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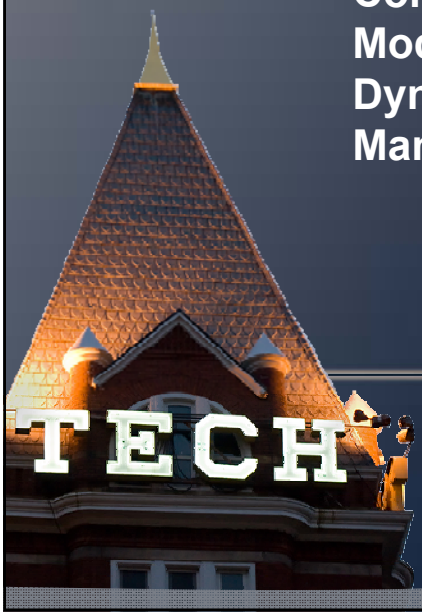

Continuous-time Integrated Transport Model System for Simulating Impacts of Dynamic and Active Mobility Management Strategies

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6th TRB Conference on Innovations in Travel Modeling

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Background

- Technology is increasingly permeating all aspects of life and significantly changing the way people go about their daily lives

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Real-time Traveler Information Systems

- Real-Time Information Systems (RTIS) increasingly deployed to manage travel demand
- RTIS provide information about prevailing network conditions, allowing users to make informed choices

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Impacts of RTIS

- RTIS facilitates efficient activity-travel choices
- Users may access and react to information in different ways
  - Unique individual constraints and interactions
  - Cascading impacts
- Need for analytical tools that can simulate and assess the impacts of RTIS

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Modeling Impacts of RTIS: Previous Work

- Earlier efforts have focused mostly on the impact of RTIS on routing decisions and network conditions
  - Through the use of traffic assignment models
- Number of other activity-travel dimensions are also directly/indirectly influenced by RTIS
  - When, where, and how the information is accessed
- The intent of the research is to develop an integrated model system which can comprehensively capture the range of pre-trip and enroute decision processes related to the planning and execution of activity-travel choices

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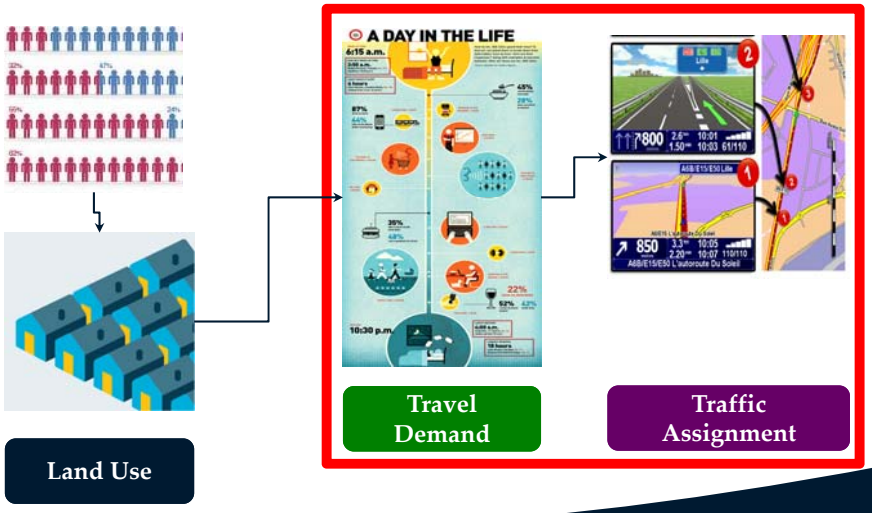
Integrated Transport Models



