Rural Transit Planning, Demand Estimation, and Cost-Benefit Analysis

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Tucson, AZ
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Small Urban and Rural Transit Center
Upper Great Plains Transportation Institute

OUTLINE

About SURTC
Overview of Demand-Response Transit
Quality of Service
Capacity Planning
Ridership Estimation
Cost-Benefit Analysis
Discussion

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Small Urban and Rural Transit Center (SURTC)

Research

Education

Training

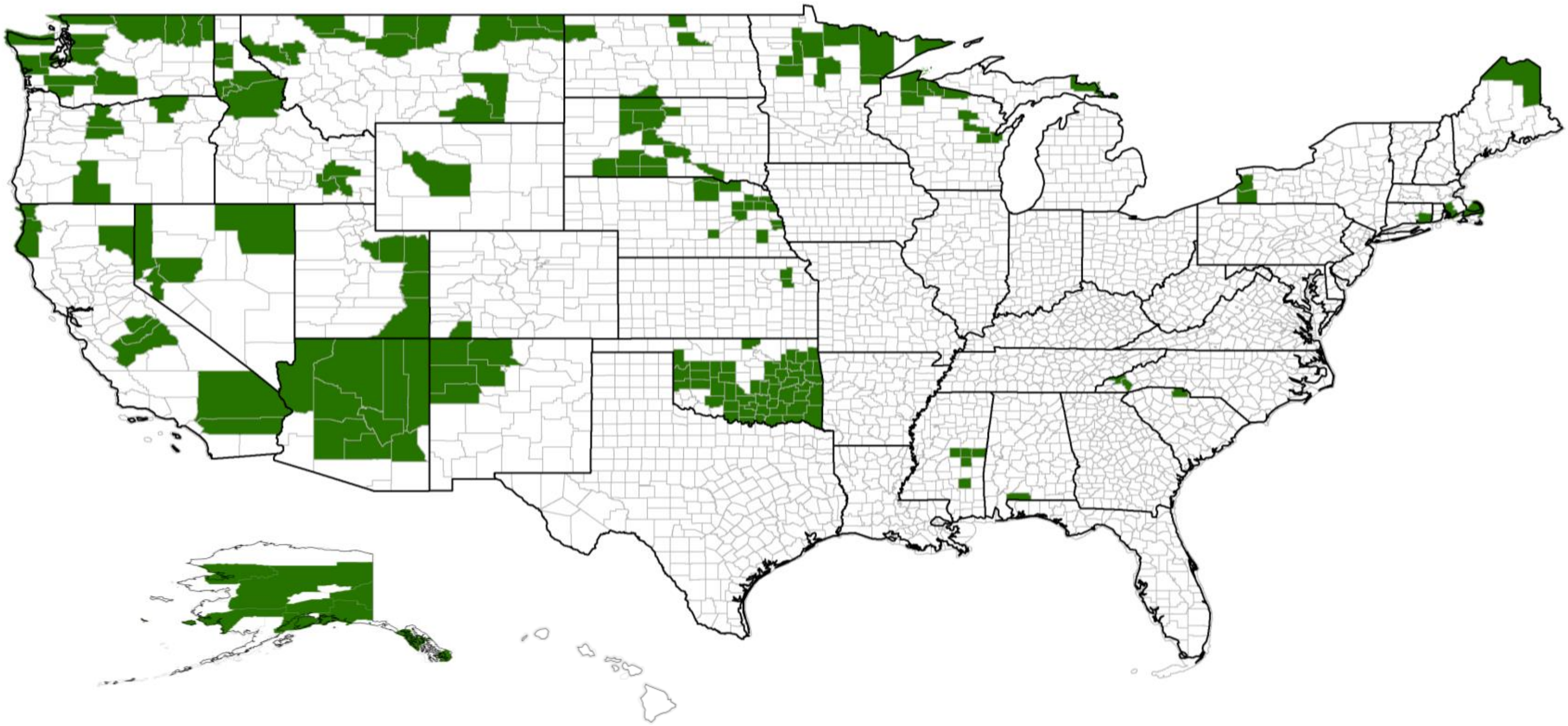
SURTC Partnerships

- Western Transportation Institute/Montana State University and Eastern Washington University
  - Small Urban and Rural Livability Center
  - Small Urban, Rural and Tribal Center on Mobility
- National Transit Institute at Rutgers University

Previous SURTC Tribal Research

• 5311(c) Tribal Transit Funding: Assessing Impacts and Determining Future Program Needs	2011
• Assessing Impacts of Rising Fuel Prices on Rural Native Americans	2008
• Tribal Transit Demographic Needs Indicators	2007
• Turtle Mountain and Rolette County Transit Development Plan	2007
• Rural Transit Fact Book	2011-17

Counties with Tribal Transit Service



Tribal Transit Statistics

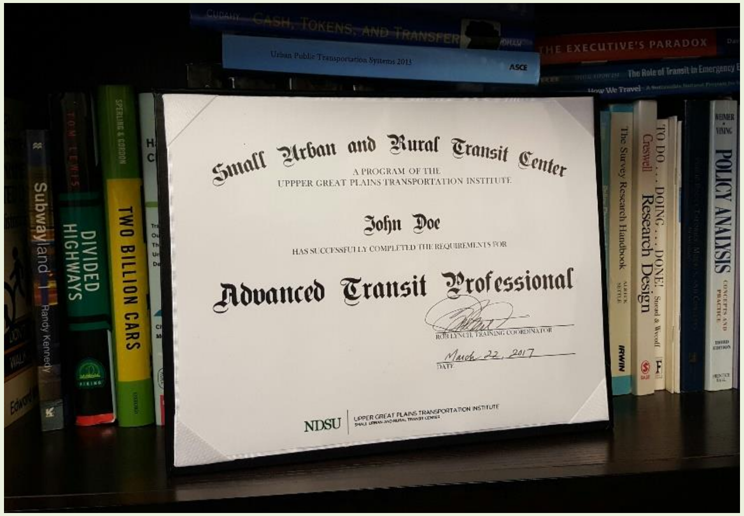
	2013	2014	2015
Number of Agencies	103	128	132
Annual Ridership (thousand rides)	2,841	2,879	3,555
Annual Vehicle Miles (thousand miles)	17,897	18,664	20,893
Annual Vehicle Hours (thousand hours)	856	914	935
Number of Vehicles	674	776	926
% Vehicles ADA	67%	67%	64%
Average Vehicle Age (years)	5.3	5.5	5.7
Average Vehicle Length (feet)	22.2	22.2	22.1
Average Vehicle Capacity	14.6	14.3	13.9
Trips per Vehicle	4,227	3,711	3,839
Miles per Vehicle	26,632	24,051	22,563
Hours per Vehicle	1,274	1,178	1,009
Trips per Mile	0.16	0.15	0.17
Trips per Hour	3.3	3.2	3.8
Operating Expense Per Trip	14.74	15.95	15.81
Operating Expense Per Mile	2.34	2.46	2.69
Farebox Recovery Ratio	0.05	0.05	0.04

SURTC Training

- TRANSIT I – The Foundations
- TRANSIT II – The Pillars
- Training workshops – numerous topics
- Tribal transit training

Advanced Transit Professional

- Complete TRANSIT I – The Foundations (formerly *Principles of Transit Management*)
- Complete TRANSIT II – The Pillars (formerly *Advanced Transit Management*)
- Non-academic track program



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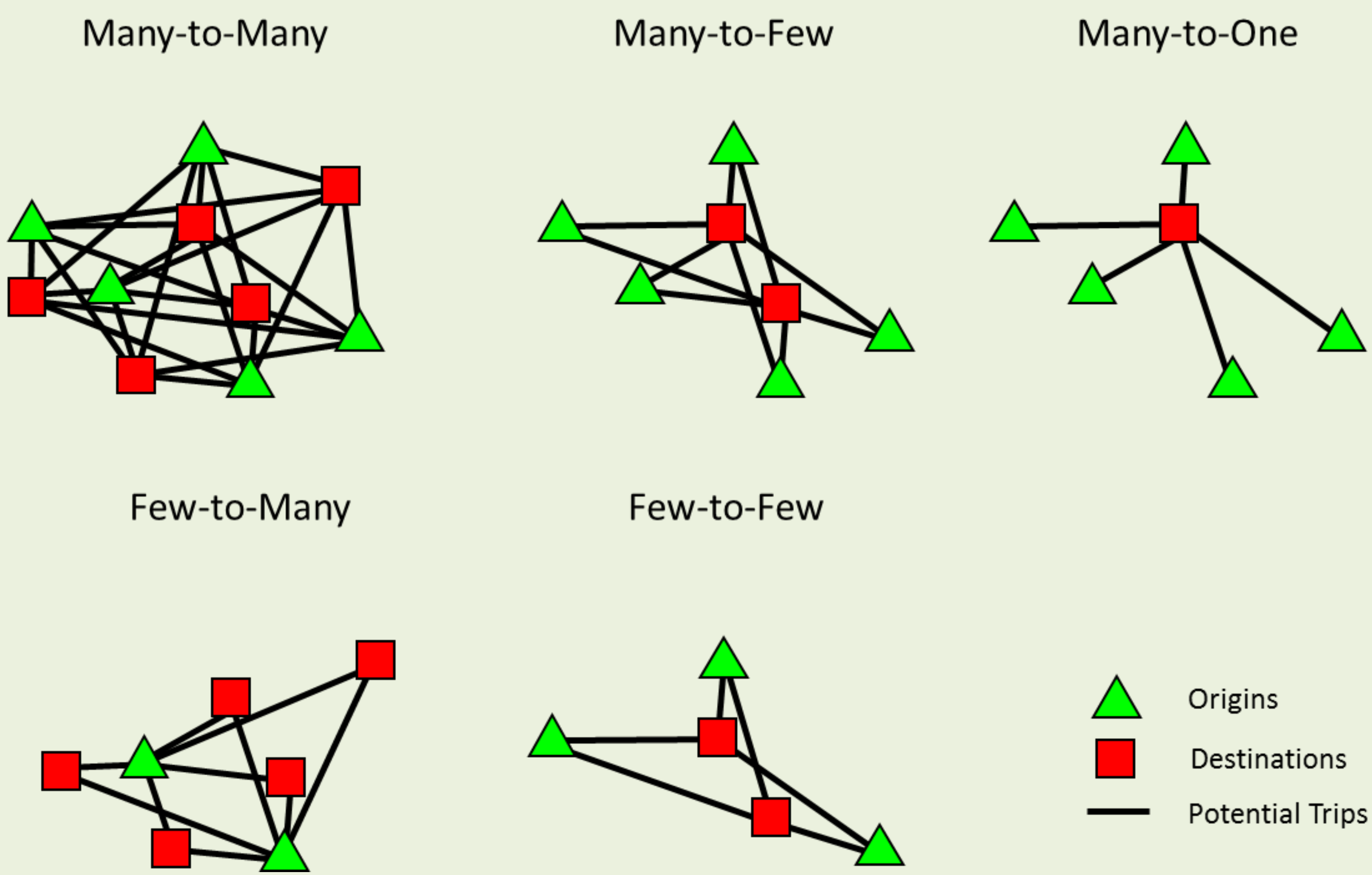
Definition and Overview

