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Research Results Digest 376

DATA NEEDS FOR ASSESSING RURAL TRANSIT NEEDS, BENEFITS, AND LEVELS OF SERVICE

This digest presents the results of NCHRP Project 20-65, Task 36, "Data Needs for Assessing Rural Transit Needs, Benefits, and Levels of Service." The project was conducted by the KFH Group under subcontract to Cambridge Systematics. Beth Hamby of the KFH Group was the Principal Investigator.

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BACKGROUND

Introduction

Rural transit provides critical mobility for residents in rural areas who lack private transportation, yet its performance and benefits to riders and the communities it serves receive far less attention than urban transit. This results both from differences in scale—urban transit carried 10,134 million passenger trips in 2009, while rural transit carried less than 2% of that, with an estimated 116 million passenger trips the same year—as well as the more limited data available for rural transit assessment.

But with the increased investment in rural transit by the federal government over the past two decades, particularly since the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), as well as growing transit needs in rural America due to its aging population and new emphasis on ensuring adequate transportation for veterans who disproportionately reside in rural areas, there is interest in improving the capability to analyze rural transit.[1]

The primary objectives of this project were to (1) review the data elements currently reported in the Rural National Transit Database (NTD) and identify data elements that are needed to record pre- and post-service change information; and (2) identify potential levels of service (LOS) options that are more accurate or useful for future evaluation of rural service. The concept of LOS can be applied to many aspects of public transit services. In this report, the expression refers to measures of service availability from the passenger's perspective, following usage of the expression in a key resource upon which this study was specifically intended to build: *Rural Transit in Oregon: Current and Future Needs.*[2]

Additionally, the project called for options for using the data elements and measures of LOS from other readily available data to conduct rural transit needs assessment and performance analysis. The researchers also developed draft tools to help state departments of transportation (DOTs) understand the effects of various service types and levels on rural communities.

[1] *TCRP Web-Only Document 46: Rural Transit Achievements: Assessing the Outcomes of Increased Funding for Rural Passenger Services under SAFETEA-LU,* by KFH Group, Transportation Research Board of the National Academies, Washington, DC, 2010, p. 3, Fig. 1.

[2] *Rural Transit in Oregon: Current and Future Needs,* conducted for the Association of Oregon Counties on behalf of the Oregon Department of Transportation, by Jennifer Dill and Margaret Neal, Portland State University, Portland, OR, 2010, pp. 49–51.

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Why This Project Is Important

State DOTs oversee public transportation in their rural communities, and they collect and use transit data for a number of purposes, including to:

- Examine the **performance** of transit services funded with state and federal dollars. Performance data are commonly used by state DOT transit managers to monitor and oversee how effectively federal and state transit dollars are being spent.
- Determine the LOS being provided in the state and examine **"unmet" transit needs** or gaps that might be filled. Data on levels of service achieved and descriptions of unmet needs are often used by state DOT transit managers to help establish state transit policies and/or program characteristics.
- Advocate for transit services by defining the **benefits of transit services** to the state and local communities served.
- **Report** transit service and financial data as required for federal and state funding programs.

It is important to keep these various uses and needs in mind in reviewing both the current Rural NTD data elements and the new data elements suggested by this study.

It is also important to emphasize that needs assessments and performance analyses are essentially different. A needs assessment looks at service from the perspective of users, and requires an understanding of the population being served, including characteristics and travel needs. A performance analysis assesses service generally from the perspective of the transit system and the funding agency or agencies. LOS measurement is also from the users' perspective, but, significantly, may be at odds with performance measurement. Higher service levels (e.g., longer hours of operation, frequent coverage of large service areas) that users view positively often result in lower performance (e.g., lower productivity and higher cost per trip if ridership does not increase proportionately with service increases), which the transit agency and its funders may not necessarily view positively.

Finally, it is important to recognize that NTD is a tool that was developed for federal funders to monitor how well federal funds are being utilized. It was not intended to be a tool to determine how well the public is served.

This project, then, provides the opportunity to comprehensively assess the data elements that are available through the Rural NTD and determine if additional data elements should be included to allow more robust evaluations of rural transit, including its performance, levels of service, benefits, and needs for additional service.

The Rural National Transit Database

The Federal Transit Administration (FTA) introduced the NTD in 2006, requiring standardized data reporting for rural transit agencies receiving financial assistance through the FTA's Section 5311 grant program. This followed the NTD for urban transit agencies by many years, requiring a reduced level of data and detail for rural reporters. Nonetheless, the introduction of Rural NTD established an avenue for formalized assessments of rural transit.

Several years of experience with Rural NTD and the new interest in rural transit performance open a window to consider new data elements for Rural NTD that will expand agencies' capability to assess rural transit, including LOS, as well as to weigh the needs for additional rural services.

Rural Data Reported in the NTD

The state agencies that administer Section 5311 funding report the data on behalf of their subrecipients of Section 5311 and 5311(f) program funds, while recipients of Tribal Transit funding and Section 5307 urbanized area funding report directly on the Section 5311-funded rural services they operate.

The NTD data elements reported for 2011 by states for their rural subrecipients (submitted through Form RU-20) are listed in Table 1.

Section 5311(f) (intercity bus) recipients report a much more limited set of data elements through Form RU-21, including:

- Service area
- Total FTA assistance under Section 5311 and the American Recovery and Reinvestment Act (ARRA)5311forplanningandcapital(combined) or operating expenses or provision of trips
- Total revenue vehicle-miles and unlinked passenger trips funded by Section 5311

Tribal Transit recipients that receive funding directly from FTA submit Form RU-20 directly to FTA and RU-22 to the state. RU-22 only includes

Table 1 Current rural NTD data elements.

- Basic Information
  - Service area
    - Type
      - County/independent city
      - Multi-county/independent city
      - Multi-state*
      - Municipality
      - Reservation
      - Other
    - Description
  - Modes operated
    - Bus
      - Deviated fixed-route
      - Fixed-route
      - Both
    - Commuter bus*
    - Demand-response (including subscription service)
    - Ferryboat (excluding intercity ferryboat service)*
    - Taxi (purchased service)*
    - Vanpool
    - Other (with description)
- Financial Information
  - Total operating expenses (aggregated for all modes)
  - Total capital expenses (aggregated for all modes)
  - Total revenues by source (aggregated for all modes)
    - Fare revenues
    - Contact revenues
    - Local funds
    - State funds
    - FTA sources by program
    - Other federal sources
- Asset and Resource Information
  - Vehicle fleet characteristics (aggregated by same vehicle type/year)
    - Number of vehicles
    - Vehicle type
    - Vehicle length
    - Seating capacity
    - Year of manufacture
    - Funding source
    - Number of ADA accessible
    - Ownership
  - Number of maintenance facilities owned or leased by service provider or public agency
  - Number of volunteer drivers
  - Number of personal vehicles in service
- Service Data
  - Revenue vehicle miles by service mode—including the miles of personal vehicles used in demand-response service (aggregated with agency vehicles)
  - Revenue vehicle hours by service mode—including the hours of personal vehicles used in demand-response service (aggregated with agency vehicles)
  - Unlinked passenger trips by service mode
  - Sponsored trips by demand-response and taxi service modes
- Safety Data
  - Number of reportable safety incidents (aggregated for all modes)
  - Number of fatalities (aggregated for all modes)
  - Number of injuries (aggregated for all modes)

*Added to the Rural NTD for the 2011 Reporting Year.

total FTA assistance under Section 5311 and ARRA 5311 for operating and capital.

Directly reporting urban recipients include any rural services they may operate in the report they submit directly to FTA. Urban recipients that receive Section 5311 funding from a state are also required to submit Form RU-23 to the state, which only reports total FTA assistance under Section 5311 and ARRA 5311 for operating and capital. Data on rural services provided by urban recipients are aggregated with the urban data that the urban recipient reports to FTA.

The Impetus for This Project

While the state-reported data items provide a good starting point for quantifying the amount of rural transit service that is supported by FTA funding, as well as quality in terms of safety incidents and age of vehicle fleets, they are not indicative of the need for rural transit service (and the degree to which these needs are being met) or the LOS availability. As noted earlier, the NTD was not developed as a means to measure LOS—for urban or rural services. Rather, it was developed as a tool to oversee how well federal funds are being utilized.

The objectives of this project were to identify data elements that are needed to record pre- and post-service change information and identify potential LOS options that are more accurate or useful for future evaluation of rural service. A number of regional studies have suggested that some data items can be tweaked and standardized to help states better use the NTD data, conduct

analysis of rural systems, and better understand rural transit benefits. There may also be ways to more clearly define the current data elements to reduce the potential for inconsistencies from state to state in how these data are defined, gathered, and aggregated.

Measuring the benefits of rural transit on a nationally consistent basis is challenging and perhaps beyond the scope of the Rural NTD. The need for, and effectiveness of, rural transit service is affected by numerous variables, such as geographic size of the service area, population size and density, terrain, distances to major medical facilities and employment centers, source of local matching funds (in many rural communities, human service contracts, such as Medicaid, are the predominant sources of local match funding), and demographic characteristics indicative of transportation need, including age, disability status, poverty status, and auto ownership. Recommended approaches for including these variables in any state-level analyses can help states better quantify the need for and benefits of rural transit services.

RESEARCH METHODOLOGY AND REPORT ORGANIZATION

The following steps were taken to conduct this project, and the digest is organized in the following sections:

- **Literature Review**—Research for this project began with a review of existing literature, research findings, and current data reporting and analysis practices that are related to measuring rural transit and particularly the NTD. Based upon the approaches to measuring rural transit identified through the review, the research team began compiling a list of potential measures that are appropriate for rural transit, in terms of performance, LOS, needs, and benefits.
- **Evaluation of Existing Rural NTD Data Elements**—The research team evaluated the utility of each of the data elements currently included in the Rural NTD in terms of measuring performance, LOS, needs, and benefit, for pre- and post-change comparisons. The measurements (primarily of performance) that can be derived from existing Rural NTD data elements were also identified.
- **Assessment of Potential Measures**—The list of potential measures of performance, LOS, needs, and benefits identified during the literature review were assessed in terms of relative utility and practicality for rural transit providers and states to implement. The data elements needed to calculate these measures were also identified. Because of the number of potential measures, the research team assigned a relative priority for each measure, to facilitate narrowing down a suggested subset of measurements for levels of service and performance measurements.
- **Identification of New Data Elements Needed**—Next, options were developed for additional data elements that, if added to the Rural NTD reporting requirements, would improve the utility of the Rural NTD data in evaluating service changes without being overly burdensome to rural transit providers and the states reporting on their behalf.
- **Measures for Assessing Rural Transit Performance**—Several key resources were identified in the literature search that presented recommended approaches and measures for evaluating rural transit service performance. Performance evaluation methods are summarized in this digest, identifying which measures are more applicable to each of the modes reported in the Rural NTD (deviated and/or fixed-route, commuter bus, demand-response, ferryboat, taxi, and vanpool).
- **Measuring Levels of Rural Transit Service**—Approaches to measuring service levels, which were identified through the literature review, are presented and discussed. Suggestions are then made to measure LOS for rural transit, specific to each of the modes reported in the Rural NTD, with an analysis of the types of systems and operating environments in which they would be appropriate.
- **Methodologies for Assessing Rural Transit Needs**—Rural transit needs assessment methodologies identified through the literature search are summarized in this section of the digest, along with a discussion on estimating need versus demand for rural transit services. Data elements available within the Rural NTD are compared to the data inputs required for selected needs assessment methodologies.

Finally, several tools were prepared under this study to help state DOTs understand the effects of various service types and levels on rural communities. Most of the tools are incorporated as tables in the document. Additionally, two electronic spreadsheets were created that include formulas to calculate one of the potential new data elements.

LITERATURE REVIEW

The resources reviewed for this study, along with the relevant measures identified in each resource, are summarized in Table 2. These include measures of need, performance, LOS, and benefits of transit.

The following key resources were the most important in shaping the analysis and conclusions of this study:

- *Rural Transit Fact Book—2011,* prepared by Small Urban & Rural Transit Center, Upper Great Plains Transportation Institute, North Dakota State University (2011). This is the first national-level publication to present a comprehensive set of statistics on rural transit based on the 2007–2009 data reported in the Rural NTD, supplemented with demographic data from the American Community Survey (ACS) 2007–2009 and the 2009 National Household Travel Survey (NHTS). Statistics are presented at the national, FTA regional, and state levels.
- *Rural Transit in Oregon: Current and Future Needs,* prepared by Jennifer Dill and Margaret Neal, Institute on Aging, Center for Transportation Studies, Portland State University (2010). This research is noteworthy in its application of the LOS concept to assess rural transit services throughout a state.
- *TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System,* prepared by Kittelson & Associates, Inc., Urbitran, Inc., LKC Consulting Services, Inc., Morpace International, Inc., Queensland University of Technology, and Yuko Nakanishi under TCRP Project G-6 (2003). While this resource is primarily focused on urban transit systems, recommendations are provided for fixed-route services in areas with population under 50,000.
- *TCRP Report 100: Transit Capacity and Quality of Service Manual,* 2nd edition, prepared by Kittelson & Associates, KFH Group, Parsons Brinckerhoff, Quade & Douglass, and Katherine Hunter-Zaworski under TCRP Project A-15A (2003). While this resource is primarily focused on urban transit systems, it has applicability for rural transit, particularly for demand-response service.
- *TCRP Report 136: Guidebook for Rural Demand-Response Transportation: Measuring, Assessing, and Improving Performance,* prepared by KFH Group under TCRP Project B-31A (2009).

In addition, the research team conducted an extensive Internet search of state DOT websites seeking relevant state-level transit and specialized transportation data collection and evaluation practices, standards, and reports. Appendix A summarizes the potentially relevant practices found through this effort, which was largely conducted in July 2011. Also reviewed were additional state-level data available off-line to the research team as part of recent projects conducted for several state agencies (including Idaho, Maryland, and Vermont).

EVALUATION OF EXISTING RURAL NTD DATA ELEMENTS

Each of the data elements reported in the Rural NTD for 2011 were listed earlier in this digest. A two-step analysis was conducted to evaluate these data in terms of utility for measuring pre- and post-service changes.

First, the research team evaluated the utility of each of the data elements currently included in the Rural NTD. Table 3 presents the results of this analysis and identifies the mode(s) in which each element is reported.

Next, the measurements (primarily of performance) that can be derived from existing Rural NTD data elements were also identified. Table 4 presents these measures.

As can be seen in Table 4, the measures which can be developed using existing Rural NTD data elements are primarily performance measures—how efficiently, effectively, and safely the service is operating. Many of these measures cannot be developed by mode and this is a major shortcoming as performance differences between fixed-route and demand-response, for example, cannot be assessed

(*Text continues on page 11.*)

Table 2 Relevant measures identified through the literature review.

Title	Author	Date	Measures of Need/ Demand	Measures of Performance	Measures of Level of Service/Service Availability	Measures of Benefits
Rural Transit Fact Book—2011	Small Urban & Rural Transit Center, Upper Great Plains Transportation Institute, North Dakota State University	2011	Not specifically addressed in this resource	• Trips per mile • Trips per hour • Operating expense per trip • Operating expense per mile • Farebox recovery ratio	• Vehicle miles • Vehicle hours • Fleet size • Accessible percent of fleet • Average seating capacity	Total passenger trips
Rural Transit in Oregon: Current and Future Needs	Jennifer Dill and Margaret Neal, Institute on Aging, Center for Transportation Studies, Portland State University	2010	• Housing density (housing units per acre) • Trips per capita (trips per person per year) • Other demographic variables derived from 2008 Arizona study by Cambridge Systematics: – 6.79 annual one-way trips per person aged 60+ – 4.49 annual one-way trips per person aged <60 with a disability – 20.50 annual one-way trips per person aged <60 living in poverty – Fixed-route service is needed for block groups 3–4+ housing units per acre (identified by GIS)	• Revenue miles per trip • Trips per revenue hour • Trips per revenue mile • Operating cost per unlinked passenger trip • Operating cost per revenue mile • Operating cost per revenue hour • Operating costs from fares and other revenues	Demand-response as single category for fixed route: • LOS 1: < 5 days/week, no weekend service • LOS 2: 5 days a week, no weekend service, more than 60-minute headways • LOS 3: 5 days a week, no weekend service, 60-minute headways or better • LOS 4: 6 or more days a week, less than 12 hours of service per weekend day • LOS 5: 6 or more days a week, 12+ hours of service per weekend day Additional variable: Intercity (Yes/No)	Not specifically addressed in this resource
TCRP Report 3: Workbook for Estimating Demand for Rural Passenger Transportation	SG Associates with Leigh, Scott & Cleary, Inc. and C.M. Research, Inc.	1995	Demand for rural passenger transportation (both general public and social service trips)	Not specifically addressed in this resource	• Vehicle miles of service • Vehicle miles per square mile	Not specifically addressed in this resource

TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System	Kittelson & Associates, et al.	2003	Numerous measures include: • Financial performance – Ridership – Productivity (passenger/hour) – Cost-effectiveness—farebox recovery ratio, operating ratio, cost per passenger/passenger mile, subsidy per passenger/passenger mile, revenue per passenger/passenger mile, cost per capita – Cost-efficiency—cost per vehicle hour, cost per vehicle mile, cost per vehicle trip • Service delivery measures – Missed trips – Complaint rate – Route directness • Safety and security measures – Accident rate – Number of incidents of vandalism	For population < 50,000, core fixed route: • Missed trips • Complaint rate • Route directness • Accident rate • No. of incidents of vandalism • Road calls • Average spare ratio vs. scheduled spare ratio • Fleet cleaning • Ridership • Productivity • Cost-effectiveness • Percent positive drug/alcohol tests Demand-response: • On-time performance • Missed trips • Complaint rate • Percentage of missed phone calls • Response time • Travel time • System speed • Accident rate • Ridership • Cost-efficiency • Cost-effectiveness • Productivity • Trip no-shows and late cancellations	For population < 50,000, core fixed route availability: • Route coverage • Frequency • Hours of service Demand-response: • Service coverage • Span of service • Service hours • Revenue hours • Service denials	For population < 50,000, core fixed-route community impact: • Personal economic impact Demand-response: • Welfare-to-work accessibility • Personal and community economic impacts • Provision of transportation service to human and social service agencies
TCRP Report 98: Resource Requirements for Demand-Responsive Transportation Services	Joseph L. Schofer, et al., Northwestern University	2003	Presents means to estimate resources needed to meet demand	Service delivery measures: • Daily hours per vehicle • Daily trip density • Average trip duration • Average vehicle-hours/trip • Passenger miles/vehicle-mile	• Size of the DRT service area • Fleet size (vehicles operated) • Daily hours of service	Not specifically addressed in this resource

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Table 2 (Continued).

