
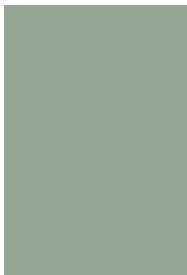
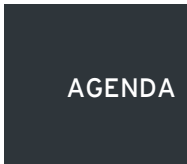



**TRANSIT MODELING 101**

September 25, 2008




1



**AGENDA**

- Travel Demand Modeling Overview
- Transit Model Objectives
- Transit Model Considerations
- Transit Model Application
- Conclusions



2



## TRAVEL DEMAND MODELING OVERVIEW



- Mathematical process
  - Divides trip making decision into four steps:
    - Trip generation
    - Trip distribution
    - **Mode choice**
    - Traffic assignment
  - Based on aggregate datasets
    - Land use
    - Roadway attributes
    - Transit attributes
    - Driver attributes



3





## TRANSIT OBJECTIVES



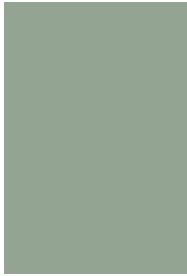
- Primary objectives of developing a transit component in a travel demand model
  - Estimate share of total person trips using transit
  - Estimate ridership numbers
    - By transit provider
    - By corridor
    - By transit route
    - By time period
    - By transit stop




4



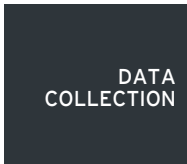

TRANSIT  
MODEL  
CONSIDER-  
ATIONS



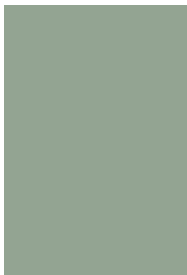
- Data collection
- Trip generation
- Trip distribution
- Mode choice
  - Equation development
- Assignment




5



DATA  
COLLECTION



- Survey data
  - On-board
  - National Household Travel Survey (NHTS)
  - Census Transportation Planning Package (CTPP)
- Route data
  - Schedule
  - Route map
  - Transfer locations
- Boarding and ridership pattern report



6

DATA COLLECTION ON BOARD SURVEY

- Data to consider includes but not limited to:
  - O-D information
  - Boarding- alighting information
  - Trip purpose
  - Socioeconomic data
    - Age, income, vehicle ownership, household size, occupation, city of residence etc.
  - Bus transfer data



Valley Transit System On-Board Survey

For those questions that apply, please circle the letter in front of the answer that you would like to select.

1. What is the bus route number you are currently riding?  
 a. 1      b. 2      c. 3      d. 4      e. 5      f. 6      g. 7      h. 8  
 i. 10     j. 11     k. 12     l. 13     m. 20     n. 30     o. 31     p. 32  
 q. 41     r. 6031   s. 7031   t. 7071   u. 8431A   v. 8431B   w. 8471   x. 8531

2. Where did you access this bus (be specific - address/intersection/business name/etc.)? \_\_\_\_\_

3. Including walking, where did your trip start (be specific - address/intersection/business name/etc.)? \_\_\_\_\_

4. Where will you exit this bus (be specific - address/intersection/business name/etc.)? \_\_\_\_\_

5. Including walking, what is your final destination (be specific - address/intersection/business name/etc.)? \_\_\_\_\_

6. What is the approximate time?  
 A.M. a. 5-6      b. 6-7      c. 7-8      d. 8-9      e. 9-10      f. 10-11      g. 11-Noon  
 P.M. h. Noon-1    i. 1-2      j. 2-3      k. 3-4      l. 4-5      m. 5-6      n. 6-7

7. How far did you walk to get onto this bus?  
 a. 1 block or less      b. 2 blocks      c. 3 blocks      d. 4 blocks      e. 5 blocks or more

8. How far will you have to walk after leaving this bus?  
 a. 1 block or less      b. 2 blocks      c. 3 blocks      d. 4 blocks      e. 5 blocks or more

9. What is the purpose of your trip on this bus? (Going to or from:  
 a. School      b. Shopping      c. Home      d. Social/Recreational  
 e. Medical/Dental      f. Work      g. Personal Business

10. Why did you choose to make this trip by bus?  
 a. Economy      b. Convenience      c. No other transportation available      d. Other \_\_\_\_\_

11. Do you plan to ride another bus today?      a. Yes - Number of anticipated trips/transfers = \_\_\_\_\_      b. No  
 If yes, please check off and fill out another survey on your return trip.

