211,765,982
REGIONAL INVESTMENT PROGRAMS				
Air Quality Related	\$254,598,000	NA	NA	\$254,598,000
Freight: <i>(Includes roadwork on the Freight Significant Network; freight rail, intermodal terminals, grade separations)</i>	\$376,779,567	NA	\$84,818,432	\$461,597,999
ITS/Safety: <i>(Includes certain roadway improvements, installation of computerized traffic control systems, Incident Management)</i>	\$517,457,158	\$62,269,438	NA	\$579,726,596
Land Use/Transportation Planning: <i>(Includes Subregional Plans)</i>	\$5,900,000	NA	NA	\$5,900,000

Local High Capacity Transit: <i>(Includes non-corridor light rail, park and ride, transit centers, demand management strategies)</i>	\$15,908,231,556	\$99,598,227	\$13,790,549,267	\$29,798,379,050
North Houston Highway Improvement Project <i>(Includes IH 45 N projects between IH 10 and BW 8)</i>	\$267,845,342	\$4,767,316,457	\$3,434,648,479	\$8,469,810,278
Other Major Roadway Improvements: <i>(Non-Corridor improvements on Major Roadways)</i>	\$391,092,183	\$708,236,636	\$2,940,572,454	\$4,039,901,273
Pedestrian/Bicycle: <i>(Includes on-street facilities, hike and bike trails and paths, and reconstructions)</i>	\$130,247,249	\$51,178,297	\$1,626,470,674	\$1,807,896,220
Regional Roadway Expenditures: <i>(Includes administration, and management/operations estimates)</i>	\$6,000,000,000	\$16,706,054,886	\$5,017,941,370	\$27,723,996,256
Thoroughfare Development: <i>(All other roadway improvements)</i>	\$107,920,880	\$746,961,935	\$6,448,737,588	\$7,303,620,403
Transit Capital <i>(Includes all other new or expanded facilities, services, and vehicles)</i>	\$4,272,120,809	\$2,404,429,566	\$7,669,280,587	\$14,345,830,962
Transit Other: <i>(Includes non-capital transit expenditures)</i>	\$22,409,478	\$99,594,550	\$427,352,346	\$549,356,374
Transit O & M: <i>(Includes all Transit Operations and Management expenditures)</i>	NA	\$22,399,862,881	NA	\$22,399,862,881
TOTAL	\$37,004,441,916	\$48,464,706,593	\$46,975,010,604	\$132,444,159,113

Table 5-4: Corridor-Based Major Investments and Regional Investment Programs

Corridor-Based Major Investments

The project listing shows investments based on the region's chief transportation corridors – and amount to approximately \$15 billion in year of expenditure dollars, 11% of the total cost of the 2045 RTP. These improvements will be among the most impactful and costly the region undertakes in the next few decades.

Regional Investment Programs

The remainder of the fiscally constrained 2045 RTP expenditures do not fit into one of the above corridors, and are represented in programs such as ITS, safety, thoroughfare development, suburban connectors, freight, pedestrian/bicycle improvements, transit, local high capacity transit and land use coordination – with descriptions accompanying each program.

Some transit expenditures fall within this category as well, including, the regional vanpool program, ADA accessible and paratransit service; preventative maintenance, facility maintenance, transit centers and Park & Rides, bus and rail systems.

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RECOMMENDATIONS

High Capacity Transit

The construction of new and ever wider highways cannot by itself support the expected growth of the region. Nor will a “highway only” mobility solution serve the travel needs of a geographically, economically, demographically and culturally diverse region. A solution that can move large numbers of people within relatively limited rights-of-way is required.

High Capacity Transit (HCT) is any form of public transportation that can move large volumes of people typically within a dedicated, if not exclusive right of way. It can do this through a combination of larger vehicles, shorter frequencies and higher speeds. HCT capacity transit can be any technology (bus or rail) or alignment (at-grade, elevated or underground), but it generally has an exclusive guideway, such as a rail line, busway, or high-occupancy vehicle lane that is separated from other traffic, thereby allowing it to operate unimpeded by normal traffic congestion. High capacity transit currently exists in the form of METRO’s light rail network, and the suburban park and ride network which uses express buses in High Occupancy Vehicle (HOV) or managed lanes. Another form of HCT, Bus Rapid Transit where buses utilize bus only express lanes both within an existing major thoroughfare and in separate exclusive lanes along the IH 610 freeway.