Title	Author	Date	Measures of Need/ Demand	Measures of Performance	Measures of Level of Service/Service Availability	Measures of Benefits
TCRP Report 100: Transit Capacity and Quality of Service Manual, 2nd edition	Kittelson & Associates, KFH Group, Parsons Brinckerhoff Quade & Douglass, Dr. Katherine Hunter-Zaworski	2003	Not specifically addressed in this resource	Numerous performance measures	Numerous measures; capacity measures are geared to urban fixed route; categories of service quality measures most applicable to rural transit services include: Availability of fixed-route: • Frequency of service—average headway (time between service) (LOS thresholds geared toward urban areas) • Hours of service—# hours per day (LOS thresholds geared toward urban areas) • Service coverage – Route miles per square mile – Percentage of system area served – LOS thresholds provided for percent of transit supportive area within ¼ mile Availability of demand-responsive: • Response time (min. advance reservation): – LOS 1: ≤½ hour – LOS 2: ½–2 hours – LOS 3: same-day service >2 hours – LOS 4: next-day service ≤24 hours – LOS 5: 24–48 hours – LOS 6: 48 hours–1 week – LOS 7: 1–2 weeks – LOS 8: > 2 weeks • Span of service (days and hours)—LOS take into account ranges of both days per week and hours per day. Examples: – LOS 1: ≥16 hrs/day, 6–7 days/week – LOS 4: 9–11.9 hrs/day, 3–5 days/week OR >12 hrs/day, 3–4 days/week – LOS 8: <4 hrs/day, <2 days/week OR any number of hours < than twice per month	Not specifically addressed in this resource

TCRP Report 136: Guidebook for Rural Demand-Response Transportation: Measuring, Assessing, and Improving Performance	Elizabeth Ellis, KFH Group, and Brian McCollom, McCollom Management Consulting	2009	Not included in this resource	• Passenger trips per vehicle-hour • Operating cost per vehicle-hour • Operating cost per vehicle-mile • Operating cost per passenger trip • Safety incidents per 100,000 vehicle miles • On-time performance • No-show/late cancellation rate • Complaint rate • Average passenger trip length • Average travel time	Not included in this resource	Though this guidebook is focused on performance measures, it does suggest some transit-impact measures: • Rate of use by seniors • Rate of use by people with disabilities • Percentage of trips to/from congregate meal sites • Percentage of trips • Number of employment trips provided per day • Number of individuals using DRT for independent living Also defines source data for performance measures: • Vehicle-hours • Vehicle-miles • Passenger trips
TCRP Report 147: Toolkit for Estimating Demand for Rural Intercity Bus Services	Frederic D. Fravel, Reyes Barboza, and Jason Quan KFH Group, Inc. and Jason K. Sartori, Integrated Planning Consultants, LLC	2011	Demand for rural intercity bus service on a particular route	Not specifically addressed in this resource	Variables in demand model include: • Interlining • Connection with local transit • Route type—dead end • Route length (one-way miles) • Frequency (trips per week) • Fare per mile • Presence/absence of key generators along route	Not specifically addressed in this resource

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Table 2 (Continued).

Title	Author	Date	Measures of Need/ Demand	Measures of Performance	Measures of Level of Service/Service Availability	Measures of Benefits
TCRP Web-Only Document 46 and Research Results Digest 93: Rural Transit Achievements: Assessing the Outcomes of Increased Funding for Rural Passenger Services under SAFETEA-LU	KFH Group	2009	Not included in this resource	Passenger trips per vehicle	Accessible percentage of vehicles	• Total number passenger trips • New routes and services created • Geographic areas (counties) served • Number of employment sites service • Number of passenger trips provided to/from employment
TCRP Web-Only Document 49: Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation	Frank Spielberg, Vanasse Hangen Brustlin, A. T. Stoddard, LSC Transportation, and Jeanne Erickson, Erickson Consulting, LLC	2010	Demand for rural passenger transportation (both general public and social service trips)	Not specifically addressed in this resource	• Rural vehicle-miles • Rural vehicle-hours • Size of service area	Not specifically addressed in this resource

with the current Rural NTD data. Measures involving cost or safety incidents can only be developed at the system level. It is important to note that the measure of revenue vehicle-hours includes hours operated by volunteer drivers and revenue vehicle-miles includes miles operated using personal vehicles as well as agency-owned vehicles.

ASSESSMENT OF POTENTIAL MEASURES

Table 5 presents a list of potential additional measures for reporting service levels, performance, benefits, and unmet needs, as derived from the literature review as well as the research team's experience with rural transit planning and evaluation. The intent in developing this list was to identify as many potential measures as possible that would be relatively realistic and meaningful in measuring rural transit, as well as practical for rural transit providers and states to implement. The data elements needed to calculate these measures were also identified.

Because of the number of potential measures, the research team assigned a relative priority for each measure, to facilitate narrowing down a recommended subset of measurements for levels of service and performance measurements. The priorities assigned were subjective, based on the research team's experience, with an intent to correlate measures of high utility and practicality with high priority. Measures which we believe would be impractical to implement (due to difficulty in gathering the data or low confidence that the data would be consistently reported across the industry, for example) were assigned a lower priority.

The measures in Table 5 are reorganized by priority and type in Table 6, and discussed below.

High-Priority Additional Measures

Because of their relative utility and ease of implementation, the following additional measures are more highly recommended than other potential measures. All three of these measures require the same new data element (in addition to what is already available through the Rural NTD): total population in the service area. The recommended definition for this data element is discussed later in this digest.

- **Vehicle revenue miles per capita**—This LOS measure provides a macro-level assessment of rural transit provided in the transit provider's defined geographic area. For transit systems operating in smaller geographic areas with a relatively concentrated population (e.g., a small city or town), the annual revenue miles is indicative of service frequency/availability. For transit systems operating in larger geographic areas (e.g., one or more counties), this number may be less meaningful in that there is no indication of how the miles are distributed (e.g., frequent service along a single route that connects two population centers could have a similar measure as infrequent service that truly covers the entire service area). However, this is still a recommended macro-level measure of service availability.
- **Vehicle revenue hours per capita**—Similar to miles per capita, this LOS measure provides a macro-level LOS assessment of rural transit availability within the transit provider's defined geographic area.
- **Passenger trips per capita**—Another macro-level assessment, this measure is indicative of benefits provided by rural transit and, indirectly, LOS. LOS is indirectly indicated if one assumes that demand is affected by service levels; a transit system with infrequent service or operating too few hours is likely to be able to serve fewer passengers than one with higher service levels.

Medium-Priority Measures

Potential additional measures with medium priority are those that would be moderately challenging to collect or aggregate data, or to implement consistently across providers, but which could provide a high degree of utility.

- **Periods of service**—This LOS measure assesses convenience of transit to riders and impacts the types of trips that can be made. It is fairly straightforward for systems with routes/services that have consistent weekday schedules, and could follow the same approach as the urban NTD reporting requirement in which starting and ending times are entered for weekdays, Saturdays and Sundays. The electronic reporting form calculates the total hours per year.

(*Text continues on page 22.*)

Table 3 Existing data elements for pre- and post-service change analysis for rural transit.

Existing Data Elements in Rural NTD	Data Reported for		If Reported for Individual Mode, Which Modes?	Comments	Data Element Role in Pre/ Post Service Change Analysis for Rural Transit
	Individual Mode	All Modes as Aggregate			
Service area description	—	Yes	—	By type and description. Not qualitative or suggestive of relative size of land area or population; description indicative only of relationship to jurisdictional boundaries.	Would need to add a qualitative element to be useful in reflecting change in service area (e.g., increase in square miles or total population served).
Modes operated	Yes	—	Bus, Commuter Bus, Demand-Response, Ferryboat, Taxi, Vanpool, "Other"	Descriptive category only; not qualitative.	Useful only in indicating which modes are operated during a particular year.
Total annual expenses	—	Yes	—	Operating and capital expenses are reported; either may include preventive maintenance.	Useful only in overall measures of service change, since expenses not reported by individual modes.
Total annual revenues by source	—	Yes	—	Fare revenues, contract revenues, local and state funds, FTA sources by program, and other federal sources are reported.	Useful only in overall measures of service performance change (e.g., farebox recovery), since revenues not reported by individual modes.
Vehicle fleet characteristics	—	Yes, except taxi	—	Aggregated by vehicle type and year. Excludes taxis and personal vehicles.	Useful in measuring overall fleet capacity and number of vehicles, extent to which overall fleet is accessible, and broad-brush replacement needs.
Number of maintenance facilities owned or leased by service provider or public agency	—	Yes	—	Disaggregated as owned or leased by service provider or public agency for service provider.	Not useful.
Numbers of volunteer drivers	—	Yes	—	Not necessarily indicative of available service capacity.	Not useful.
Number of personal vehicles in service	—	Yes	—	Not necessarily indicative of available service capacity.	Not useful.

Annual vehicle rev. miles	Yes	—	Bus, Commuter Bus, Demand-Response, Ferryboat, Taxi, Vanpool, "Other," Intercity Bus	"Bus" mode may include mix of regular fixed-route (FR) and deviated FR. "Demand-Response" (DR) mode includes volunteer personal vehicles. Vehicle rev. miles for DR defined as pull-out to pull-in, which is not consistent with definition for DR for Urban NTD reporting.	Increase or decrease in annual vehicle rev. miles denotes a change in level of rural transit service, as described by the amount of service provided.
Annual vehicle rev. hours	Yes	—	Bus, Commuter Bus, Demand-Response, Ferryboat, Taxi, Vanpool, "Other"	"Bus" mode may include mix of regular FR and deviated FR. "Demand-Response" (DR) mode includes volunteer personal vehicles. Vehicle rev. hours for DR defined as pull-out to pull-in, which is not consistent with definition for DR for Urban NTD reporting.	Increase or decrease in annual vehicle rev. hours denotes a change in level of rural transit service, as described by the amount of service provided.
Annual regular unlinked passenger trips	Yes	—	Bus, Commuter Bus, Demand-Response, Ferryboat, Taxi, Vanpool, "Other"	"Bus" mode may include mix of regular FR and deviated FR. "Demand-Response" (DR) mode includes trips provided on volunteer personal vehicles but excludes sponsored trips. "Taxi" mode excludes sponsored trips. Unlinked passenger trips defined as number of passengers who board public transportation vehicles, counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.	Increase or decrease in annual unlinked passenger trips generally denotes a change in level of rural transit service consumed—unless service is restructured so that the need to transfer between routes changes.

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Table 3 (Continued).

Existing Data Elements in Rural NTD	Data Reported for		If Reported for Individual Mode, Which Modes?	Comments	Data Element Role in Pre/ Post Service Change Analysis for Rural Transit
	Individual Mode	All Modes as Aggregate			
Annual sponsored unlinked passenger trips	Yes for two modes	—	Demand-Response, Taxi	"Bus" mode may include mix of regular FR and deviated FR. "Demand-Response" (DR) mode includes trips provided on volunteer personal vehicles. Unlinked passenger trips defined as number of passengers who board public transportation vehicles, counted each time they board vehicles no matter how many vehicles they use to travel from their origin to their destination.	Increase or decrease in annual unlinked passenger trips generally denotes a change in level of rural transit service consumed—unless service is restructured so that the need to transfer between routes changes.
Annual number of reportable safety incidents	—	Yes	—	Defined as an incident with a fatality, injuries requiring immediate medical attention away from the scene for one or more persons, or property damage equal to or exceeding $25,000.	Safety incidents per 100,000 miles is a key measure of service quality.
Annual number of fatalities	—	Yes	—		
Annual number of injuries	—	Yes	—		

Table 4 Measures to evaluate rural transit LOS, benefits, performance, and unmet need with existing NTD data elements.

Measure	Data Elements Needed	Type of Measure	Usefulness of Measure	Comments	Ranking for Use in Rural Transit Evaluation
Passenger trips per vehicle revenue hour; also known as productivity	– Total passenger trips – Vehicle revenue hours	Performance	Key measure for assessing service effectiveness.	Can be calculated for the rural transit modes reported for Rural NTD—Bus, Commuter Bus, Demand-Response, Ferryboat, Taxi, Vanpool, "Other." However, Bus mode may include mix of regular fixed-route and deviated fixed-route.	High
Operating cost per vehicle revenue hour	– Total operating cost – Vehicle revenue hours	Performance	Key measure for assessing cost efficiency. Not available by mode in current Rural NTD.	Expenses are not reported by individual modes in current Rural NTD. Operating costs may or may not include preventive maintenance. Revenue vehicle hours include vehicle hours of volunteers as well as paid drivers.	High
Operating cost per vehicle revenue mile	– Total operating cost – Vehicle revenue miles	Performance	Key measure for assessing cost efficiency. Not available by mode in current Rural NTD.	Expenses are not reported by individual modes in current Rural NTD. Operating costs may or may not include preventive maintenance. Revenue vehicle miles include vehicle miles of personal vehicles as well as agency vehicles.	High
Operating cost per passenger trip	– Total operating cost – Total passenger trips	Performance	Key measure for assessing cost efficiency. Not available by mode in current Rural NTD.	Expenses are not reported by individual modes in current Rural NTD. Operating costs may or may not include preventive maintenance.	High
Safety incidents per 100,000 vehicle-miles	– Total safety incidents – Vehicle revenue miles	Performance	Key measure for assessing service quality. Not available by mode in current Rural NTD.	Safety incidents are not reported by individual modes in current Rural NTD.	High

(*continued on next page*)

Table 4 (Continued).

Measure	Data Elements Needed	Type of Measure	Usefulness of Measure	Comments	Ranking for Use in Rural Transit Evaluation
Average passenger trip length (vehicle revenue miles per passenger trip)	– Vehicle revenue miles – Total passenger trips	Performance	Measures ridership relative to available service, though less meaningful as a performance indicator in large, sparsely populated areas. Can be indirectly indicative of size and population density of service area. Affects productivity and cost per passenger trip.	Can be calculated for the rural transit modes reported for Rural NTD.	Medium
Average travel time (vehicle revenue hours per passenger trip)	– Vehicle revenue hours – Total passenger trips	Performance	Useful for comparing to auto travel time. Long ride times can be indicative of long travel distances coverage or in case of demand-response trips, over-grouping of trips.	Can be calculated for the rural transit modes reported for Rural NTD.	Medium
Farebox recovery ratio	– Total annual operating expenses – Fare revenues	Performance	Useful for evaluating overall financial viability of service and determining funding needed to sustain the service.	Expenses are not reported by individual modes in current Rural NTD. Operating costs may or may not include preventive maintenance.	Medium
Passenger trips per vehicle	– Total passenger trips – Fleet vehicles	Performance/ Benefits	Useful for measuring productivity of vehicle fleet and benefits of service.	Would need to extract passenger trips provided in personal vehicles for this to be accurate/meaningful.	Medium

Table 5 Analysis of additional measures to evaluate rural transit.

Measure	Data Elements Needed for Measure		Type of Measure	Level of Effort to Collect New Data Element	Comments	Ranking for Use in Rural Transit Evaluation
	Reported for Rural NTD	New				
For All Modes						
Periods of service	Not reported	Days and hours when rural transit provided	Level of service	Low to moderate. Data readily available, but will require multiple entries or data averaging for systems with routes that don't operate on consistent schedules.	For systems with routes/services that have consistent schedules, this is a straightforward measure requiring no calculation; assesses convenience of transit to riders and impacts the types of trips that can be made and can be reported comparably to urban NTD (average system start- and end-times would be reported for weekday, Saturday and Sunday). However, many rural systems have service segments that don't operate on consistent weekday schedules. Recommended approach is therefore total average hours for each day of the week (averaged across all routes for Bus and service segments for other modes). Services that only operate seasonally also present a challenge.	Medium
Vehicle revenue miles per capita	Vehicle revenue miles	Total population in service area	Level of service	Low. Population data readily available for census-defined places.	Measure provides macro-level assessment of rural transit provided in the defined geographic area.	High
Vehicle revenue hours per capita	Vehicle revenue hours	Total population in service area	Level of service	Low. Population data readily available for census-defined places.	Measure provides macro-level assessment of rural transit provided in the defined geographic area.	High
Population per peak vehicle	Not reported	Total population in service area Peak vehicles	Level of service	Low to moderate.	Not recommended for systems which are predominantly volunteers operating personal vehicles.	Medium
Passenger trips per capita	Total passenger trips	Total population in service area	Benefits & indirectly, Level of service	Low. Population data readily available for census-defined places.	Measure provides macro-level assessment of rural transit provided in the defined geographic area.	High

(*continued on next page*)

Table 5 (Continued).

