State-of-the-Art Transportation Systems Modeling for Personalized Smart Mobility and Demand Management

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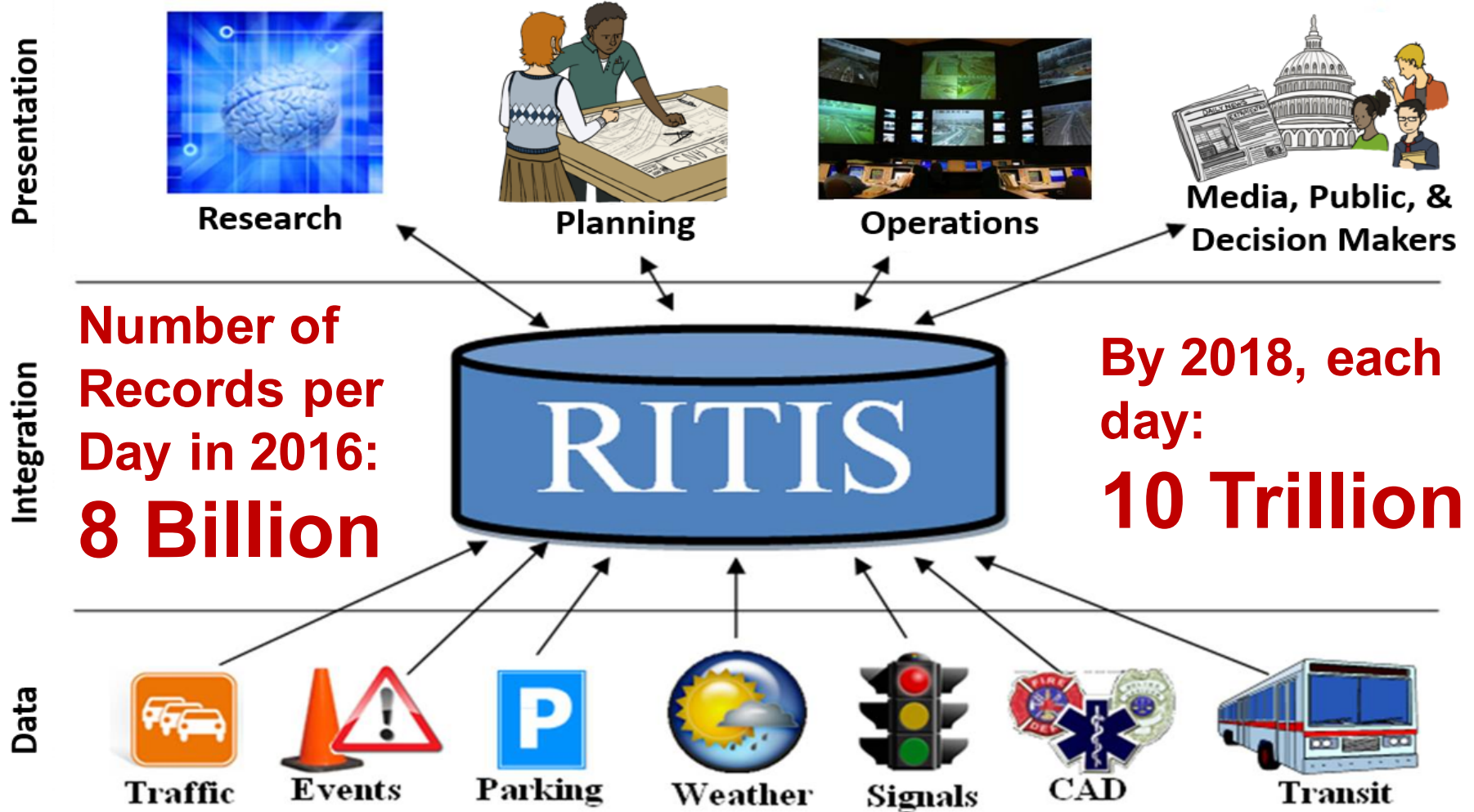
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National Transportation Center