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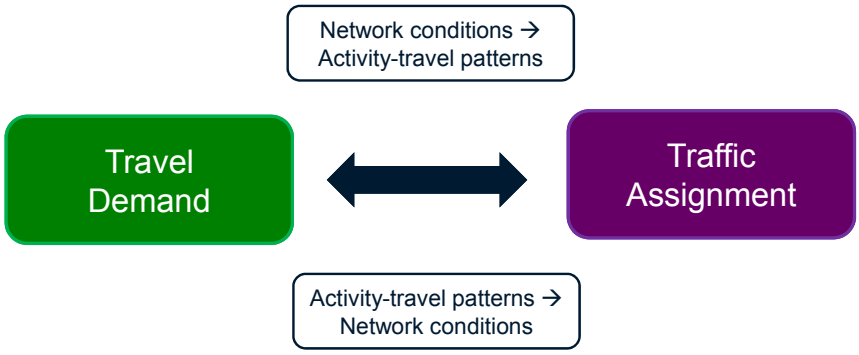
Integrated Transport Models: Components and Interactions



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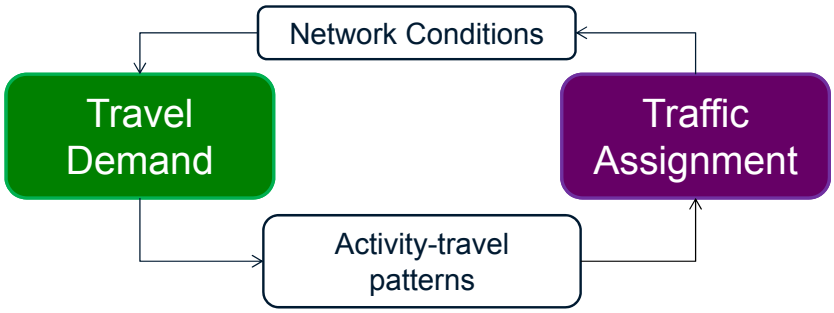
Integrated Transport Models: Sequential Paradigm



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Integrated Transport Models: A Continuous-time Integration Paradigm

- Dynamic or event-driven integration paradigm
- Travel demand and traffic assignment models communicate with one another along the continuous time axis
- Account for changes in routes, destinations, and activity schedules that may result from RTIS

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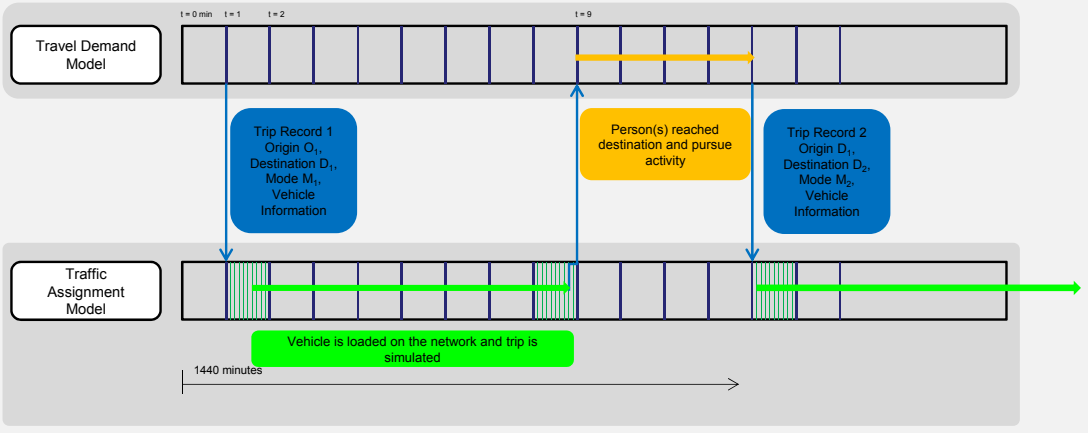
Continuous-Time Integrated Transport Modeling Framework (SimTRAVEL, 2012)



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SimTRAVEL: A Continuous-Time Integrated Transport Model System