12. How did you pay for your fare on this trip?  
 a. \$1.50 cash      b. \$5.75 cash      c. Day Pass      d. 10 - Ride Ticket  
 e. \$2.10 - Ride Ticket      f. Single-Ride Ticket      g. Free Pass

13. Sex:      a. Male      b. Female

14. Age Group:      a. 10 or under      b. 11 - 15      c. 16 - 18      d. 19 - 22  
 e. 23 - 29      f. 30 - 45      g. 46 - 64      h. 65 or over

15. Marital Status:      a. Single      b. Married      c. Divorced      d. Widowed

16. Number of people in your household (include yourself):  
 a. 1      b. 2      c. 3      d. 4      e. 5      f. 6      g. 7 or more

17. Which City, Village, or Town do you live in:  
 a. City of Appleton      b. City of Kaukauna      c. City of Neenah      d. City of Menasha  
 e. City of Oshkosh      f. Village of Kimberly      g. Village of Little Chute      h. Village of Combined Locks  
 i. Town of Hartland      j. Town of Buchanan      k. Town of Grand Chute      l. Town of Kaukauna  
 m. Town of Neenah      n. Town of Menasha

18. Occupation:      a. Student (K-12)      b. College Student      c. Homemaker      d. Professional/Technical  
 e. Laborer      f. Retail      g. Sales      h. Manager  
 i. Other      j. Unemployed

TURN OVER



19. Do you own:      a. One or more vehicles (not school buses)      b. No owned personal vehicles      c. Two or more personal vehicles  
 d. Some other type of vehicle

20. Household Income (Estimated):  
 a. Under \$10,000      b. \$10,000 - \$19,999      c. \$20,000 - \$29,999      d. \$30,000 - \$39,999  
 e. \$40,000 - \$49,999      f. \$50,000 - \$59,999      g. \$60,000 - \$69,999      h. \$70,000 - \$79,999  
 i. \$80,000 - \$89,999      j. \$90,000 - \$99,999      k. \$100,000 - \$109,999      l. \$110,000 - \$119,999

21. How often do you use the bus (excluding transfers)?  
 a. Daily/Everyday      b. 2-3 times per week      c. 1-2 times per week      d. 1-2 times per month  
 e. 1-2 times per year      f. 1-2 times per year      g. 1-2 times per year      h. 1-2 times per year

22. Accessibility evaluation for your household:  
 a. None      b. One      c. Two      d. Three or more

23. Accessibility alighting status:  
 a. Unimpaired and able to alight      b. Not impaired by a leg      c. Unimpaired but unable to alight  
 d. Other \_\_\_\_\_

24. Have other bus users been advised to an alternative for you? (Yes/No)  
 a. Always      b. Usually      c. Occasionally      d. Almost never      e. Never

25. How often do you take the bus (excluding transfers)?  
 a. Daily/Everyday      b. 2-3 times per week      c. 1-2 times per week      d. 1-2 times per month  
 e. 1-2 times per year      f. 1-2 times per year      g. 1-2 times per year      h. 1-2 times per year

26. How often do you take the bus (excluding transfers)?  
 a. Daily/Everyday      b. 2-3 times per week      c. 1-2 times per week      d. 1-2 times per month  
 e. 1-2 times per year      f. 1-2 times per year      g. 1-2 times per year      h. 1-2 times per year

27. Which of the following best describes your view of the bus? (Circle 1-5)  
 a. Pleasant      b. Not pleasant      c. Not pleasant      d. Not pleasant      e. Not pleasant

28. Would you be willing to pay a higher fare to maintain the current level of service?  
 a. Yes      b. No

29. How do you rate the following aspects of the current bus service? (Rate 1-5)  

Rating	Frequency of buses	Convenience of bus stops	Reliability of bus service	Quality of bus service	Cost of bus service
1	a	b	c	d	e
2	f	g	h	i	j
3	k	l	m	n	o
4	p	q	r	s	t
5	u	v	w	x	y