History of Traffic Simulation Modeling

Time	Trend&Technology	Applications	Model Innovations
1960s	Minicomputers available to agencies	Signal timing and optimization	Macroscopic simulation: TRANSYT; Microscopic simulation: UTCS
1970s	Transportation System Management	Bus operations, adaptive control, safety, emissions & energy	Mesoscopic/Hybrid: TRAFLO, Micro: TEXAS,
1980~ 1990s	Personal computer, Environmental impact, ISTEA	Traffic control measures, traffic impact, integrated and coordinated signal	NETSIM, FRESIM, CORSIM, DTA, commercial software
2000~ 2010s	Parallel/GPU/Cloud computing, Performance-based decision making	ICM, ATM, ATIS, C/AV, TSM&O, Reliability, Real-time decision support	V2V/V2I simulation, Scenario cluster, Online simulation, Multi-resolution methods

Evolution of Travel Behavior Modeling

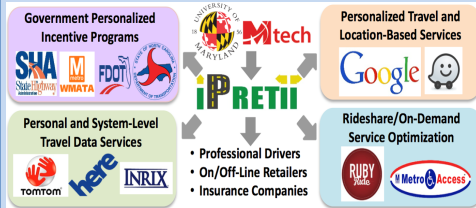| Time	Trend & Policy	Applications	Model Innovations
1960s	Auto ownership, Suburbanization, Federal funds for highways	Where to built new highways and how many lanes	Aggregate 4-Step: BPR UTPS, CATS Study
1970s	Transportation System Management	Mode choice	Disaggregate 4-Step: USDOT Williamsburg Conference, BART Study
1980~ 1990s	ISTEA, CAAA, Environmental impact	Air quality conformity, Traffic control measures, Demand management	Tour/Activity-based, DTA: TRANSIMS Project
2000~ 2010s	Integrated Planning and Operations,	TSM&O, Shared, connected, and automated mobility, Mobility as a Service	Integrated behavior and traffic models, Descriptive models w.fast convergence, Advanced computing

Big Data

Presentation
- Research
- Planning
- Operations
- Media, Public, & Decision Makers

Integration

Number of Records per Day in 2016: 8 Billion

RITIS

By 2018, each day: 10 Trillion

Data
- Traffic
- Events
- Parking
- Weather
- Signals
- CAD
- Transit

State-of-the-Art Data and Modeling

Traveler Interface via Smartphone and Mobile Web

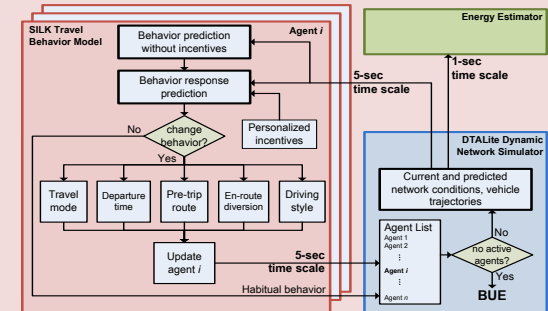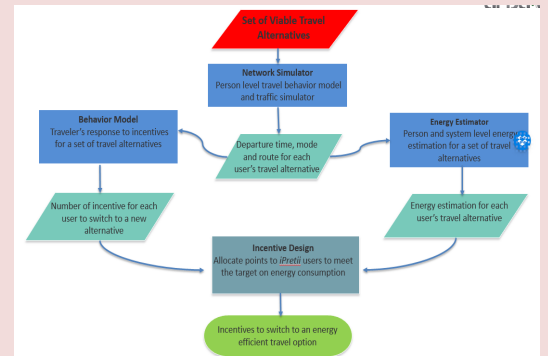**Agency and Private-Sector Client Tools, Software and Dashboards**
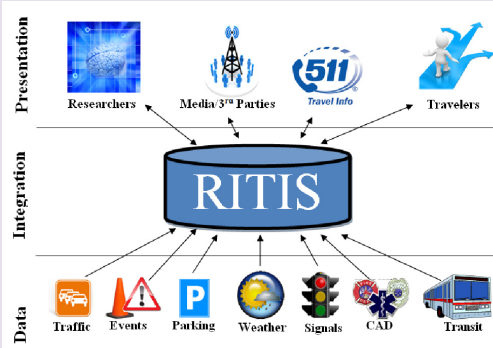
Big Data