- Demand response transit (DRT) is a form of public transportation characterized by flexible routing and scheduling of small- to medium-size vehicles operating in a shared-ride mode between pick-up and drop-off locations according to passengers' needs
- Historically, DRT has been referred to as "dial-a-ride" service
- More recently, DRT has evolved to include a range of services—flexible transit services—that share attributes of pure DRT and fixed-route service
  - Share a common element of trip reservation
  - Services vary in their degree of flexibility, rider groups served, and operational and performance attributes

Service Pattern Types



Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Types of DRT Service

- General Public
- Limited Eligibility
- ADA Paratransit
- Human Service Transportation
- Jitney
- Flexible Transit Services

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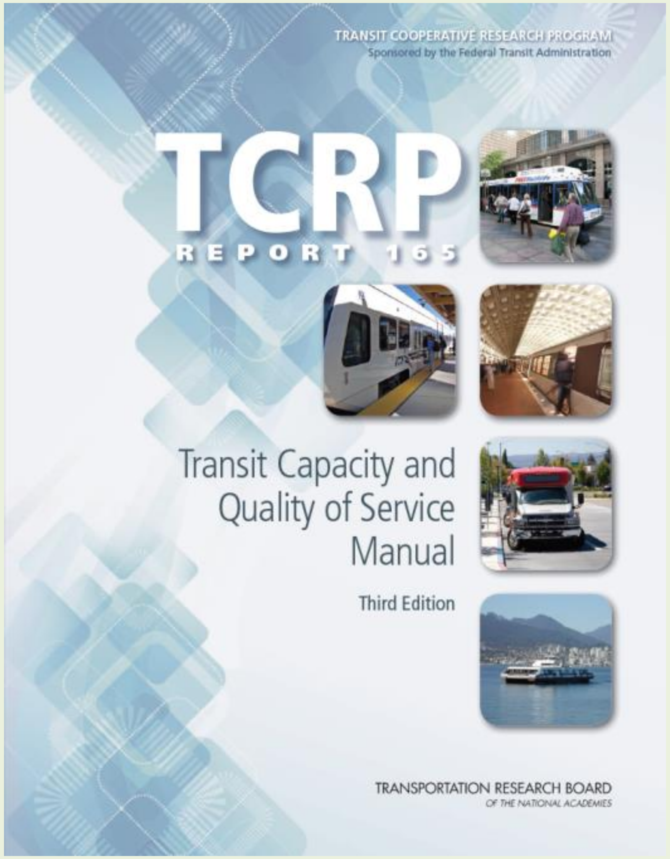


TCRP Report 165: Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition

Kittleson & Associates, Inc., Parsons Brinckerhoff, KFH Group, Inc., Texas A&M Transportation Institute, ARUP

2013

What Matters to Customers?

- Service availability
  - Is transit an option?
- Comfort and convenience
  - If it is an option, would you want to use it?

- Quality of service (QOS) focuses on the passenger point of view
- Other points of view are also valid and need to be considered
  - May have conflicting objectives (e.g., passenger comfort vs. agency resources)
  - Best-quality passenger service may not be feasible or desirable
  - ADA requirements must always be met

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Transit Trip Decision-Making Process

<u>Availability:</u>

- A key decision is determining whether or not transit service is even an option for a particular trip.
- Transit service is option only when:

  1. *Service is available at or near the locations and times that one wants to travel, and one can access it* ***(spatial availability)****;*
  2. *Service is provided at the times one desires to travel-often including the return trip* ***(temporal availability)****;*
  3. *One knows how to use the service* ***(information availability)****; and*
  4. *Sufficient space is available on transit vehicles and, potentially, at supporting facilities such as park-and-ride lots* ***(capacity availability)****.*

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Transit Trip Decision-Making Process

Comfort and Convenience:

- If transit service is available as described before, then transit becomes an option for a given trip.
- At this point, passengers weigh the comfort and convenience of transit against competing modes.
- Some of the things that a potential passenger may consider include the following:
  1. *Is the service reliable?*
  2. *How long is the wait? Is shelter available at the stop while waiting?*
  3. *Are there security concerns-walking, waiting, or riding?*
  4. *How comfortable is the trip? Will I have to stand? Are there an adequate number of securement spaces? Are the vehicles and transit facilities clean?*
  5. *How much will the trip cost?*
  6. *Is a transfer required?*
  7. *How long will the trip take in total? How long relative to other modes?*

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Seven Demands of Public Transit*

1) It takes me *where* I want to go.
2) It takes me *when* I want to go.
3) It is a good use of my *time*.
4) It is a good use of my *money*.
5) It *respects* me in the level of safety, comfort, and amenity it provides.
6) I can *trust* it.
7) It gives me *freedom* to change my plans.

*Source: Walker, Jarrett. *Human Transit: How Clearer Thinking about Public Transit Can Enrich Our Lives and Our Communities.* Washington, DC: Island Press, 2012.

Quality of Service (QOS) Framework Outline

- Based on:
  - Availability
  - Comfort and convenience
- Performance measures
  - Used to set service standards
  - Evaluate the quality of service provided

Exhibit 4-10
Quality of Service Framework: Fixed-Route Transit

Availability	Comfort and Convenience
Frequency	Passenger Load
Service Span	Reliability
Access	Travel Time

Exhibit 4-11
Quality of Service Framework: Demand-Responsive Transit

Availability	Comfort and Convenience
Response Time	Reliability
Service Span	Travel Time
Service Coverage	No-shows

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Response Time

- Defines how far in advance passengers must schedule a DRT trip
- Measured as the minimum amount of time a rider needs to schedule and access a trip, or the minimum advance reservation time
- Many DRT providers also stipulate a maximum response time
  - Helps to reduce number of cancellations when passenger plans change and no-shows, when the passenger forgets to cancel the reservation

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Response Time: Seven service levels

- Guaranteed (standing-order or subscription service)
- Same-day service
- Same-day service on a space-available basis
- Will-call/call when ready
- Next-day/24-hour advance reservation
- Two-day/48-hour advance reservation, up to a week
- More than one week in advance

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Service Span

- Measures the days per week and hours per day that DRT service is available
- Particularly important for the DRT mode because many small communities provided limited service
- As number of days of service decreases, DRT service becomes more of a lifeline service
- As number of hours of service per day decreases, number of trip purposes served decreases and requirement for pre-planning trips increases

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Days of Service: Five service levels

- 7 days per week
- 6 days per week
- 5 days per week
- 1 to 4 days per week
- Less than weekly

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Hours of Service: Five service levels

- 16 or more hours per day
- 12 to 15 hours per day
- 9 to 11 hours per day
- 5 to 8 hours per day
- Less than 5 hours per day

