Chapter 2
Needs Identification and Validation Process

2.0 Strategy

Early in the WIST needs assessment, a decision was made to include a broad spectrum of surface transportation sectors. Each sector was to be treated equally with respect to its information needs. The initial sectors selected for assessment were roadways, railways, the Marine Transportation System (MTS), and pipeline systems. Sectors for transit (metropolitan/regional transit systems) and airport ground operations were added as the sampling process evolved.

The process began by creating a model for identifying weather information that might be needed or useful in operating surface transportation systems in these sectors. The model included identification of mission statements, weather factors, time scales, weather information providers, and information delivery methods. The Joint Action Group for Weather Information for Surface Transportation (JAG/WIST) coordinated the federal initiative. Individual members of the JAG/WIST coordinated their agencies' responses and provided guidance for subsequent steps in the needs assessment.

Identification of WIST needs began with broad characterizations of transportation sectors, without attempting to capture the nuances and variations within these sectors. The starting objective was to identify as many weather characteristics as possible that affect surface transportation. Then, as the needs identification process passed through successive iterations, subsectors were identified and refined with respect to substantive differences in their weather-related impacts or potential actions in response to weather information. These subsectors were eventually termed "activities" within a sector, and the term "activity" is used in Chapter 4 and in the WIST needs templates. The rationale for delineating an activity within a sector was either the uniqueness of the activity's needs and requirements or differences in institutional operations among activities within a sector.

2.1 First WIST Symposium

The goal of the first WIST Symposium, held in December 1999, was to establish national needs and requirements for weather information associated with decision-making actions involving surface transportation (OFCM 2000). This goal was consistent with a major theme of the historic *Transportation Equity Act for the Twenty-First Century*. Former Secretary of Transportation Rodney E. Slater, in his summary message describing this important legislation, stated that

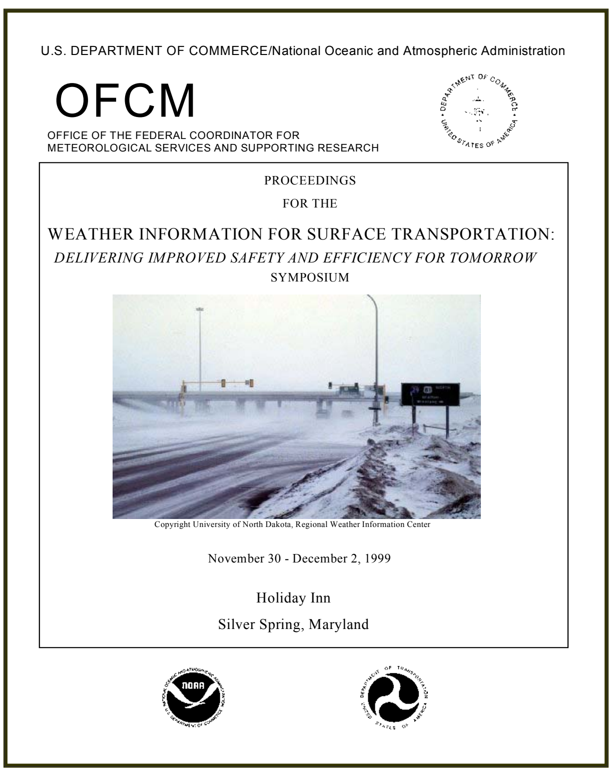
> *… transportation is about more than concrete, asphalt, and steel: it is about people, and providing them with the opportunity to lead safer, healthier, and more fulfilling lives.*

Implicit in Secretary Slater's statement was recognition of the effects weather has on the safety, health, and productivity of the nation's citizens. Actions to be taken in response to this legislation included expanding the coordinated response to identified national needs. More than 120 transportation and weather professionals attended the plenary sessions and three workshops.