30. List the five aspects of bus service which you have just rated which you most like and dislike (Rank 1-5)  
 (Rank 1-5 by the most favorable and 5 by the least favorable)  
 Most favorable: \_\_\_\_\_      2nd most favorable: \_\_\_\_\_      3rd most favorable: \_\_\_\_\_  
 4th most favorable: \_\_\_\_\_      5th most favorable: \_\_\_\_\_  
 Least favorable: \_\_\_\_\_      2nd least favorable: \_\_\_\_\_      3rd least favorable: \_\_\_\_\_  
 4th least favorable: \_\_\_\_\_      5th least favorable: \_\_\_\_\_

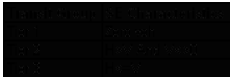
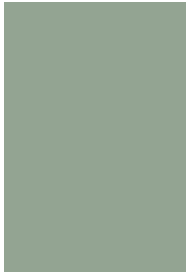

31. How would you rate the overall quality of Valley Transit service?  
 a. Excellent      b. Good      c. Average      d. Below average      e. Poor

32. How interested are you in a future survey?  
 a. Extremely      b. Very      c. Somewhat      d. Not interested

33. Have you visited Valley Transit's website?  
 a. Yes      b. No

34. Where would you like to see new bus service provided?  
 \_\_\_\_\_

Thank you for your participation.


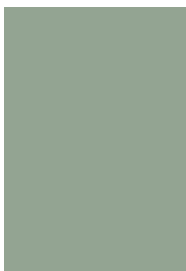
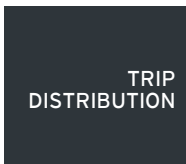



**TRIP GENERATION**

- Person trips
  - Consider cross-classification
  - Consider all trips, not just vehicle
- Socioeconomic classes
  - E.g. Estimate proportion of person trips based on automobile ownership or income

**HNTB**

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**TRIP DISTRIBUTION**

- Trip distribution affected by transit availability between O-D pairs
  - Friction factor typically a function of auto travel time skims
  - Consider introduction of a transit parameter in estimation of friction factor function
- Split person O-D tables by socioeconomic classes

**HNTB**

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LOGIT MODEL ESTIMATION\*

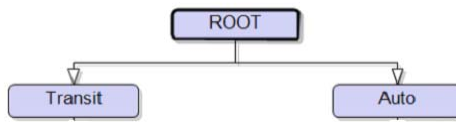
- Discrete choice models
  - Substitute for regression model with categorical dependent variables
  - Formulated as stochastic models
  - Multinomial Logit (MNL) Model
  - Nested Logit (NL) Model



<sup>11</sup> \* Adapted from Training Guide for Travel Demand Modeling with TransCAD

LOGIT MODEL ESTIMATION\*

- Discrete choice model

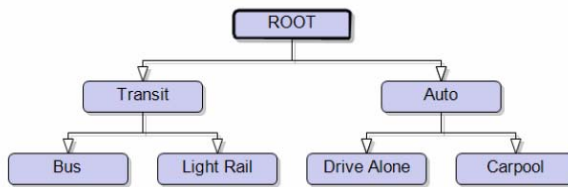


<sup>12</sup> \* Adapted from Training Guide for Travel Demand Modeling with TransCAD

LOGIT MODEL ESTIMATION\*

•NL Models

- Relaxes the assumption that disturbances of alternatives are independent
- Used when there are similarities among alternatives




<sup>13</sup> \* Adapted from Training Guide for Travel Demand Modeling with TransCAD

LOGIT MODEL ESTIMATION

- Data needs to develop equations \*
  - Single record per decision maker
  - Numeric choice field containing alternative chosen
  - Fields for all explanatory variables
- Consider borrowing equations & variables from comparable system
- Equation evaluation
  - Use t-statistic to evaluate variable significance
  - Use judgment to evaluate if coefficient signs are consistent with expectations
  - Use training and testing datasets if enough data available



<sup>14</sup> \* Adapted from Training Guide for Travel Demand Modeling with TransCAD



## MODE CHOICE



- Mode choice calibration involves use of survey data to refine model
- User attributes that affect mode choice need to be calibrated
- Out of vehicle components
  - Walk speed
  - Maximum walk distance
  - Perceived wait time factors
  - Boarding penalty
- In vehicle components
  - In vehicle travel time
- Parking cost
- Average fare
- Maximum path time