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

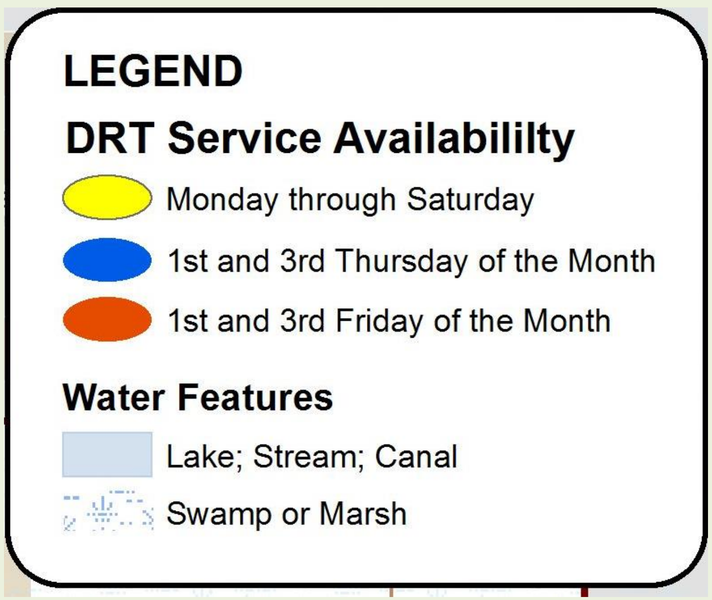
Service Coverage

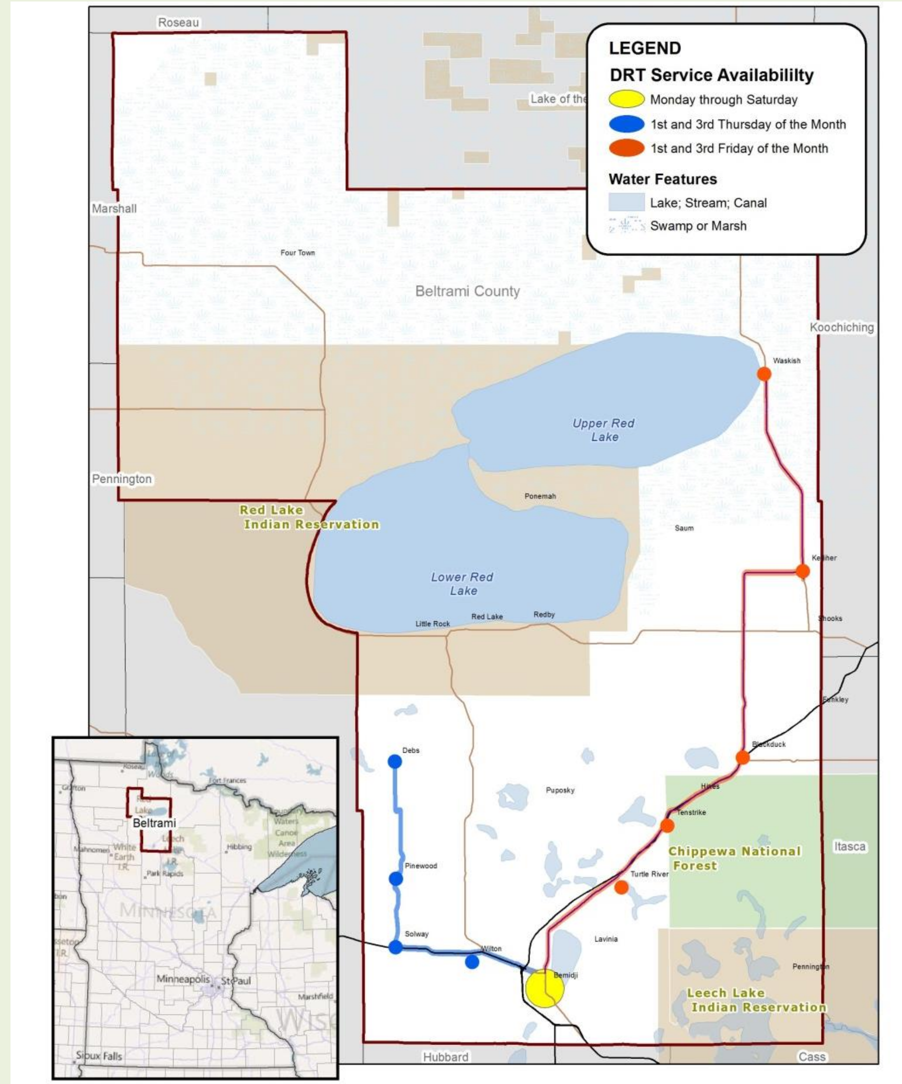
- Measures the geographic area where DRT service is provided
- Typical for service to be available throughout a jurisdiction, as opposed to fixed-route service
- When service coverage and service span vary within a service area, it may be useful to map the different levels of DRT availability

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Service Coverage Map Example

- Based on service span provided
  to different portions of the service area





Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Reliability

- A critical measure of service level from the passenger's perspective
  - Will I be able to reserve a ride when I call, or will all the rides be taken?
  - Will the driver get me to my appointment on time?
- Because of the shared-ride nature of DRT service, there is more variability than with fixed route service
  - Available capacity to serve a trip request
  - Window of time when the pick-up will occur
  - Variable travel time to the destination, depending on other passenger pick-ups and traffic conditions
- Two measures used to assess reliability
  - On-time performance
  - Trips turned down

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

On-Time Performance

- Measures the degree to which DRT vehicles arrive at the scheduled times
  - Calculated at the pick-up end of a trip
  - For time-sensitive trips (e.g., work, school, medical appointments), also calculated for the drop-off end
- For pick-ups, any time with the provider's defined pick-up window is considered on-time
- For drop-offs, any time at or before the required time is considered on-time
- Measured by percentage of on-time trips
- Calculate from driver logs
- High levels of on-time performance will negatively impact productivity

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

On-time Performance: Five service levels (these assume 30-min “on-time” window)

- 95% on-time or better
- 90 to 94% on time
- 80 to 89% on time
- 70 to 79% on time
- <70% on time

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Trips Turned Down

- Measures the degree to which passengers can obtain service at their desired time or at a negotiated time that also works for them
- Calculated as the percent of service requests that are turned down due to a lack of capacity at the passenger's desired time(s)
- Most DRT providers turn down trips on an occasional basis
  - Unusual demand
  - Temporary shortage of drivers
- Frequent trip turn-downs signal insufficient capacity
  - May require adjustments to driver schedules
  - May require mix of full-time and part-time driver shifts
  - Might consider passenger incentives to travel at less-busy times
  - May require additional vehicles after operational and policy changes to maximize efficiency have been tried

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Trips Turned Down: Five service levels

- 0 to 1%
- >1 to 3%
- >3 to 5%
- >5 to 10%
- >10%

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Travel Time

- Compares time to an exclusive-ride trip (i.e., no ride-sharing)
  - Ideal from a passenger point-of-view, but shouldn't be expected
  - From the operator point-of-view, travel times that are either too short or too long are undesirable
- Actual travel time can be calculated using a sample of completed trips for different passengers, using automated records from mobile data computers or written records from driver manifests
- Exclusive-ride trip can be calculated from an Internet mapping program
- TCQSM provides guidance on sample size to use, along with other details

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Travel Time: Five service levels

- Up to 25% longer than exclusive-ride trip
- Up to 50% longer than exclusive-ride trip
- Up to 75% longer than exclusive-ride trip
- Up to 100% longer than exclusive-ride trip
- More than 100% longer than exclusive-ride trip

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

No-Shows

- A no-show occurs when a passenger fails to show up for a scheduled trip
- From a passenger perspective, QOS is affected because passengers already on-board the vehicle have wasted time traveling to the pick-up location and waiting for the missing rider
- From a transit agency perspective, no shows reduce productivity and increase operating costs
- Calculated as the sum of passenger no-shows divided by the total number of scheduled trips

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

No-Shows: Three service levels

<2%

2 to 5%

>5%

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Potential Applications for DRT Quality of Service

- Developing service standards, balancing the QOS provided with operating cost considerations
- Comparing actual performance to service standards
- Identifying potential problems with excessive cancellations and no-shows
- Identifying the potential need for additional staff training
- Identifying the potential need for additional capacity

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

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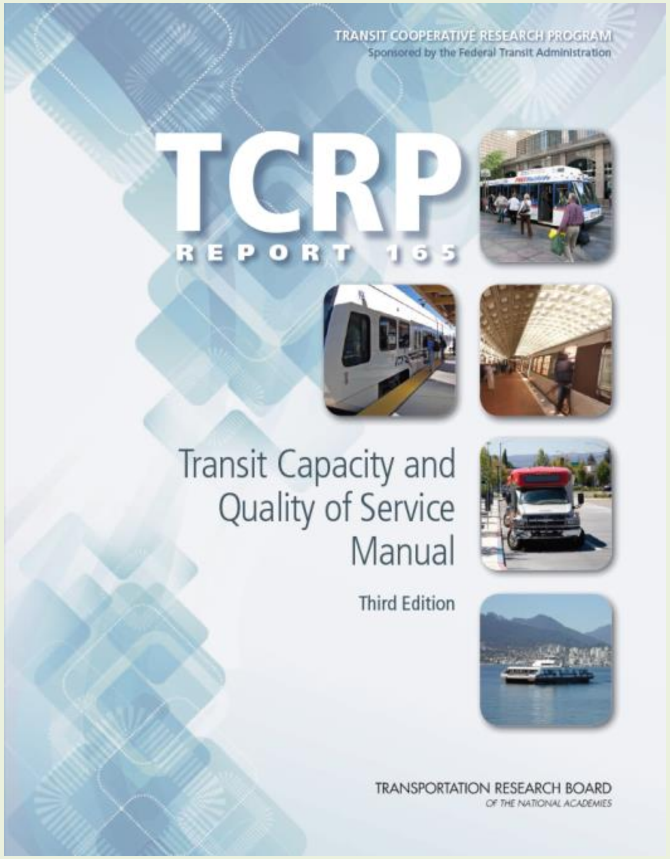

TCRP Report 165: Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition

Kittleson & Associates, Inc., Parsons Brinckerhoff, KFH Group, Inc., Texas A&M Transportation Institute, ARUP

2013

Capacity Issues

- How many vehicles and vehicle service hours are required to accommodate a given passenger demand and service area?
- DRT capacity depends on vehicle size and the operating policies

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Capacity Factors

- Ridership demand
- Passenger characteristics
- Peak period demand
- Service area size
- Service area characteristics
- Trip pattern type
- Operating policies