The High Capacity Transit Task Force report identifies the need and opportunity for HCT in the region. To create a financially-constrained transit network for inclusion in the 2045 RTP, elements of the HCT Vision Network were selected for inclusion in the HCT Priority Network. The services indicated in the Priority Network are mode, technology and alignment neutral. Significant features of the Priority Network include service to all eight counties in the H-GAC transportation planning region with new local, high capacity transit and other express bus services, particularly those that will expand access to “suburban” employment centers.

The High Capacity Transit (HCT) Task Force’s recommendations are to:

- Include the projects from the HCT Priority Network in the 2045 RTP;
- Encourage the concepts and policies that support the increased use of transit, such as a Regional Fare; System, Universal Accessibility and First Mile/Last Mile connections;
- Examine HCT opportunities, set priorities and develop new funding sources; and
- Recommend Phase II of the HCT Task Force effort.

Automated and Connected Vehicles

The region’s transportation system is nearing capacity limits as traffic congestion levels remain high despite billions of dollars of investments in new or expanded highways. To sustain regional mobility, new convenient and accessible options for travel must be developed. Emerging technologies like autonomous and connected vehicles (AV/CV) have great potential to affect and influence the regional transportation system. Additionally, the emergence of private on-demand providers, such as Uber and Lyft, has fostered the development of new technologies and opportunities for the expansion of AV/CV vehicles. The effects of these new technologies are still being investigated.

H-GAC’s Vision for autonomous and connected vehicles is to lead local governments and stakeholders in maximizing the benefits of automated and connected vehicle technology to improve quality of life across our region. H-GAC supports its partners in planning for sustainable integration of Connected and Automated Vehicles

that move people and goods with greater safety, reliability and efficiency. Benefits will be achieved through the following action steps:

- Develop an integrated multimodal transit system with focus on first-last mile connections which makes maximum application of Connected and Automated Vehicle technology, especially with combination of Connected and Automated Vehicle Microtransit connecting to Connected and Automated Vehicle high capacity transit, thereby expanding traveling mode choice options;
- Educate public officials and the public about Connected and Automated Vehicle deployment benefits;
- Develop and promote a strategic plan by engaging public and private partners;
- Identify opportunities to leverage investment in existing services and infrastructure for early deployment of Connected and Automated Vehicles;
- Identify public/private opportunities to reduce operating costs for all transportation modes, particularly those delivering freight and demand-response transit; and
- Seek public/private partnerships which open new economic development opportunities along or near Connected and Automated Vehicle routes.

Active Transportation

The Active Transportation vision is “Pedestrians and bicyclists of all ages and abilities can travel conveniently and comfortably in all communities using connected and well-maintained networks of walkways and bikeways.”

Recommendations from the Active Transportation Plan are to:

- Achieve the vision for our regional active transportation network, we developed a set of strategies for each of the five recommendations;
- Improve safety for people walking, biking, and rolling;
- Ensure that all people – regardless of age, ability, or location within the region – have access to walkways and bikeways that are safe, convenient and comfortable;
- Build interconnected networks of walkways and bikeways in Focus Areas and between regional hubs like employment and population centers and tourist destinations;
- Maintain and improve the existing network of walkways and bikeways in the region and coordinate regional data collection for active transportation infrastructure; and
- Encourage and incentivize the use of walkways and bikeways to mitigate congestion, improve air quality, and increase physical activity.

Freight

The Houston-Galveston region is served by an intermodal network of road, rail, water, air, and pipeline facilities. Ports are major generators of freight, thus requiring a reliable roadway and rail network with capacity to handle this traffic. The growing economy, population, and freight capacity of the region’s ports will only increase the demand placed on the regional transportation network.

Recommendations to address the freight needs of the region include:

- Collaborate with regional partners to mitigate short-term deficiencies on the freight-significant network;
- Develop a concept of operations for a freight ITS program;
- Improve flow of containers through a virtual container yard to reduce truck trips; and
- Provide access to growing economic centers outside the urban core.