They represented federal entities, state and city governments, urban and rural transportation agencies, professional and trade organizations (with member corporations), and weather service providers (government and commercial). The sessions focused on:

- Department of Commerce and Department of Defense services and capabilities for surface transportation decision support
- Commercial weather information production capabilities and services
- Federal entity weather information needs
- State and local weather information needs
- Weather information needs of professional and trade organizations
- Research and technology innovation for decision support.

Not surprisingly, the symposium produced some shared themes. The participants emphasized weather events that trigger decisions, spatial and temporal dependencies, standards and formats, decision-making authorities, user and provider capabilities and responsibilities, new initiatives, and implementation. They emphasized both the importance of weather observations relevant to surface transportation and the current lack of observations suited to the needs of transportation decision makers. *The attendees also overwhelmingly supported a proposal to establish a nationwide baseline of weather information needs for surface transportation and endorsed the pursuit of solutions that would meet their specific mission needs.*


U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

OFCM

OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

PROCEEDINGS

FOR THE

WEATHER INFORMATION FOR SURFACE TRANSPORTATION:

DELIVERING IMPROVED SAFETY AND EFFICIENCY FOR TOMORROW

SYMPOSIUM

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November 30 - December 2, 1999

Holiday Inn

Silver Spring, Maryland

Cover from WIST I proceedings.

2.2 Initial Information Gathering

The process of identifying and building a nationwide baseline of weather information needs began in earnest shortly after the WIST I symposium. The first stage was to identify the agencies and activities that had a stake in this information resource. The next stage was to implement a process to collect and validate data on WIST user needs.

To identify existing and potential WIST users, the study staff sent a letter to request participation, with a questionnaire, to surface transportation professionals from federal, state, and local governments and from the commercial sector. The questionnaire solicited comments on agency missions, identification of operations impacted by weather elements, actions and decisions taken in response to weather elements, and general information on availability of weather information to meet user needs. This last category included sources and communications media such as newspaper, radio, and television. The distribution list for this initial contact letter was compiled with the help of the JAG/WIST members and other staff from the WIST-relevant programs of the FCMSSR federal partners.

The request letter and questionnaire were sent to more than 700 persons, of which about 500 were transit managers across the United States. The 108 responses provided the basis for expanded sampling of weather information needs from entities of transportation modes that represented a cross-section of geographical areas and regional concerns. In addition to the data from the replies, the staff, with assistance from members of the JAG/WIST, conducted one-on-one interviews with representatives of the FCMSSR federal partners and with operations and management officials of metropolitan transit authorities in the local area. The responses to the initial request for participation provided two kinds of information for continuing the WIST needs identification process. First, interested individuals from across the target transportation sectors were identified for participation in subsequent steps of identifying and validating WIST needs. For sectors in which there were few responses or in which major activities within the sector had few responses, additional names were sought for and request letters were sent out.

Second, the responses to the initial questionnaire and the staff interviews were used to refine and expand the data gathering model. Overall, the responses confirmed that weather is indeed a factor in many phases of transportation operations. The responses also reinforced the view that more accurate, timely, and mission-specific information about current and forecast weather will conserve resources and enhance operational effectiveness, efficiency, and safety. Two shortcomings of currently available weather information also emerged from these responses:

1. A lack of definitive information at the spatial and temporal scales required for many users' decision processes
2. A lack of specific thresholds at which information on identified weather elements was needed.

2.3 Follow-up Survey

To address the limitations in the first questionnaire and to build upon the information obtained from the First WIST Symposium, the questionnaire responses, and the agency interviews, OFCM staff, with the assistance of the JAG/WIST, prepared a follow-up survey. The survey was sent to recipients of the original WIST questionnaire, plus others identified over the course of the first year of information gathering. More than 750 surveys were distributed.

The extended survey sought details on the time and distance scales, thresholds, and operational decisions and actions important for each weather element of potential interest to the respondent. The survey form was formatted as a table shell, or ***template***, with weather elements as the rows of the table and columns for thresholds, lead times, impacts, and mitigating actions for each weather element.