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Capacity Factors

- Ridershiр demand
  - Key factor for the calculation of needed capacity
  - Demand should be determined on an average weekday basis as well as a peak-period basis
- Passenger characteristics
  - Is service for general public or a specialized group?
  - ADA paratransit cannot limit its capacity for eligible riders
  - Differences in passenger characteristics can impact wait times or dwell times, affecting capacity
    - Services designed for people with disabilities will have longer wait times and longer dwell times

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Capacity Factors

- Peak period demand
  - If DRT systems have peaked ridership demand, additional capacity is required at those peak times
  - A DRT vehicle generally does not carry more passengers during peak times (unlike fixed-route buses), so DRT providers may need to provide more service during peak demand periods
  - Ways to provide additional service
    - Deploy additional vehicles
    - Supplement DRT service with non-dedicated service such as taxis
    - Improve DRT vehicle schedules to ensure adequate capacity
  - Whether a DRT provider can manage demand during peak periods will affect capacity needs

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Capacity Factors

- Service area size
  - A large service area results in longer passenger trips, lowering productivity and increasing need for additional capacity
  - Service area may be divided into zones, which offer connections to the fixed-route network and also serve neighborhoods with short trips to local destinations
  - Number of vehicles needed for each zone depends on number of passengers from that area
- Service area characteristics
  - Locations of major bridges, railroad crossings, geographic features, and other characteristics of the service area can increase travel time and impact capacity
- DRT trip pattern type
  - If a DRT service can group more riders (many-to-one, many-to-few, few-to-few), it will have a higher productivity
  - Many-to-many results in fewer passenger trips per vehicle because of greater dispersion of origins and destinations, resulting in a need for additional capacity

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Capacity Factors

- Operating policies
  - A policy with a short on-time window (e.g., 15 or 20 min) that requires high on-time performance standards will result in less grouping of passenger trips, limiting productivity and requiring additional capacity
  - A policy that increases the time to serve each passenger trip (the wait time for riders at pick-up location) will increase rider travel times, which also lowers productivity and requires additional capacity

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Summary of Factors Affecting DRT Capacity

- ***Demand for DRT service*** - estimated in terms of one-way passenger trips
- ***DRT provider policies*** - particularly the amount of capacity to be deployed, which may be affected by available funding or other local issues
- ***Passenger characteristics*** - whether the service is provided for the general public or specialized rider groups
- ***Peak-period demand*** - when demand during peak periods is significantly greater than off-peak, additional capacity may be needed
- ***Service area size and characteristics*** - in particular, a large service area results in longer passenger trips, lowering productivity with additional capacity needed to serve the demand
- ***Trip pattern type*** - many-to-few, many-to-one and few-to-few DRT services can group passenger trips, achieving higher productivities and requiring fewer vehicles than a service that operates many-to-many
- ***Service policies***, such as the size of the on-time window - the shorter the window, the more the window constrains scheduling, with a resulting need for additional vehicles.

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Capacity Calculation Procedures

- Analogy method
- DRT resource estimation model
- Analytical model
- Non-dedicated DRT service
- Rural DRT

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Analogy Method

- Estimates number of vehicles and vehicle service hours needed using data from similar DRT systems (comparable communities or areas)

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

DRT Resource Estimation Model

- Developed in *TCRP Report 98: Resource Requirements for Demand-Responsive Transportation Services*
- The model estimates the number of vehicles needed
- Trade-off between high service quality and cost – the model shows the trade-off between fleet size and share of market served at a given level of service quality
- Model inputs: definition of service area, type of riders to be served, vehicle capacity, hours of service, pick-up and drop-off windows, expected number of trip requests per day
- Model estimates fleet size, vehicle miles, vehicle hours

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Analytical Model

- Developed by L. Fu and presented in *Transportation Research Record 1841*
- Estimates fleet requirements, system capacity, and quality of service measures for specific operating conditions
- The minimum number of vehicles needed
  - directly related to trip demand and service area
  - inversely related to acceptable passenger ride times, average travel speed, dwell times, and the on-time window
- Incorporates peak-period demand – fleet size depends on peak period demand

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Non-dedicated DRT Service

- Non-dedicated services included vehicles that serve both DRT riders and other riders not affiliated with the DRT service (e.g., taxis)
- Using non-dedicated vehicles can be an effective strategy for dealing with capacity issues, such as excess peak-period demand, and long, out-of-the-way trips

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Non-dedicated DRT Service

- *TCRP Report 121: Toolkit for Integrating Non-Dedicated Vehicles in Paratransit Service*
  - Guidance and a software tool for how to provide capacity with taxis or other transportation resources not solely serving the provider's passengers
  - Determine optimum split between dedicated and non-dedicated service
  - Two component models
    - 1) Driver/run optimization model to determine the most cost-effective schedules for the DRT-dedicated vehicles
    - 2) DRT capacity estimation model, incorporating service supplied, non-dedicated vehicles available for DRT use, operating costs, ridership demand, and service area characteristics

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

Rural DRT

- Method presented in a paper by Sandlin and Anderson in *Journal of Public Transportation,* Vol. 5, No. 3
- Rural DRT model determines the total area that can be served with a given budget, for a particular set of demand characteristics
- Basis is the economic notion of diminishing returns
- Variables needed: operational costs (per mile), transit need (likely users), the charge for the service, distance to each stop

Source: Transit Capacity and Quality of Service Manual, 3rd Edition

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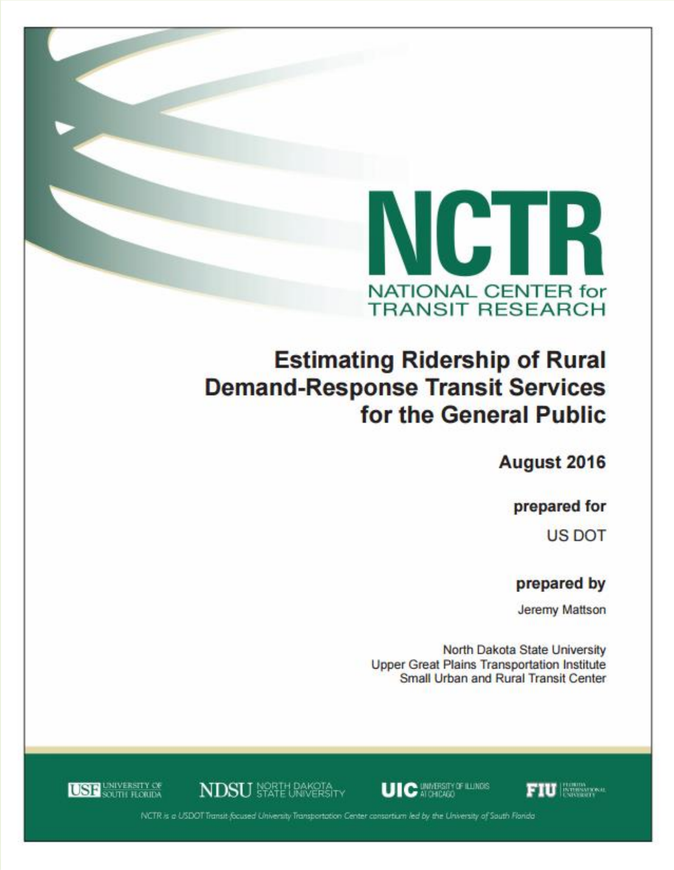
ESTIMATING RIDERSHIP OF RURAL DEMAND-RESPONSE TRANSIT SERVICES FOR THE GENERAL PUBLIC


NCTR
NATIONAL CENTER for TRANSIT RESEARCH

Estimating Ridership of Rural Demand-Response Transit Services for the General Public

August 2016

prepared for
US DOT

prepared by
Jeremy Mattson

North Dakota State University
Upper Great Plains Transportation Institute
Small Urban and Rural Transit Center

USF UNIVERSITY OF SOUTH FLORIDA NDSU NORTH DAKOTA STATE UNIVERSITY UIC UNIVERSITY OF ILLINOIS AT CHICAGO FIU

NCTR is a USDOT Transit focused University Transportation Center consortium led by the University of South Florida

Objectives

Previous research

Model development

Data collection

Results

Applications

Objective

Develop a model for estimating demand for rural demand-response transit services for the general public

Specific objectives

Estimate impacts of service characteristics

- Span of service
- Service coverage
- Fares
- Reservation requirements

Estimate impacts of service area characteristics

- Population
- Demographics

Previous Demand Models

TCRP Report 161: *Methods for Forecasting Demand and Quantifying Need for Rural Passenger Transportation*

- General public rural passenger transportation
- Passenger transportation specifically related to social services or other programs
- Fixed-route transit in micropolitan areas
- Commuter services from rural counties to urban centers

ADA Paratransit Research

- TCRP Report 119: *Improving ADA Complementary Paratransit Demand Estimation.*
- TCRP Report 158: *Improving ADA Paratransit Demand Estimation: Regional Modeling.*
- Goodwill and Joslin (2013) *Forecasting Paratransit Services Demand - Review and Recommendations.* National Center for Transit Research, University of South Florida.