- SimTRAVEL: Simulator of Transport, Routes, Activities, Vehicles, Emissions, and Land
- Continuous-time integrated modeling framework
- Second version combines:
  - **openAMOS**: an open-source activity-based travel demand model system
  - **DTALite**: an open-source dynamic traffic assignment model system

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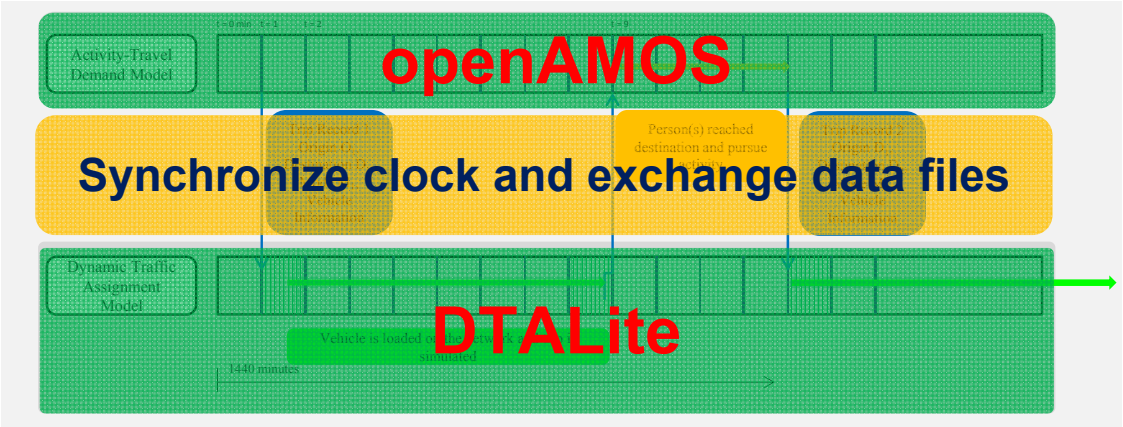
SimTRAVEL: Continuous-time Integration



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SimTRAVEL: Phased Development of Capabilities to Evaluate RTIS

✓ **Level 0**	**Baseline integration of openAMOS and DTALite with no pre-trip or enroute behaviors**
✓ **Level 1**	**RTIS: Pre-trip behaviors**
✓ **Level 2**	**RTIS: Pre-trip + Enroute route choice behaviors**
Level 3	**RTIS: Pre-trip + All Enroute behaviors**

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Level 0: Baseline integration of openAMOS and DTALite

- ABM and DTA model integrated with data exchange along a continuous time axis
  - Arrival times based on experienced conditions on the network
- Experienced network conditions from the previous iteration are used to simulate activity-travel choices in current iteration
- No pre-trip and en-route adjustments are considered for activity-travel choices in this level

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Level 1: Pre-trip Behaviors in Response to RTIS

- Pre-trip decision making in activity-travel choices
  - All information is available to traveler prior to embarking on trip
  - Choices are simulated based on pre-trip information
- No en-route adjustments to activity-travel choices
  - Not sensitive to availability of real-time information "en-route"
  - Traveler continues to intended destination along the planned route regardless of changes in prevailing network conditions