Measure	Data Elements Needed for Measure		Type of Measure	Level of Effort to Collect New Data Element	Comments	Ranking for Use in Rural Transit Evaluation
	Reported for Rural NTD	New				
Percentage of trips by trip purpose	Total passenger trips	Passenger trips by trip purpose	Benefits	High, and only feasible for services that require advanced reservation.	Useful to demonstrate that rural transit is a lifeline to jobs, medical appointments, and other basic needs.	Low
Percentage of trips by demographic group	Total passenger trips	Passenger trips by demographic group (seniors, people with disabilities, etc.)	Benefits	High, and only feasible for services that require advanced reservation and eligibility screening.	Useful to demonstrate that rural transit is a lifeline for vulnerable populations, but categorization of public transit riders only feasible for eligibility for reduced fares, ADA paratransit, or sponsored trips.	Low
For Bus Mode						
Headways	Not reported	Minutes between route trips (e.g., >60 or ≤60 minutes)	Level of service	Low to moderate. Data readily available, but may require multiple entries for systems with routes that don't operate on consistent schedule.	For small systems with routes/services that have consistent schedules, this is a straightforward measure requiring no calculation; assesses convenience of transit to riders. More complex for systems with multiple services with varying schedules (e.g., parts of the county are served 5 days/wk., other parts are served 2 days/mth.) but calculations could be achieved in a spreadsheet. Rural services operated outside of a city or town typically have very long headways, and this measure may not be meaningful for outlying service.	Medium
Vehicle revenue miles per square mile of service area	Vehicle revenue miles	Square miles of service area	Level of service	High. Requires calculation of buffer (e.g., ¾ mi.) around all routes (GIS capability); updates needed whenever routes change.		Low
Vehicle revenue hours per square mile of service area	Vehicle revenue hours	Square miles of service area	Level of service	High. Requires calculation of buffer (e.g., ¾ mi.) around all routes (GIS capability); updates needed whenever routes change.		Low

Route miles per square mile of service area	Not reported	Route miles, Square miles of service area	Level of service	High. Requires calculation of buffer (e.g., ¾ mi.) around all routes (GIS capability); updates needed whenever routes change.		Low
For DR Mode						
Vehicle revenue miles per square mile of service area	Vehicle revenue miles	Square miles of service area	Level of service	Moderate to high. Where service area is clearly defined Census-defined area, data available. But rural DR often travels outside main service area for medical and other trips, or through/ around large unpopulated areas (e.g., parkland or wilderness), so difficult to determine true service area.	Measures that require data on the actual size of DR service areas will often yield misleading results.	Low
Vehicle revenue hours per vehicle	Vehicle revenue hours (though includes hours of personal vehicles) Vehicles (though aggregate only)	Need to disaggregate • Vehicles assigned to DR service • Hours using personal vehicles	Level of service	Moderate. Would need to disaggregate hours operating personal vehicles and vehicles assigned to DR service; definition would need to specify how to calculate (e.g., average vehicles in service weekdays, maximum vehicles in service).	Straightforward measure that assesses how intensively vehicles are used in service; higher numbers are better.	Medium
Square miles per peak vehicle	Not reported	Square miles of service area Peak vehicles	Level of service	Moderate to high. Where service area is clearly defined Census-defined area, data available. But rural DR often travels outside main service area for medical and other trips, or through/ around large unpopulated areas (e.g., parkland or wilderness), so difficult to determine true service area.	Measures that require data on the actual size of DR service areas will often yield misleading results. Not recommended for systems which are predominantly volunteers operating personal vehicles.	Low

(*continued on next page*)

Table 5 (Continued).

Measure	Data Elements Needed for Measure		Type of Measure	Level of Effort to Collect New Data Element	Comments	Ranking for Use in Rural Transit Evaluation
	Reported for Rural NTD	New				
Trip requests that could not be accommodated	Not reported	Trip requests that could not be accommodated (denials/missed)	Unmet need	Moderate. Transit systems with ADA paratransit should already be documenting.	Would need to define what constitutes an unmet request (e.g., within established service parameters but capacity unavailable vs. requests that fall outside of the established service parameters—both of which indicate unmet requests). Systems which provide ADA paratransit may not fully report to avoid self-incrimination regarding capacity constraints.	Low
Response time	Not reported	Minimum advanced reservation (in hours or days)	Level of service	Low for stated policy. High for actual experiences.	Policy may vary from actual practice (e.g., a system may have a next-day policy but in practice tend to fill up days in advance) but can still be indicative of unmet need.	Medium
On-time performance (percentage of trips that met on-time standard)	Not reported	• On-time trips • Policy for length in minutes of pickup window (or real-time)	Performance & Level of service	Moderate to high. Transit systems with ADA paratransit should already be documenting.	Key measure for assessing service quality. Would also need to ask for local definition of "on-time" (e.g., within pick-up window, which would also need to be defined since being late for a 15-minute window is very different than being late for a 45-minute window). Systems which provide ADA paratransit may not fully report to avoid self-incrimination regarding capacity constraints.	Low

Table 6 Additional measures to evaluate rural transit by priority and type.

Ranking for Use in Rural Transit Evaluation	Type of Measure				Measure	New Data Elements Needed
	Level of Service	Performance	Benefits	Unmet Need		
High	x				Vehicle rev. miles per capita	• Total population in service area
High	x				Vehicle rev. hours per capita	• Total population in service area
High	x				Passenger trips per capita	• Total population in service area
Medium	x				Period of service	• Total average hours per weekday, Saturday and Sunday when rural transit provided
Medium	x				Population per peak vehicle	• Total population in service area • Peak vehicles
Medium	x (Bus mode)				Headways	• Minutes between route trips (e.g. >60 or ≤60 min.)
Medium	x (DR mode)				Vehicle rev. hours per vehicle	Need to disaggregate: • Vehicles assigned to DR service • Hours using personal vehicles
Medium	x (DR mode)				Response time policy	• Minimum advanced reservation policy (in hours or days)
Low	x				Vehicle rev. miles per square mile of service area	• Square miles of service area
Low	x (Bus mode)				Vehicle rev. hours per square mile of service area	• Square miles of service area
Low	x (Bus mode)				Route miles per square mile of service area	• Route miles • Square miles of service area
Low	x (DR mode)				Square miles per peak vehicle	• Square miles of service area • Peak vehicles
Low	x (DR mode)	x (DR mode)			On-time performance (percentage of trips that met on-time standard)	• On-time trips • Local definition of "on-time" • DR mode: length in minutes of pickup window policy
Low			x		Percentage of trips by trip purpose	• Passenger trips by trip purpose
Low			x		Percentage of trips by demographic group	• Passenger trips by demographic group (seniors, people with disabilities, etc.)
Low				x (DR mode)	Trip requests that could not be accommodated	• Trip requests that could not be accommodated (denials/ missed)

However, for many rural transit systems, determining average weekday starting and ending times will be challenging, since different routes and service elements often have different schedules. For systems that cover portions of their service areas fewer than five days per week (not uncommon for those with multi-county coverage areas—some outlying areas may only be served once or twice per month), this challenge is compounded.

A suggested alternative compromise is to calculate total **average weekly period of service** for each route or service segment in the system, and then calculate the average of those averages, to determine the **average period of service per weekday hours** across all routes/service segments.[3]

Another variable that will impact complexity and accuracy of the average time period is seasonality of operations (such as ski shuttles or routes geared toward college students and staff). This could be addressed by factoring in weeks per year of each route, but it does increase the reporting burden for the rural transit provider.

- Population per peak vehicle.
- Headways (for bus mode only).
- Vehicle revenue hours per vehicle (for demand-response mode only).
- Response time (for demand-response mode only).
- Pick-up window (for demand-response mode only).

Low-Priority Measures

Low-priority measures are those which would likely be highly challenging to collect consistent or accurate data from rural transit providers.

- Square miles per peak vehicle (demand-response mode)
- Vehicle revenue miles per square mile of service area
- Vehicle revenue hours per square mile of service area
- Route miles per square mile of service area
- On-time performance (percentage of trips that met on-time standard)
- Percentage of trips by trip purpose
- Percentage of trips by demographic group
- Trip requests that could not be accommodated

The data elements that would be needed to calculate the above measures are discussed in the next section.

IDENTIFICATION OF NEW DATA ELEMENTS NEEDED

Based on the suggested additional measures as discussed in the preceding section and summarized in Tables 4 and 5, the following new data elements would be needed to produce these measures:

- **High-Priority Data Elements**—The following data elements are relatively easy to collect and would provide beneficial data for calculating levels of service as well as service performance by mode.
  - **Total Population in Service Area**—For the sake of simplicity and reporting consistency, it is recommended that the total population of the transit provider's entire defined service area (e.g. whole jurisdictions) be based upon the U.S. Census population estimate for the same reporting year as the data. These estimates are readily available at the County and Place (cities and towns) level from the U.S. Census website as well as through most states' data centers. The anticipated benefit of this data element is the ability to calculate macro-level LOS measures.
  - **Revenue vehicle-hours disaggregated** into those operated using personal vehicles separately from those operated using agency fleet vehicles. Transit systems which have been tracking revenue hours accurately (as opposed to estimating revenue vehicle-hours based on payroll hours) should be able to track hours for agency and personal vehicles separately at the local level.

[3]An even simpler, macro-level approach could be to calculate average hours per weekday per vehicle. However, the nuances regarding the true time period of the service for any given portion of the service area would not be captured. The period of service measure would be the same for a transit system operating across its entire service area 12 hours per weekday vs. one that served a different portion of the service area for six hours two days per week, another portion for the rest of that vehicle's time on those two days per week, and an entirely different area altogether for three days per week.

- **Revenue vehicle-miles disaggregated** into those operated using personal vehicles separately from those operated using agency fleet vehicles. As with tracking hours, local practices to track revenue vehicle-miles accurately should be easily able to track miles for agency and personal vehicles separately at the local level.

- **Medium-Priority Data Elements**—The following data elements would be likely to either involve a moderate level of effort to collect or present a moderate possibility of reporting inconsistencies.
  - **Span/Periods of Service**—Days and hours when rural transit is provided. The anticipated benefit of this data element is a simple measure of LOS reflecting temporal service availability. However, the complexity of the schedules of some rural transit systems will complicate their reporting of span of services and requires aggregation of various service levels before reporting on the NTD, either by the rural transit provider before reporting to the state, or at the state level before completing the Rural NTD. If this data element is added to the Rural NTD at some point, it is suggested that the aggregation be conducted by state program staff to ensure statewide consistency of reporting.

    Two new tools were developed to assist states, rural transit managers, and planners in calculating average span of service for a transit system with varying service spans for different routes and/or different parts of a demand-response service area: one electronic spreadsheet for calculating averages of routes that operate at least weekly, and one for calculating averages of routes or services that operate less than weekly. These are provided in electronic format with printed versions attached to this digest as Appendix B.
  - Vehicles by mode
  - Number of peak vehicles (total or by mode)
  - Average fixed-route headways (number of minutes between vehicle trips in a single direction on each route)
  - Demand-response response time (minimum advance reservation)—established policy rather than actual experience

- **Low-Priority Data Elements**—Each of the following measures would likely create a substantial record-keeping and reporting burden for local transit agencies or present a high possibility of reporting inconsistencies.
  - Square miles of service area—an in-depth discussion of the issues with this data element in rural areas is provided following this list.
  - Route miles.
  - Demand-response trips that were on-time.
  - Demand-response trip requests that could not be accommodated (including trip denials as well as missed trips).
  - Passenger trips by trip purpose—not feasible except for trips sponsored by a human service agency that reports trip purpose to the transit agency.
  - Passenger trips by demographic group—not feasible for services that are truly open to the public, except for trips sponsored by a human service agency that reports eligibility requirements to the transit agency.

Issues with Measuring Rural Transit Service Area

The service area is an important factor for rural transit performance, predominantly for demand-response services. The size of the service area as well as the number of people living there and the distribution of residential areas and trip destinations all affect performance. A large service area will tend to generate longer trips, and a low-density service area with a dispersion of activity centers means there is less opportunity to group trips. These are frequently the characteristics of rural service areas. The longer trips require more time and miles, with a negative effect on productivity (passenger trips per hour) and cost per passenger trip.

Defining Service Area

The NTD recognizes the importance of service area. Urban reporters are to report square miles. The 2011 NTD glossary defines this measure as follows:

> Service area is a measure of access to transit service in terms of population served and area coverage (square miles). For bus (MB), trolleybus (TB), and rail service, use ADA definitions and requirements to determine service area boundaries and population. The bus service area essentially is

defined as ¾ mile on each side of a fixed route. The rail service area definition focuses on a ¾-mile radius around each station.

For demand-response (DR) and demand-response-taxi mode, if your service area extends beyond ADA requirements of ¾ mile around fixed routes, use the actual service area.

For modes not covered by ADA, including ferryboat (FB) and vanpool (VP), determine service area and population using locally defined criteria.

Rural reporters specify one of five categories of coverage that suggest relative size: municipality, county/independent city, multi-county, reservation, and other. The NTD does not currently ask rural reporters to specify the size of their service area in square miles, perhaps with an objective of placing less reporting burden on rural transit systems, but it also may reflect issues that impact accurate and meaningful data for service area size.

Experience with urban NTD has found service area size data, as well as population, are not reported consistently. Urban reporters are to report their service area size (in square miles) and their population. The NTD spells out the definitions for these data elements: service area for bus and Americans with Disabilities Act (ADA) paratransit is defined according to the ADA as the ¾-mile corridors around fixed routes (although if the agency's demand-response service exceeds the ADA definition, the *actual* service area is reported), and population is that population within the ADA-defined area. For rail, the service area also corresponds to the ADA definition: a ¾-mile radius around each station. For ferryboat and vanpool, service area and population are determined using locally defined criteria.

Yet, recent federal research finds that service area size and service area population are the most error-prone data among the urban NTD, along with two other data elements.[4] The responsibility for recording and tracking service area size and population does not reside with transit agencies, and determining the size of the ¾-mile buffer around an agency's fixed routes requires GIS mapping capabilities.

Use of Geospatial Data to Determine Service Coverage Area

GIS applications offer powerful tools for determining transit needs and evaluating service levels, factoring in dimensions of demographic data. The Oregon study demonstrates how these tools can be used to determine areas that need more transit service. This study defined service area as a ¼-mile buffer on either side of fixed routes within cities and a ½-mile radius around intercity stops. For demand-response service, the study used a system's jurisdictional boundaries (typically city or county limits) based on the service area described on the system's website. Service areas were mapped and overlaid with data on housing density (housing units per acre) at the Census block group level. Through this geospatial analysis, the Oregon study was able to identify unserved and underserved areas by assessing densities that would support fixed-route transit (indicated as at least three to four housing units per acre based upon two sources cited in the study).[5] Further, the LOS of each fixed-route system could be overlaid with the housing densities. Other demographic variables (such as percentage of the population living in poverty) were also compared to service levels.

While GIS is a desirable method to capture geospatial data with accuracy in order to identify transit need and demand, GIS capabilities are not available to many rural transit providers. A rural transit program that is part of a local government entity or regional planning organization is likely to have at least periodic access to GIS mapping and data services through its planning department. However, private non-profit entities are less likely to have this capability available in-house, since GIS applications are expensive and require specialized training to use. For many rural transit systems, geospatial analysis may only be feasible as part of a larger planning project conducted by another entity (such as a consulting firm, a regional planning organization conducting a Transit Development Plan, or a local public transit–human service transportation coordination study).

Adding GIS-derived data to the Rural NTD reporting requirements is not currently recommended, because for Section 5311 systems without GIS capabilities, the burden to conduct the geospatial analysis would be placed on states as part

[4] *TCRP Report 141: A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry,* by P. Ryus, et al., Transportation Research Board of the National Academies, Washington, D.C., 2010, p. 70. The other two data elements are vehicle system failures and route miles vs. track miles.

[5] *Rural Transit in Oregon,* p. 56.

of their preparations to complete the annual Rural NTD report. In all but the smallest states, it would be a significant effort to map the services of each Section 5311 recipient in the state and update this on an annual basis. If, in the future, GIS tools become more widely available and easier to use (perhaps through some form of web-based mapping technology), the feasibility of including geospatial data in the Rural NTD could be revisited.

Challenges with Accuracy and Consistency in Defining a Very Large Service Area

For rural transit agencies, the issue of accurately reporting service area size is compounded by the fact that the *actual* service area—where trips are provided—may be only part of the formal county or multi-county square area.[6] The vast majority of rural transit agencies are counties and multi-county entities, and it is not uncommon that such areas have geographic features such as mountains, national forests, or other large-sized geographic or topographic features. The square area of such features is included in the overall square mileage calculation, but they are not part of the inhabited county land, and therefore not part of the day-to-day transit service area. To include large-scale uninhabited areas usually misrepresents the service area data and impacts calculations and performance measures that use the service area data element, although in some cases the impact is meaningful. (Exceptions could include uninhabited areas that must be crossed or passed circumferentially to reach a populated area that is part of the transit system's service area, since travel through or around the uninhabited area could significantly affect revenue vehicle miles and hours required to cover the populated service area.) However, measuring and subtracting those areas from the formal jurisdictional service areas are not straightforward calculations, and to require such calculations from rural reporters is probably not reasonable.

[6]According to *TCRP Report 136: Guidebook for Rural Demand-Response Transportation: Measuring, Assessing and Improving Performance,* the large majority, 76%, of rural systems are provided in single county or multi-county areas. Furthermore, the *Status of Rural Transit,* prepared by the National Rural Assistance Program and the Community Transportation Association of America, 2007, reports that 89% of rural transit agencies provide demand-response service.