Resiliency

According to the FHWA’s definition, “Resilience” is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.” Due to its low-lying coastal geography and semi-tropical climate, the Houston-Galveston region is vulnerable to extreme weather events like heat, drought, tropical storms, and flooding. The risk of these extreme events impacting the region’s population, economy, and transportation infrastructure is expected to worsen because of the amplification of related stressors – land use changes, population growth, congested transportation systems, and climate change

The 2045 RTP’s recommendations to focus on resiliency include:

- Conduct a Transportation Vulnerability Assessment Study
 - Form a transportation resiliency working group to develop a multi-year strategy
 - Contribute to Texas Resiliency and Planning workshops
 - Participate in the Cedar Bayou Initiative

Air Quality

Current State of Regional Air Quality

The U.S. Environmental Protection Agency (EPA) has established national air quality standards for several pollutants known to have negative effects on human health and the environment. Under these rules, the region does not meet the federal standard for ground-level ozone. Ground level ozone is produced through a photochemical reaction between nitrogen oxides (NOx) and volatile organic compounds (VOCs). Over half of the NOx produced in the region is emitted by mobile source vehicles and equipment.

For decades, H-GAC and regional stakeholders have worked to develop projects to improve regional air quality, resulting in significant reductions of ozone. Current efforts to reduce regional ozone concentrations focus on cutting the NOx emissions at their source, applying two broad strategies: (1) replacing or retrofitting older vehicles and engines; and (2) reducing the vehicle miles traveled within the region by expanding commute alternatives. It’s imperative that H-GAC continue to fund these programs for the foreseeable future and continue to reach for new ways to reduce emissions and improve air quality for the health of all of our region’s residents.

Recommended Air Quality programs include:

- **Vehicle Retrofit and Replacement Programs**
H-GAC developed several voluntary programs aimed at reducing emissions by retrofitting and replacing high-emitting heavy-duty diesel vehicles or engines with newer or alternative fueled models. These programs work to improve the region’s air quality while helping local governments, businesses, and school districts save money through improved fuel economy and lower

maintenance costs. These programs include the Clean Vehicles Program, Regional Heavy-Duty Vehicle Project, the Drayage Truck Project and the Clean School Bus Program. <http://www.h-gac.com/clean-vehicles/default.aspx>.

- **Commute Alternatives**

To reduce traffic and improve air quality in the Houston-Galveston region, H-GAC continually promotes travel alternatives through the Commute Solutions program. Alternatives to driving alone such as carpooling, transit, walking, biking, teleworking, and working a compressed workweek not only improves the air, but also makes the region more livable, accessible, and economically competitive. <http://www.h-gac.com/commute-solutions/default.aspx>.

Commuter and Transit Services Pilot Program

While our region has an extensive transit network that serves millions of riders annually, many transit service gaps still exist in areas where services are needed and are potentially feasible, but not tested. H-GAC uses the Commuter and Transit Services Pilot Program to support the development of new transit services within the region.

- **Houston-Galveston Clean Cities Coalition**

Networking efforts by this coalition work to connect regional stakeholders and businesses with manufacturers of alternative fuels and refueling sources and to provide information about funding availability, case studies and success stories to assist fleets better understand the benefits of alternative fuels. <http://www.h-gac.com/clean-cities/default.aspx>

Environmental Justice

Effective and equitable transportation decision-making depends on understanding and properly addressing the unique needs of all residents from different socio-economic groups – including the traditionally underserved. Environmental justice is defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Established as federal policy in 1994 through Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” the law is administered under the non-discrimination umbrella of Title VI of the Civil Rights Act of 1964.

To be the focal issue it is intended to be, environmental justice principles must permeate the transportation planning process and be embraced as an issue of regional interest. The strategies that follow are offered as possible approaches to elevate and advance the federal environmental justice and non-discrimination directives more purposefully in the transportation programs.

The recommendations for Environmental Justice include:

- Increase environmental justice awareness within the transportation management area.
- Enhance sensitivity to Title VI and environmental justice in transportation investment decisions.
- Support local efforts to improve transportation service in the underserved communities.
- Improve safety in the environmental justice communities.
- Increase public involvement by the underserved population.

Chapter 6

TRANSPORTATION CONFORMITY

The U.S. EPA has established health-based standards for six criteria pollutants – referred to as the National Ambient Air Quality Standards (NAAQS). The Houston-Galveston-Brazoria (HGB) region does not meet the standard for ground level Ozone. The Clean Air Act requires the Houston-Galveston-Brazoria region to demonstrate that transportation projects contained in the TIP and the RTP conform to the Motor Vehicle Emission Budget (MVEBs) established in the air quality State Implementation Plan (SIP). This process is called transportation air quality conformity (conformity).