2.4 Data Extraction and Analysis for Summary WIST Needs Templates

Data extracted from the initial questionnaires and the follow-up survey were used to identify transportation activities (subsectors) within the six major sectors, weather elements and thresholds, mitigating actions and key decisions, and time and spatial scale sensitivities. These data were incorporated into summary tables of draft WIST needs, with one table for each transportation sector. The summary tables, called WIST Needs Templates, were used in the validation phase. The final seven templates for the six major sectors, representing all the needs identified and validated during the study, are reproduced in Appendix B. In addition to a general Roadways template, a template specifically for federal highways was prepared to capture the scope and interests of programs within the Federal Highway Administration. Tracking information for participants' organizations and administrative data, along with general comments, was also collected and maintained, although these data are not included in the WIST Needs Templates.

Weather Elements

A ***weather element*** is a particular weather condition or a consequence of weather conditions that WIST participants identified as affecting (1) transportation system operations (e.g., road or railway maintenance; traffic management on rail, road, or marine transportation systems) or (2) the safety, economic value, or efficiency (time as well as cost) of transportation activities using those systems (e.g., ship or barge movement on the MTS, truck and car movement on roadways). The categories of weather elements that emerged from the initial data gathering and the first WIST Symposium are precipitation elements; temperature-related elements; thunderstorm-related elements; winds; visibility; tropical cyclone, sea state, and ice (on waterways); and miscellaneous elements. Table 2-1 lists the individual weather elements, as identified by the respondents, in each of these categories.

This list of WIST weather elements contains many traditional meteorological parameters. But it also contains some unique and nontraditional elements for which the weather information provider community has not routinely provided information to their customers in the past. For example, freezing precipitation is a standard element, but "ice accumulation on structures, in inches" is not. Likewise, air temperature is a standard element, but air temperature change rate, rail temperature, and subsurface temperature are not. Some of the elements desired by WIST users are clearly not meteorological in nature and would be characterized by environmental scientists as hydrologic, geophysical, or oceanographic data. However, the users view all these elements as ***conditions about which they need information*** and which, to them, are intrinsically linked to the impact of weather on their operations.

Table 2-1 Weather Elements Identified by WIST Users, Grouped by General Category

Precipitation Elements

- Freezing precipitation (ice)
- Structure ice accumulation (inches)
- Pavement ice accumulation (inches)
- Frozen precipitation (snow, inches)
- Snow accumulation observation (inches)
- Roadway snow depth observation (inches)
- Roadway snow pack depth observation (inches)
- Adjacent snow depth observation (inches)
- Snow/ice bonding observation (inches)
- Drifting snow (inches)
- Snow drift levels observation (inches)
- Blizzard
- Liquid precipitation
- Precipitable water vapor observation (inches)
- Soil moisture
- Flooding
- Water course flow volume (cubic meters per second)
- Water body depths (feet)

Thunderstorm Related

- Thunderstorms with lightning (includes microburst event; proximity to route or operations, in miles)
- Thunderstorm with hail (proximity to route or operations, in miles)
- Thunderstorms with tornado (proximity to route or operations, in miles)
- Severe storm cell track (location, direction, speed, severity, proximity to route or operation area)

Temperature Related

- Air temperature (°F)
- Air temperature including maximum and minimum (°F)
- Air temperature (°F) first occurrence of season
- Air temperature change rate (°F per 24 hours)
- Air temperature (°F relative to freezing) to include trend (rising or falling)
- Dew point temperature (°F)
- Wet bulb temperature (°F)
- Relative humidity (percent)
- Rail temperature (°F)
- Pavement temperature
- Pavement freeze point temperature with dew point temperature
- Pavement condition
- Chemical concentration (in-road sensor or mobile infrared)
- Water temperature
- Soil temperature
- Wind chill
- Heat index
- Cooling or heating degree days
- Air stability

Winds

- Wind (speed and direction), includes microburst event
- Wind—head, tail, cross (speed)
- Upper air winds

Visibility

- Visibility (statute miles) to include restriction (e.g., fog, haze, dust, smog)
- Sun glare