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## MODE CHOICE



- Logit model estimated earlier needs to be calibrated by adjusting the constants to account for
  - Transit usage by socioeconomic classes
  - Transit usage by trip purposes




16



ASSIGNMENT


- Apply auto occupancy factors for auto assignment
- Do transit assignment to estimate boardings
  - By transit provider
  - By corridor
  - By transit route
  - By time period
  - By transit stop



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TRANSIT APPLICATION  
-  
NORTHEAST REGION MODEL

- Demand model encompasses portions of ten different counties in the Northeast region of Wisconsin
  - Brown, Calumet, Dodge, Fond du Lac, Oconto, Outagamie, Shawano, Washington, Waupaca, Winnebago



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## NE REGION MODEL DETAILS

- Developed in Cube/TPPlus
- Four time periods
  - AM (6:00 AM - 9:00 AM), MD (9:00 AM - 3:00 PM), PM (3:00 PM - 6:00 PM), NT (6:00 PM - 6:00 AM)
  - Feedback loop that inputs congested skims from assignment back into distribution
  - Mode choice modeling for transit service in four cities- Green Bay, Appleton, Oshkosh, Fond du Lac



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## EQUATION DEVELOPMENT


- Starting equations adapted from previously developed Green Bay model
- Equation refined to take into account income, household size vs availability, trip purpose
- Starting utility equations
  - HBW
    - $U(\text{Auto}) = 2.8 - 0.025 * IVTT(\text{auto}) - 0.050 * WALKTIME(\text{auto}) - 0.005 * 15 * DIST(\text{auto}) - 0.025 * PARKINGCOST(\text{auto})$
    - $U(\text{Transit}) = -0.025 * IVTT(\text{transit}) - 0.050 * WALKTIME(\text{transit}) - 0.050 * (WAITTIME(\text{transit}) + XWAITTIME(\text{transit})) - 0.005 * FARE(\text{transit})$
  - HBO
    - $U(\text{Auto}) = 5.4 - 0.008 * IVTT(\text{auto}) - 0.025 * WALKTIME(\text{auto}) - 0.010 * 15 * DIST(\text{auto}) - 0.025 * PARKINGCOST(\text{auto})$
    - $U(\text{Transit}) = -0.008 * IVTT(\text{transit}) - 0.025 * WALKTIME(\text{transit}) - 0.025 * (WAITTIME(\text{transit}) + XWAITTIME(\text{transit})) - 0.010 * FARE(\text{transit})$
  - NHB
    - $U(\text{Auto}) = 3.8 - 0.020 * IVTT(\text{auto}) - 0.050 * WALKTIME(\text{auto}) - 0.006 * 15 * (auto) - 0.016 * PARKINGCOST(\text{auto})$
    - $U(\text{Transit}) = -0.020 * IVTT(\text{transit}) - 0.050 * WALKTIME(\text{transit}) - 0.050 * (WAITTIME(\text{transit}) + XWAITTIME(\text{transit})) - 0.006 * FARE(\text{transit})$



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**TRANSIT NETWORK CODING**

- User defined transit routes (e.g. bus routes)
- Schedule attributes
  - Headway
  - Run Time
  - Bus Stops




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**TRANSIT ROUTES- NE REGION MODEL**




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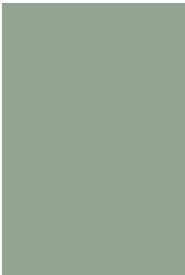



