Impacts of Climate Change and Variability on Transportation Systems and Infrastructure
The Gulf Coast Study

While confidence in global climate change projections has increased steadily over recent years, investigations into the potential impacts of projected changes on a regional scale have been scarce. The exact risks that climate change poses to transportation systems are not yet well known. Because key transportation infrastructure components—such as rail lines, major highways, bridges, and ports—are expected to provide service for up to 50 or 100 years, it is important to consider any factors that could affect the future operation, maintenance, and lifespan of this infrastructure.

To better understand climate change impacts on transportation infrastructure and identify potential adaptation strategies, the U.S. Department of Transportation (U.S. DOT) is conducting a comprehensive, multi-phase study of climate change impacts in the Central Gulf Coast region. This region is home to a complex multimodal network of transportation infrastructure and several large population centers, and it plays a critical economic role in the import and export of oil and gas, agricultural products, and other goods. The study, sponsored by the U.S. DOT’s Center for Climate Change and Environmental Forecasting, is managed by FHWA.

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The Gulf Coast Study: Two Phases
The Gulf Coast Study includes two distinct phases. Phase 1 (completed in 2008) examined the impacts of climate change on transportation infrastructure at a regional scale. Phase 2 (ongoing, with expected completion in 2013) is focusing on a smaller region, enhancing regional decision makers’ ability to understand potential impacts on specific critical components of infrastructure and to evaluate adaptation options.

**Phase 1**
U.S. DOT partnered with the United States Geological Survey and the U.S. Climate Change Science Program (CCSP) to investigate potential climate change risks and impacts on coastal ports, along with road, air, rail, and public transit systems in the central Gulf Coast, with a study area stretching from Houston/Galveston, Texas, to Mobile, Alabama. The study assessed likely changes in temperature and precipitation patterns, sea level rise, and increasing severity and frequency of tropical storms. Phase 1 then explored how these changes could impact transportation systems.

**Phase 2**
Currently underway, Phase 2 narrows the focus to the Mobile, Alabama, region. In Mobile, U.S. DOT is assessing the vulnerability of the most critical transportation assets to climate change impacts. U.S. DOT will then develop risk management tools to help transportation system planners, owners, and operators determine which systems and assets to protect and how to do so. The methods and tools developed under Phase 2 are intended to be replicable to other regions throughout the country.

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Phase 1

Purpose

The first phase addressed four main objectives: (1) to gather data necessary for analyzing the potential impacts of climate change on transportation infrastructure; (2) to determine the usefulness of climate projections in assessing the vulnerability of infrastructure in the region; (3) to identify and implement an assessment approach; and (4) to then develop an overview of the potential impacts on infrastructure. The Phase 1 study used historical data on weather events, recent climate data, and projected changes in climate for the coming century.

Study Area

The Gulf Coast transportation network is uniquely susceptible to the effects of climate change. Much of the region is low-lying and already frequently affected by flooding and tropical storms. It is also home to key transportation assets that serve vital roles for the national economy and energy supply, for local residents, and as storm evacuation routes. The Phase 1 study area includes 17,000 miles of major highways and the largest concentration of freight ports in the United States, handling around 40% of the country’s waterborne shipments. Two-thirds of U.S. oil imports are transported through this region.

Figure 1: Phase I Study Area

Source: U.S. Census Bureau; ESRI, Inc.; National Transportation Safety Bureau, all via the U.S. Climate Change Science Program (2008), Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I.
Key Findings

Some of the climate changes and related transportation impacts projected for the region over the 21st century include:

- Relative sea levels could rise by 1 to 6 feet, major coastal storms could increase in intensity, and the intensity of precipitation events is likely to increase. A 4-foot increase in sea levels could affect a quarter of interstates and arterials and nearly 75 percent of port facilities.
- Average temperature could increase 2° to 4°F by 2050. The numbers of days with high temperatures above 90°F and 100°F are both projected to increase, which could lead to higher construction and maintenance costs, increased use of energy for refrigerated storage, and other impacts.

Figure 2: Hurricane Damage to Highway 90 in Bay St Louis, MS


Sea-Level Rise: A Particular Threat

Much of the low-lying area in the Phase 1 study region is experiencing subsidence of land due to dewatering of loosely deposited sediments. When combined with the effect of global sea level rise (SLR), the region could experience a relative SLR (RSLR) of at least one foot, with some areas experiencing as much as six to seven feet of RSLR by the end of the century. With a RSLR of two to four feet, much of the study area could be affected.

Implications for Transportation Systems

The implications of projected changes in climate for regional transportation systems are significant. Increasing temperatures are likely to require modifications to materials and maintenance. At temperatures higher than 90°F, highways, bridges, and rail lines deteriorate more quickly than at lower temperatures. In addition to long-term wear and tear on concrete and steel, intense heat events can cause damage (such as buckling) that requires immediate attention.

Expected Inundation with Four Feet of Sea Level Rise

- 27% of the Gulf Coast region’s major highways
- 9% of rail lines
- 72% of ports

Increased severity of precipitation events could exacerbate incidents of flash flooding, threatening the stability of soils and foundational materials. Relative sea level rise (the combined effects of land subsidence and absolute sea level rise) could permanently inundate some existing infrastructure. Finally, an increase in the severity of tropical storms could have significant impacts on coastal infrastructure. Approximately 64 percent of interstate highways, almost half of rail miles, and virtually all coastal ports are vulnerable to storm surges of 23 feet. Damages due to combined storm surge and wave action, as well as winds and flying debris, can be catastrophic, as has been seen with previous hurricanes (see Figure 2).
Phase 2

Purpose
While Phase 1 took a broad look at the entire Central Gulf Coast region and provided a “big picture” view of the climate-related challenges facing infrastructure, Phase 2 is focusing on the single Metropolitan Planning Organization (MPO) region of Mobile, Alabama. The purpose of this focused study is to evaluate which transportation infrastructure components are most critical to economic and societal function, and assess the vulnerability of these components to weather events and long-term changes in climate. Phase 2 will also develop tools and approaches that the South Alabama Regional Planning Commission (which includes the MPO for the Mobile area) and other public and private system operators can use to determine which systems most need to be protected, and how best to adapt infrastructure to the potential impacts of climate change. Through this study, U.S. DOT intends to create a template for an assessment process that can be replicated in other regions of the country.

Primary Phase 2 Activities
• Identify critical transportation assets in Mobile County
• Evaluate projected climate change effects (changes in temperature, precipitation, storm surge, and sea level rise) for Mobile County
• Investigate relationships between changes in climate and impacts to infrastructure
• Combine information on critical assets with information on climate to assess vulnerability
• Conduct detailed engineering/risk assessments for the most vulnerable assets and identify costs/benefits of adaptation strategies
• Use lessons learned through the work in Mobile to develop generic screening tools and approaches that could be employed by other regions to identify which transportation systems need to be protected, and how to protect/adapt those systems

For More Information
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Figure 3: Gulf Coast Phase 2 Study Area with Major Highways and Urban Clusters

**Why Study Mobile, Alabama?**
- Many transportation modes are well represented, including highways, transit, ports, rail, aviation, and pipelines.
- Engaged stakeholders
- Critical port location for the entire United States (import and export of industrial, commercial, and agricultural products, oil and gas)
- Large variety and quantity of available data

Figure 3: The study area includes all of Mobile County including Dauphin Island, as well as touch-down points in Baldwin County for key infrastructure that crosses Mobile Bay

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