Tropical Cyclone, Sea State, Ice

- Tropical cyclone or hurricane (winds, sea state, storm surge, flooding)
- Seas (wave height in feet)
- Wind wave height (feet)
- High surf
- Freezing spray (seas and low temperature)
- Storm surge/abnormal high or low tides
- Tsunami, tidal surge
- Inland ice coverage
- River ice/ice gouging
- Open water sea ice

Miscellaneous

- Seismic activity, earthquakes (any land motion, land slides, avalanches, etc.)
- Nuclear, biological, or chemical hazard dispersion
- Atmospheric transport and diffusion
- Air quality (characterization/code)
- Fire and fire weather
- Total sun (insolation hours per day)
- Cloud cover forecast
- Fair weather
- Avalanche danger
- Volcanism
- Volcanic ash
- Space weather (e.g., solar flares)

Several respondents and symposium participants commented that meteorological information available today is heavily biased toward (1) the protection of life and property (e.g., severe convective, winter, and tropical storms) and (2) aviation forecasts and observations. Several expressed the belief that surface transportation weather products and services will one day be on a par with aviation weather products. The "nonstandard" elements in Table 2-1 provide insight into the information content that will be needed in WIST products and services to meet these expectations in the user communities.

A plume of nitric acid fumes rises from an industrial accident site. Atmospheric transport and diffusion is among the nontraditional weather elements important to WIST users. Copyright AP Wide World Photos.

Thresholds

As noted, the responses to the initial WIST questionnaire emphasized the importance of specific ***thresholds*** at which a weather element affects a transportation activity or (in the case of multiple thresholds) affects it differently. In some cases, any occurrence of a weather element has impacts and requires action. For other elements, thresholds are critical to defining the users' information need.

Scale Factors

The data requested on scale factors included topography, time (forecast lead time required to affect decisions or and actions), and spatial resolution.

Topography. The questionnaire and survey allowed users to comment on an agency's area of responsibility and the regional topography. Responses on regional topography ranged from coastal marine environments and waterway marshlands to deserts and mountain forests.

Forecast Lead Time Required for Action-Decision. One of the most critical factors in supporting surface transportation with weather information is, "How much lead time does the user need?" For the WIST needs identification, lead time was defined as the advance warning prior to an event. This advance warning gives the decision maker the time needed to make the necessary preparations to minimize the effects of the weather on the specified event or activity. The survey used a decision time line to solicit users' responses on the lead times they require.

The query was designed to focus on three conventional support cycles for weather information: planning (climatology, historical probabilities), preparation (forecasts in near-term), and action (nowcasting in near real-time).

When the data for the three support cycles were consolidated, four specific time segment maxima were evident (Figure 2-1). For the planning cycle, a major response spike occurs at 3–6 months and a smaller spike occurs at 7–10 days. For the preparation cycle, a major maximum occurs at 1–3 days. For the action cycle, a peak occurs at 1–3 hours, but the response distribution is fairly evenly dispersed from the 6–12 hour threshold to the actual event. The distribution of user responses along this timeline suggests that, to provide the greatest benefits, planning information should be available up to 6 months before the weather event is likely to occur. Near-term forecast information is needed for preparation actions three days in advance of a weather event. Near-real-time nowcast information is needed for final implementation decisions throughout the 12-hour period just prior to an event.