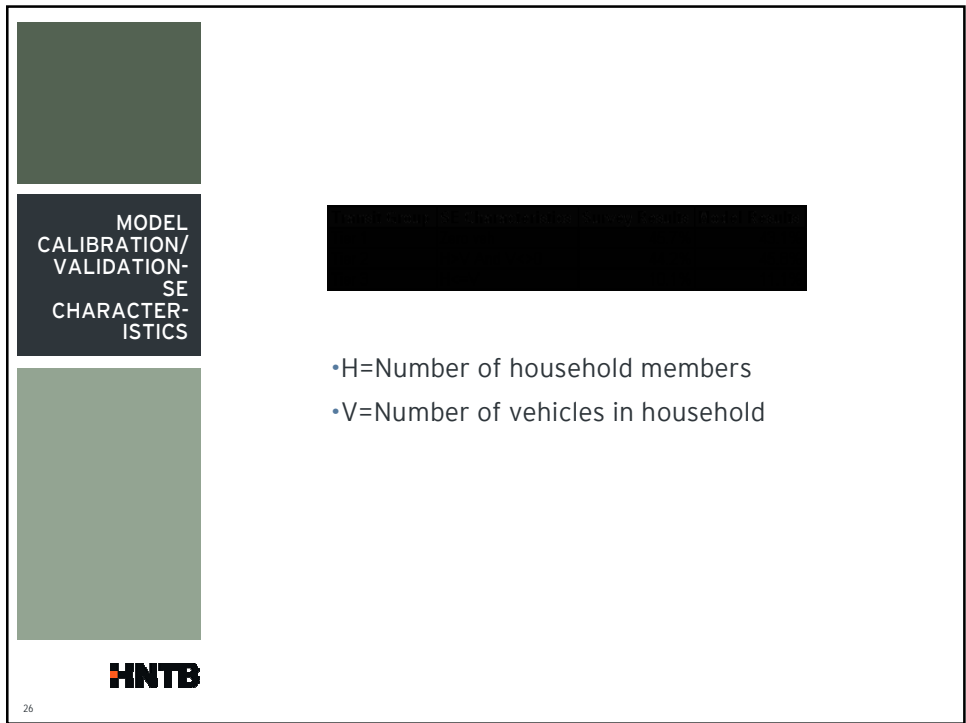
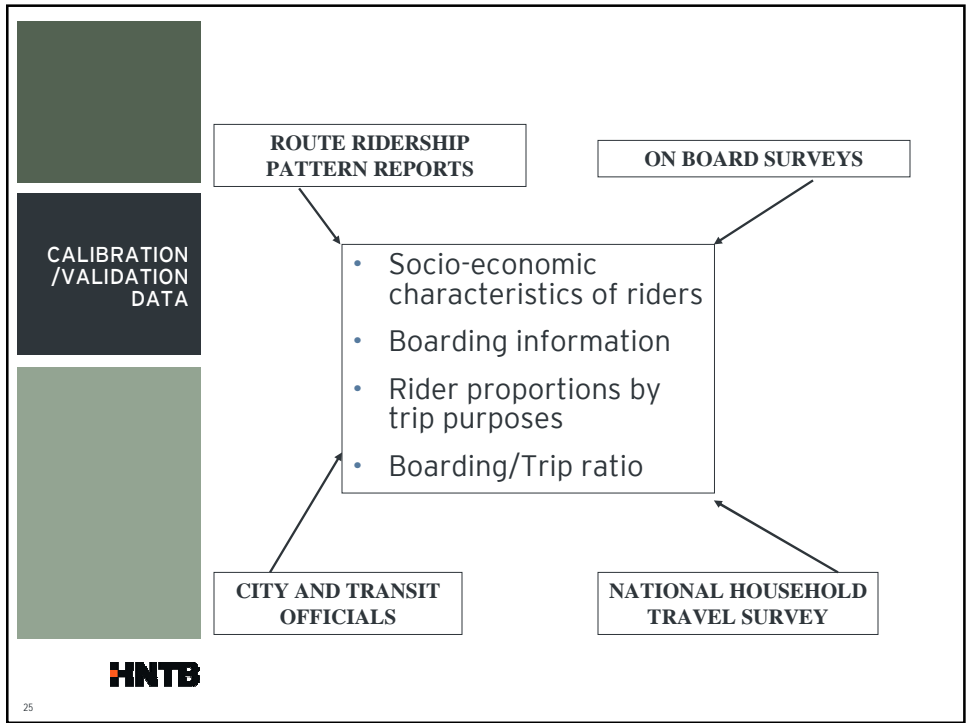
**E.g. VALLEY TRANSIT**

Route	6:00AM - 9:00 AM AM Headway	9:00 AM - 3:00 PM MD Headway	3:00 PM - 6:00 PM PM Headway	6:00 PM – 6:00 AM NT Headway	Runtime
1	36	51	36	180	25
2	30	60	36	180	25
3	36	51	36	180	25
4	30	60	36	180	25
5	36	51	36	180	25
6	30	60	36	180	25
7	36	51	36	180	25
8	30	60	36	180	25
11	60	60	60	180	55
12	60	60	60	240	55
15	60	60	60	180	55
20	60	60	60	144	55
30	60	60	60	144	55
31	60	60	60		25
32	60	60	60		25
41	90	60	60		55