Much-Faster-than-Real-Time Computing Solutions

Integrated Travel Behavior and Dynamic Traffic Models

Real-Time-Capable System Control & Optimization

Model Details

Real-Time Decision Support

Density (vhc/mile/ln)
- 0.00 - 11.00
- 11.00 - 17.00
- 17.00 - 25.00
- 25.00 - 35.00
- 35.00 - 45.00
- > 45.00

Band Width: Link Volume Per Hour
3000   1500
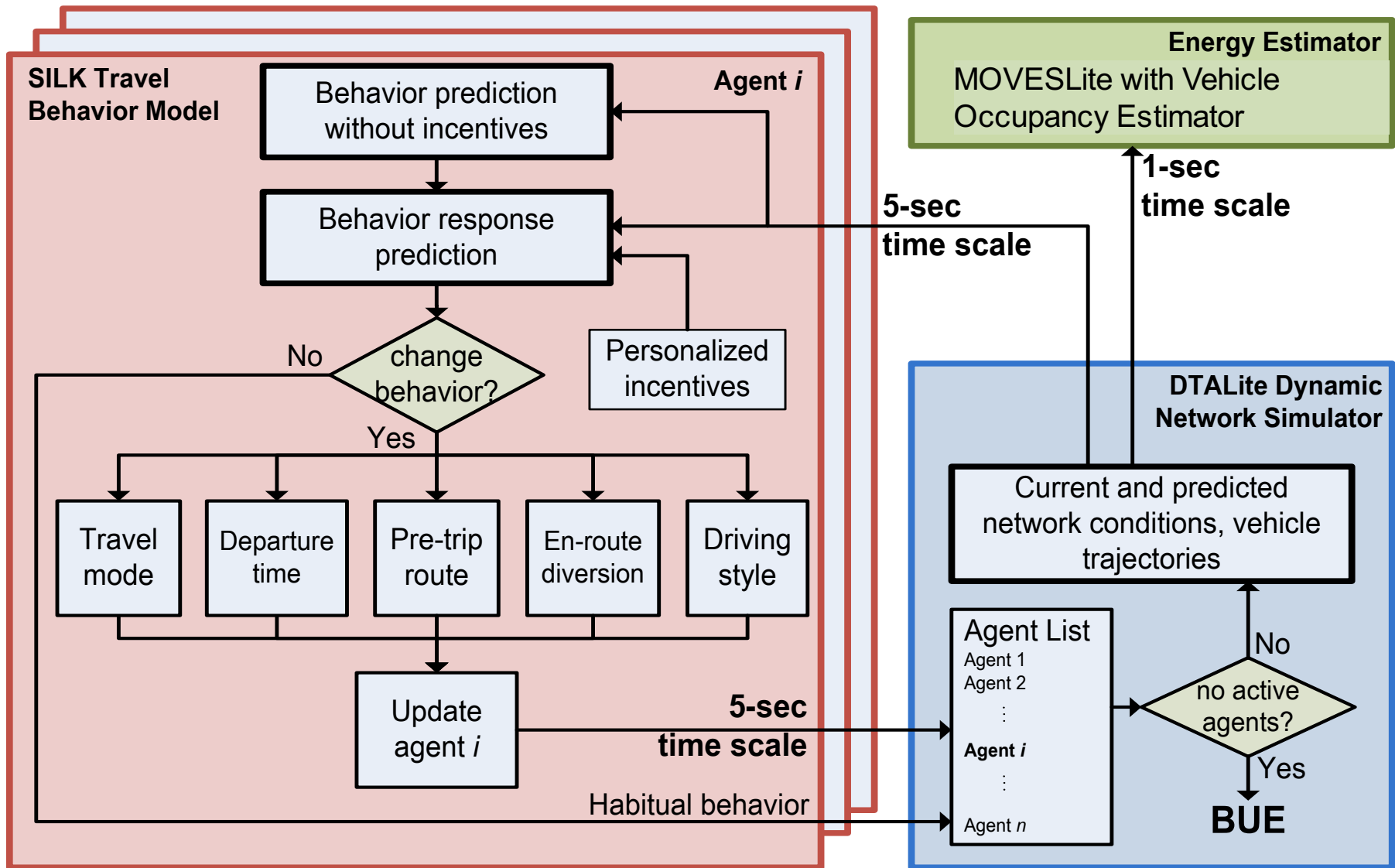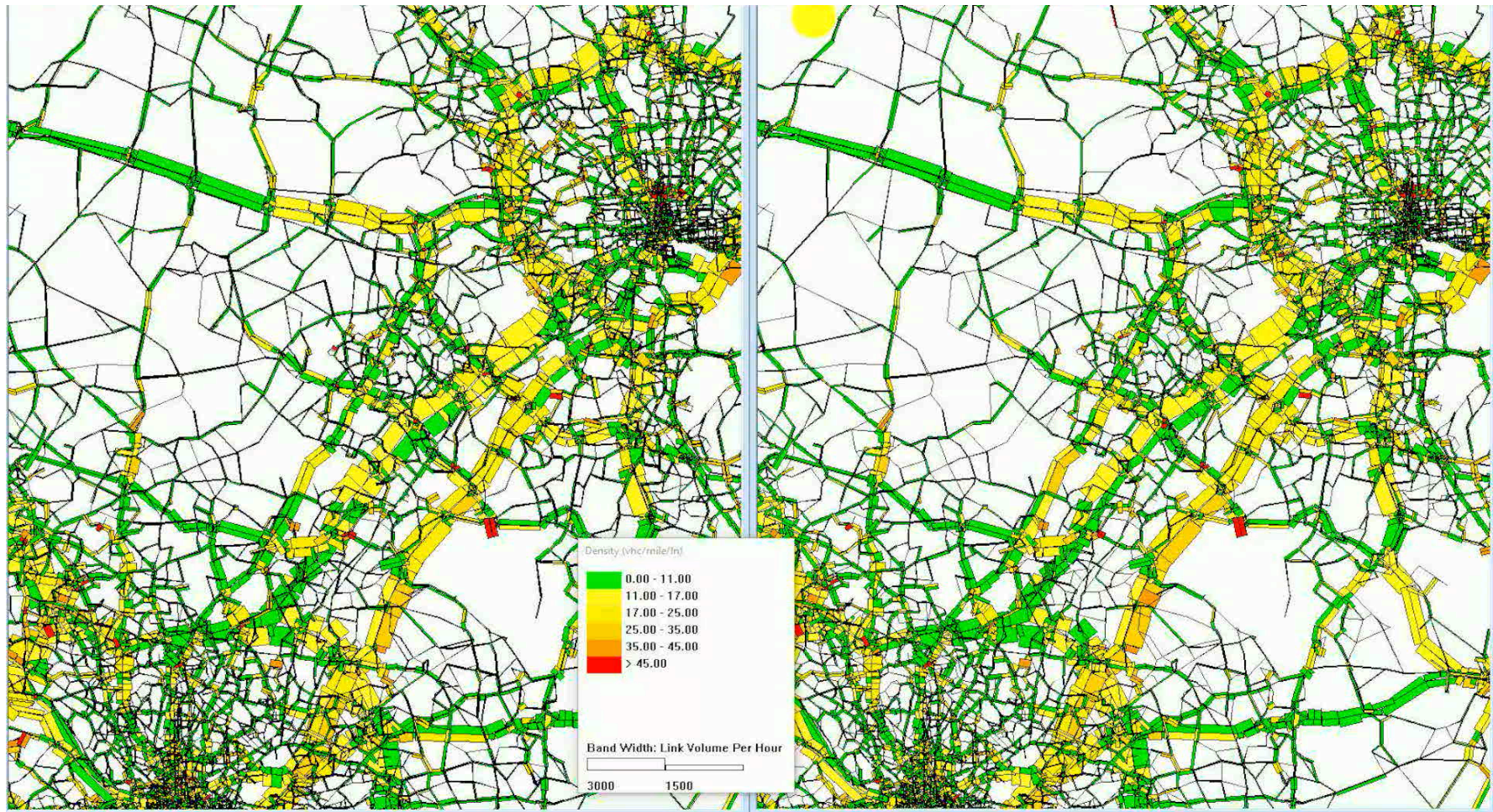
Clock: 4:00pm
No Accident