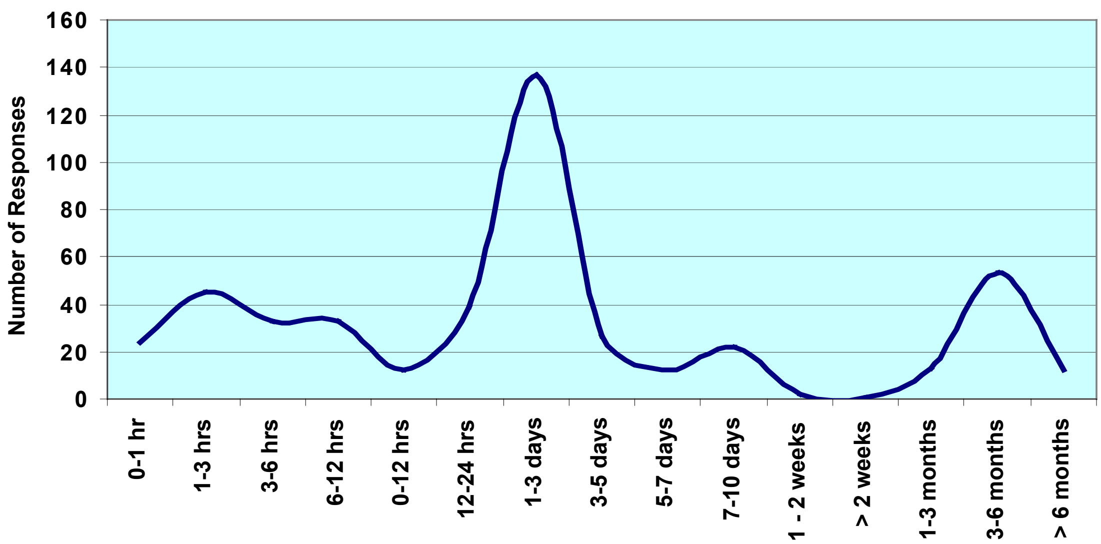


Figure 2-1 Distribution of desired lead times, all sectors.

Spatial Resolution. Spatial scale refers to the spatial distribution or density of information that users need—or would prefer to have—to support decisions in response to weather events. The weather forecast community typically uses three broad categories to describe spatial scale:

- ***Synoptic scale*** is the scale of a typical continent-wide weather map showing features that cover hundreds of kilometers horizontally, such as high-pressure and low-pressure systems and their associated fronts.
- ***Mesoscale*** is the scale of meteorological phenomena that range in size from a few kilometers (horizontal scale) to about a hundred kilometers. Typical mesoscale phenomena include local winds, thunderstorms, and tornadoes. Meteorologists sometimes differentiate between the meso-β-scale and meso-γ-scale, where the

former discriminates phenomena ranging from 20 to 100 kilometers in the horizontal and the latter discriminates phenomena ranging from 2 to 20 km. (Kluzek 1999).

- ***Misoscale*** phenomena range in size from a few meters (horizontal scale) to about 4 kilometers. Typical misoscale phenomena include whirlwinds, dust devils, small waterspouts, and channeling or funneling of winds around buildings and overpasses or through tunnels.

Of the 262 responses received from participants in the needs identification survey, 100 included information on spatial scale. The extracted data on spatial scale are represented by Figure 2-2. The pattern of responses suggests two required levels of resolution; a synoptic scale and a very strongly supported mesoscale. Not surprisingly, users want refined levels of analyses and predictions beyond what is now available. Of the 100 responses that included scale information, 57 desired data resolution at 5 km or less.

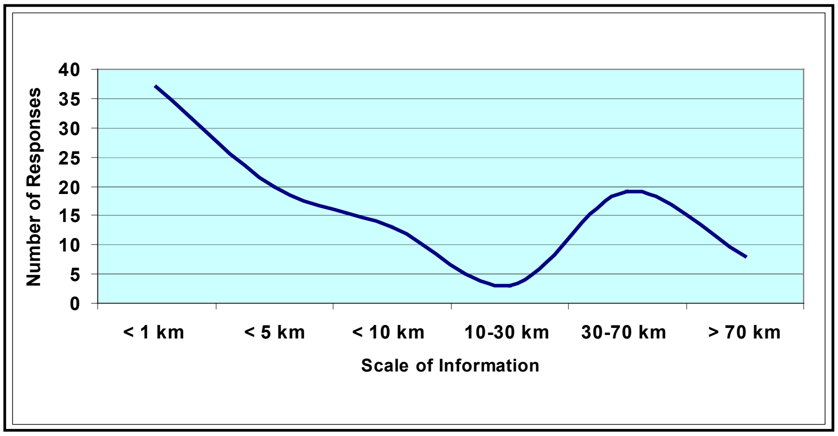


Figure 2-2 Spatial grid spacing desired by weather information users. A 30–70-km grid represents the state of current global atmospheric model technology. A grid with less than 10 km spacing represents the state of the art for modeling mesoscale phenomena.