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- 
- ADDITIONAL  
TRANSIT  
PARAMETERS**
- 
- Walk speed
  - Maximum walk distance
  - Maximum path time
  - Boarding penalty
  - Perceived wait time factors
  - Parking cost
  - Average fare
- 
- 24



MODEL CALIBRATION/  
VALIDATION-  
BOARDING INFORMATION

- Boarding data available
  - By route
  - By time of day
  - By transit system
- Result summary (daily boardings)

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MODEL CALIBRATION/  
VALIDATION-  
RIDER PROPORTIONS BY TRIP PURPOSE

Transit Proportions- NHTS		
HBW	HBO	NHB
31.13%	15.82%	51.95%
Transit Proportions- Fox Valley Survey		
WORK	OTHER	
57.81%	42.19%	
Transit Proportions-Model		
HBW	HBO	NHB
26.82%	17.06%	56.31%
Home Based Splits-Model		
HBW	HBO	
60.04%	39.96%	

- HBW= Home Based Work trips
- HBO= Home Based Other trips
- NHB= Non Home Based trips

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BOARDING  
: TRIP  
RATIO



- One trip may have multiple boardings
- Boarding/Trip for Appleton based on January-May 2009 data=1.4
- Systemwide Boarding/Trip from NE Region Model output=1.44

**HNTB**

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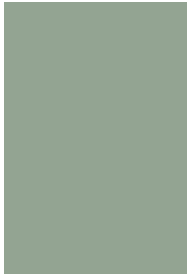


MODEL  
APPLICATION



- What *can* be evaluated by model?
  - Boarding estimates for new routes
  - Boarding comparisons for alternative routes
  - Effect of adding new route on ridership of other routes
  - Modifications in headways and runtimes


**HNTB**

30

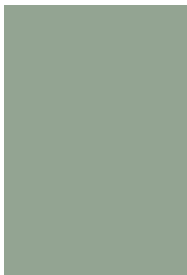
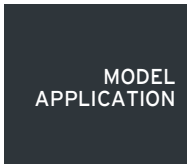



MODEL APPLICATION

- What *can not* be evaluated by model?
  - Bus stop location optimization
  - Bus capacity modification effects
  - Bus time synchronization




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MODEL APPLICATION

- What *could* be evaluated by the model?
  - Effect of transit fare modification
    - Can estimate route and system ridership based on modification of average fare
  - Effect of change in generalized automobile cost
    - Can estimate route and system ridership on modification of generalized automobile cost
  - Non-bus transit route introduction (E.g. Light rail)



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MODEL APPLICATION : ADD THREE NEW TRANSIT ROUTES

- Routes
  - Fox River Mall/Airport/Greenville Route
  - Tripper Route 70
  - Thrivent & Park-N-Ride
- Input data requirements
  - Roadway routes for the bus
  - Bus stop locations
  - Headways
  - Runtimes



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MODEL APPLICATION : ROUTES



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MODEL APPLICATION : DATA INPUTS AND ASSUMPTIONS

- Data available
  - Fox River Mall/Airport/Greenville Route
    - Bus route ✓
    - Bus stop locations X
    - Headway X (AM=40 min, MD=40 min, PM=40 min)
    - Runtime ✓ (30 minutes)
  - Tripper Route 70
    - Bus route ✓
    - Bus stop locations ✓
    - Headway ✓ (AM=180 min, PM=180 min)
    - Runtime ✓ (AM=32 min, PM=42 min)
  - Thrivent & Park-N-Ride
    - Bus route ✓
    - Bus stop locations X
    - Headway ✓ (AM=40 min, PM=40 min)
    - Runtime ✓ (40 min)

HNTB

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MODEL APPLICATION : RESULTS (Boardings)



HNTB

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## CONCLUSIONS



- Requires additional data collection efforts
- Transit model should be sensitive to socio-economic characteristics
- How can model outputs be used in transit decision making process?
- Estimate:
  - Impact of adding new routes: Model can
    - Estimate new route ridership
    - Estimate resulting effect on other routes
    - Compare ridership estimates for alternative routes
  - Effect of parking costs on transit
  - Effect of fare on transit



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