The Role of Long-Distance Trips

Another complexity in the accurate computation of service area is that many rural transit systems have historically provided long-distance transportation between the rural service area and the closest metropolitan area, to provide access to regional medical facilities and major shopping destinations well beyond the core service area. A typical practice is to group as many passenger trips as possible onto the vehicle in the morning, travel to a large urbanized area to take passengers to their medical appointments, remain there during the day (and potentially transport passengers to multiple destinations), and return to the rural community late in the day. While this type of service can result in a relatively high number of revenue vehicle miles and hours per trip, and accurately so, the miles operated from the rural transit operator's primary service area (e.g., a county) to the regional destination (e.g., through an adjacent county and into an urbanized area) would not typically be considered part of the rural transit operator's funded service area (although potentially this service could be operated in coordination with the adjacent county's transit system, further muddying the waters).

However, it is possible that long-distance service may be declining among rural public transit providers, as an increasing number of state Medicaid programs adopt brokerages and other organizational models that shift Medicaid transportation from rural public transportation providers to private medical transportation companies. While much of the long-distance service provided by rural public transportation systems has been historically sponsored by Medicaid, it is (or was) not uncommon for the transit provider to carry general public riders as well. However, without Medicaid revenue, long-distance transportation may be too costly for some rural public transportation providers to provide.

Concluding Remarks

If service area is suggested as a new Rural NTD data element, it may be preferable to use the Census definition for reporting the service area. This would avoid the need for the transit agency to try and calculate its day-to-day service area when this is less than the formal Census-defined area. What this also suggests is that performance measures based on "per capita" may be more accurate and in most cases more meaningful for rural transit than measures that use service area.

MEASURES FOR ASSESSING RURAL TRANSIT PERFORMANCE

Performance measurement for transit has been the topic of considerable research and guidance, though much of the research has been focused on urban transit, for which a national database has existed for decades. While many of the same concepts are applicable to rural transit (measures of productivity, cost-efficiency, cost-effectiveness, reliability, etc., can be used by all types of transit systems), general standards for what can be considered good or poor performance in urban communities do not readily translate. The nature of the rural operating environment means that, in general, productivity will likely be lower and trip lengths will be longer. At the same time, unit operating costs per mile and hour are likely to be lower in rural areas, where salaries tend to be lower, unions may not be in place, and transit organizations are likely to have fewer support functions (and thus smaller overhead expenses).

Development of performance standards for rural transit is not suggested at a national level, because of the wide range of operating environments, population densities, and travel distances involved in reaching regional destinations. Development of performance standards is more appropriate at the state level, where the actual operating environments, economic and regulatory conditions, and state-level program goals and objectives can be taken into account. The population density and terrain of rural Maryland is quite different from those of rural Montana. Transit agencies in some states are funded through local sales tax, while many rural transit agencies in other states subsist on human service agency contracts that provide most of the local match for FTA grants, in some cases without any local governmental funding.

State Development of Performance Measurement Standards

A state-by-state list of state-level performance measurement tools and publications identified in the literature review can be found in Appendix A. Although comprehensive research on state practices was beyond the scope of this study, it appears that many if not most states compile and report performance measures for their subrecipients. *TCRP Synthesis 56,* published in 2004, identified at least six states that based operating funding decisions in part on local system performance (California, Illinois, Indiana, Iowa, North Carolina, and Ohio).[7] The research team is also aware of several other states (including Maryland and Vermont) that factor in performance as a criterion for funding decisions.

Examples of state-level performance measurement systems for subrecipients include:

- **Idaho**—In 2011, the Idaho Transportation Department (ITD) created a new Division of Transportation Performance, which is responsible for ITD's performance management system, processes, and training, in addition to ITD's multimodal planning and grants administration functions (including all functions of the previous Division of Public Transportation). The ITD is currently in the process of developing a grants and performance management system.[8]

  Local transit data have been compiled historically and performance measures developed in Idaho. Performance measures used in state-level reports on local subrecipients in 2011 are reported separately for each mode (intercity bus, local motor bus, demand-response, vanpool, taxi, and personal vehicles) and include:
  - Operating cost per passenger trip
  - Operating cost per vehicle revenue mile
  - Operating cost per vehicle revenue hour
  - Passenger trips per vehicle revenue hour

  The development of ITD performance standards was not identified through the literature search.
- **Maryland**—In 2003, the Maryland Transit Administration adopted performance standards for two categories of services: small urban fixed-route service and demand-response/rural route service. For each category, "successful," "acceptable," and "needs review" ranges were developed for seven performance measures:
  - Operating cost per hour—total operating cost divided by vehicle-hours of service

[7] *TCRP Synthesis 56: Performance-Based Measures in Transit Fund Allocation,* by Robert G. Stanley and Patricia G. Hendren, Cambridge Systematics, Inc., Transportation Research Board of the National Academies, Washington, DC, 2004, p. 17.

[8] *Idaho 2011 Transit Technology Plan* (Final Draft), prepared for the Idaho Transportation Department, Division of Transportation Performance, by McFarland Management, LLC, October 2011.

- Operating cost per mile—total operating cost divided by vehicle-miles of service
- Operating cost per passenger trip—total operating cost divided by the number of passenger boardings
- Local operating revenue ratio—revenues generated through the farebox, advertising, contracts, and other local sources divided by total operating cost
- Farebox recovery ratio—fare revenues divided by total operating cost
- Passenger trips per mile—total passenger trips divided by service miles
- Passenger trips per hour—total passenger trips or boardings divided by service hours

The ranges were based upon detailed analysis of subrecipient data reported for FY 2002. Maryland continues to use these measures in evaluating the performance of each route and demand-response service funded as part of the annual grant application. Services with a pattern of measures in the "needs review" range are reviewed closely and may become ineligible for continued funding through the state.

- **Ohio**—As part of the quarterly reports submitted to the Ohio DOT Office of Transit, local transit providers report data calculated by the reporting form (an electronic spreadsheet) to provide the following performance measures for fixed-route, deviated-route, and demand-response services:
  - Safety—accidents per 100,000 vehicle-miles
  - Reliability—road calls per 100,000 vehicle-miles
  - Service effectiveness—trips per revenue hour
  - Cost-effectiveness—cost per passenger trip
  - Operating recovery ratio—farebox plus contract revenue divided by total operating expense
  - Cost-efficiency—cost per revenue mile
  - Service accessibility—unmet trip requests per total passenger trips requested
  - ADA compliance—ADA-eligible passenger trips denied per total passenger trips denied

  The state publishes an annual *Status of Public Transit in Ohio* report. For rural transit services, the following performance measures are reported for fixed-route and demand-response services:
  - Operating recovery ratio
  - Operating expense/vehicle-mile
  - Operating expense/trip
  - Passenger trips/vehicle-mile
- **Vermont**—The Vermont Agency of Transportation Public Transit Section submits an annual report to the state legislature on public transit route performance. "Successful" thresholds were developed to evaluate routes classified by seven categories:
  1. *Urban*—routes operating primarily in an urbanized area with all-day, year-round service. The city served by the route has a population of at least 17,500 people and high-density development.
  2. *Small Town*—routes operating in towns with 7,500 to 17,500 people with all-day, year-round service. The route typically stays within one town or two adjoining towns, but does not run through long stretches of rural areas.
  3. *Rural*—routes operating in towns with fewer than 7,500 people or connecting two small towns running through undeveloped areas. These routes operate year-round with all-day service, but the frequency may be low (more than one hour between trips).
  4. *Demand-Response*—service does not operate on a fixed schedule, nor does it operate on a fixed route.
  5. *Tourism*—seasonal services that are keyed to a specific trip generator, such as a ski area.
  6. *Commuter*—routes defined as operating primarily during peak periods and often including express segments.
  7. *Volunteer Driver*—a program that is operated with volunteer drivers using their own vehicles. Drivers are reimbursed for mileage at the federal rate but donate their time.[9]

  "Successful" thresholds were developed and are updated annually for two key performance measures:
  - Productivity—defined as passengers per mile for urban routes; passengers per hour for small town, rural, demand-response, and tourism services; and passengers per

[9] *Public Transit Route Performance Reviews, Annual Report for State Fiscal Year 2010,* Vermont Agency of Transportation, 2011, p. 1.

vehicle trip for commuter routes. Productivity is not measured for volunteer driver services.
  - Cost per passenger.

  The state works with the transit agency of any routes and services which do not meet the threshold for success during two consecutive years. If ridership cannot be increased through marketing, route changes, and other appropriate means, funding is discontinued for the underperforming route and reallocated to other unmet needs in the region or state.

- **Washington**—The Washington State DOT Public Transportation Division publishes an annual Summary of Public Transportation that provides data to transit providers, legislative transportation committees, and local and regional governments. Total operating statistics and performance measures are reported for rural, small urban, and urbanized areas and grouped by type of service (including fixed-route, deviated-route, demand-response, and vanpool for rural systems). For the first three categories, the following performance measures are reported:
  - Passenger trips per revenue hour
  - Passenger trips per revenue mile
  - Revenue hours per employee (full-time equivalent)
  - Operating cost per revenue hour
  - Operating cost per revenue mile
  - Operating cost per passenger trip
  - Farebox recovery ratio

  For vanpool services, a common mode among rural and urban transit systems in Washington State, the following subset of the above measures is reported:
  - Passenger trips per revenue mile
  - Operating cost per passenger trip
  - Farebox recovery ratio

Performance Measures for Rural Demand-Response Transportation

TCRP Report 136: Guidebook for Rural Demand-Response Transportation: Measuring, Assessing, and Improving Performance recommends the following six key performance measures:

- **Passenger trips per vehicle-hour**—a productivity measure, defined as total passenger trips divided by total vehicle-hours. As noted in *TCRP Report 136,* this measure is considered by many to be the most important performance measure for demand-response transit.

  Revenue-hours can also be used in place of vehicle-hours, but as observed in this guidebook, the 2008 Rural NTD definition of revenue vehicle-hours for demand-response service (time from pull-out to pull-in) did not align with the urban reporting definition (time from first passenger pick-up to last passenger drop-off). The rural definition would therefore include the deadhead time between pull-out and first passenger pick-up as well as between last passenger drop-off and pull-in—essentially making it equivalent to total vehicle-hours rather than revenue-hours. This discrepancy continues to exist as of the 2010 Rural NTD reporting year.
- **Operating cost per vehicle-hour**—a cost-efficiency measure, defined as total operating cost divided by total vehicle-hours. The use of revenue-hours in place of vehicle-hours is also an option for this type of measure, with the same caveat about the definition of revenue vehicle-hours for demand-response service in the Rural NTD.
- **Operating cost per vehicle-mile**—a cost-efficiency measure, defined as total operating cost divided by total vehicle-miles. Although it provides a similar perspective on performance as operating cost per vehicle-hour, this measure was included in the guidebook as an option for rural systems with limited data reporting practices (i.e., vehicle-miles are more likely to be accurately tracked than vehicle-hours).
- **Operating cost per passenger trip**—a cost-effectiveness measure, defined as total operating cost divided by total passenger trips. As observed in the guidebook, this measure relates productivity to cost-efficiency.
- **Safety incidents per 100,000 vehicle-miles**—a safety and service quality measure, defined as the sum of NTD-defined safety incidents divided by 100,000 vehicle-miles.
- **On-time performance**—a service quality measure, defined as total on-time trips, including no-shows, divided by the sum of total completed trips plus no-shows plus missed trips. The definition of on-time trips is locally determined with variations that include whether the pick-up

time or drop-off time is used, and if pick-up time, how the pick-up window is defined (e.g., a 30-minute span in which the passenger can expect the vehicle to pick them up).[10]

Additional measures recommended by *TCRP Report 136* as interim measures used for assessment of specific service aspects that affect efficiency, effectiveness, or service quality, include:

- **No-Show/Late Cancellation Rate**—defined as the sum of total no-shows plus total late cancellations divided by the total number of scheduled trips. This measure impacts productivity and operating cost-effectiveness.
- **Complaint Rate**—complaints per 1,000 passenger trips or per 1,000 revenue hours. This measure indicates customer satisfaction and is calculated by dividing total passenger trips (or revenue hours) into total number of complaints and multiplying by 1,000. The total number of passenger trips completed or scheduled can be used.
- **Average passenger trip length**—defined as total passenger miles divided by the total number of passenger trips. This measure impacts productivity.
- **Average travel time**—defined as total passengers' travel time divided by the total number of passenger trips. This measure indicates the degree of ride sharing as well as service quality, since ride sharing increases productivity but can also diminish service quality if travel times become too long.[11]

TCRP Report 136 also provides in-depth discussion on what high and low performance on the measures can indicate, as well as the relationships of the recommended measures to each other and the importance of considering them in relation to each other when evaluating a system's performance, and the extent to which variables are under control of the transit agency.

[10]*TCRP Report 136: Guidebook for Rural Demand-Response Transportation: Measuring, Assessing, and Improving Performance,* by Elizabeth Ellis, KFH Group, Inc. and Brian McCollom, McCollom Management Consulting, Transportation Research Board of the National Academies, Washington, DC, 2009, pp. 11–29.

[11]*TCRP Report 136,* pp. 29–31.

Performance Measures for Rural Fixed-Route Transportation

TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System[12] puts forth a set of core performance measures for fixed-route services of various sizes, and defines these and other measures in a detailed catalog. For transit agencies serving areas with populations under 50,000, the following performance measures are recommended for fixed-route:

- Financial Performance Measures
  - **Ridership**—defined as the number of passengers transported.
  - **Productivity**—defined as total passengers divided by total revenue or service hours.
  - **Cost-effectiveness**—a measurement category defined as the ability to meet the demand for transit services given existing resources. Examples of cost-effectiveness measures include farebox recovery ratio, operating ratio, cost per passenger/passenger mile, subsidy per passenger/passenger mile, revenue per passenger/passenger mile, cost per capita.
  - **Cost-efficiency**—a measurement category defined as ability to provide service outputs within the constraints of service inputs. Examples of cost-efficiency measures include cost per vehicle hour, cost per vehicle mile, and cost per vehicle trip. TCRP Report 88 did not include cost-efficiency among the core measures for rural areas,[13] but the category is included here because the research team feels cost per mile and cost per hour are core performance measures for transit in all sized communities.
- Service Delivery Measures
  - **Missed trips**—defined as trips removed from the daily schedule, determined from vehicle and route schedules and incident/dispatching logs.
  - **Complaint rate**—defined as the number of passenger complaints or compliments per

[12]*TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System,* by Kittelson & Associates, Inc., et al., Transportation Research Board of the National Academies, Washington, DC, 2003.

[13]*TCRP Report 88,* p. 112, Table 16.

a specified number of hours, passengers, or trips.
  - **Route directness**—defined as the amount of route deviation from a direct path; examples include ratio of route length to the shortest-path length, additional travel time/distance for a one-way trip, additional travel time/distance compared to an auto making the same trip, number of deviations, difference in overall passenger travel time.
- Safety and Security Measures
  - **Accident rate**—defined as the number of accidents (vehicle and/or customer) per specified distance or time.
  - **Number of incidents of vandalism**—criminal activity directed against transit property.

Note that service *availability* measures recommended by this study will be discussed under "Measuring Levels of Rural Transit Service." Although *TCRP Report 88* also recommends measures of community impact, maintenance, and agency administration, these measures measure aspects of service that require data elements which are not feasible for inclusion in the Rural NTD.

The Oregon study presented the following performance measures for Oregon's rural transit systems (fixed-route and demand-response):

- Revenue miles per trip
- Trips per revenue hour
- Trips per revenue mile
- Operating cost per unlinked passenger trip
- Operating cost per revenue mile
- Operating cost per revenue hour

In addition, percent of operating costs from fares (farebox recovery ratio) as well as percent of operating costs from other revenue sources are presented, although not broken out by mode.

2009 Rural Transit Performance Measures from the Rural NTD

The *Rural Transit Fact Book—2011* presents the following national-level average performance measures of rural transit from the 2009 Rural NTD:

- Trips per mile (fixed-route: 0.63, demand-response: 0.12, total: 0.23) (also cross-tabulated against number of miles provided)
- Trips per hour (fixed-route: 10.8, demand-response: 2.0, total: 3.9) (also cross-tabulated against number of hours provided)
- Trips per vehicle (5,572)
- Miles per vehicle (23,857)
- Hours per vehicle (1,418)
- Operating expense per trip (fixed-route only: $5.96, demand-response only: $15.18, total: $9.91)
- Operating expense per mile (fixed-route only: $3.06; demand-response only: $2.01, total: $2.31)
- Farebox recovery ratio (fixed-route only: 9%, demand-response only: 7%, total: 8%)

Operating expenses per trip and mile and farebox recovery ratio are also presented by size of agency (broken out by number of vehicles into six size categories).

Performance measures are also broken out by FTA region, state, and total Tribal Transit measures.[14]

Concluding Thoughts on Performance Measurements

There are numerous performance measures that can be used to evaluate how well transit services are performing and to diagnose areas of potential improvement. The appropriate measures and standards that a state or transit system selects to use should be driven by program and organizational goals, recognizing that some services that appear to be poor performers may be essential lifeline services.

A core set of performance measures that are frequently used and recommended for rural transit, and which can be derived using data that are already available through the Rural NTD at the system level, include:

1. Passenger trips per vehicle revenue hour
2. Operating cost per vehicle revenue hour
3. Operating cost per vehicle revenue mile
4. Operating cost per passenger trip
5. Farebox recovery ratio
6. Safety incidents per 100,000 vehicle-miles

Ideally, the first five of these measures should be calculated by the mode (at the state level), as

[14] *Rural Transit Fact Book—2011,* Small Urban & Rural Transit Center, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, ND, 2011, pp. 15–17.

well as by individual route and service component (at the system level). Because operating costs are not reported by mode in the Rural NTD, the measures with cost as a factor can only be calculated at the system level using current Rural NTD data elements.