Clock: 4:01pm
Accident on I-95 NB

Travel Intent Prediction

Short-Term/Real-Time Prediction of Travel Behavior

- **Destination of the next trip: 62~73%.**

- **Purpose of the next trip: 83~99%.**

- **Social-demographic and economic characteristic of the traveler (income, age, gender, education etc.): 59~94%.**

- **Activity-travel plan of the rest of the day: 76%.**

- **All accuracy levels are based on results after four weeks of location traces are analyzed through machine learning.**

Person-Level "Signal" Optimization

Strategic Planning
Optimize:
Technology adoption
Mode choice
Long-term eco-driving target

Day-Ahead Operations
Optimize:
Pre-trip mode choice
Departure time
Route choice
Pre-trip eco-driving target

Real-Time Operations
Optimize:
En-route diversion
En-route eco-driving
Update solutions in Day-Ahead Operations

Control Decisions

- **Whether or not to incentivize a particular traveler**
- **Which travel choice(s) to influence**
- **Type and intensity of personalized incentive to be delivered.**

Goal

- **System optimality**
- **No false information to travelers**
- **Pareto optimality among users**
- **Reducing congestion, energy use, emissions etc.**

Example: incenTrip in D.C.-Baltimore
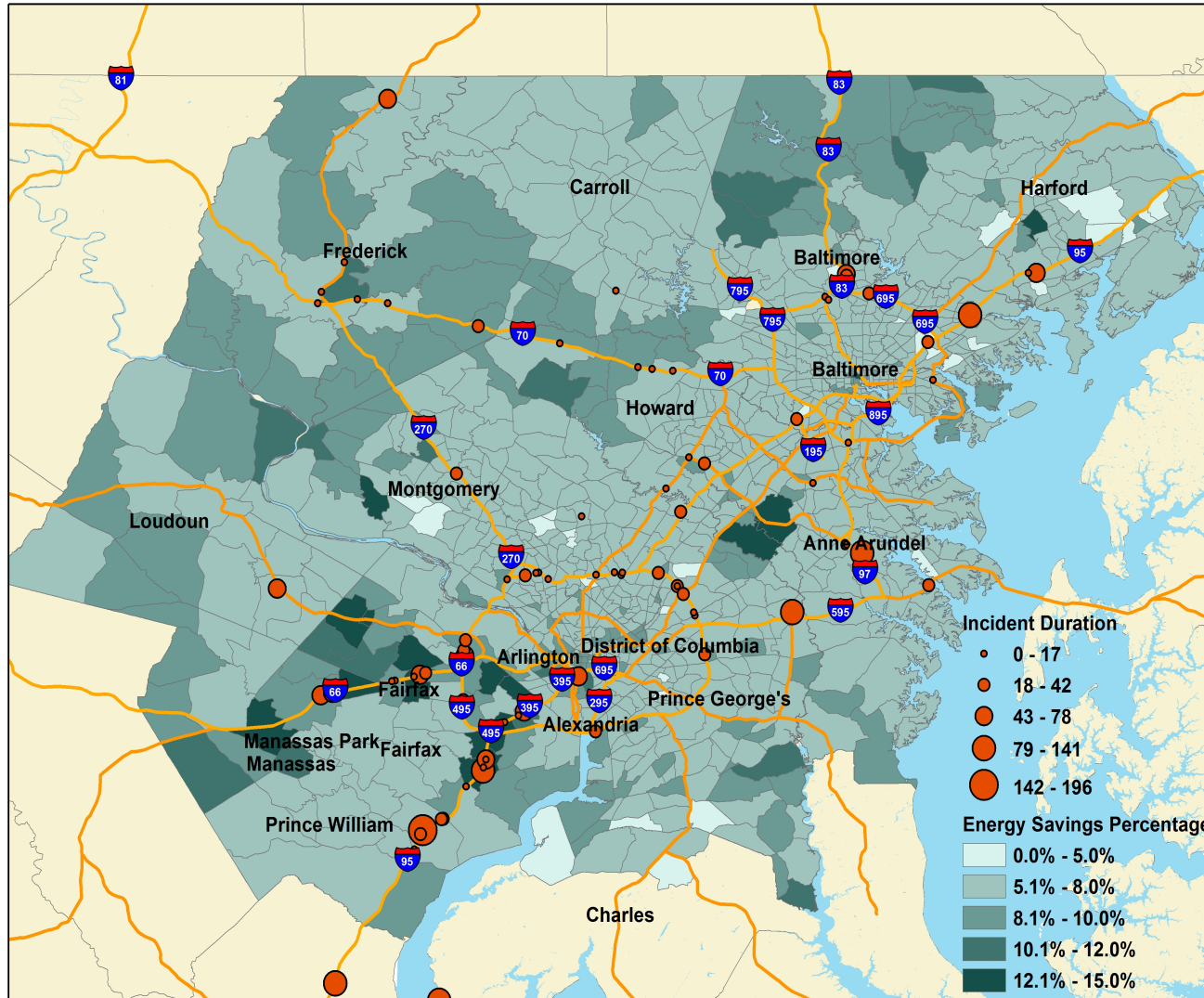
Funded by DOE ARPA-E TRANSNET.