TCRP Report 161: Demand for rural general public, non-program-related service

- Two methods
  - Peer data
    - Passenger trips per capita, passenger trips per vehicle mile, passenger trips per vehicle hour
    - Calculate mean, median, and ranges for systems in similar settings
  - Demand function developed based on 2009 rural NTD data
    - Based on the assumption that older adults, people with mobility limitations, and people without access to a vehicle represent the main users of these services

Non-program Demand (trips per year) = (2.20 x Population Age 60+) + (5.21 x Mobility Limited Population Age 18-64) + (1.52 x Residents of Household Having No Vehicle)

Browse All Items
Browse By Subject
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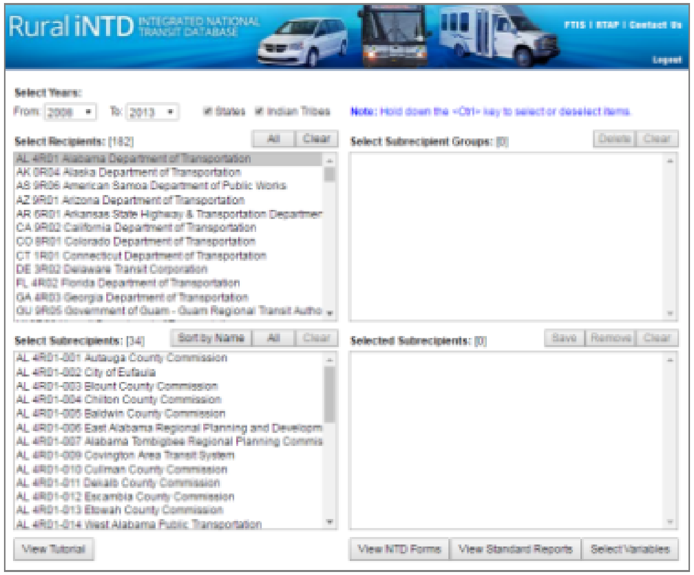
Topic Guides
Rural iNTD

Rural Integrated National Transit Database (iNTD)



The **Integrated National Transit Database (iNTD)** is a major component of the Florida Transit Information System (FTIS), developed by Florida International University (FIU) for Florida DOT. Previously known as INTDAS, iNTD integrates multiple years of NTD data and includes performance measures at different aggregate levels. It allows users to quickly and easily retrieve and analyze data.

National RTAP worked with FIU to develop a rural iNTD module similar to the urban module. This project integrates rural data since 2007. On an annual basis rural NTD data from the previous year will be uploaded into the rural module. (NOTE: the addition of the 2014 data is in progress.)

The system was developed to help rural transit providers and state DOTs quickly select NTD data and variables for Section 5311 recipients and subrecipients. Performance measures relevant to rural systems are included in the module. Users can run standard reports, view NTD forms, or select their own variables.

Get Started

To access to the Rural iNTD system, **register here** and then enter your password on the **Rural iNTD login page**. (To log in for the Urban iNTD, **click here**.)

There are video tutorials within Rural iNTD that will show you how to use the system to access the rural data, view trends, and compare peer states and transit providers. You can also view the **Rural iNTD Overview Webinar** from June 2015 for an overview of the tool and some guidance on how to use it.

TCRP Report 161: Demand for program-related trips

Demand for program trips

=

Number of Program Participants

×

Program Events per Week

×

the Proportion of Program Participants who attend the Program on an Average Day

×

the Proportion of Program Participants that are Transit Dependent or Likely to Use the Transit Service provided/funded by the Agency

×

the Number of Weeks per Year the Program is Offered

×

2 (trips per participant per event)

TCRP Report 161: Demand for small-city fixed-route service

Unlinked passenger-trips = 5.77 × Revenue-hours of Service + 1.07 × Population + 7.12 × College/University Enrollment

Conditions of application: Population of urban center < 50,000.

Does not include community college enrollment.

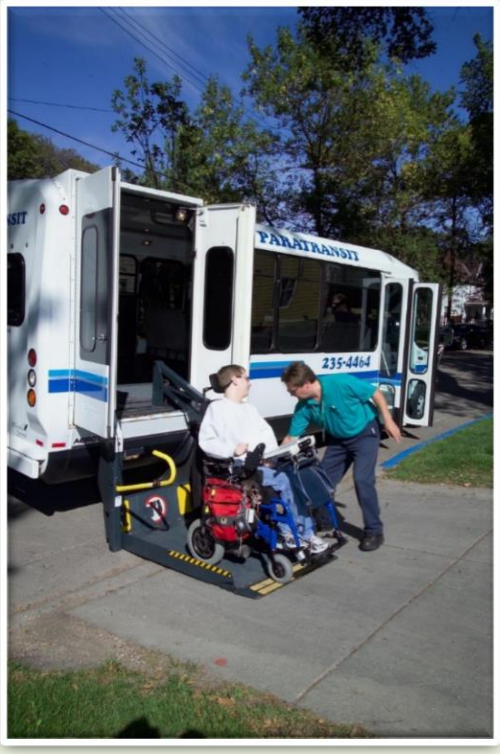
TCRP Report 161: Demand for commuter transit

Commuter trips by transit from County to Urban Center per Day = Proportion Using Transit for Commuter Trips from Rural County to Urban Place × Number of Commuters × 2

Proportion Using Transit for Commuter Trips from Rural County to Urban Place = 0.024 + (0.0000056 × Workers Commuting from Rural County to Urban Place) - (0.00029 × Distance in Miles from Rural County to Urban Place) + 0.015 (if the Urban Place is a state capital)

ADA Paratransit Demand

- TCRP 119 provides a tool based on the following variables
  - Service area population
  - Base fare
  - Percentage of applicants for found conditionally eligible
  - Whether or not trip-by-trip eligibility determination based on conditions of eligibility is used
  - Percentage of service area population with household incomes below poverty line
  - Effective window used to determine on-time performance
- TCRP 158: More advanced regional planning model
- Goodwill and Joslin
  - Forecasted demand for transportation-disadvantaged services
  - Method used trip rates from the 2009 NHTS



Factors Affecting Ridership

- Demand for the service
  - Population
  - Demographics
- Level of service provided/Service characteristics
  - Days per week
  - Hours per day
  - Advance reservation requirements
  - Both demand-response and fixed-route?
  - Overlap in service area?
  - Regional or cultural differences, tribal transit?
- Cost of the service

Models

- Two models
- Data sources
  - Model #1
    - Rural National Transit Database, 2013
    - American Community Survey (ACS) 2009-2013 5-year estimates
  - Model #2
    - Survey of rural transit agencies

Model #1

- Ridership is determined by:
  - Demand factors
    - Service area population
    - Demographic characteristics of service area
      - Percentage older adult (65 or older)
      - Percentage without a vehicle
      - Percentage with a disability
  - Service characteristics
    - Operates both fixed-route and demand-response
    - Service area overlaps
    - Serves only a municipality
  - Fare level
  - Other
    - Tribal transit
    - Region
- Data for 731 agencies for 2013

Summary Statistics for Model #1 Variables

	Mean	Median	Standard Deviation	Minimum	Maximum
Passenger trips	26,344	14,976	31,758	180	180,983
Population	30,448	24,609	24,619	204	100,000
Percentage elderly	0.17	0.16	0.04	0.06	0.30
Percentage no vehicle	0.01	0.01	0.01	0	0.11
Percentage disability	0.15	0.14	0.04	0.04	0.32
Fixed route	0.20	0	0.40	0	1
Percentage overlap	0.23	0	0.41	0	1
Municipality	0.16	0	0.37	0	1
Tribal	0.01	0	0.12	0	1
Fare	1.24	0.90	2.41	0	25.89

Limitations of Rural NTD Data

- Incomplete and imprecise service area information
- No data:
  - Hours per day
  - Days per week
  - Advance reservation requirements
  - Type of service provided

Survey of Transit Agencies

- Collected detailed information
  - Geographic service area
  - Span of service
  - Advance reservation requirements
  - Service eligibility and type
- Data collected for 68 rural demand-response transit agencies

Model #2

- Ridership is determined by:
  - Service area population
  - Hours of service per day
  - Days of service per week
  - Advance reservation time
  - Operates both fixed-route and demand response
  - Fare level

Summary Statistics for Model #2 Variables

	Mean	Median	Standard Deviation	Minimum	Maximum
Passenger trips	31,103	19,490	45,351	63	343,937
Population	41,302	24,666	48,245	1,119	177,453
Percentage with 6 or 7 days	0.29	0	0.43	0	1.00
Percentage with 5 days	0.62	1.00	0.45	0	1.00
Percentage with 12 or more hours	0.34	0	0.45	0	1.00
Percentage with less than 5 hours	0.03	0	0.14	0	1.00
Same-day reservation	0.43	0	0.50	0	1.00
Prior-day reservation	0.49	0	0.50	0	1.00
Fixed-route	0.25	0	0.47	0	1.00
Fare	1.54	1.19	1.27	0	6.46

Results: Model #1

- Population has a positive effect on ridership.
  - A 1% increase in population leads to a 0.83% increase in ridership.
- Demographics impact ridership.
  - Areas with a higher percentage of older adults or households without access to a vehicle have higher levels of ridership.
  - If the percentage of the population that is aged 65 or older increases by one percentage point, ridership increases by 8%.
  - If the percentage of the population without a vehicle increases by one percentage point, ridership increases by 21%.

Results: Model #1

- Agencies that provide both fixed-route and demand-response service have lower levels of demand-response ridership than agencies that provide just demand-response service, after accounting for all other variables.
- Agencies that serve areas where more than one transit provider is available have lower levels of ridership.
- Demand-response providers that strictly serve a municipality have higher levels of ridership than those serving a larger geographic area, after accounting for population and other factors.