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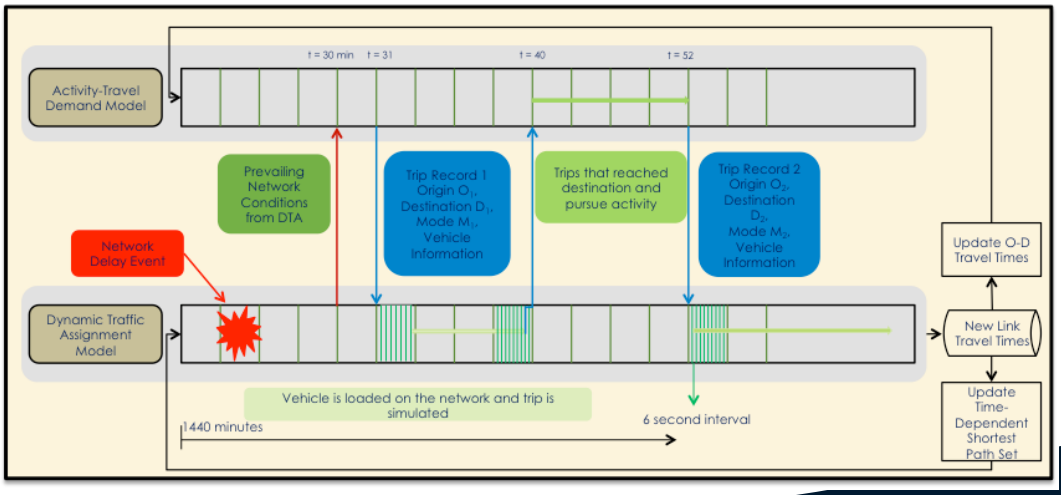
Level 1: SimTRAVEL



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Level 2: Pre-trip + Enroute Route Choice Behaviors in Response to RTIS

- In addition to Level 1, enroute decision making for **route choice**
- Extend the integrated modeling framework to accommodate enroute adjustments to route choice
  - **Level 1**: Network model invokes demand model only when traveler arrives at destination
  - **Level 2**: Network model checks status of travelers every n^{th} minute
  - Based on information availability, and updated travel time information to intended destination, traveler may adjust route choice

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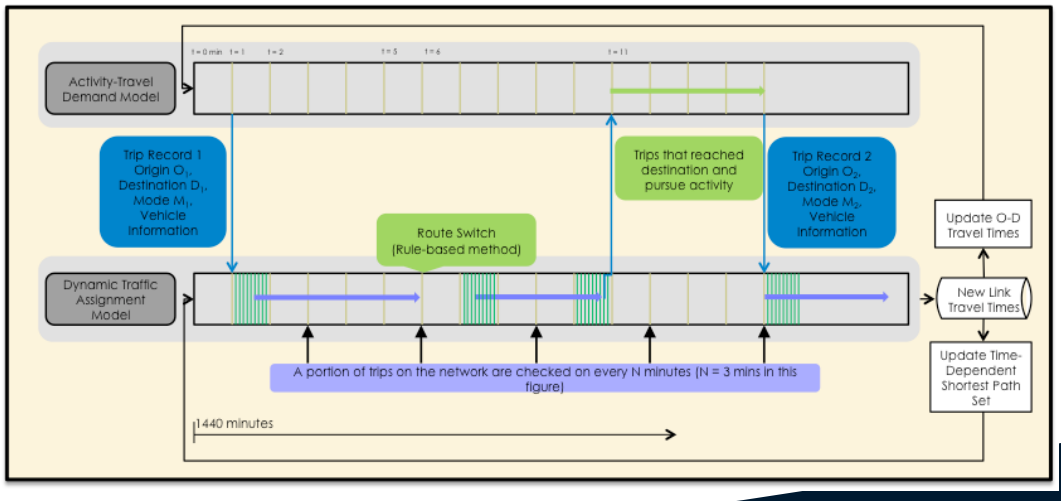
Level 2: Integration Overview



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Level 3: Pre-trip + Enroute Behaviors in Response to RTIS

- In addition to Level 1&2, enroute decision making for all activity-travel choices
- Further extend framework to accommodate enroute adjustments to full array of activity-travel choices
  - In response to information about network conditions or attributes, traveler may switch route (Level 2 Integration)
    - **No stress experienced**: Traveler is able to identify alternate route that meets time-space prism constraints
    - **Stress experienced**: Traveler is not able to find an alternative route
  - For traveler under stress, DTA model will communicate to activity model the subset of trips for which "acceptable" alternate route cannot be found
  - Activity model considers adjustments to destination choice, mode choice, and activity participation choice in that order