MEASURING LEVELS OF RURAL TRANSIT SERVICE

This section addresses approaches to measuring the levels of rural transit. While this study uses the term "performance measurements" to refer to measures that indicate how *well* a rural transit service is operating—measures of efficiency, effectiveness, cost-effectiveness, safety, and reliability—the term LOS refers to the relative amount of service provided within a given area—how much service is available in terms of time, geographic coverage, and capacity from the perspective of the passenger. Higher levels of service are presumed to meet more transportation needs, attract more riders, and result in higher levels of satisfaction among riders.

The intent of the proposed LOS approaches in this digest is to measure service levels in a manner that allows for meaningful comparisons from one transit system or geographic area to another, as well as for comparing current service levels with the levels that would be appropriate for meeting different degrees of transportation need or demand.

Service Availability Measures from *TCRP Report 88*

For transit agencies serving areas with populations under 50,000, the following service availability measures are recommended as core measures for fixed-route service in *TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System:*

- **Route coverage**—measures of spatial availability such as route miles per square mile, route miles per capita, directional route miles per square mile, and transit street miles per square mile.
- **Frequency**—temporal availability measure indicative of the number of transit vehicles per hour or day (at a specific location or between two locations). The reciprocal measure is *headway,* defined as the time interval between transit vehicles.
- **Hours (span) of service**—temporal availability measure indicative of how long service is provided during a day.[15] This measure corresponds to the "period of service" data in the urban NTD report.

Recommendations in *TCRP Report 88* for measuring demand-response service availability include:

- **Service coverage**—measures of spatial availability such as area served by transit and percent of transit-supportive area[16] served by transit.
- **Hours (span) of service**—temporal availability measure as identified above for fixed-route service.
- **Service hours**—temporal availability measure of revenue hours plus deadhead time.
- **Revenue hours**—temporal availability measure indicative of the number of transit vehicle-hours when passengers are being transported. This measure is similar to revenue vehicle-hours in the Rural NTD (except that *TCRP Report 88* follows the definition used by urban reporters, which is different from the definition used by rural reporters).
- **Service denials**—measure of paratransit availability indicative of the percentage of trip requests in which service cannot be adequately provided, based upon the ADA-defined failure to provide a scheduled trip within an hour of either side of the requested time to travel. *TCRP Report 88* specifically recommends this measure for ADA paratransit, but it can also be useful for rural demand-response service that may experience capacity constraints.
- **Response time**—temporal availability measure indicative of the minimum time between when service is requested and when service can be provided.[17]

  It should be noted that *TCRP Report 88* indicates that this measure is best suited for systems with same-day service and ADA

[15] *TCRP Report 88,* pp. 180–202.

[16] "Transit-supportive area" is defined as "minimum household density of three households per gross acre, or minimum job density of four jobs per gross acre" and thus this second measure is more appropriate for urban transit agencies than rural transit agencies.

[17] *TCRP Report 88,* pp. 180–202.

complementary paratransit to monitor performance and ADA compliance, i.e., measuring actual scheduling and dispatching experiences. However, the response time policy (advanced reservation requirement) can still be a useful measure for rural demand-response public transportation.

- **Welfare-to-work accessibility**—measures of mobility and availability such as the percent of Temporary Assistance to Needy Families (TANF) clients within a specified number of miles, minutes, dollars (presumably total fare), or transfers of daycare, the percent of TANF clients able to access welfare-to-work transportation programs, percent of entry-level jobs with transit service during work hours, and percent of daycare centers with transit service during business hours.[18]

Other non-core measures of service availability included in *TCRP Report 88* that are potentially meaningful for rural transit include:

- **Vehicle coverage**—temporal availability measures such as vehicle-miles/hours per square mile, vehicle-miles/hours per capita, vehicle-miles/hours per route mile, vehicles per zone per hour, and annual vehicle-miles traveled. While *TCRP Report 88* recommends this type of measure specifically for fixed-route service, it is also relevant for demand-response service.
- **Fleet composition**—temporal availability measures indicative of the percent of fleet accessible to particular groups of users, such as percent of trips/vehicles that are wheelchair accessible, percent of fleet composed of low-floor buses, and percent of bus fleet equipped with bicycle racks.[19]

Service Availability Measures from *TCRP Report 100*

The second edition of the *Transit Capacity and Quality of Service Manual* (*TCQSM*)[20] published in 2003 as *TCRP Report 100,* also focuses on urban transit but offers measures that can be applied to rural transit programs.[21] The *TCQSM* uses the LOS concept:

> . . . to quantify quality of service. LOS is used for two main reasons: to ease the explanation of transit service quality concepts to laypeople and for consistency with how other modes already measure quality of service. Fixed-route transit LOS is based on an "A" (highest quality) through "F" (lowest quality) system similar to, but not exactly the same as, letter grades in school. Because of fundamental differences both between fixed-route and demand-responsive services, and among different types of demand-responsive service, a 1 through 8 scale is used to describe demand-responsive LOS.[22]

While LOS thresholds are suggested in the manual, it notes that determination of LOS ranges is a local decision, and the *TCQSM* does not suggest setting national standards:

> The selection of LOS thresholds for each of the service measures presented in this manual represent the collective professional judgment of the TCRP Project A-15A team and panel. However, the LOS ranges—in particular, LOS "F" for fixed-route service and LOS "8" for demand-responsive service—are not intended to set national standards. It is left to local transit operators and policy agencies to decide how or whether to describe performance in terms of levels of service. It is also left to local decision-makers to determine which LOS ranges should be considered acceptable, given the unique characteristics of each agency and the community served. To aid in this effort, this manual provides guidance on the changes in service quality perceived by passengers at each LOS threshold.[23]

It is also important to emphasize that the *TCQSM*'s application of the LOS concept is geared toward the point of view of the passenger, rather than the point of view of the transit agency.

Among the numerous measures included in the second edition of the *TCQSM,* the categories of service quality measures most applicable to rural transit services include:

[18] *TCRP Report 88,* p. 243.
[19] *TCRP Report 88,* pp. 180–202.
[20] *TCRP Report 100: Transit Capacity and Quality of Service Manual,* 2nd edition, by Kittelson & Associates, KFH Group, Parsons Brinckerhoff, Quade & Douglass, and Dr. Katherine Hunter-Zaworski, Transportation Research Board of the National Academies, Washington, DC, 2003.
[21] A current TCRP project, A15-C, is developing the 3rd edition of the *Transit Capacity and Quality of Service Manual* and the conceptual framework for assessing LOS (the A–F scale for fixed-route and the 1–8 scale for demand-response) is being reconsidered.
[22] *TCQSM,* p. 1-2.
[23] *TCQSM,* p. 3-2.

Availability of Fixed-Route Service

- **Service frequency**—how many times an hour a user has access to the transit mode or **average headway**—the inverse measure of the time between service. Geared toward urban areas (and therefore calibrated too highly for most rural areas), the suggested LOS thresholds for average headway range from LOS A: less than 10 minutes to LOS F: greater than 60 minutes.
- **Hours of service or service span**—measured at the route segment or corridor level and defined as the number of hours when service is offered at least hourly without interruption. Geared toward urban areas (and therefore calibrated too highly for most rural areas), the LOS thresholds suggested range from LOS A: 19–24 hours to LOS F: 0–3 hours.
- **Service coverage**—described as a measure of the area within walking distance of transit service, with ¼ mile suggested as a walking radius and therefore service coverage area. Specific measures suggested include route miles per square mile, percentage of the system area served, and percentage of the transit-supportive area covered by transit. For the last measure, the LOS thresholds suggested range from LOS A: at least 90% of transit-supportive area covered, to LOS F: less than 50% coverage.[24]

Availability of Demand-Responsive Service

- **Response time** (or minimum advanced reservation)—minimum amount of time a user needs for scheduling and accessing a trip. Suggested LOS ranges are:
  - LOS 1: < ½ hour
  - LOS 2: ½–2 hours
  - LOS 3: same-day service >2 hours
  - LOS 4: next-day service <24 hours
  - LOS 5: 24–48 hours
  - LOS 6: 48 hours–1 week
  - LOS 7: 1–2 weeks
  - LOS 8: > 2 weeks, or not able to accommodate the trip
- **Span of service**—the number of hours during the day and days per week that demand-response service is available in a particular area. The dimension of days of service is added for the demand-response mode to accommodate rural transit, and LOS measures are presented in a matrix with days of service along the *x* axis and hours of service along the *y* axis. Sample LOS designations for this measure include:
  - LOS 1: >16 hours/day, 6–7 days/week
  - LOS 4: 9–11.9 hours/day, 3–5 days/week *or* >12 hours/day, 3–4 days/week
  - LOS 8: <4 hours/day, <2 days/week *or* any number of hours, < twice per month

Reliability of Demand-Response Service

The following measure, while first a measure of reliability, can also be considered a measure of capacity limitations and unmet need/demand:

- **Trips not served**—includes trips denied and missed trips. LOS measures related to number of trips indicate the experience of any particular customer traveling one round trip per weekday.
  - LOS 1: 0–1% trips not served (No trip denials or missed trips within month)
  - LOS 2: >1%–2% (1 denial or missed trip within month)
  - LOS 3: >2%–4% (1–2 denials or missed trips within month)
  - LOS 4: >4%–6% (2 denials or missed trips within month)
  - LOS 5: >6%–8% (3 denials or missed trips within month)
  - LOS 6: >8%–10% (4 denials or missed trips within month)
  - LOS 7: >10%–12% (5 denials or missed trips within month)
  - LOS 8: >12% (More than 5 denials or missed trips within month)[25]

Fixed-Route Levels of Service Developed for the Oregon Study

As a reference document, *Rural Transit in Oregon: Current and Future Needs* (Dill and Neal, 2010) is noteworthy in its application of the LOS concept to assess rural transit services at the state level.

The Oregon study follows a numerical system for LOS ranges that has an inverse relationship to those used in *TCRP Report 88* and *TCRP Report 100.* That is, a higher-numbered LOS indicates a higher service level, whereas the earlier approaches, which

[24] *TCQSM,* pp. 3-30–3-34.

[25] *TCQSM,* pp. 3-53–3-58.

were modeled on the traditional use of highway congestion LOS, use a lower number or earlier letter to designate a higher service level—comparable to a traditional academic grade or numeric ranking.

The Oregon study also combined several temporal measures into a relatively simple, single range of LOS availability measures. Specifically, for rural fixed-route, five levels of service were developed to measure rural Oregon transit service availability from the perspective of time:

- LOS 1: < 5 days/week, no weekend service
- LOS 2: 5 days a week, no weekend service, more than 60-minute headways
- LOS 3: 5 days a week, no weekend service, 60-minute headways or better
- LOS 4: 6 or more days a week, less than 12 hours of service per weekend day
- LOS 5: 6 or more days a week, 12+ hours of service per weekend day

Recognizing that transit systems often operate different LOS on different routes, the study based each transit system's LOS measure on the best service available for the system (while acknowledging that this may result in an overestimation of service levels).

Demand-response service was essentially classified as a sixth service level in this study, regardless of days per week or hours per day of demand-response service availability.

For the analysis of service availability, the Oregon study presented intercity service as an additional variable/dimension in LOS, rather than addressing LOS specifically for intercity services. Intercity bus was indicated as being provided (or not), similar to demand-response service, and in combination with the other two modes. The set of options for service availability used in several analyses in the study was:

- No service
- Intercity only
- Demand-response only
- Demand-response & intercity only
- Fixed-route LOS 1, no intercity
- Fixed-route LOS 2, no intercity
- Fixed-route LOS 3, no intercity
- Fixed-route LOS 4, no intercity
- Fixed-route LOS 5, no intercity
- Fixed-route LOS 1 & intercity
- Fixed-route LOS 2 & intercity
- Fixed-route LOS 3 & intercity
- Fixed-route LOS 4 & intercity
- Fixed-route LOS 5 & intercity

Among its analyses, the Oregon study looked at LOS by service area housing density (1, 2, 3, or 4 or more housing units per acre) and population. To develop service area measures, the project team mapped the service areas of each rural transit system in Oregon as follows:

- Fixed routes were mapped as lines. A ¼-mile buffer was created around each line to create boundaries for the service area coverage.
- Intercity routes were mapped as a series of points (stops spaced out along the route) and a ½-mile buffer was created around each stop.
- Demand-response services were mapped as the city, county, or other jurisdictional boundary served.

The Oregon study also summarized the extra challenges involved with providing transportation services to persons living in frontier areas (citing the National Center for Frontier Communities definition of six or fewer people per square mile). This was a significant consideration for Oregon, where 78% of the state's geography was considered frontier, but only 3% of the 2000 population lived in frontier areas. Due to the extreme challenge of serving frontier areas—where trip lengths are necessarily longer and resources expended per passenger trip will be extreme—LOS and performance measures relevant to small towns (urban clusters) and higher density rural areas are perhaps not meaningful for frontier areas.

Implications of Using this Approach to Evaluate LOS of Section 5311 Providers through Rural NTD Data

LOS for Rural Fixed-Route Systems. One of the objectives of the current research project is to determine appropriate LOS standards in rural settings for fixed-route, demand-response, and volunteer transportation, building on the findings of *Rural Transit in Oregon.* The Portland State University findings provide a well-researched foundation for measuring LOS for rural fixed-route systems operating along the lines of a traditional urban bus system (though on a smaller scale), i.e., fixed routes operating within a relatively small geographic area along a regular schedule. However, it is important to realize that this type of service represents a small subset of the variety of rural transit service designs operating across the country; demand-response service represents the large majority of rural transit systems across the

Table 7 Summary of the fixed-route LOS ranges in the Oregon study.

Hours per Day	Weekdays		Weekend Days	
	Fewer than 5	5	6	7
Fewer than 12	LOS 1 (< 5 days/ week, no weekend service)	If headways > 60 min.: LOS 2 If headways ≤ 60 min.: LOS 3 (5 days/week, no weekend service)	LOS 4 (6 or more days a week, less than 12 hours of service per weekend day)	
12 or more			LOS 5 (6 or more days a week, 12 or more hours of service per weekend day)	

U.S.[26] Therefore, rural demand-response service levels are likely to be as important as rural fixed-route service levels in many (if not most) states. The LOS standards developed in the Oregon study may have been limited by necessity to the type of transit that can be most readily measured in a standardized way.

The LOS thresholds developed for the analysis of fixed-route Oregon rural transit providers are illustrated in the matrix in Table 7.

While primarily based on time span of service (number of days per week and, on weekends, number of hours per day), frequency of service (headways) is factored in to determine the threshold between LOS 2 and LOS 3.

The Oregon study proposes thresholds for LOS that may be appropriate for use in other states seeking to measure LOS of their rural fixed-route systems, though some states may wish to make modifications to reflect the state's Section 5311 program goals and objectives. For example, instead of factoring headways into the threshold between LOS 2 and LOS 3, it may be important to differentiate between service that is available 5 days a week but fewer than 10 hours per day, and service that is available at least 10 hours per weekday, since below this threshold the transit system will be able to provide trips to a limited number of full-time jobs that fit within the window of operations. As another example, provision of service 7 days a week may be more meaningful in some states than the number of hours provided on a single weekend day.

Considerations in Developing Levels of Service Availability for Rural Demand-Response Services

LOS Numbering Approach

The suggestions in this section follow the Oregon study's use of a scale of LOS 1 and 5, with 1 indicative of the lowest LOS and 5 indicative of the highest LOS. This scale is used here because of the intuitive relationship of numbering the levels as well as its relative simplicity. Also, the 8-level approach of the *Transit Capacity and Quality of Service Manual* was designed to accommodate urban transit services as well as rural services, and the higher levels of service are less likely to be relevant for rural transit. Even for measures where rural and urban transit are comparable, the differences are likely to be more pronounced between 5 gradations than between 8 gradations (although there will be a corresponding loss in measuring precision).

For most of the measures suggested, LOS 4 generally represents the service level necessary to allow for transportation to and from a typical full-time office job (i.e., an 8-hour work shift plus a lunch break, Monday through Friday). This provides an anchor point at which a rural transit provider can meet a significant portion of a community's transportation needs.

Breaking Down Temporal Availability

Developing LOS based on temporal availability—comparable to the LOS for rural fixed-route in the Oregon study—is challenging for rural demand-response service due to the range of service designs and widely varying levels that are found in rural demand-response. The matrix approach for demand-response transit in the *TCQSM* addresses both days and hours in a comprehensive yet streamlined fashion, yet the highest two levels are beyond the financial ability of most rural transit systems to provide.

Another approach could be to separate the dimensions measuring LOS:

- Days of service per week or month, for example:
  - LOS 1: less than weekly (for example, once or twice a month)
  - LOS 2: 1 or 2 days per week
  - LOS 3: 3 or 4 days per week

[26] *Rural Transit Fact Book—2011,* p. 7.

- LOS 4: 5 days per week (enables full-time work trips if combined with corresponding LOS for hours per day)
- LOS 5: 6 or 7 days per week

- Hours of service per day, for example:
  - LOS 1: fewer than 4
  - LOS 2: 4–6 hours per day
  - LOS 3: 7–9 hours per day
  - LOS 4: 10–12 hours per day (enables full-time work trips if combined with corresponding LOS for days per week)
  - LOS 5: more than 12 hours per day
- Response time, for example:
  - LOS 1: more than one week advance notice; waiting list for subscription trips
  - LOS 2: one week–48 hour advance request
  - LOS 3: 24-hour advance request
  - LOS 4: next-day service (per ADA paratransit requirements)
  - LOS 5: real-time scheduling (immediate-response, similar to taxi service)

The response time is often related to service capacity, discussed later in this section.