Conformity is the way to ensure that federal funding and approval is only given to those projects and activities that are consistent with air quality goals. Under the Clean Air Act, proposed transportation projects and air quality modeling must be coordinated to ensure the TIP and RTP are consistent with or conform to the targets set by the SIP. This integration of transportation planning and air quality review is designed to ensure that transportation plans, programs, and projects do not aggravate an existing NAAQS violation, cause a new violation, or delay the attainment of designated regional milestones.

MILESTONES AND BACKGROUND

On April 20, 2018, the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) certified that the amendments to the Houston-Brazoria-Galveston region's *2040 Regional Transportation Plan) Update* and the *2017-2020 Transportation Improvement Program* met all the requirements for a joint conformity determination to the SIP for the Houston-Galveston-Brazoria (HGB) ozone nonattainment area.

This new conformity determination is being prepared to support the new 2045 Regional Transportation Plan (RTP) and amendments to the 2019-2022 Transportation Improvement Program (TIP). Major elements of the amendments include:

- Adjustment to the scope, schedule, and funding of projects;
- Addition of TxDOT projects that are undergoing environmental review and project development activities.
- New development of SH 35 from Bellfort to Downtown
- Bus Rapid Transit through IH 10

In accordance with 23 CFR§450.324, all projects are constrained by the financial resources estimated to be reasonably available within the RTP timeframe. A complete listing of the projects in the RTP and TIP that affect this conformity analysis will be included in Appendix 3 of the conformity report.

This conformity will comply with the non-attainment designation for the 2015 8-hr Ozone Standard (effective date August 3, 2018) with "marginal" classification. Under the Clean Air Act, the conformity demonstration is required within one year of designation to avoid a conformity lapse. In addition, this conformity complies with the 2008 8-hr Ozone NAAQS.

This conformity will demonstrate compliance to the latest emission budgets based on the latest revision to the air quality State Implementation Plan for the 2008 8-hr Ozone Standard due to the reclassification from “marginal” to “moderate” with attainment year 2017. The Reasonable Further Progress (RFP) SIP budget was found adequate by the Environmental Protection Agency (EPA) on June 6, 2017 with an effective date of June 21, 2017.

The February 16, 2018 court decision on South Coast Air Quality Management District versus EPA does not affect transportation conformity requirements for the 2015 ozone NAAQS.¹

CONFORMITY REQUIREMENTS

H-GAC demonstrates transportation conformity by using a modeling network to estimate the motor vehicle emissions from all of the regionally significant, nonexempt projects in the TIP and RTP, and comparing those emissions against the motor vehicle emission budgets established by the state air quality plan. Conformity analysis is a robust procedure that consists of:

- The latest planning assumptions;
- Analysis based on the latest emission estimation model available;
- Interagency consultation, and a public involvement process;
- Timely implementation of Transportation Control Measures (TCMs);
- An RTP and TIP that are consistent with the MVEBs established in the applicable SIP; and
- All regionally significant projects expected in the nonattainment and maintenance are in the RTP and TIP.

REGIONAL INVENTORY

This conformity analysis developed an air quality regional inventory of the HGB nonattainment area. It accounts for emissions resulting from the nonattainment area’s transportation plans, including all regionally significant projects and the effects of emission control programs, such as the inspection and maintenance programs.

MOTOR VEHICLE EMISSION BUDGETS

Table 6-1 describes the budgets established in the RFP SIP.

RFP MVEB

RFP Demonstration Budgets (t/d)		
Year	NO _x	VOC
2017	121.81	68.04

Table 6-1: RFP Demonstration Budgets

Source: RFP SIP, TCEQ, effective June 21, 2017

EMISSIONS TESTS

As specified by the Code of Federal Regulations (40 CFR 93.109[c], as amended by 62 CFR 43807, Aug. 15, 1997) all ozone nonattainment areas designated moderate and above must pass a MVEB test if an approved SIP budget exists. The HGB region has been re-classified as “moderate” for the 2008 8-hr Ozone Standard, with an attainment year of 2017. The RFP SIP budget was found adequate by the EPA on June 6, 2017 with an effective date of June 21, 2017. In addition, the HGB region has been re-classified as “marginal” for the 2015 8-hr Ozone Standard.

Since the “marginal” classification, the HGB region did not get new MVEBs, and therefore, according with the conformity rule, must use previous ones established in the SIP for the 2008 Eight-Hour. In this case, the budget test must be satisfied using the MVEBs established in the RFP SIP mentioned above. Specifically, this test is satisfied when ozone precursor (VOC and NO_x) emissions for each analysis year are less than or equal to the MVEBs established in the SIP. For the test, the regional emission analysis should be performed for any years selected according to the conformity rule. Table 6-2 shows the results of this conformity analysis.