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Level 3: Pre-trip + Enroute Behaviors in Response to RTIS (2)

- If activity is mandatory and fixed in space, then traveler must proceed to fixed destination and experience late arrival
- For non-mandatory activity

1. If no alternative path is satisfactory (need to define "satisfactory"), then destination choice is re-simulated (if destination is flexible)
2. Given new destination, a new route is simulated based on prevailing traffic conditions and traveler is routed to new destination
3. If no alternative destination is reachable within time-space prism constraints, then activity may be dropped/canceled/rescheduled to a later time
4. Check availability of other household members to potentially reassign activity to another household member

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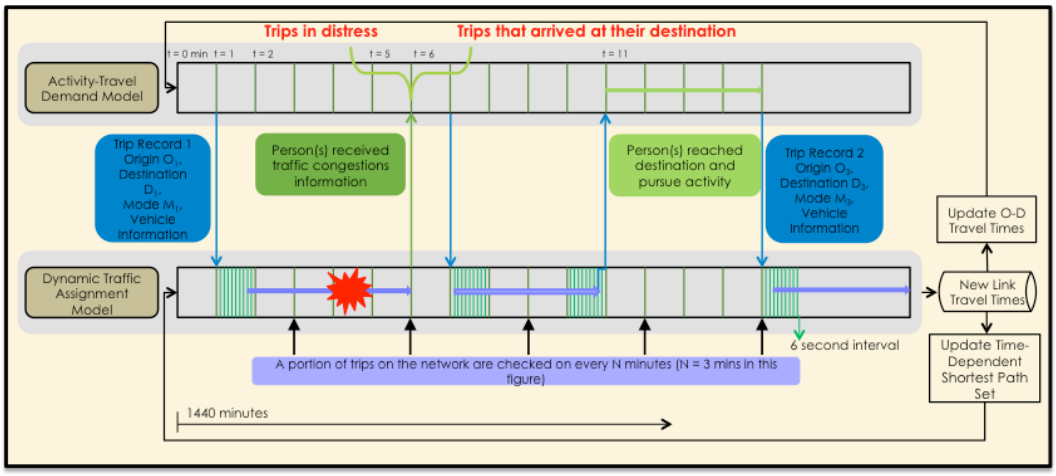
Level 3: Integration Overview



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Level 3: Integration Overview

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Study Area

- Sioux Falls test network
  - 25 zones
  - 76 links (60 mph speed limit)
  - A total of 112 households and 346 persons

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Scenarios for Level 1 Integration

Baseline : No Disruption

- Everyone goes about business as usual

No Pre-trip Information Scenario

- Disruption from 7:00 AM – 11:00 AM on one link

50% Pre-trip Information Scenario

- Disruption from 7:00 AM – 11:00 AM on one link
- 50% of travelers have **pre-trip** information ONLY

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Pre-trip ONLY: Simulation Results

Indicator	Baseline	No Pre-trip Information	50% Pre-trip Information
Households	112	112	112
Persons	346	346	346
Total Trips	1509	1512	1563
Total Auto Trips	1199	1205	1233
Total Travel Time (minute)	14498	16661	15919
Total Travel Distance (mile)	13098.3	13071.5	13606.3
Average Trip Rate	4.36	4.37	4.52
Average Trip Duration (minute)	9.61	11.02	10.18
Average Trip Length (mile)	8.68	8.65	8.71
Average Travel Speed (mph)	60.00	53.33	58.53
Average Trip Duration (minute) during Network Disruption	9.92	15.76	12.60
Average Trip Length (mile) during Network Disruption	8.99	8.91	9.50

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Pre-trip ONLY: Time-Use Patters