A Combined Approach with Geographic Availability as Factor

Of course, LOS based on temporal availability alone has limited meaning. The size of the service area, the shape of the population distribution, the location of the major destinations, and the timing of the service to provide meaningful mobility are also important considerations. Particularly when service hours are limited, directionality of service is critical. For example, the rural transportation may be oriented to bring residents of outlying rural areas into the largest town in the service area in the morning, and return them in the afternoon. In contrast, it may be confined to town limits, enabling local residents to travel all over town throughout the day.

Similar to the Oregon study's approach for fixed-route services, a simplified approach could combine two or more LOS variables into defined LOS for demand-response availability. An example is provided in Table 8.

Compounding the complexity of measuring rural demand-response service availability, rural demand-response systems may serve vast areas, or portions of vast areas, on different days of the week and during limited time windows during the day.

Table 8 Sample demand-response service availability thresholds.

Level of Service	Days and Hours of Service Coverage
LOS 1	Most of the service area covered less than 3 days/week
LOS 2	3–4 days/week (or most parts of the service area covered 5 days/week with some areas covered less than 3 days/week), at least 8 hrs/day
LOS 3	All parts of the service area covered 5 days/week, with some parts of the service area covered at least 10 hrs/day
LOS 4	All parts of the service area covered 5 days/week, at least 10 hrs/day, with some weekend service in most parts of the service area
LOS 5	All parts of the service area covered 6–7 days/week, at least 10 hrs/day Mon–Fri

It is not unusual for a multi-county rural service provider to operate very different schedules from one county to the next and even from some parts of any particular county. For example, a transit provider may serve an outlying community 1 or 2 days a week, or twice a month, or even as infrequently as monthly for longer-distance trips. Though very infrequent, this LOS can provide an essential lifeline to rural residents needing transportation to medical appointments or major shopping destinations, and it is a common strategy to stretch limited resources across a large service area.

For example, the Capital Area Rural Transportation System (CARTS), a rural transit provider based in Austin, Texas, serves the non-urbanized areas of nine counties. Among CARTS's family of services are two municipal systems (one fixed-route, one deviated fixed-route), commuter and connector routes from rural communities providing connecting service to the urban transit system in Austin, and curb-to-curb demand-response transportation throughout the nine counties in the CARTS service area, with varying days of service for particular areas. Some areas are served 5 days per week, while others are served 1 to 4 days per week, and others only once or twice a month. Public schedules are published for each of the nine counties so residents of each community know the days on which service is available in their

community.[27] This service approach allows CARTS to stretch resources across its entire, very large service area, serving the less densely populated and more remote areas less frequently than the more populated areas.

Capacity Constraints

Another important factor in demand-response availability is available capacity. If the service is operated 10 hours per day, but only during certain hours of the day, the need/demand exceeds the available capacity. This in effect renders the service unavailable during some peak hours (at least for persons who are denied service during those hours). For example, a rural transit system providing subscription service for human service agency clients to access a day program that begins at 9:00 a.m. and ends at 3:00 p.m. may be unable to accommodate other, non-agency trip requests between 8:00–9:00 a.m. and 3:00–4:00 p.m. (perhaps with a waiting list for service during these hours). Thus, the system could be considered to have a lower LOS because its capacity is inadequate during those hours.

Capacity availability often correlates with response time, since systems with limited capacity often have longer advance notice requirements. Other indicators of capacity constraints include a pattern of late service, missed trips, waiting lists, trip denials, and long telephone hold times or frequent busy signals experienced by those attempting to schedule trips.

The following provides examples of potential LOS thresholds pertaining to rural demand-response service capacity:

- LOS 1: demand strongly exceeds capacity—waiting list for subscription trips, frequent trip denials during 2 or more hours per day, frequent missed trips, long telephone hold times
- LOS 2: demand exceeds capacity—waiting list for subscription trips, infrequent trip denials, infrequent missed trips, frequent late trips, long telephone hold times
- LOS 3: capacity meets demand—infrequent trip denials, infrequent late trips
- LOS 4: capacity exceeds demand—all trip requests met with capacity available to provide more trips
- LOS 5: capacity strongly exceeds demand—periods of vehicle down time

Other Factors

Other factors that influence functional availability of rural demand-response transit service include:

- Fare policy (if service is priced too highly, it becomes unavailable to those in need)
- Accessibility (if there are times of the service period when a wheelchair-accessible service is not available, the service becomes unavailable to anyone who uses a wheelchair)
- Terrain and its relationship to weather conditions (mountainous areas, areas subject to flooding, unpaved roads, and extreme weather conditions can make service unavailable in some areas some of the time)

Clearly there are many variables that affect how available demand-responsive service is with respect to a particular community and mobility need. Development of an algorithm to calculate LOS standards factoring these (and potentially other) variables is a potential project for future research beyond the scope of this study.

Mobility Goals and Service Area Characteristics for Adjusting LOS Measurement

As discussed in the previous section, multiple dimensions come into play in determining appropriate service levels. In an effort to simplify this process, the following key considerations are suggested as starting points for determining an appropriate approach for defining LOS thresholds—a framework tool for defining the shape of the service area and the desired direction(s) of travel.

1. **What are the mobility goals for the service? Is the service intended to provide mobility . . .**
   - **within a small city or town?** This type of mobility need can be efficiently served by a demand-response or route (fixed or flexible) service.
   - **to connect towns?** This type of mobility need calls for intercity service, which could be operated on a fixed- or flexible-route basis.

[27]Service schedules posted on the CARTS website, www.ridecarts.com, as accessed July 2011.

- **throughout a large area (such as an entire county)?** This type of mobility need calls for demand-response or flexible-route service.
- **to a destination outside of the core service area?** Examples:
  - Provide access to a regional destination in another county
  - Connect with a regional/national intercity carrier

  These types of mobility needs call for "many to one" or "many to few" service designs, with the service schedule anchored by the arrival time(s) to be met at the destination(s). Depending upon the size of the area from which riders would originate, the "many" could be served by demand-response or deviated-route service.

  For any particular rural transit provider, the responses to the above questions may include more than one "yes." The responses should shape how measurement of geographic service level is approached.

2. **Are the major trip generators distributed or concentrated?**
   - **What is the population density of the area(s) to be served (measured as persons per square mile or housing units per acre)?** Higher density areas can be efficiently and effectively served by fixed routes or flexible routes, with service frequency a significant factor. Lower density areas may be more efficiently served with demand-response or flexible-route services.
   - **Is the population mostly concentrated in small areas or dispersed across the service area?** It is generally more efficient to serve dispersed populations with demand-response service. Concentrations of population could be served with routed or demand-response service, depending upon the distances involved and their relationship to travel destinations.
   - **Are the major travel destinations clustered in one area** (e.g., the county seat) **or distributed in multiple areas?** (e.g., tribal members may need to access tribal services on a reservation as well as other services, retail, and employment in the largest town near the reservation). The proximity and density of the relationship to the travel origin(s) (population bases) must be taken into account to determine optimal service design in relation to travel destinations.

Defining the LOS for any particular service area and mobility goal(s) should take into account the optimal, sustainable type of service for the area/goal(s). The LOS ranges should then be calibrated or adjusted accordingly.

If this approach is taken, Table 9 presents some suggested categories of service designs based on mobility goals and service area characteristics.

The following service categories are indicated in Table 9 with quotation marks, and will be used for LOS purposes in the next section:

- Small city demand-response
- Small city route
- Large area demand-response
- Intercity

Basing LOS Thresholds on Trip Purpose

Determining the breaking points between service levels is somewhat arbitrary. One recommended approach is to determine LOS thresholds based upon the types of trips that can be made using the service.

- Lifeline transportation—medical appointments, food bank, grocery shopping, Social Security check pick-up—**weekly or biweekly service can begin to meet these needs.**
- Daily needs with fewer than 8 hours at the travel destination—sponsored human service agency trips (day programs), senior lunches, part-time employment, dialysis treatments (typically three days per week), education—**inbound/outbound service at least 5–6 hours per day can begin to meet these needs.**
- Full-time employment
  - Traditional office hours—**am/pm peak-hour only or span of at least 10 hours per weekday can begin to meet these needs.**
  - Retail/restaurant/janitorial—**evening hours on weekdays (in addition to "office hours" span) can begin to meet these needs, weekend hours important.**
  - Manufacturing—**service needs to be available around shift change times, including weekends.** Night shift needs could begin to be addressed with peak only service.

  It is important to note that the lowest LOS for this type of trip can be provided at a fairly

Table 9 Identifying LOS categories for rural transit.

Mobility Goal	Suggested Service Design Options		
	Demand-Response	**Flexible-Route**	**Fixed-Route**
Within small city or town	"Small City Demand-Response" <500 persons/sq mi	"Small City Route" 500–1,000 persons/sq mi	"Small City Route" >1,000 persons/sq mi
Connect towns	"Intercity" Establish demand-response feeder service to town stop where <500 persons/sq mi	"Intercity" Intercity stops in towns with 500–1,000 persons/sq mi	"Intercity" Intercity stops in towns with >1,000 persons/sq mi
Throughout large area	"Large Area Demand-Response" Typically most efficient in areas with widely dispersed populations	"Intercity" Recommended to connect areas of concentrated populations and destinations	Not recommended for rural transit
Destination outside of the core service area	"Intercity" Establish demand-response feeder service from origins where <500 persons/sq mi to a departure stop	"Intercity" From origins in towns with 500–1,000 persons/sq mi, at destination	"Intercity" Only appropriate for rural areas if in conjunction with feeder service

low frequency and still meet needs of transit-dependent riders, so long as service is timed to meet shift starting and ending times. The service frequencies that would be needed to attract "choice" riders are unlikely to be financially feasible for rural transit to provide except in very small service areas, or for destinations with parking constraints (such as resort areas).

- Seasonal visitor/employment needs (resort communities, college towns)—service to support local economy serving both transit-dependent passengers (employees) and choice passengers (visitors/students) during peak seasons—with reduced service in off-season if full-time residents would need some level of access to these areas for employment.
  - Beach towns—peak service in summer season
  - Ski areas—peak service in winter season
  - College towns—peak service during academic year

  A relatively high frequency is needed for "choice riders"; however, high-frequency service could potentially be limited to peak hours and still be an attractively high LOS, depending upon the needs of the local area and the hours of the activity/attraction/employment shift being served.
- Connectivity to regional/national intercity carriers—The minimum service periods will vary widely for any given community, as intercity services may serve the local area at times well outside of the traditional time span for local trip needs—or they may coincide with local trip times.

For each of the service categories indicated in the preceding table with quotation marks, levels of service are suggested in Table 10 to correspond with various trip purposes. Note that this table does not take into account seasonal/resort trips or trips specifically to connect to regional/national intercity carriers.

Estimating Extent to Which Rural Transit Provides Access to Employment

Another possible approach to measuring LOS is to consider the hours of service and geographic coverage in terms of employment access. Such an approach is put forth not as a suggestion for NTD data augmentation, but as an approach that can be used in more in-depth planning studies and where GIS capabilities exist (as discussed earlier in this report under "Issues with Measuring Rural Transit Service Area").

Table 10 Suggested LOS for four service categories.

Level of Service	Target Trip Purpose	Small City Demand-Response	Small City Route	Large Area Demand-Response	Intercity Route
LOS 1	Lifeline—medical, grocery shopping	2–6 hrs/day, or < 5 days/wk	2–6 hrs/day, or < 5 days/wk	Monthly—weekly service	Monthly—weekly service
LOS 2	Human service programs/some part-time jobs	Mon–Fri, 7–9 hrs/day	Mon–Fri, 7–9 hrs/day	2–8 hrs/day, or 2–4 days/wk	2–4 days/week
LOS 3	Some full-time employment (traditional office)	Mon–Fri, 10–12 hrs/day	Mon–Fri, 10–12 hrs/day	Mon–Fri, 90–11 hrs/day	Mon–Fri, 2 round trips/day
LOS 4	More full-time jobs including some alternative shift times	Mon–Fri, 13–15 hrs/day + weekend service	Mon–Fri, 13–15 hrs/day + weekend service	Mon–Fri, ≥ 12 hrs/day	Mon–Fri, ≥ 3 round trips/day
LOS 5	More full-time jobs including more alternative shift times	Mon–Fri, ≥ 16 hrs/day + weekend service	Mon–Fri, ≥ 16 hrs/day + weekend service	Mon–Fri, ≥ 12 hrs/day + weekend service	Mon–Fri, ≥ 3 round trips/day + weekend service

An example of such an approach could be to identify the percentage of the service area that includes major employment destinations and is covered by at least 10 hours per day, 5 days per week (for access to typical office jobs), and longer hours of service/weekend service for round-the-clock work shifts (providing access to manufacturing, retail, and janitorial types of jobs):

- LOS 1: less than 50% of the major employment areas are covered by at least 6 hours per day, 5 days per week
- LOS 2: at least 50% of the major employment areas are covered by 6–9.5 hours per day, 5 days per week
- LOS 3: at least 50% of the major employment areas are covered by at least 10 hours per day, 5 days per week
- LOS 4: 50–75% of the major employment areas are covered by at least 10 hours per day, 6 or more days per week
- LOS 5: More than 75% of the major employment areas are covered by at least 10 hours per day, 6 or more days per week

To be meaningful, this type of approach also needs to take into account where people live, such as by factoring in overall population density or housing density, as well as indicators of where transit-dependent persons live (such as numbers, density, and percentages of households living below the poverty line or with no car available).

Volunteer Transportation

Measuring volunteer transportation service levels should be approached based on the mode of transportation provided. In terms of service availability, from the rider's point of view, the same concerns about time span of service, response time, and geographic area of coverage apply to volunteer-operated service as to professionally operated service.

One potential additional measure for volunteer transportation is the ability of volunteer-operated service to provide more specialized demand-response service, including door-to-door or door-through-door assistance, waiting at intermediary stops (for example, waiting in the pharmacy parking lot while a passenger gets a prescription refilled, or waiting for a parent to drop off children at daycare before driving them to work). These are service features that are not typically considered elements of public transit service, yet in a rural community with very limited transit services, the availability of a volunteer to wait at the daycare center can make the difference in a person being able to keep a job. However, the highly individualized nature of this type of service enhancement makes it challenging to measure.

Concluding Thoughts on Measuring Levels of Rural Transit Service Availability

As demonstrated through the preceding discussion, there is no simple, straightforward way to measure rural transit service levels of availability, given the number of variables involved, and the research team has not attempted to put forward a single set of standards for use on a national level.

Instead, state DOTs are encouraged to take into account the service area characteristics and mobility goals within their state to determine appropriate thresholds for LOS pertaining to availability.

However, from a national perspective, the following three macro-level measures are recommended, as described earlier in this report:

- Vehicle revenue miles per capita
- Vehicle revenue hours per capita
- Passenger trips per capita

Because population within transit service areas is not currently collected in the Rural NTD, national-level data are not readily available for calculating these measures. Before recommending national LOS standards that make use of rural transit service area population, population data are needed.

The *Rural Transit in Oregon* study made use of estimated rural population as the total population outside of urbanized areas in each state. Using 2007 Rural NTD data and 2000 population outside of urbanized areas, the study calculated the following ranges of service:

- 2007 estimated unlinked trips per capita: 0.18 (Florida)—8.95 (Colorado)
- 2007 estimated vehicle-miles per capita: 1.24 (New Hampshire)—17.48 (Vermont)
- 2007 estimated revenue hours per capita: 0.00 (Alabama, Arkansas, Kansas, New Hampshire, Pennsylvania, Vermont, Wisconsin)—2.09 (Alaska)[28]

It is important to note that the population totals in the Oregon study include many areas that are not served by rural transit, and therefore the miles, hours, and trips per capita do not accurately reflect what levels of service are being provided at the local level.

[28]*Rural Transit in Oregon,* p. 70, Table 4-15.

NEEDS ASSESSMENT METHODOLOGIES

A transit needs assessment evaluates the numbers of people in the particular area of interest that will likely *need* transit service based on demographic characteristics affecting transit use, including for example, lack of automobile ownership, disability, and age. The estimated number of trips that they may make on transit is referred to as transit *demand.*[29] The two terms are sometimes used interchangeably, but the distinction is worth noting.

A recent TCRP reference[30] refines the definitional difference between transit need and demand with the following:

> "Need is defined in two ways:
>
> 1. The number of people in a given geographic area likely to require a passenger transportation service, and
> 2. The difference between the number of trips made by persons who reside in households owning no personal vehicle and the number of trips that would likely be made by those persons if they had access to a personal vehicle. This measure is referred to as the Mobility Gap."

Demand, however, is defined as:

> "The number of trips likely to be made over a given period within a given geographic area at a given price and level of service."

Transit demand is typically estimated as part of the planning and implementation of transit service. While there is more attention placed on transit demand analyses for urbanized areas, there are various methodologies for estimating rural transit need and demand.

Current Research Updating the Arkansas Model

Research is currently underway to develop recommendations for quantifying need for rural

[29]*Guidebook for Planning Small Urban and Rural Transportation Programs,* prepared for the New Mexico State Highway and Transportation Department by COMSIS Corporation, U.S. Dept. of Transportation Technology Sharing Reprint, June 1990.