CONFORMITY ANALYSIS RESULTS

Year	NO _x Emissions (tpd)	NO _x Budget (tpd)	VOC Emissions (tpd)	VOC Budget (tpd)	VMT
2020	79.62	121.81	45.92	68.04	186,102,566
2030	34.20	121.81	22.66	68.04	227,527,778
2040	43.09	121.81	22.87	68.04	261,487,989
2045	47.43	121.81	23.89	68.04	284,677,064

Table 6-2: VOC and NO_x emissions for Conformity Analysis Years

The results of this conformity determination demonstrate that the 2045 RTP and the 2019-2022 TIP for the HGB TMA meet the requirements of the air quality SIPs for the HGB ozone nonattainment area and are in accordance with the Clean Air Act (42 U.S.C. 7504, 7506 (c) and (d)), as amended on November 15, 1990, and the final conformity rule (40 CFR Parts 51 and 93). See Figure 6-1 and Figure 6-2.

This conformity determination involved a pre-analysis review discussion with the review agencies, and a public comment period.

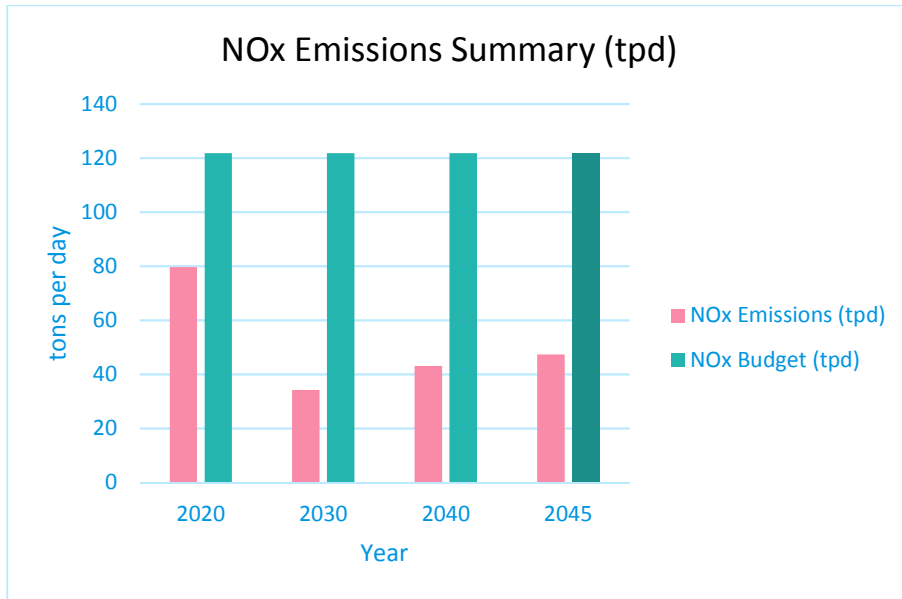


Figure 6-1: NOx Emissions Summary

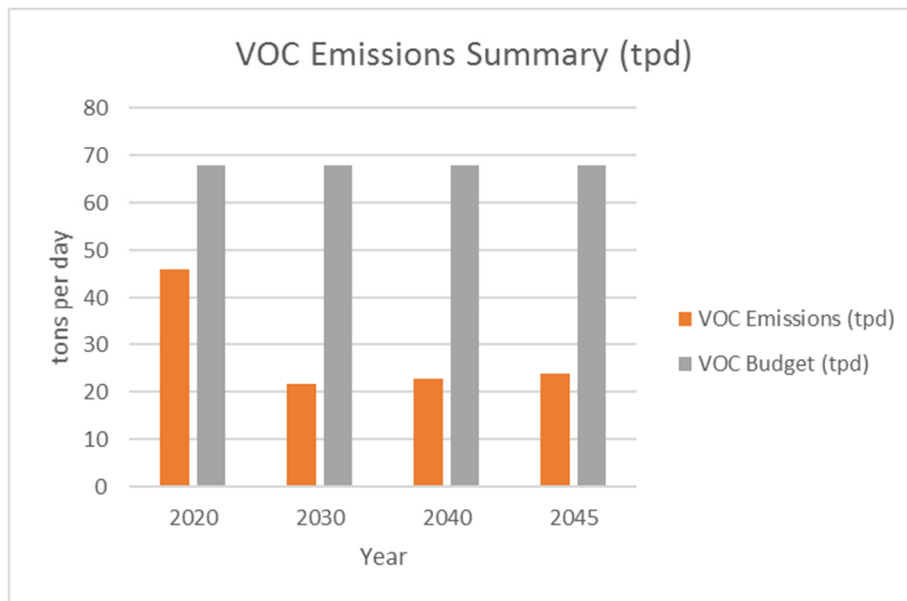


Figure 6-2: VOC Emissions Summary

Chapter 7

PUBLIC INVOLVEMENT

The quality and effectiveness of transportation decision-making often depends on how well the different needs and perspectives of the residents are understood and addressed. Public involvement consequently plays a crucial role in the preparation of any transportation plan. Guided by the Public Participation Plan (PPP), H-GAC implemented a broad-based public outreach program in the development of the 2045 RTP.

PUBLIC PARTICIPATION PLAN

H-GAC's Public Participation Plan defines the MPO's responsibilities, goals, and strategies for engaging the public in transportation planning activities. The plan prescribes an open process that encourages regional stakeholders and the general public to provide comments and other relevant input before key planning decisions are made.

H-GAC's public participation plan was updated in 2017 to meet several new requirements specified in the FAST Act.¹ In compliance with the federal regulations, several new stakeholders were added to the list of interested parties that must be included in the transportation planning process. The new target groups include representatives of public ports, freight shippers, private providers of transportation services, employer-based commuting programs, convention and visitors' bureaus, and tourism information services. These stakeholder groups were engaged in the planning decision-making through the public meeting and comment process. The updated public participation plan can be viewed at: https://www.h-gac.com/transportation-public-outreach/documents/2017_Public_Participation_Plan_FINAL9.25.17.pdf.