	Baseline	No Pre-trip Information	50% Pre-trip Information
Time Spent in activities			
Home	1044.3	1046.0	1043.5
Work	166.3	165.2	165.6
School	84.2	82.9	84.2
Maintenance	56.7	52.7	53.7
Discretionary	33.4	30.5	32.0
Pick-Up	0.1	0.1	0.1
Drop-Off	2.0	1.8	1.3
Other	10.9	12.4	13.4
Sub Total	1397.9	1391.6	1393.8
Time Spent in Travel			
Home	17.5	17.6	18.4
Work	5.1	6.6	5.5
School	0.9	1.5	1.0
Maintenance	10.2	11.3	11.7
Discretionary	2.6	2.8	2.8
Pick-Up	1.4	1.9	1.9
Drop-Off	3.6	5.7	3.8
Other	0.8	1.0	1.2
Sub Total	42.1	48.4	46.2
Total	1440.0	1440.0	1440.0

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Scenarios for Level 2 Integration

Baseline Scenario: No Disruption

- Everyone goes about business as usual

No Information Scenario

- Disruption from 8:00 AM – 4:00 PM on 3 contiguous links

50% Information Scenario

- Disruption from 8:00 AM – 4:00 PM
- 50% of travelers have **pretrip+enroute** information

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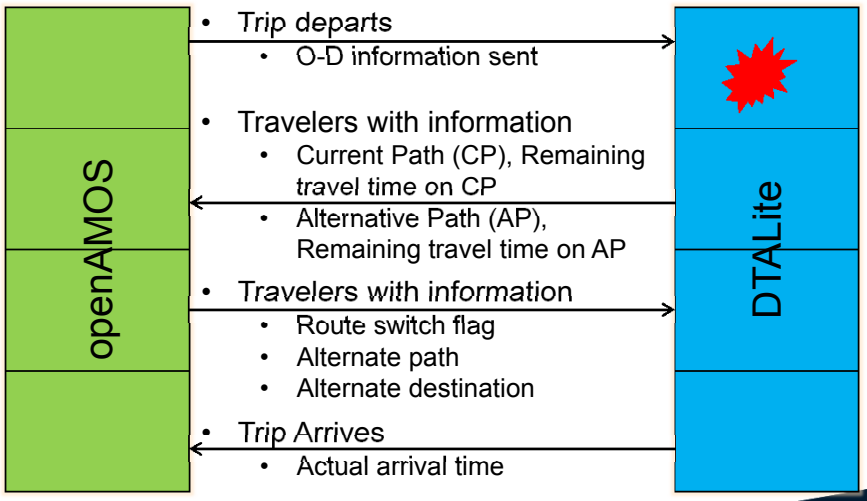
Level 2 Implementation Schematic



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No Information → No Route Change

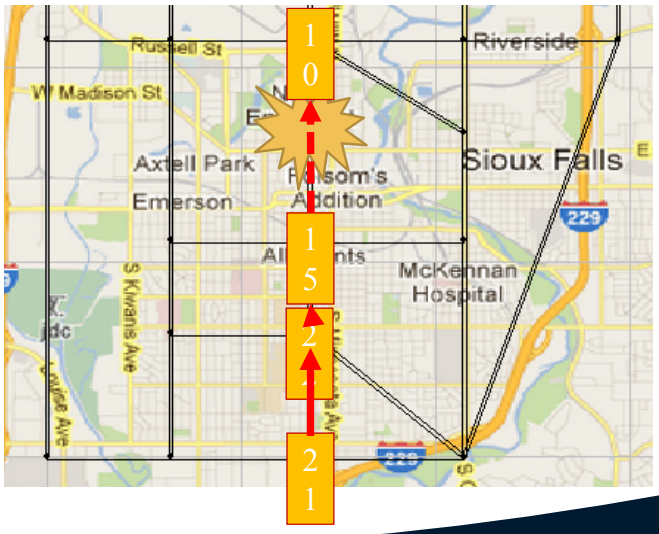

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Illustration of Enroute Changes: Example 1

Household ID: 22290
Person ID: 1
Household Size: 3
Number of Children: 1
Age: 45
Employment Status: Worker
Gender: Male