Administrative Information

The administrative data on survey respondents includes the following information:

• Agency name	Office title, e.g., Federal Highway Administration
• Organization	Type of agency, e.g., federal, state, commercial, university
• Transportation mode	Mode and sector distinction, e.g., Roadway, Railway
• Agency mission	Narrative description of the agency's mission
• Action-decision	Narrative of the action or decision to be made that is affected by weather
• Address(es)	Mailing, office codes, email, phone numbers, etc.

Chapter 4 discusses and analyzes the responses from the questionnaire and the survey in detail, as the basis for drawing conclusions about WIST needs.

2.5 Validation and Verification of Sector-Specific WIST Needs Templates

The first drafts of the summary WIST Needs Templates were distributed to surface transportation professionals in each sector for verification and validation. Over 165 agencies and user groups provided inputs to the templates, answered supplemental questions during the study, and coordinated on validating the templates for one or more modes of transportation within the sectors (Table 2-2). Appendix A lists all the participants and the transportation sectors of interest to them. Their responses were consolidated into the appropriate template, and a final agency validation or concurrence was obtained for each summary template. The final versions from this validation process are the templates in Appendix B.

Table 2-2 Participating Users and Entities

24	federal agencies
	15 FCMSSR partners
	9 other federal agencies
26	state departments of transportation
40	rural/urban transit authorities
13	public school districts
20	regional airports
26	trade associations
4	airline companies
8	railroad companies
7	petroleum/natural gas companies
2	government corporations

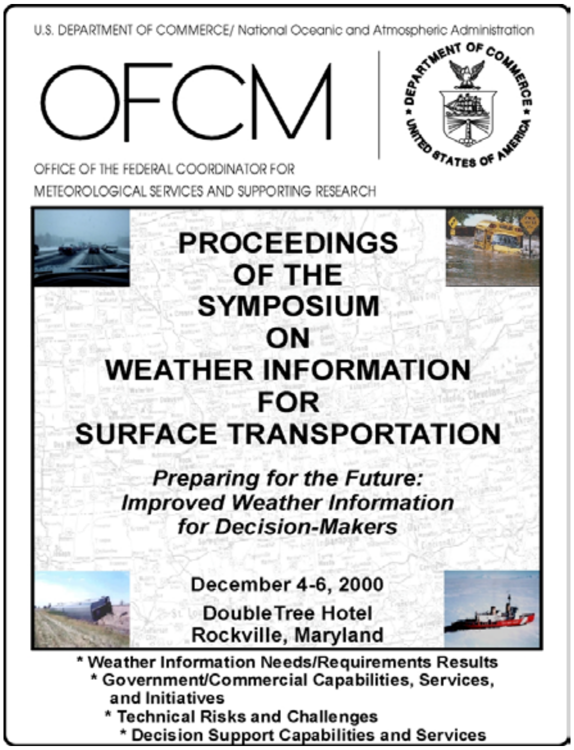
2.6 Second WIST Symposium

While the First WIST Symposium focused on identifying the wide range of weather information needs for the nation's surface transportation activities, the goal of the second symposium (WIST II) was to provide ***a framework for improving weather information for those who make operational decisions about surface transportation systems***. The symposium's theme reflected this goal: *"Preparing for the Future: Improved Weather Information for Decision-Makers*" (OFCM 2001a).