The public participation plan provides specific guidelines for the 2045 RTP consultation process:

- Provide adequate and timely notice about outreach events and opportunities for the public to review and comment on key decisions;
- Provide the public, stakeholders, and policy makers with reasonable access to information about pertinent transportation issues;
- Employ effective visual techniques to aid the public's understanding of technical transportation issues;
- Make meeting notices and project information available in electronically accessible formats;
- Hold public meetings at accessible locations and during hours convenient for the target communities;
- Provide a variety of opportunities to comment on the RTP, including in person as well as electronic means;

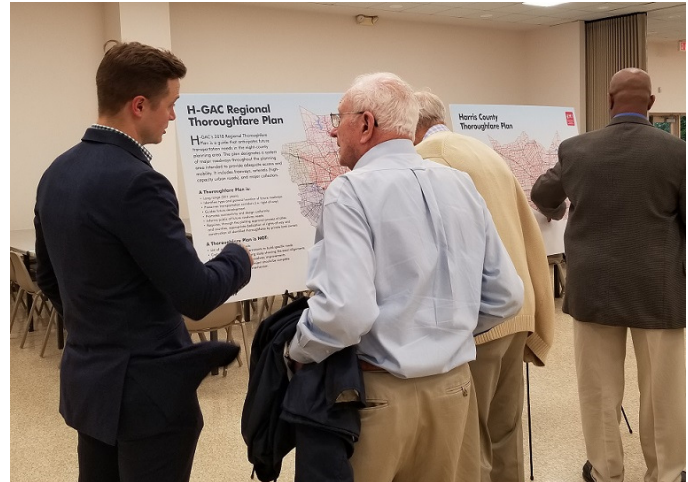
¹ Ref: 23 CFR 450.316(a).

- Demonstrate explicit responsiveness to public input received during the outreach process;
- Proactively seek out and consider the needs of the traditionally underserved population and make reasonable accommodations for persons with limited English language communication skills; and
- Periodically review the effectiveness of the plan in creating opportunities for meaningful involvement for all communities.

PUBLIC OUTREACH STRATEGIES

H-GAC hosted more than 20 public meetings and open house events for the 2045 RTP and the 2018 “Call for Projects.” At least one meeting was held in each of the eight counties that make up the metropolitan planning area.

Overall, more than 400 individuals and stakeholder representatives attended the public meetings, several of whom participated virtually, through a dedicated livestream. Staff utilized graphic boards and PowerPoint slides to illustrate their presentations. An opportunity was provided for meeting participants to ask questions, and meeting participants were invited to leave comments. A list of the public meetings with their venues and scheduled times is presented in Table 7-1.