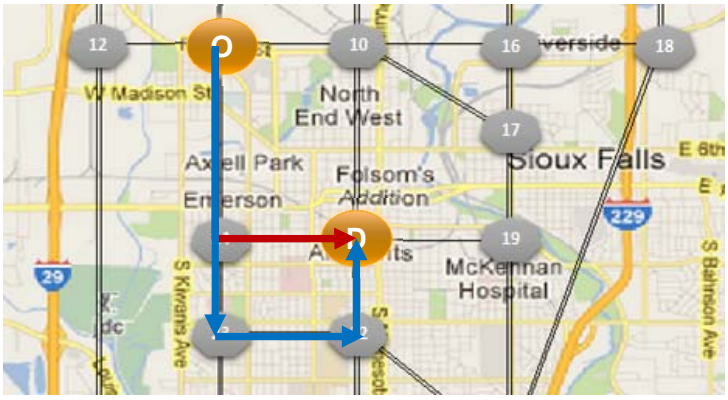

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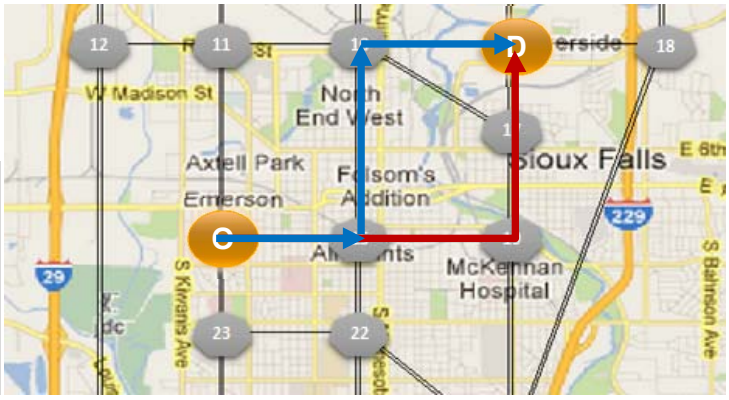
Illustration of Enroute Changes: Example 2

Household ID: 26719
Person ID: 2
Household Size: 4
Number of Children: 1
Age: 60
Employment Status: Worker
Gender: Female



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Conclusions

- Developed continuous time integrated travel modeling framework to model information scenarios
  - Work underway to complete the different levels of integration
  - Planning for Operations: Erasing the Line That Divides
- Value of open source integrated modeling projects
  - Not without its fair share of challenges
  - Differences in design principles/database structures/ programming languages/computational issues

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In Progress...

- Finish developing the software system to accommodate all levels of integration
- Address computational issues using enhanced data handling processes
- Extensive testing, calibration, validation, and scenario analysis

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Acknowledgements

- Funding Agencies
  - New England University Transportation Center for the funding support
  - Federal Highway Administration
  - US Department of Transportation

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Please visit:

http://www.simtravel.org

https://github.com/foss-transportationmodeling

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Pre-trip + Enroute: Simulation Results

Indicator	Baseline	No Information	50% Information
Households			
Persons			
Total Trips			
Total Auto Trips			
Total Travel Time (minute)			
Total Travel Distance (mile)			
Average Trip Rate			
Average Trip Duration (minute)			
Average Trip Length (mile)			
Average Travel Speed (mph)			
Average Trip Duration (minute) during Network Disruption			
Average Trip Length (mile) during Network Disruption			

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Pre-trip + Enroute: Time-Use Patterns

	Baseline	No Information	50% Information
Time Spent in activities			
Home			
Work			
School			
Maintenance			
Discretionary			
Pick-Up			
Drop-Off			
Other			
Sub Total			
Time Spent in Travel			
Home			
Work			
School			
Maintenance			
Discretionary			
Pick-Up			
Drop-Off			
Other			
Sub Total			
Total	1440.0	1440.0	1440.0

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