[30]*TCRP Web-Only Document 49: Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation,* by Frank Spielberg, A. T. Stoddard, and Jeanne Erickson, Transportation Research Board of the National Academies, Washington, DC, 2010, p. 3.

transportation services under TCRP Project B-36, "Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation." An interim report[31] was published as *TCRP Web-Only Document 49: Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation,* by Frank Spielberg et al. (submitted Dec. 2009 and published Aug. 2010). The interim report provides a workbook and electronic spreadsheet for estimating both demand and need, based on earlier research and industry-standard models developed by Spielberg and documented in *TCRP Report 3: Workbook for Estimating Demand for Rural Passenger Transportation,* by SG Associates with Leigh, Scott & Cleary, Inc. and C.M. Research, Inc. (1995), including a model that is sometimes referred to as the Arkansas model.

TCRP Web-Only Document 49 defines trips as one-way but notes that they are accounted for differently in the data sources used in the workbook model. Whereas one-way trips reported in the NTD are defined as being counted each time a person boards the vehicle (i.e., unlinked, with a transfer counting as a separate trip), social service program or sponsored trips are considered linked trips. This is an important distinction since this demand model factors in existing levels of program or sponsored trips.

It is also important to note that the Spielberg model relies on a key demographic input that has historically been included in the decennial Census, but was not collected in the 2010 Census: persons aged 16–64 with a mobility disability.

Commonly Used Methodologies Identified in the Literature

Through statewide transit needs assessments published on state DOT websites, as identified during the literature review task, several other commonly used needs assessment and demand projection methodologies were identified and are introduced here.

It is worth noting that some of the statewide studies use the expressions of *need* and *demand* synonymously when estimating passenger ridership that could be experienced in the rural transportation environment.

It is also important to note that many of these methods rely on the use of persons aged 16–64 with a mobility disability, which as noted above is not included in the 2010 Census. The ACS does include disability data, but not specifically mobility disabilities.

Commonly used rural transit need and demand estimation models identified through the literature search are listed with their data inputs in Table 11 and discussed further in the rest of this section.

Arkansas Model

The Arkansas model, also known as the Arkansas Public Transportation Needs Assessment (APTNA) method, was developed in the early 1990s by SG Associates and published in the 1992 *Arkansas Public Transportation Needs Assessment and Action Plan.* This model developed an approach using trip rates for three categories of rural public transportation passengers: older people, people with mobility disabilities, and people living in poverty.

The Arkansas model has been used and adapted in other states, including Arizona.[32] The *Arizona Rural Transit Needs Study* indicates that the APTNA method was used to project rural transit demand by county using the following trip rates:

- 6.79 trips per person per year for elderly persons age 60 and over,
- 4.49 trips per person per year for persons with disabilities under age 60, and
- 20.50 trips per person per year for persons living in poverty under age 60.[33]

Mobility Gap Estimate

The Mobility Gap model calculates need for rural public transportation using two data sources:

- From the NHTS, trips per rural household per day taken by households with zero cars as compared to households with one car. The difference between the two trip rates is referred to as the mobility gap. This measure is computed at the regional and national level.

[31]Note that at the time this research report was being finalized, the final Spielberg-Stoddard model was being prepared under TCRP Project B-36, following the interim panel meeting in January 2012, with a final report anticipated in 2012.

[32]*Rural Transit in Oregon* specifically references the adaptation of the Arkansas model in Arizona, and other studies sometimes refer to the "Arizona model" as well.

[33]*Arizona Rural Transit Needs Study,* prepared for the Arizona Department of Transportation by Cambridge Systematics, 2008, p. 3–13.

Table 11 Rural transit need and demand estimation models identified through the literature search.

Methodology	Notes	What It Estimates	States That Have Used It in Their State-Level Transit Studies (As identified through the online literature search)	Data Inputs
Arkansas Model (a.k.a. APTNA, SG Associates)	Described in *TCRP Report 3,* updated in a workbook in *TCRP Web-Only Document 49*	Demand for rural passenger transportation (both general public and social service trips)	Arizona, Iowa, Minnesota, New Mexico, West Virginia	• Total persons aged 60+ • Persons 16–64 who are mobility limited • Persons living in poverty under age 60 • Trips per mile • Trips per hour • Trips per capita • For program/sponsor trip: number of persons participating in social service programs
Arizona Model	Based upon the Arkansas model; used the following trip rates in the 2008 Arizona Rural Transit Needs Study: • 6.79 annual trips per person aged 60+ • 4.49 annual trips per person aged <60 with a disability • 20.50 annual trips per person aged <60 living in poverty	Need	Minnesota, Oregon	• Total persons aged 60+ • Persons with disabilities under age 60 • Persons living in poverty under age 60
Methods using Trips per Capita (total population)	• Minnesota used trips per capita rates for six categories of rural and urban transit programs—"Peer System Model" • Oregon study calculated trips per capita rates for all rural providers and used rate at the 75% percentile	Need	Minnesota, Oregon	• Population • Current ridership Per Minnesota Peer System Model: • Type of system

(*continued on next page*)

Table 11 (Continued).

Methodology	Notes	What It Estimates	States That Have Used It in Their State-Level Transit Studies (As identified through the online literature search)	Data Inputs
Minnesota Hybrid Model	Combines elements of Arkansas Model and Mobility Gap approach	Need	Minnesota	• Base year population • Base year elderly population (65+) • Base year population below poverty estimate • Base year disabled population estimate • Base year zero vehicle households • Base year total occupied households • Projected population • Projected elderly population
Mobility Gap Model	Described in *TCRP Web-Only Document 49*	Need	Arizona, Iowa, Minnesota, New Mexico	• Persons residing in households below the poverty level • Persons residing in households without a vehicle • Trips per rural household per day with no car available • Trips per rural household per day with one car available
Need Curves	Curves built with peer data; plots supply and demand for different groups of systems—fixed routes only	Need and demand	Connecticut	• Population • Passenger trips • Revenue hours
Washington State Approach	Three models developed at Washington State University for the Washington State DOT for rural counties	Transit-dependent demand/demand by demographic group (3rd model)	Iowa, Minnesota	First two models use: • Total population • Senior population (65+) • Number of persons with a disability (16–64) • Percent of population above poverty threshold Third model also uses: • Youth (<16) • Adult (16–64)
TCRP Report 147: Toolkit for Estimating Demand for Rural Intercity Bus Services	Electronic toolkit applies one of two models based upon user inputs	Rural intercity bus demand for specific route	(Just published in 2011)	• Name of the state primarily served • Name of the urbanized areas and census-designated places where the service will stop • Whether or not the route will serve an airport with commercial air service • Whether or not the route will be operated by a national or regional bus carrier that is part of the national intercity bus network

- From the ACS 3- and 5-year estimates (and prior to 2010, from the Decennial Census), persons residing in households without a vehicle.

The mobility gap multiplied by the number of persons residing in households without a vehicle yields the number of unmade trips.[34]

Methods Using Trips per Capita (Trip Rates for Total Population)

TCRP Web-Only Document 49 recommends developing peer trip rates for passenger trips per capita, passenger trips per vehicle mile (by service type), and passenger trips per vehicle hour (by service type), and using these rates to estimate the resulting ridership based on population to be served and miles and hours to be operated. For each measure, calculating average, minimum, maximum, and median is recommended. These measures were calculated using 2007 Rural NTD data to develop national-level trip rates, although at the simplest level; in this document the rates are disaggregated by service type.

The Minnesota Peer System Model, in developing the Greater Minnesota Transit Plan 2010–2030, uses trips per capita rates for six groups of transit systems: urban fixed-route, ADA paratransit, county, multi-county, and two sizes of small urban (population over 10,000 and under 10,000).

The Oregon study took a slightly different approach, calculating trips per capita for all rural systems in the state and determining the trip rate at the 75th percentile (i.e., the rate at which 75% of providers provide fewer trips per capita and 25% provide higher trips per capita). This 75th percentile rate was used to estimate unmet need for those systems experiencing lower trip rates based on their current service levels.[35]

Need Curves

In *Bus Transit Needs Analysis—Connecticut 2007,* Urbitran Associates prepared need curves that plotted passenger trips per capita against revenue hours per capita for the fixed routes of four categories of systems (major urban, medium/large urban, small urban, and rural), with the assumption that at some point the market will be saturated and demand will level out despite increases in supply. For Connecticut's four rural systems, the need curve shows demand increasing with supply until revenue hours per capita reaches 0.96 (at which point demand is shown to peak at 3.0 passengers per capita—meeting total need based on an optimal LOS). The analysis also calculates 90% and 80% of total need for use in costing out different levels of meeting need, with 90% indicated as optimal service levels. For the rural systems, the 90% level is 0.67 revenue hours per capita, with a corresponding need/demand of 2.7 trips per capita.[36]

Minnesota Models

Several models were used to develop transit need and demand estimates for the *Greater Minnesota Transit Investment Plan* (completed in 2011). Two of the models were specific to Minnesota: the Minnesota Peer System Model and the Minnesota Hybrid Model.

As noted above, the Minnesota Peer System Model, used by the Minnesota DOT in developing the *Greater Minnesota Transit Plan 2010–2030,* uses trips per capita rates for six groups of transit systems.

The Minnesota Hybrid Model incorporates elements of both the Arkansas Model (used in rural areas) and the Mobility Gap approach (used as a starting point in counties with an urban center population above 50,000 as well as counties with unique travel markets such as college students).[37]

Washington State Approach

At least two other states (Iowa and Minnesota) have applied an approach developed for the Washington State DOT for estimating transit-dependent demand. Three models were developed by researchers at Washington State University[38] using survey data from transit systems operating in four mostly rural Washington counties, including both fixed-route and demand-response services. The primary data inputs for this model are total county population, senior

[34]*TCRP Web-Only Document 49.*

[35]*Rural Transit in Oregon,* p. 37.

[36]*Bus Transit Needs Analysis—Connecticut 2007,* prepared for Transit for Connecticut by Urbitran Associates, Inc., 2007, Technical Appendix, pp. 25–26.

[37]*Greater Minnesota Transit Investment Plan,* "Transit Needs Calculation Tech Memo," prepared for Minnesota Department of Transportation by SRF Consulting Group, Inc., 2010, pp. 5, 8–9.

[38]*Demand Forecasting for Rural Transit,* prepared for the Washington State Department of Transportation by Kathleen M. Painter and Kenneth L. Casavant, Washington State University, 1999.

population (age 65 and over), the number of persons with a disability (age 16–64), and the percent of population living above poverty. Two different models/trip rates were developed for systems with and without fares. A third model was developed that also takes into account youth (under 16) and adult (age 16–64) populations, which projects ridership by youth, adults, seniors, and persons with mobility limitations.

Estimating Rural Intercity Bus Demand

The recently published *TCRP Report 147: Toolkit for Estimating Demand for Rural Intercity Bus Services,* provides a sketch-planning guide and supporting electronic tools for estimating demand for rural intercity bus services, such as (but not limited to) those funded under Section 5311(f). The electronic toolkit estimates demand for a specific route using one of two models, based on the inputs submitted, including name of the state primarily served, names of the urbanized area and Census-designated places where the service will stop, population data for any stops not already incorporated into the Census data included in the electronic toolkit, whether or not the route will serve an airport with commercial air service, and whether or not the route will be operated by a national or regional bus carrier that is part of the national intercity bus network. One model estimates the annual ridership based on the average population of the stops served by the route (excluding the largest population stop), route length, and whether or not the route serves an airport or would be operated by a carrier within the national intercity bus network. The other model applies a trip rate using NHTS data on the number of trips over 50 miles in length made by rural residents using public transportation modes.[39]

Availability of Updated Rural NTD Data

A recently updated source of Rural NTD trip rates per hour and mile by service type (fixed-route and demand-response) is the *Rural Transit Fact Book—2012,* published by the Small Urban & Rural Transit Center (SURTC), Upper Great Plains Transportation Institute, North Dakota State University. The 2011 edition was based on Rural NTD data from 2007–2009 and also used data available from the 2007–2009 ACS and the 2009 NHTS. The 2012 edition has updated the original *Fact Book* by adding data for 2010. The 2012 edition had not yet been published during the research summarized in the present digest, and thus data from the 2011 edition were used for this study. An annual update would be an indispensable resource for analyzing and planning for rural public transportation.

In addition to providing trips per mile and trips per hour at the national, state, and tribal levels, the *Rural Transit Fact Book—2011* also breaks out the 2009 trip rates for ranges of miles and hours provided, at the national level. Interestingly, the systems that fell within the smallest 10% in terms of total miles operated in 2009 had by far the highest trips-per-mile rates for both fixed-route (1.61) and demand-response (2.32) services. As noted in the narrative, this may be due to more concentrated service hours in a smaller service area. Public transit services that are limited to a small city or town are also not stretched to cover as much sparsely populated area; with a concentration of residences and destinations, it is easier to provide more trips because the travel distances are limited.[40]

Also as observed in the *Rural Transit Fact Book—2011* narrative, other than in the smallest 10% of systems, the average trips per mile tended to increase (ranging from 0.31 to 0.64) as the number of fixed-route miles increased, while average trips per mile decreased (ranging from 0.35 to 0.09) as the number of demand-response miles increased. The decrease in trips per mile for the increases in demand-response miles may reflect larger service areas of very low density; travel distances tend to be longer when the service area covers an entire county or multiple counties. On the fixed-route side, more miles likely mean more frequent service and/or greater coverage of populated areas, resulting in increased demand as service becomes more convenient and it is possible to go more places within the service area.

A similar relationship was found in the analysis of average trips per hour: beyond the smallest 10% of systems, the average trips per hour increased (4.3 to 13.6) with an increase in total hours of fixed-route systems. For demand-response systems, the average trips per hour decreased (3.8 to 1.8) as the total hours increase. The smallest 10% in terms of hours for both fixed-route and demand-response services

[39] *TCRP Report 147: Toolkit for Estimating Demand for Rural Intercity Bus Services,* by Frederic D. Fravel, Reyes Barboza, Jason Quan, and Jason K. Sartori, Transportation Research Board of the National Academies, Washington, DC, 2011.

[40] *Rural Transit Fact Book—2011,* pp. 15–16.

had a relatively high average trips per hour (6.3 and 6.0, respectively).

These findings underscore the importance of using data from peer systems with comparable numbers of vehicle miles and hours, and not assuming that a single trip rate is scalable to systems of very different size when projecting demand.

Concluding Thoughts on Rural Transit Need Assessment Methodologies

This study provides only a brief overview of several common practices for estimating rural transit need and demand based on the literature search. Most of these methods involve a mobility disability data input that is no longer being compiled as part of the Decennial Census. The most frequently used models appear to be the Arkansas Model (which provided a basis for *TCRP Report 3* and was updated in *TCRP Web-Only Report 49*) and the Mobility Gap Model.

Perhaps the simplest approach for any given community is to determine trips per capita among peer communities. However, it is important to note that the trips per capita approach does not take into account LOS and may underestimate actual need or demand. Basing the peer groupings in part on LOS may help address this.

It is important to differentiate between need and demand. Whereas *need* is defined as the number of people in a given geographic area likely to require a passenger transportation service, *demand* is defined as the number of trips likely to be made over a given period within a given geographic area at a given price and LOS. Because rural transit services are typically constrained by available resources to a relatively low LOS, estimating need, specifically unmet need, is likely to be a first priority.

Research conducted under TCRP Project B-36 has resulted in an in-depth workbook for estimating need and demand for rural transit. TCRP Project B-36, scheduled to conclude in 2012, will much more fully address the topic than the scope of this NCHRP project allows.

TOOLS FOR UNDERSTANDING EFFECTS OF SERVICE TYPES AND LEVELS ON RURAL COMMUNITIES

This study has built on the existing research and presents tools for states and planners at all levels to use in considering how different types and levels of service provide the mobility in different sizes of rural communities:

- Two average span of service worksheets: one electronic spreadsheet for calculating averages of routes that operate at least weekly (as well as demand-response service areas that are covered at least weekly), and one for calculating averages of routes or services that operate less than weekly. These are provided in a Microsoft Excel workbook format; printed versions are attached to this digest as Appendix B.
- Drawing from the literature, a synthesis of potential measures that can be used to evaluate rural transit (as summarized in Tables 4 and 5).
- A framework for approaching LOS measurement as described under Mobility Goals and Service Area Characteristics for Adjusting LOS Measurement (beginning on page 37).

Summary of Recommendations for Core Measurements

Indicators of Performance

The following performance measures are frequently used and recommended for rural transit, and can be derived using data that are already available through the Rural NTD at the system level:

- Passenger trips per vehicle revenue hour
- Operating cost per vehicle revenue hour
- Operating cost per vehicle revenue mile
- Operating cost per passenger trip
- Farebox recovery ratio
- Safety incidents per 100,000 vehicle-miles

Indicators of Level of Service

From a national perspective, the following three macro-level measures are recommended:

- Vehicle revenue miles per capita
- Vehicle revenue hours per capita
- Passenger trips per capita

Population within each local system's rural transit service area is suggested as a new data element for the Rural NTD in order to calculate these measures indicative of level of service.

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Arkansas Public Transportation Needs Assessment and Action Plan, prepared for the Arkansas State Highway and Transportation Department by SG Associates, 1992.

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Public Transit Route Performance Reviews, Annual Report for State Fiscal Year 2010, Vermont Agency of Transportation, 2011.

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Rural Transit in Oregon: Current and Future Needs, conducted for the Association of Oregon Counties on behalf of the Oregon Department of Transportation, by Jennifer Dill and Margaret Neal, Portland State University, Portland, OR, 2010.

Status of Rural Transit, by the National Rural Assistance Program and the Community Transportation Association of America, 2007.