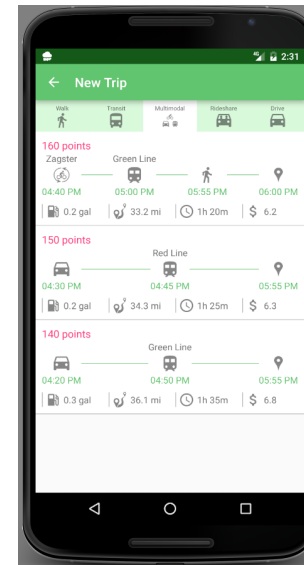**System-Wide Impact:**

8.7%

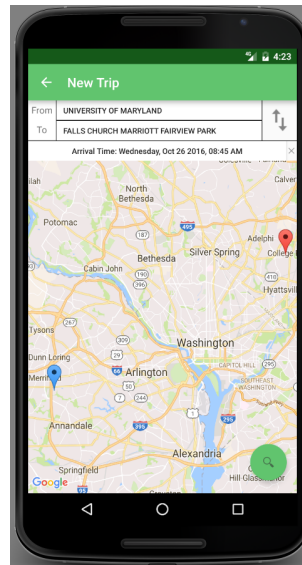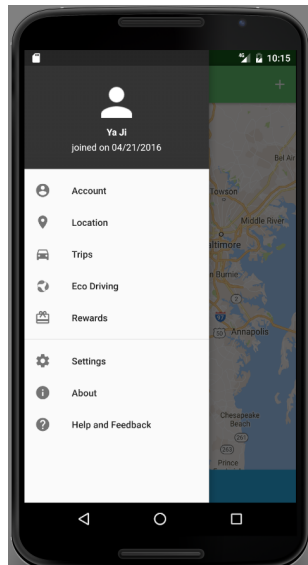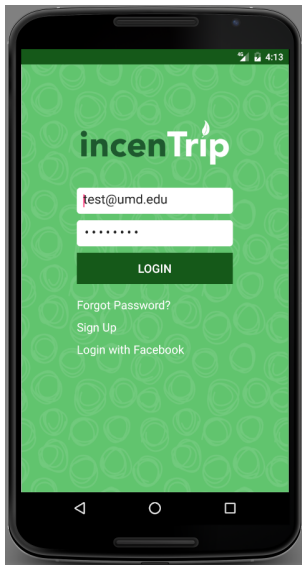reduction in energy use

User%: 7.5% Monetary Incentive: $6 million per year for the PM peak period.