The objectives of WIST II were to:

- Summarize activities and progress over the 12 months since the first WIST symposium
- Present and discuss the status of the needs and analysis represented by the WIST Needs Templates
- Solicit feedback on the WIST needs identification and validation process
- Identify initiatives and programs that were relevant to identifying or meeting WIST needs and either underway at the time of WIST II or planned
- Illuminate strategic thrust areas where additional effort was required
- Identify next actions or other steps toward improving weather information for decision makers.

WIST II brought together key stakeholders from federal entities, private industry, and the academic research community. Reports and briefings showed significant progress in improving weather information for surface transportation decision makers. Nevertheless, by the conclusion of WIST II, it was clear that certain areas still require concerted attention and action. Further actions are needed to ensure advances in technical knowledge, implementation of new technologies, and validation of the weather information needs of surface transportation activities in the various transportation sectors. The participants agreed on a list of actions, to be taken by the OFCM and other participants, which would foster further improvements. Chapter 5 uses the



WIST II showed that significant progress had been made to improve weather information for surface transportation decision makers but, also identified strategic areas that require concerted attention and action.

results of the WIST needs validation process to provide a foundation for the strategic thrust areas and next steps that emerged from WIST II.

2.7 Special-Case Needs Validation Processes

This section describes how the WIST needs data were collected and compiled for two sectors that differed to some extent from the general process described in Sections 2.2 and 2.3.

2.7.1 Long-Haul Railways Sector

For rail transportation, the information obtained from the questionnaire and survey showed that there are two distinct operational entities: long-haul railways versus rail as a component of local or regional transit operations. Transit operations include bus and van service on streets and roadways, as well as railways, such as surface "light rail" and metropolitan subway lines, which are principally oriented toward moving people. The long-haul railways, which operate on more than 144,000 miles of track (see Figure 2.3), provide primarily cargo services, moving over 1.8 billion tons of freight annually.[1] These long-haul railways also provide intercity passenger service through Amtrak. The differences in operational settings, impacts, and actions of the two types of rail transport were distinct enough to define them as separate transportation sectors for the purposes of WIST needs identification.

[1] Rail mileage and freight statistics for long-haul railways are from the "Railroads and States—1999" web page of the Association of American Railroads, available at <http://www.aar.org/rrstates1999.nsf>.