Results: Model #1

- Fares have a negative impact on ridership. A 1% increase in fares leads to a 0.24% reduction in ridership.
- There are some regional differences in ridership not accounted for by these variables. Notably, region 5 agencies have higher levels of ridership, and agencies in regions 3 and 4 have lower levels.

Results: Model #2

- Population has a positive effect on ridership.
  - A 1% increase in population leads to a 0.69% increase in ridership.
- Ridership is impacted by the number of days that service is available.
  - As the percentage of service area population with service 5 days per week increases by one percentage point, ridership increases 1.41%.
  - Ridership increases 1.65% as the percentage of service area population with service 6 or 7 days per week increases by one percentage point.

Results: Model #2

- Advance reservation time has a negative impact on ridership.
  - Compared to agencies that require reservation two or more days in advance, ridership is 124% higher for providers that require reservation one day in advance and 201% higher for agencies that allow same-day service.
- Agencies that provide both fixed-route and demand-response service have lower levels of demand-response ridership than agencies that provide just demand-response service, after accounting for all other variables.
- Fares have a negative impact on ridership.
  - A 1% increase in fares leads to a 0.12% reduction in ridership.

Applications

- Forecast demand for new service
- Estimate the impact of service changes
  - Geographic coverage
  - Span of service
  - Fares
  - Reservation requirements
- Project future ridership based on population and demographic changes

Applying Model #1: The Formula

Natural log of ridership =

0.83 × natural log of population

+ 7.99 × percentage of population aged 65 or older

+ 21.15 × percentage of population without access to a vehicle

- 0.65 if the agency also operates a fixed-route service

- 0.41 × percentage of population that has access to other demand-response service

+ 0.77 if the agency operates strictly within a municipality

- 0.24 × natural log of the fare

- 0.56 if agency operates in FTA region 3

- 0.81 if agency operates in FTA region 4

+ 0.50 if agency operates in FTA region 5

Applying Model #1: The Data

- Demographic data from the ACS
- U.S. Census Bureau's American Fact Finder: www.factfinder.census.gov

Variable	ACS Table
Total population	B01001
Population aged 65 or older	B01001
Population without access to a vehicle	B08014
Population with a disability	B18101

Applying Model #1: Calculations

- Natural log of population and fares
- A number can be converted to its natural log in Excel using the following formula:

=LN(number)

- Percentages of populations of older adults and households without vehicles must be calculated and represented as decimal numbers ranging from 0-1
- The resulting calculation is the estimate for the natural log of ridership
  - The natural log of ridership can be converted to actual ridership using the following formula in Excel:

=EXP(number)

Applying Model #2: The Formula

Natural log of ridership =

0.69 × natural log of population

+ 1.65 × percentage of population with service 6 or 7 days per week

+ 1.41 × percentage of population with service 5 days per week

+ 2.01 if agency allows same-day reservations

+ 1.24 if agency requires reservations made one day in advance

- 0.65 if agency operates fixed-route service

- 0.12 × natural log of fare

Applying Model #2: The Data and Calculations

- Population data from the American Fact Finder
  - Counties, county subdivisions, cities, census tracts, block groups
- Need to estimate percentages of service area population receiving service 6+ days per week and 5 days per week
- Resulting calculation is an estimate of the natural log of ridership

Conclusions

- Existing demand models have a limited set of variables
- Two models developed
  - 2013 rural NTD data
  - Detailed service data collected by survey of agencies
- A number of factors affect ridership
- Improvement over previous models

Conclusions

- Demographic characteristics are important
  - Older adults
  - People without access to a vehicle
- Geographic characteristics of service are important
- Fare elasticity estimated at -0.12 to -0.24
- Availability of service/quality of service impacts ridership
  - Agencies providing more days of service had higher levels of service
  - Advance reservation time is important

Conclusions

- Two new tools for estimating ridership
- A greater number of variables and more specific service information improves the performance
- Limited by data availability
- Identify high-productivity systems
- Many factors specific to each agency and community not captured by the model

OUTLINE

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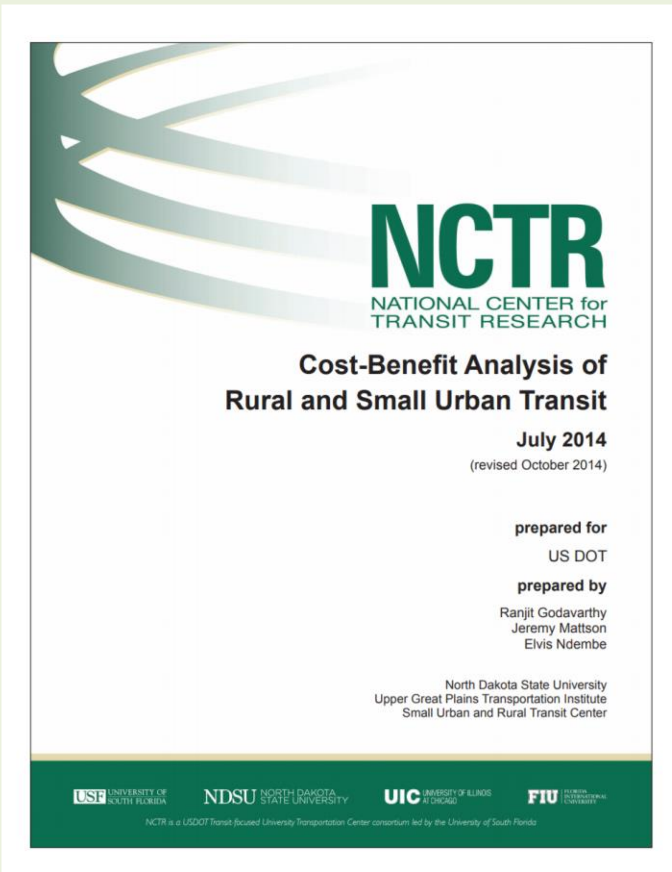
COST BENEFIT ANALYSIS OF RURAL AND SMALL URBAN TRANSIT


NCTR
NATIONAL CENTER for TRANSIT RESEARCH

Cost-Benefit Analysis of Rural and Small Urban Transit

July 2014
(revised October 2014)

prepared for
US DOT

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UIC UNIVERSITY OF ILLINOIS AT CHICAGO
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NCTR is a USDOT Transit-focused University Transportation Center consortium led by the University of South Florida

Objectives

Previous research

Study methods

Results

Conclusions

Background

- The value of transit services in rural and small urban areas is largely unmeasured and impacts are often unidentified.
- Some benefits lend themselves easily to quantification while others do not.
- Information is needed for both costs and benefits of transit operations to support transit investment decisions.

Objectives

- Review previous cost-benefit research for rural and small urban areas
- Develop a methodology for assessing benefits at the national, regional, and statewide levels
- Estimate the economic costs and benefits of rural and small urban transit
- Identify and describe social, environmental, and other benefits

Scope of Research

- Small urban and rural transit agencies across the country
- Small urban defined as urban transit agencies serving area with population under 200,000
- Data from NTD and Rural NTD
- 1,392 rural agencies and 351 small urban agencies
- Fixed-route bus and demand response service studied
- Results presented at national, regional, and state levels

Previous Research

Skolnik and Schreiner (1998)	• Studied small urban area of Connecticut • Benefit/cost ratio of 9.7 to 1
Burkhardt (1999)	• National and local analyses of rural systems • Returns on investment of 3 to 1
Southworth et al. (2002, 2005)	• Rural and small urban systems in Tennessee • Benefits of rural systems vary significantly • Benefit/cost ratios greater than 1.0
HLB Decision Economics (2003, 2006)	• Studied Wisconsin • Return on investment of 6 to 1
HDR Decision Economics (2011)	• Conducted in South Dakota • Every dollar spent generated $1.90 in economic activity

Research on Foregone Trips

Health care trips

- Previous studies have shown ability to drive and use of transit increases number of health care trips
- TCRP (Web-Only Doc 29) report by Hughes-Cromwick et al. (2005) conducted cost-benefit analysis of providing NEMT for seven chronic conditions and five preventive conditions
  - Benefit is the difference between well-managed and poorly-managed care, which can include reduction in more costly care and improved quality of life
  - Net health care benefits of increased access to NEMT exceeded additional costs
  - Transportation is relatively inexpensive compared to cost of health care
- Other studies have considered home healthcare costs or medical institutionalization costs avoided

Research on Foregone Trips

Work trips

- Many rely on transit as a means to travel to work
- Studies have estimated value of lost work trip as value of lost wages
- HLB Decision Economics estimated the benefit of providing work trips as the impact it has on reducing public assistance spending – They found there would be a 12% increase in spending in Wisconsin without transit
- HDR Decision Economics similarly estimated the increase in welfare recipients