The MPO maintains several databases of individuals and stakeholder groups who receive notices about scheduled public meetings and other opportunities to provide comments on transportation planning issues. In developing the 2045 RTP, H-GAC collaborated with elected and appointed officials, business and chambers of commerce institutions, representatives of public transportation, non-profit agencies, community organizations, public agencies, public ports, the freight industry, private transportation providers, commuter programs, active transportation, environmental justice, LEP advocates, tourist organizations, media representatives, and other interested parties.

As innovations in communication technology revolutionize the ways people obtain news and share information, the MPO has adapted its public involvement procedures to include modern communication preferences. The 2045 RTP meeting invitations and informative fact sheets were published by email blasts, digital and social media advertising, social media postings, U.S. postal service, direct mail marketing, utility bill inserts, digital newsletters, video, dynamic message signs, newspapers, radio and television announcements, and through the agency website.

Date	Location	County Represented	Number of Attendees
March 15, 2018	Dawson High School	Brazoria	43
March 21., 2018	Prairie View A&M University*	Waller	16
March 22., 2018	Alief Community Center*	Harris	14
March 28., 2018	Sugarland City Hall	Fort Bend	30
March 29., 2018	Kashmere Gardens Multi-Service Center*	Harris	17
April 4, 2018	Oscar Johnson Jr. Community Center	Montgomery	19
April 5, 2018	Leon Z. Grayson Community Center*	Harris	8
April 11, 2018	Cleveland High School	Liberty	15
April 12, 2018	Eagle Pointe Recreation Center – Magnolia Room	Chambers	8
April 19, 2018	Houston METRO	Harris	20
April 24, 2018	Helen Hall Library	Galveston	25
April 26, 2018	Houston-Galveston Area Council	Harris	22
May 1, 2018	Baytown Community center	Harris	10
January 24, 2019	Friendswood City Hall	Galveston/Harris/Brazoria	32
January 29, 2019	Liberty City Hall	Liberty/Chambers	39
February 5, 2019	Kingdom City Houston	Harris/Fort Bend/Waller	15
February 7, 2019	Tomball City Hall	Harris/Waller/Montgomery	27
February 12, 2019	Houston-Galveston Area Council	Region/(Livestream)	31/(75)

Table 7-1: Schedule of Public Meetings for the 2045 RTP Update

* Indicates location is in an underserved community


[Calendar](#)
[Resources](#)
[Blog](#)
[About](#)
[Engage](#)

Your Comments Are Needed

By 2045, the Houston Galveston region will be home to nearly 11 million people.

How will we manage traffic congestion and improve safety?

2045RTP
REGIONAL TRANSPORTATION PLAN

[Click Here To Add Your Comments](#)

The 2045 RTP for the Houston-Galveston area is a guiding document that sets multimodal transportation investment priorities for the region to improve safety, mobility, state of good repair, economic competitiveness and quality of life.

H-GAC has created an [FAQ](#) page to help you understand what H-GAC and the 2045 RTP is:

What Is The Houston-Galveston Area Council (H-GAC)?

ENVIRONMENTAL JUSTICE

Environmental justice policy requires the MPO to verify that low-income and minority communities are not disproportionately impacted by government activities. The MPO is also enjoined to ensure that these traditionally underserved communities receive transportation investments just like other communities in the region, and that they are offered opportunities for “full and fair” participation in the transportation decision-making process.²

A variety of strategies were used to encourage participation by the traditionally underserved population. An environmental justice community outreach database was created to facilitate targeted messaging to community advocates, non-profit organizations, elected officials, faith-based organizations, neighborhood associations, housing advocates, community development organizations, special interest groups, private transportation providers, and individuals with demonstrated interest in the environmental justice

FAST ACT COMPLIANCE

H-GAC’s public participation plan was updated in 2017 to add new stakeholder groups to the list of interested parties for public engagement. These include representatives of public ports, freight interests, private providers of transportation services, employer-based commuting programs, convention and visitors’ bureaus, and tourist information services.

communities. Because community partnerships have been found to be a particularly successful strategy for boosting participation in the minority and immigrant communities, H-GAC partnered with local elected officials and community leaders to circulate information about public meetings and opportunities for citizen involvement.