Personalized Incentives & Information
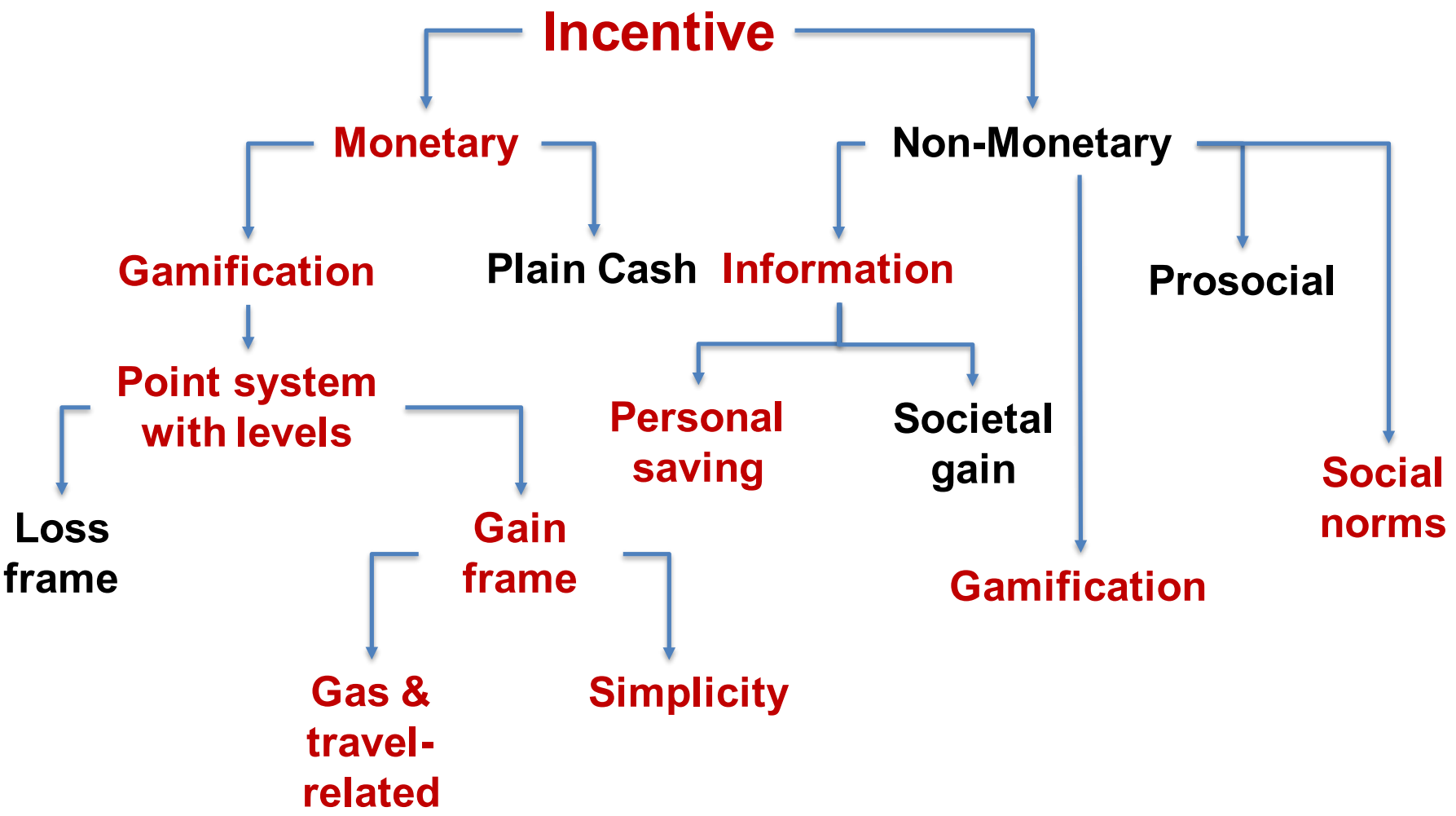
User Smart Phone App
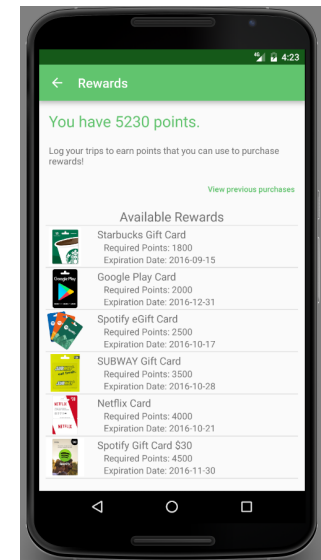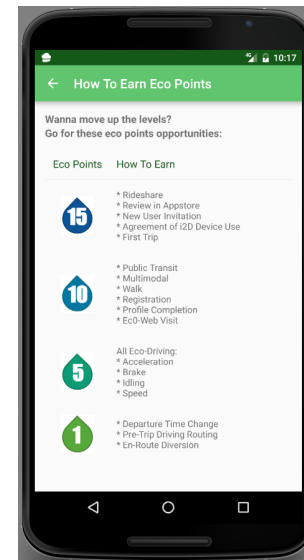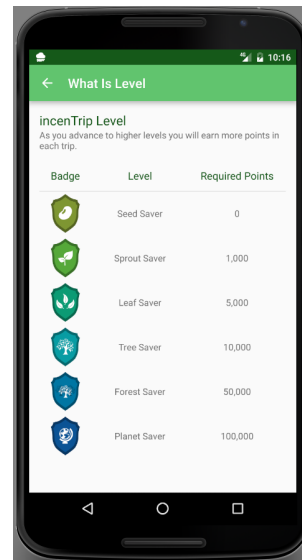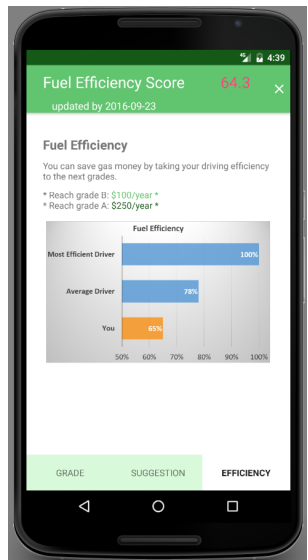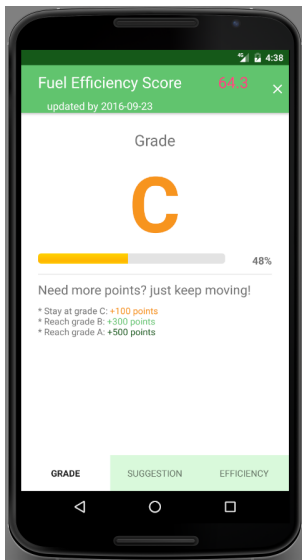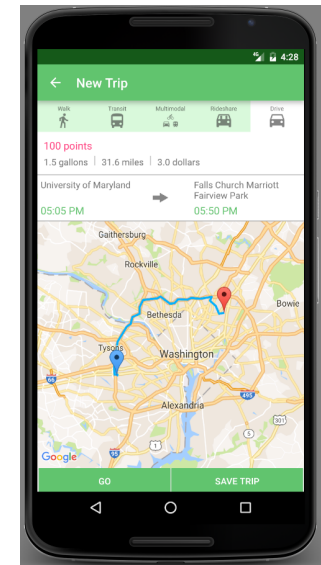
Agency Dash Board