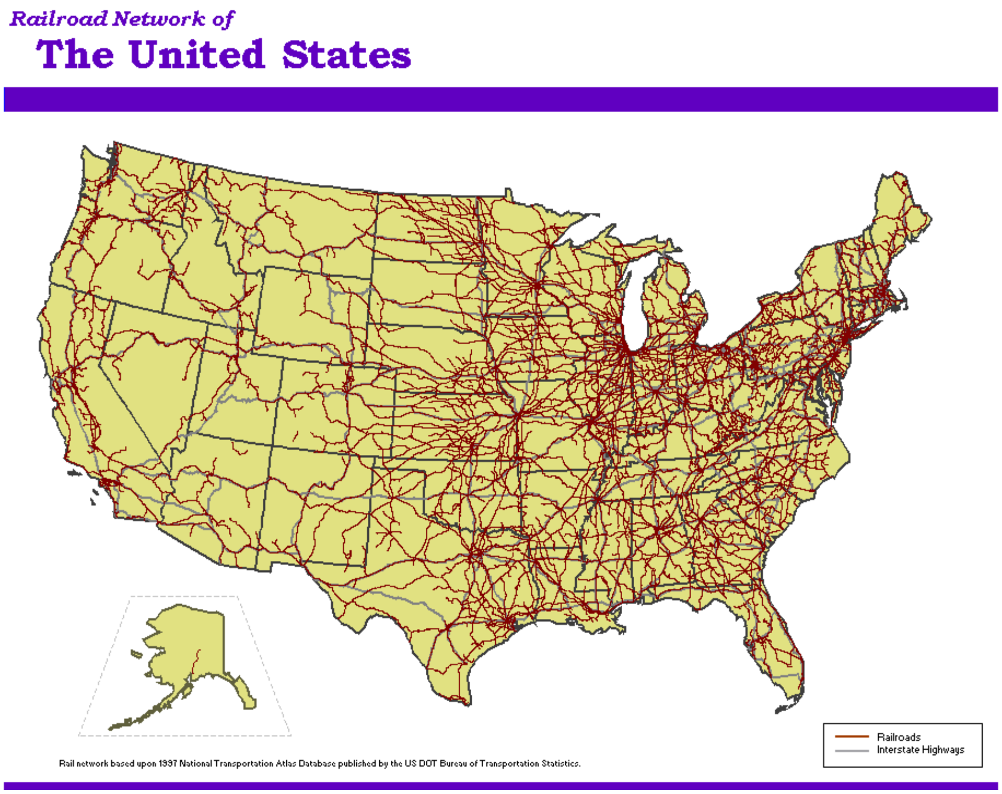


Figure 2-3 Railroad network of the United States. Source: AAR 2002.

The original questionnaire and survey included 47 responses that addressed rail operations in both categories. However, the absence of information from long-haul carriers was a concern, so a special effort was made to seek participation from several of the major long-haul rail companies. After the WIST II conference in December 2000, OFCM staff set up a draft WIST Needs Template for long-haul railways and met with the Association of American Railroads (AAR), a railway trade association, to review the weather-related information needs of the long-haul railway sector. The AAR reviewed the draft template with its members, and their suggestions were incorporated in a revised version. This revised template was distributed to the AAR members, and their comments were incorporated to complete the validation step of the process. The final WIST Needs Template for long-haul railways is in Appendix B-2.

2.7.2 Pipeline System Sector

The design of the WIST project included pipeline systems as a surface transportation sector. Surface transportation sectors were defined as activities supporting the safe, efficient and economical transport of people, goods, and services, so pipelines fall under the definition.

Direct and Indirect Effects of Weather Elements on Pipeline Systems

Even though pipelines are a controlled, closed system, weather elements do affect their safe, economical, and efficient operation. The weather elements that factor into impacts and actions for this sector are rarely the primary meteorological parameters such as precipitation air temperature. For example, in October 1994, a major flood on the San Jacinto River near Houston undermined numerous pipelines. Consequently, eight pipelines ruptured, igniting petroleum spills into the river. More than 500 people suffered burn injuries. (The most frequent factor in pipeline damage or failure is third-party excavations, e.g., utility trenching and digging by private homeowners.)

The WIST Identification and Validation Process for the Pipeline System Sector

The pipeline system sector was by far the most difficult of the surface transportation sectors about which to acquire WIST user information. Of the questionnaires and surveys distributed, only four responses were received for pipeline systems.[2] Only one of the responses addressed weather issues for pipeline systems and the impacts and actions related to weather elements. The response received from the Department of Transportation's Office of Pipeline Safety (OPS) and information gleaned from the Code of Federal Regulations (CFR 193–195) were used to create a follow-on survey for this sector. Few recipients of the second survey form responded until a baseline WIST Needs Template was drafted, which incorporated the concerns of other surface transportation sectors and the input from OPS.

The OFCM staff identified commercial pipeline companies and contacted them individually to foster interest in participating in the WIST needs process. In addition to pipeline companies, several pipeline trade associations were contacted. The trade associations proved an invaluable aid in reaching the industry. The American Petroleum Institute (API) distributed the draft WIST Needs Template for pipeline systems to its client members. API also invited OFCM staff to the 52nd Annual API Pipeline Conference, held on April 17–18, 2001, in San Antonio, to discuss the WIST project during ad hoc meetings. This effort allowed the data gathering phase to be completed and initiated a successful validation phase.

After the API conference, an updated pipeline template was distributed to pipeline companies and trade association clients. This template was overwhelmingly approved and accepted as the benchmark for weather information needed to support pipeline operations. In particular, key personnel in one operational control center (of the Buckeye Pipe Line Company) graciously reviewed the template and concurred with the contents.

[2] The vast majority of surface transportation responders were associated with the roadway and railway sectors. Only a small segment identified pipelines as a concern.