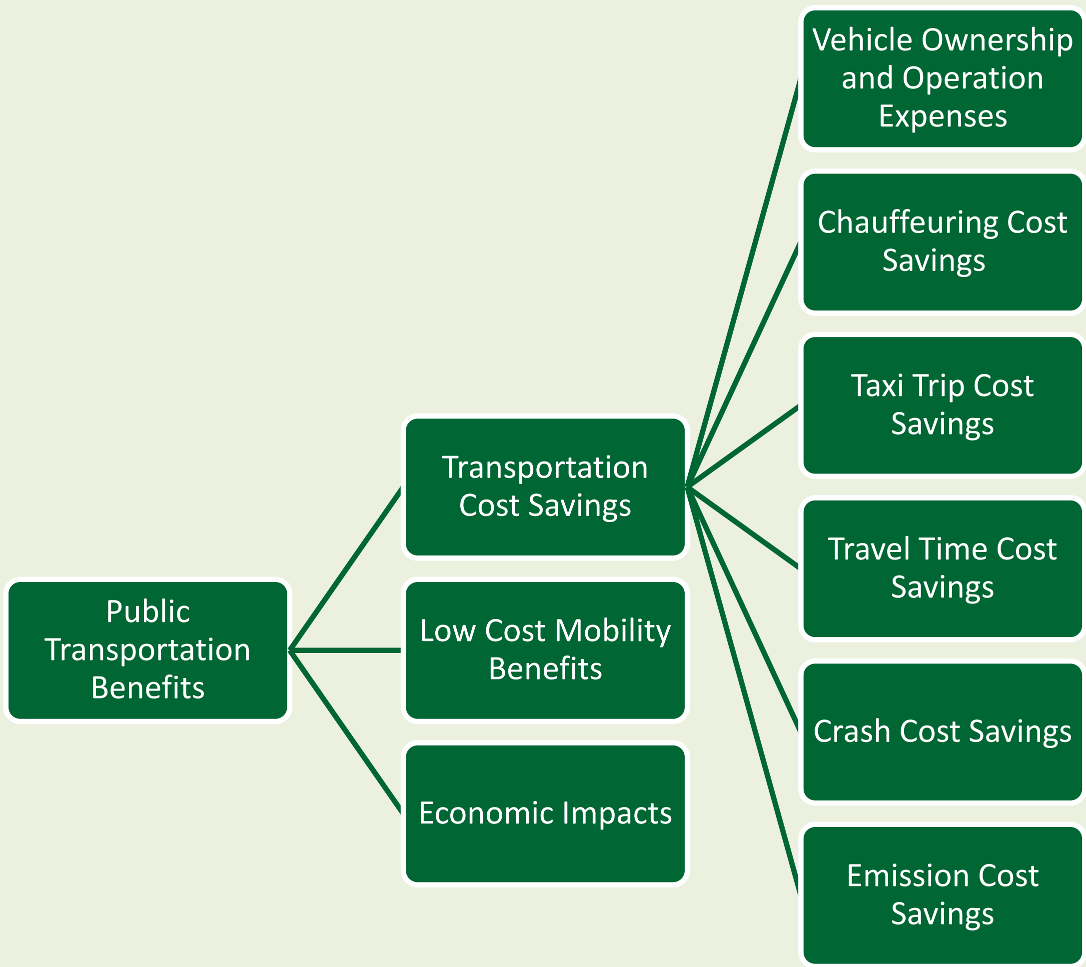
Other trips

- Education trips: Differences in expected earnings
- Shopping trips: Shopping expenditures per trip

Categorization of Transit Benefits

Transportation cost savings	Costs that would have been incurred if transit rider used different mode in absence of transit
Low-cost mobility benefits	Benefits of trips made that would otherwise be foregone in the absence of transit
Economic impacts	Economic activity resulting from the existence of transit operations

Categorization of Transit Benefits



Study Methodology


Travel behavior in the absence of transit: alternative modes and foregone trips


Trip purpose information


Costs incurred on alternative modes

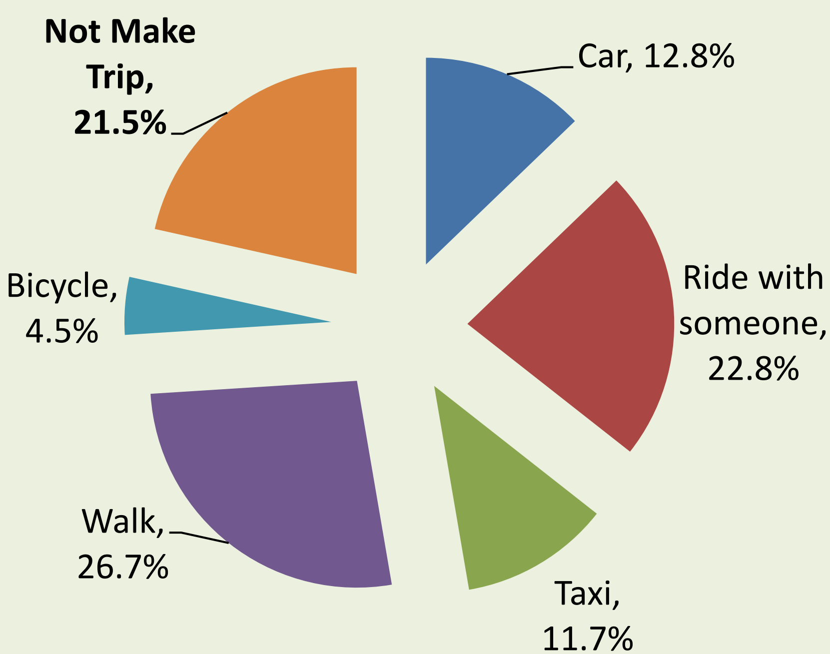

Value of foregone trips, by trip purpose


Economic impacts from operations

Compare calculated benefits with costs of providing transit

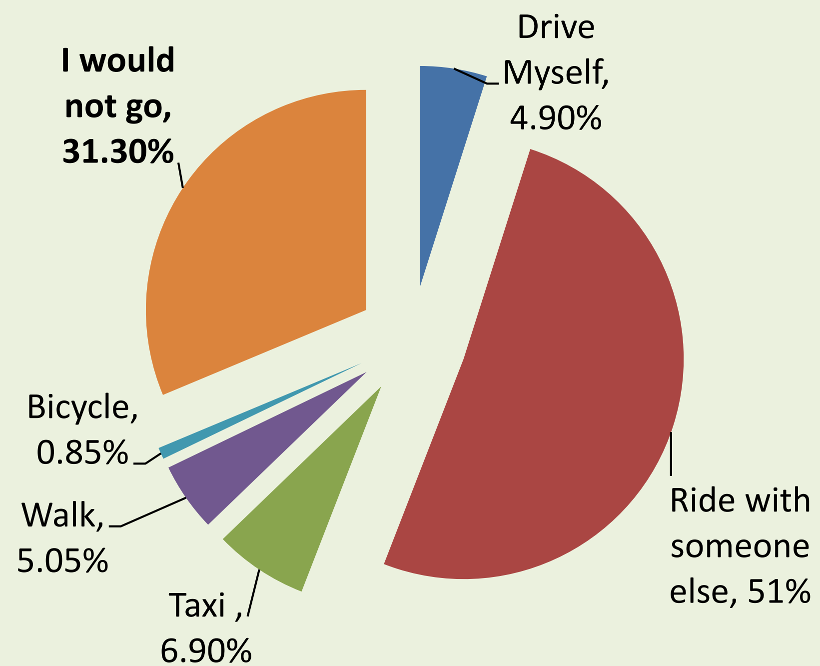
Trip Alternatives in Absence of Transit

Fixed-Route Bus



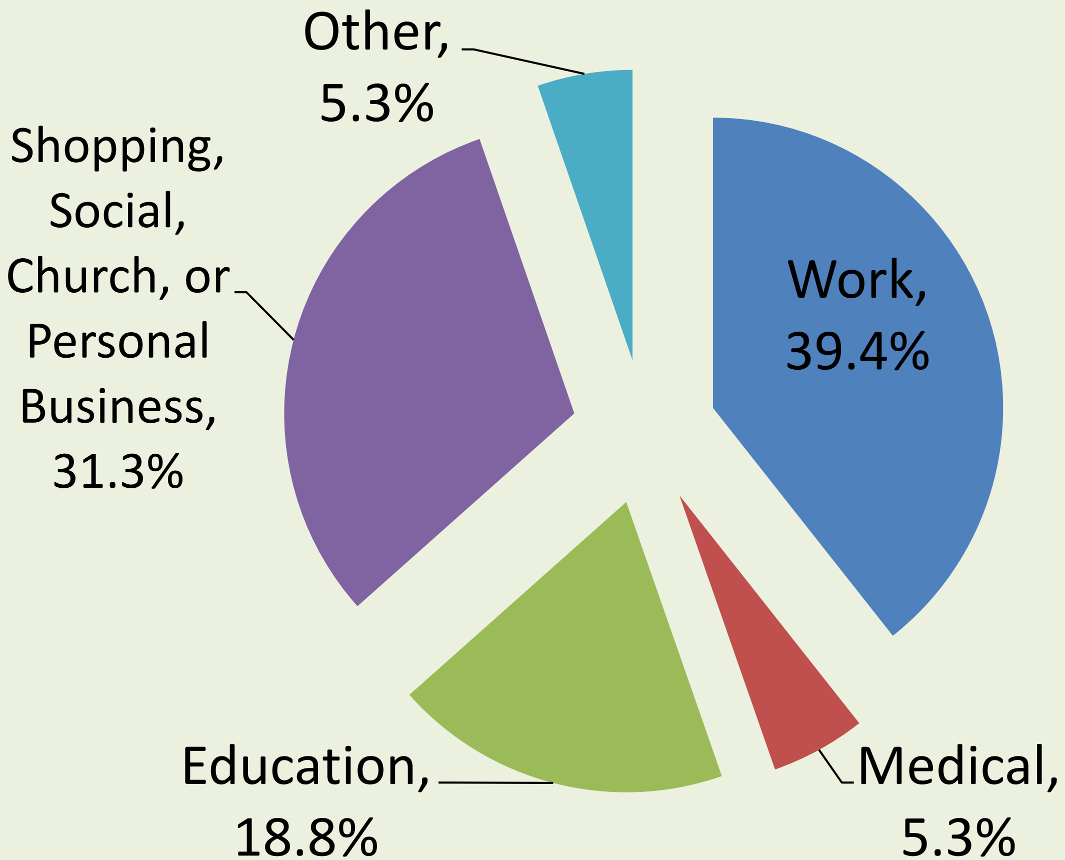
Source: Transit Performance Monitoring System (TPMS) (2002)