TCRP Report 3: Workbook for Estimating Demand for Rural Passenger Transportation, by SG Associates with Leigh, Scott & Cleary, Inc. and C.M. Research, Inc., Transportation Research Board of the National Academies, Washington, DC, 1995.

TCRP Web-Only Document 46: Rural Transit Achievements: Assessing the Outcomes of Increased Funding for Rural Passenger Services under SAFETEA-LU, by KFH Group, Transportation Research Board of the National Academies, Washington, DC, 2010.

TCRP Web-Only Document 49: Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation, by Frank Spielberg, A. T. Stoddard, and Jeanne Erickson, Transportation Research Board of the National Academies, Washington, DC, 2010.

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TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System, by Kittelson & Associates, Inc. et al., Transportation Research Board of the National Academies, Washington, DC, 2003.

TCRP Report 100: Transit Capacity and Quality of Service Manual, 2nd edition, by Kittelson & Associates, KFH Group, Parsons Brinckerhoff, Quade & Douglass, and Katherine Hunter-Zaworski, Transportation Research Board of the National Academies, Washington, DC, 2003.

TCRP Report 136: Guidebook for Rural Demand-Response Transportation: Measuring, Assessing, and Improving Performance, by Elizabeth Ellis, KFH Group, Inc. and Brian McCollom, McCollom Management Consulting, Transportation Research Board of the National Academies, Washington, DC, 2009.

TCRP Report 141: A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry, by P. Ryus et al., Transportation Research Board of the National Academies, Washington, DC, 2010.

TCRP Report 147: Toolkit for Estimating Demand for Rural Intercity Bus Services, by Frederic D. Fravel, Reyes Barboza, Jason Quan, and Jason K. Sartori, Transportation Research Board of the National Academies, Washington, DC, 2011.

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APPENDIX A: STATE-LEVEL TRANSIT AND SPECIALIZED TRANSPORTATION DATA COLLECTION AND EVALUATION PRACTICES, STANDARDS, AND REPORTS

Information gathered per websites of state DOTs and transit associations.

State	Online Transit and Specialized Transportation Data Collection and Evaluation Practices, Standards, and Reports
Alabama	None found online
Alaska	None found online
American Samoa	None found online
Arizona	Arizona Rural Transit Needs Study (2008): http://www.azdot.gov/mpd/Community_Grant_Services/ArizonaRuralTransitNeedsStudy.asp—estimates need/demand based on the Arkansas Public Transportation Needs Assessment (APTNA) method (p. 3–13—this is the method used in the Oregon study) and also refers to the "Mobility Gap method" State Management Plan mentions Transit Automated Programs Systems (TAPS), which includes performance statistics for Section 5311 (data and forms not found online)
Arkansas	None found online
California	http://www.dot.ca.gov/hq/MassTrans/Transit-Research.html (July 2011)—"DMT staff is currently administering a Transit Data Collection Study" and also "DMT is currently in the process of developing a statewide transit database"
Colorado	None found online
Connecticut	Bus Transit Needs Analysis—Connecticut 2007 is referenced on the state transit association website (http://www.cact.info/resources.htm)—link to report is broken but it is available at: http://ctenvironment.org/images/stories/file/Transportation_PDFs/full_bus_needs_report.pdf Makes use of "need curve" (p. 21)—hours per capita and trips per capita
DC	No rural areas
Delaware	None found online
Florida	Florida Commission for the Transportation Disadvantaged Instructions for Completion of the 2009/2010 Annual Operating Report: http://www.dot.state.fl.us/ctd/docs/2010AORInstructions.pdf Data reported includes unmet trip requests (indicative of unmet need) by type of trip purpose, and reason for denial (specialized not rural public service)
Georgia	Monthly data requirements outlined in the Georgia Rural Public Transportation Program Administrative Guide for Local Programs: http://www.dot.state.ga.us/localgovernment/intermodalprograms/transit/Documents/Section5311.pdf (note: 12M file)
Guam	None found online
Hawaii	None found online
Idaho	Performance reporting requirements: http://i-way.org/Mobility%20Funding/performance Current Service Level Collection Form: http://i-way.org/_literature_77764/Current_Service_Level_Collection_Form—For each route or service segment, collects data on temporal availability, capacity, frequencies, annual service miles and hours, and ridership
Illinois	None found online
Indiana	Quarterly operating data reporting form (trips, miles, hours) on p. IV-20 (92) of: http://www.in.gov/indot/files/5311_Bluebook.pdf (note: 22M file) Population, ridership, miles included in annual report peer comparisons: http://www.in.gov/indot/files/2009IPTAnnualReport.pdf [p. 20 small urban (smaller than as defined for 5307), p. 24]

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(Continued).

State	Online Transit and Specialized Transportation Data Collection and Evaluation Practices, Standards, and Reports
Iowa	Iowa Passenger Transportation Funding Study (2009): http://www.iowadot.gov/transit/regulations/final_funding_study_report_12-15-09.pdf Needs quantification begins on p. 17, refers to Arkansas Public Transportation Needs Assessment (APTNA) Approach, Washington State DOT Approach, and Mobility-Gap Model Local transit reporting requirements described in local transit manual: http://www.iowadot.gov/transit/handbook/Chapter_6.pdf (login required to access online reporting system)
Kansas	Instructions for completing NTD form RU-20: http://www.ksdot.org/burTransPlan/pubtrans/pdf/2008%20Sample%20RU%2020.pdf Vehicle ridership form (by pass. type) and definitions (trips and miles): http://www.ksdot.org/burTransPlan/pubtrans/TransitForms.asp Kansas 2010 demographics by county (provided by KUTC for planning/applications): http://www.kutc.ku.edu/pdffiles/2010KSCountyDemographics.pdf
Kentucky	Monthly summary report (trips by amb/non-amb, miles, days, hours): http://transportation.ky.gov/Transportation-Delivery/Forms/Monthly Summary Report.xls
Louisiana	None found online
Maine	Projected FY 2009 trips, miles and estimated population for each provider in Biennial Operations Plan for Transit: http://www.maine.gov/mdot/passenger-transportation-planning/bop.php Section 5311 is allocated based on regional population (per decennial census), road mileage and square miles Road miles per 1,000 persons (described on p. 13 on SMP): http://www.maine.gov/mdot/passenger-transportation-planning/documents/smp/smpjune222009.pdf Spreadsheet of regions on p. 10 of SMP appendices: http://www.maine.gov/mdot/passenger-transportation-planning/documents/smp/smpappendicesjun222009.pdf
Maryland	Not posted online; resources available off-line include performance standards established for subrecipients, the report that recommended these standards, and subrecipient reporting forms
Massachusetts	None found online
Michigan	Michigan Public Transit Facts Program Data: http://www.michigan.gov/mdot/0,1607,7-151-9625_21607-55117—,00.html Passengers by type, miles, hours; calculate passengers per population in performance report
Minnesota	Greater Minnesota Transit Investment Plan: http://www.dot.state.mn.us/transit/reports/investmentplan/index.html Transit Needs Calculation Technical Memorandum explores five models (Minnesota Peer Model, Arkansas Model, Arizona, and develops a new "Minnesota Hybrid Model") 2010 Transit Report/Operating Report includes ridership, hours: http://www.dot.state.mn.us/transit/reports/transitreports/10/index.html Revenue Hours per Capita are assessed as part of peer review in the 2008 Greater Minnesota Public Transportation Plan: http://www.dot.state.mn.us/transit/reports/transitplan/index.html
Mississippi	None found online
Missouri	None found online
Montana	Quarterly report for operating assistance requires ridership, miles, hours, days: http://www.mdt.mt.gov/business/grants_transit.shtml
Nebraska	2005 rural study final report & exec summary can be downloaded through this page: http://www.dor.state.ne.us/rpt/pub-transp.htm (no quantitative data though)
Nevada	None found online
New Hampshire	None found online
New Jersey	None found online

State	Online Transit and Specialized Transportation Data Collection and Evaluation Practices, Standards, and Reports
New Mexico	New Mexico Statewide Public Transportation Plan (2010): http://nmshtd.state.nm.us/upload/images/Programs-Transit%20and%20Rail-/NM%20Statewide%20Public%20Trans%20PlanFINAL.pdf Beginning p. 44: analysis of needs (per Cambridge Systematics methodology developed for New Mexico Strategic Multimodal Plan, 2007) and demand (Cambridge Systematics, 2006, based on TCRP Report 3)
New York	Annual Report on Public Transportation Assistance Programs in New York State, 2005 (nothing newer posted): https://www.nysdot.gov/divisions/policy-and-strategy/public-transportation/reports-publications#B (includes traditional performance measures)
North Carolina	Trips, miles, hours in FY 2010 Ridership Report: http://www.ncdot.gov/nctransit/
North Dakota	Quarterly request for operating reimbursement requires trips by type, miles, hours: http://www.dot.nd.gov/forms/sfn58544.pdf
Northern Mariana Islands	None found online
Ohio	Rural operating data form and definitions: http://www.dot.state.oh.us/Divisions/Planning/Transit/Pages/Rural.aspx Includes trip denials/refusals/turndowns (indicative of unmet need) Trips (E&D broken out), miles and hours reported in the annual Status of Public Transit reports: http://www.dot.state.oh.us/Divisions/Planning/Transit/Pages/StatusofPublicTransit.aspx
Oklahoma	2010 Directory of Rural Transit Providers (with trips, revenue miles, passenger miles): http://www.okladot.state.ok.us/transit/pdfs/2010dir.pdf
Oregon	Oregon Public Transit Information System (OPTIS) web-based grant management software (requires login): http://www.oregon.gov/ODOT/PT/TECH_ASSIST/OPTIS_FILES.shtml Agency Quarterly Report and Instructions: http://www.oregon.gov/ODOT/PT/reporting/index.shtml#quarterlyreporting [includes one-way rides (& E&D), revenue service miles, revenue service hours]
Pennsylvania	Transit Operator Performance Measures (2007) developed recommendations: ftp://ftp.dot.state.pa.us/public/Bureaus/Cpdm/TAC/TRANSIT_OPERATOR_PERFORMANCE_MEASURES_Final_Report.pdf PA Public Transportation Annual Performance Report Fiscal Year 2009–10 Transit Agency Profiles—April 2011: ftp://ftp.dot.state.pa.us/public/bureaus/PublicTransportation/GeneralInformation/BPTFY2009-10Profiles.pdf
Puerto Rico	None found online
Rhode Island	A Vision for the Future of Transit in Rhode Island, RIPTA's Five Year Strategic Plan to Keep Rhode Island Moving—Goal 3, Objective 5: Reduce flex scheduling requirements from 48 hours to 24 hours (refers to rural service): http://www.ripta.com/stuff/contentmgr/files/0/650ecd673e64ab35f9e45ac146a62ea5/miscdocs/12.pdf
South Carolina	Trips, vehicle miles, vehicle hours in South Carolina Transit Trends Annual Report FY 2009–2010 Public Transportation Performance Report: http://www.dot.state.sc.us/getting/pdfs/FY2010TransitTrendsAnnualReport.pdf Transit need quantified (Arkansas and Mobility Gap Methods) in South Carolina Statewide Transit Plan (2008): http://www.scdot.org/inside/multimodal/pdfs/STP-StatewideTransitPlan.pdf. (Also compared ridership need per capita in Iowa, Minnesota, North Carolina, and Washington (pp. 56–57) and "Adjusted Needs" method decided upon) Public Transportation Return-on-Investment Study is underway: http://www.scdot.org/inside/transitplanning-ongoing.shtml

(*continued on next page*)

(Continued).

State	Online Transit and Specialized Transportation Data Collection and Evaluation Practices, Standards, and Reports
South Dakota	2009 statistical report includes passenger type breakdown, trip purpose breakdown, and total miles: http://www.sddot.com/fpa/transit/docs/FY09Stat%20Report.pdf Data collection online requires password: http://apps.sd.gov/applications/ha56transit/transitreporting.asp
Tennessee	Includes trips, revenue miles, revenues hours, peak vehicles and service area population; reports passenger trips per capita: http://www.tdot.state.tn.us/publictrans/docs/FY09MultimodalAnnualReport.pdf
Texas	Section 5311(f) subrecipients are required to report number of one-way scheduled stops, per p. 31 of the grant application: http://ftp.dot.state.tx.us/pub/txdot-info/ptn/rfp_annual.pdf 2009 transit statistics report http://ftp.dot.state.tx.us/pub/txdot-info/ptn/2009_transit_statistics.pdf (reports for rural subrecipients, revenue & actual service miles & hours, passenger trips)
Utah	None found online
Vermont	Public Transportation Policy Plan Performance Framework includes measures related to LOS, including miles and hours per service day: http://www.aot.state.vt.us/PublicTransit/documents/PTPP/AOT-OPS-PT_PTPP_Chapter3.pdf Public transit route performance reviews were also available off-line.
Virgin Islands	None found online
Virginia	Transit Service Design Guidelines (2008) indicate typical operating characteristics for various modes: http://www.drpt.virginia.gov/activities/files/Transit_Service_Design_Guidelines_FINAL.pdf Local Bus, Feeder Service, and Circulators—p. 39, Demand Response Bus—p. 41 (seem geared toward urban services)
Washington	Local services report trips, miles and hours in report: http://www.wsdot.wa.gov/NR/rdonlyres/FD3B3296-B33B-4386-9357-800CC7DC0F3E/77915/AppendixB.pdf, p. 40 2009 Statewide Operating Statistics includes employee FTEs, p. 5: http://www.wsdot.wa.gov/NR/rdonlyres/58224063-BFE5-46DA-877B-6C47E01AB24E/0/2009TransitUpdate.pdf
West Virginia	In the West Virginia Multi-modal Statewide Transportation Plan (2010), transit demand was estimated using TCRP Report 3, APTNA, and Peterson and Smith Trip Generation Rate Model, grouped into 6 county peer groups (p. 5–8): http://www.transportation.wv.gov/highways/programplanning/planning/statewide/Documents/West_Virginia_Long_Range_Multi-modal_Transportation_Plan.pdf
Wisconsin	System Effectiveness and Performance Goals report, in Shared-Ride Taxi Operating Assistance Program 2011 Application Booklet, includes passengers/capita and revenue hours/capita: http://www.dot.state.wi.us/localgov/docs/operating-booklet-taxi-2011.pdf Service Characteristics report form includes platform hours: http://www.dot.state.wi.us/localgov/transit/ruralsmall.htm
Wyoming	None found online

Small Urban & Rural Transit Center (SURTC):

Transportation, Distance, and Health Care Utilization for Older Adults in Rural and Small Urban Areas (2010). Available at: http://www.ugpti.org/pubs/pdf/DP236.pdf.

Identifying Anticipated Transportation Investments, Quantifying Projected System Revenues, and Determining the Adequacy of Resulting Levels of Service (current research). Available at: http://www.surtc.org/research/details.php?view=78.

Rural Transit Fact Book (completed August 2011). Available at: http://www.surtc.org/transitfactbook/.

Tribal Transit Demographic Need Indicators (2007). Available at: http://www.ugpti.org/pubs/pdf/DP197.pdf.

APPENDIX B

Worksheet for calculating average period of service for services that operate at least one day per week.

	Route/service/zone name	Weeks operated per year	Hours Available per Day (total span)							Week Totals		Mon-Fri Totals & Averages				Sat-Sun Totals & Averages				Annual Totals	
			Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total days per week	Total hours per week	Total week-days per week	Total weekday hours per week	Average hours per weekday - active weeks*	Average hours per weekday - over 12 months**	Total weekend days per week	Total weekend hours per week	Average hours per weekend day - active weeks*	Average hours per weekend day - over 12 months**	Total Days Operated per year	Total Hours Available per year
1										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
2										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
3										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
4										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
5										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
6										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
7										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
8										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
9										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
10										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
11										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
12										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
13										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
14										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
15										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
16										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
17										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
18										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
19										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
20										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0
etc. - Insert rows above and copy formulas as needed.										0	0	0	0	0.00	0.00	0	0	0.00	0.00	0	0

** Average during those weeks of actual operation.*
*** Average per week for entire year (including weeks during which service did not operate).*

Worksheet for calculating average period of service for services that operate less than weekly.

	Route/Service/Zone Name	Schedule Description *(example: 2nd & 4th Tues per month)*	Total Hours Available on Days of Service	Days Operated Per Month	Months Operated Per Year	Total Hours Available Per Active Month*	Total Hours Available Per Year	Total Days Operated Per Year	Average Weekly Period of Service-Active Months*	Average Hours Per Week-Over 12 Months**
1						0	0	0	#DIV/0!	0.00
2						0	0	0	#DIV/0!	0.00
3						0	0	0	#DIV/0!	0.00
4						0	0	0	#DIV/0!	0.00
5						0	0	0	#DIV/0!	0.00
6						0	0	0	#DIV/0!	0.00
7						0	0	0	#DIV/0!	0.00
8						0	0	0	#DIV/0!	0.00
9						0	0	0	#DIV/0!	0.00
10						0	0	0	#DIV/0!	0.00
11						0	0	0	#DIV/0!	0.00
12						0	0	0	#DIV/0!	0.00
13						0	0	0	#DIV/0!	0.00
14						0	0	0	#DIV/0!	0.00
15						0	0	0	#DIV/0!	0.00
16						0	0	0	#DIV/0!	0.00
17						0	0	0	#DIV/0!	0.00
18						0	0	0	#DIV/0!	0.00
19						0	0	0	#DIV/0!	0.00
20						0	0	0	#DIV/0!	0.00
etc.–Insert rows above and copy formulas as needed.						0	0	0	#DIV/0!	0.00

*Average during those months of actual operation.
**Average per week for entire year (including months during which service did not operate).

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