Several of the 2045 RTP Update public meeting events were scheduled for venues within communities identified as

sensitive for environmental justice, to facilitate participation by area residents (See Table 7-1). Lastly, MPO outreach staff attended the organized neighborhood association and civic group meetings in the underserved communities and gave presentations on the 2045 RTP as part of the meeting agenda.

LIMITED ENGLISH PROFICIENCY

The H-GAC Public Participation Plan institutes a language assistance program for persons with limited proficiency in the English language or who are unable to communicate effectively due to disability. American sign language interpreters as well as Spanish, Chinese, Vietnamese, and Hindi translators were available for certain public meetings, to ensure that language isolation was not a barrier to effective participation by the public.

H-GAC’s language assistance strategy also includes translating vital documents and outreach materials in the non-English languages with the largest population of native speakers. Legal notices and public service announcements about the 2045 RTP were placed in the different native languages in the local community newspapers and on the community radio and television stations. Comments cards were also produced in English and in Spanish – the two languages most prominently spoken in the region.

² FHWA Environmental Justice Order 6640.23A.

PUBLIC COMMENTS

More than 1,200 comments were received verbally or provided on comment cards distributed at the 2045 RTP public meetings and open house events. Comments were also received electronically via email, by telephone, via the 2045 RTP website, and by U.S. postal service. The feedback on the transportation challenges and priorities help to identify community needs and define preferences for the transportation plan. The top ten citizen priority areas derived from the 2045 RTP comments are shown in Figure 7-1. A collection of the public comments received for the 2045 RTP and the Call for projects is available in Appendix O.

TOP TRANSPORTATION PRIORITIES

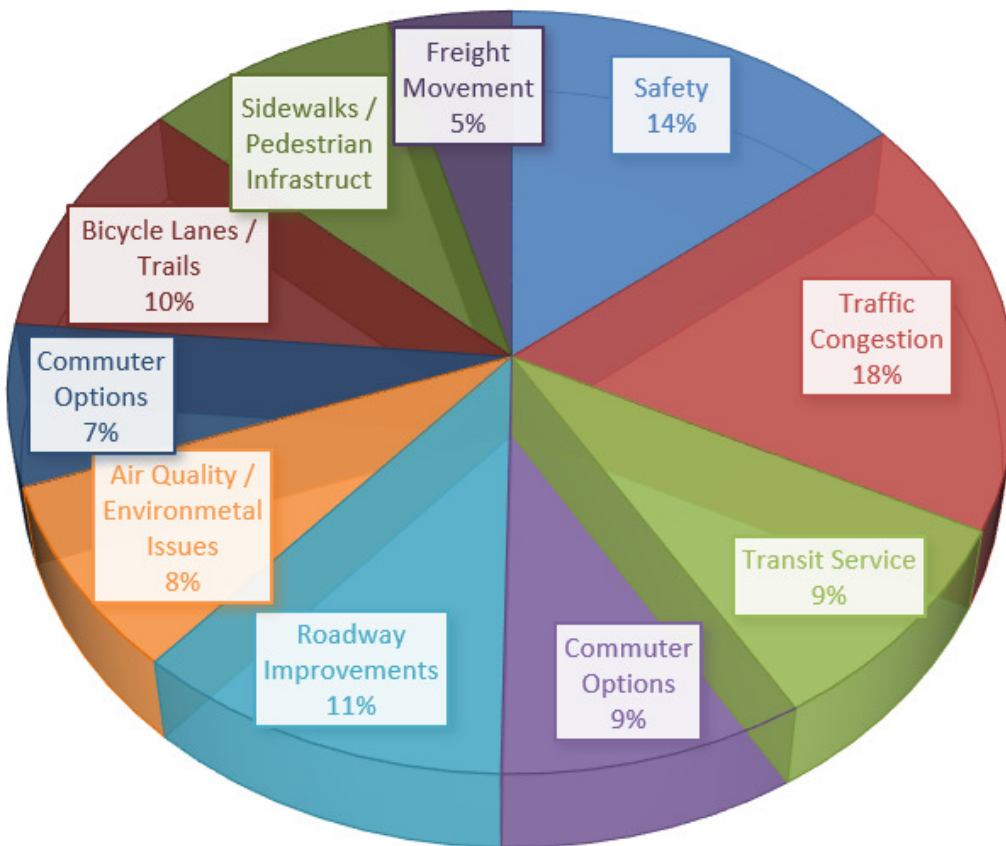


Figure 7-1: Citizen's Top Ten Transportation Priority Areas