Demand Response Service



Source: Mattson et al. (2014) Report # 21177060-NCTR-NDSU05

Small Urban: Transit Trip Purpose



Source: Transit Performance Monitoring System (TPMS) (2002)

Rural: Transit Trip Purpose

Trip Purpose	Percentage of Transit Trips
Work	41%
Medical	7%
Education	20%
Shopping, Recreation and Tourism	29%
Other	3%

Source: 2012 Rural Transit Fact Book

Benefit Category 1: Transportation Cost Savings

Vehicle Ownership and Operation Cost Savings

- Some riders would choose to drive in the absence of transit
- AAA cost estimates used: $0.65 per mile

Avoided Chauffeuring Costs

- Some would get a ride from a family member or friend
- Litman (2012) estimated the cost as $1.05 per chauffeured mile

Taxi Fare Savings

- Some would take a taxi
- An average taxi fare of $2.25 per mile was used from Litman (2012)

Travel Time Savings

- Travel time differences between transit and other modes monetized

Crash Cost Savings

- Differences in crash costs between transit and other modes

Environmental Emission Cost Savings

- Differences in emissions costs between transit and other modes

Benefit Category 2: Low-Cost Mobility Benefits

Benefit of Providing New Trips

Medical trips

- Cost difference between well-managed and poorly-managed care, plus improvements in quality of life, minus additional medical costs incurred, divided by number of trips required

Work trips

- Reduction in TANF and SNAP benefits

Other trips

- Change in consumer surplus

Unit Costs Used for Monetizing Transit Benefits

Parameter	Value
Vehicle ownership and operating cost ($/mile)	$0.65
Chauffeuring costs ($/mile)	$1.05
Taxi fare ($/mile)	$2.25
Value of travel time ($/hour)	$4.14
Crash costs ($/vehicle mile)	
Transit	$0.29
Automobile	$0.10
Emission costs ($/vehicle mile)	
Transit	$0.15
Automobile	$0.06
Cost of foregone trips ($/one-way trip)	
Medical	$357
Work	$49

Benefit Category 3: Economic Impacts

Economic Impacts of Spending on Transit

Direct effects

- Jobs created directly by the transit system

Indirect effects

- Jobs and income spent in industries that supply inputs to transit

Induced economic activity

- Economic activity resulting from income generated through both direct and indirect effects

Economic Impacts of Spending on Transit

- Chu (2013) developed a tool to estimate economic impacts of spending on transit
- Regional Input-Output Modeling System (RIMS II) multipliers
- Economic impacts vary based on source of funds and share of spending that occurs within the community
- Chu's tool was applied to the state of North Dakota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Results

Estimated Transportation Cost Savings and Low-Cost Mobility Benefits, 2011

Rural Transit

	Total Benefits	Benefits per Trip
Fixed-route	$934 million	$13.50
Demand-response	$673 million	$16.35
Total	$1.6 billion	$14.56

Rural Transit: Benefits Summary (2011)

Transit Benefit Category	Fixed Route	Demand Response	Total
	-----------------million dollars-----------------		
Transportation Cost Savings			
Vehicle Ownership and Operation Costs	$35	$8	$42
Chauffeuring Costs	$50	$84	$134
Taxi Cost Savings	$109	$38	$148
Travel Time Cost Savings	-$20	-$36	-$56
Accident Cost Savings	$29	-$13	$16
Emission Cost Savings	-$7	-$47	-$54
Total Transportation Cost Savings	*$196*	*$34*	*$230*
Low Cost Mobility Benefits			
Foregone Medical Trip Benefits	$393	$340	$733
Foregone Work Trip Benefits	$296	$256	$552
Other Foregone Trip Benefits	$49	$42	$92
Total Low Cost Mobility Benefits	*$738*	*$639*	*$1,377*
Total Transit Benefits	**$934**	**$673**	**$1,607**

Estimated Transportation Cost Savings and Low-Cost Mobility Benefits, 2011

Small Urban Transit

	Total Benefits	Benefits per Trip
Fixed-route	$3.4 billion	$10.23
Demand-response	$244 million	$14.31
Total	$3.7 billion	$10.43

Small Urban Transit: Benefits Summary (2011)

Transit Benefit Category	Fixed Route	Demand Response	Total
	------------------million dollars------------------		
Transportation Cost Savings			
Vehicle Ownership and Operation Costs	$110	$4	$113
Chauffeuring Costs	$158	$40	$198
Taxi Cost Savings	$346	$18	$365
Travel Time Cost Savings	-$148	-$17	-$165
Accident Cost Savings	$42	-$18	$24
Emission Cost Savings	$6	-$9	-$3
Total Transportation Cost Savings	*$513*	*$18*	*$531*
Low Cost Mobility Benefits			
Foregone Medical Trip Benefits	$1,362	$101	$1,463
Foregone Work Trip Benefits	$1,390	$103	$1,493
Other Foregone Trip Benefits	$160	$22	$182
Total Low Cost Mobility Benefits	*$2,913*	*$226*	*$3,138*
Total Transit Benefits	**$3,425**	**$244**	**$3,669**

Benefit-Cost Analysis

National Summary: Transit Benefits and Costs

	Small Urban Areas	Rural Areas
Transit Benefits	Benefits/Trip	Benefits/Trip
Vehicle ownership and operation cost savings	$0.32	$0.38
Chauffeuring Cost Savings	$0.56	$1.21
Taxi cost savings	$1.04	$1.34
Travel time cost savings	-$0.47	-$0.58
Accident cost savings	$0.07	$0.15
Emission cost savings	-$0.01	-$0.49
Cost of foregone medical trips	$4.16	$6.65
Cost of foregone work trips	$4.24	$5.00
Cost of other foregone trips	$0.52	$0.83
Total Transit Benefits	*$10.43*	*$14.49*
Transit Costs	Cost/Trip	Cost/Trip
Operational Expenses	$4.49	$10.78
Capital Expenses	$0.33	$1.03
Total Transit Costs	*$4.83*	*$11.81*
Benefit/Cost Ratio	***2.16***	***1.20***

Sensitivity Analysis

Sensitivity Analysis

- For monetizing the transit benefits, many assumptions were made regarding travel behavior and unit costs from previous studies.
- Useful to understand national transit benefits by using different unit costs and travel behavior from base condition.
- Six scenarios were considered for sensitivity analysis.

Sensitivity Analysis

Scenario 1	• Foregone trips increased to 50%
Scenario 2	• Walk/bicycle trips decreased by half for fixed-route
Scenario 3	• Automobile cost increased from $0.65 to $0.84 per mile
Scenario 4	• Cost of foregone medical and work trips increased 25%
Scenario 5	• Cost of foregone medical and work trips decreased 25%
Scenario 6	• Value of travel time for transit and automobile set equal

Sensitivity Analysis Results	Transit Benefits (in Millions)						
	Base Case	Scenarios					
		1	2	3	4	5	6
Total Transit Benefits	5,277	**9,935**	5,287	5,322	**6,337**	4,216	5,327
		(88%)	(0%)	(1%)	**(20%)**	(-20%)	(1%)
Benefit Cost Ratio	1.68	3.17	1.69	1.70	2.02	1.35	1.70

Transit Benefits Measured in the Study

Transportation cost savings — Costs that would have been incurred if transit rider used different mode in absence of transit

Low-cost mobility benefits — Benefits of trips made that would otherwise be foregone in the absence of transit

Economic impacts — Economic activity resulting from the existence of transit operations

"Economic impacts of transit operations were estimated for the state of North Dakota. Results show that every $1 invested in public transportation results in $1.35 in output, $0.57 in value added, and $0.37 in earnings, and 10.3 jobs are supported for every $1 million invested."

"HDR Decision Economics studies economic impacts of Transit in South Dakota and found that for every $1 spent on public on Transit generated $1.90 in economic activity.

Economic Impacts from Spending on Transit in North Dakota

Type of Spending	Type of Impacts			
	Output	Value Added	Earnings	Jobs
	For every $1 invested			For every $1 million invested
Unit Gross Impacts				
Total Spending	$1.35	**$0.57**	$0.37	10.3
Unit Net Impacts (Local dollars: 25% operating, 5% capital)				
Total Spending	$1.02	**$0.43**	$0.28	7.8
Unit Net Impacts (Local dollars: 50% operating, 20% capital)				
Total Spending	$0.69	**$0.29**	$0.19	5.3

Summary and Conclusions

Conclusions

- Benefit-cost ratios being greater than 1, the results show that benefits provided by transit in rural and small urban areas in US are greater than costs of providing services.
- Benefit-cost ratios are higher in small urban areas than in rural areas.
- Fixed route service had higher benefit-cost ratio than demand response service.
- Most of the benefits of small urban and rural transit services are generated by creating trips for individuals who would not be able to make the trip if the service was not available.

- Results are highly sensitive to percentage of trips that would be foregone in the absence of transit, cost of value assigned to those foregone trips, and percentage of trips that are for medical purposes.
- The implication of the results is that transit services that serve a higher percentage of transit-dependent riders and those that provide a great percentage of medical or work trip will provide more benefits per trip.

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Thank you!

Questions?

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