incenTrip — DOEE Agency Dashboard

Area: **District of Columbia** [Select New Area]   Time Period: **01/01/2016 – 12/31/2016** [Select New Time Period]   Total Users: **2,126**   Total Trips: **512,175**

Total Gallons of Fuel Saved **320,625**
Total Cost of Fuel Saved **$818,734**

Total Tons of Emission Reduced **14,528**
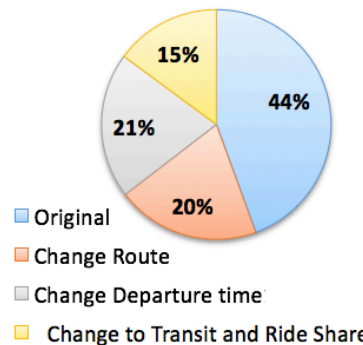Total Cost of Emission Reduced **$290,808**

Total Hours of Congestion Saved **36,829**
Total Cost of Congestion Saved **$570,725**

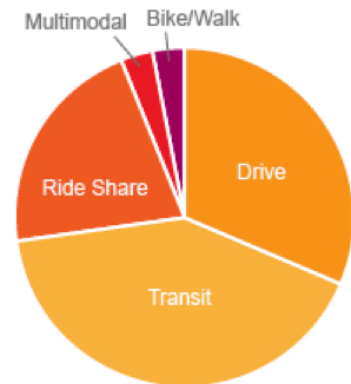**Total Benefits: $1,780,267**
Total Incentives: $308,652

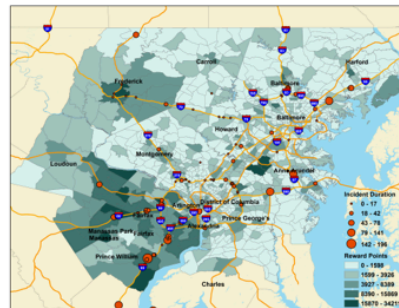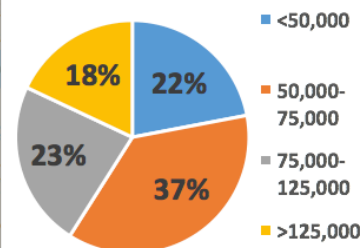**Return on Investment: 561%**

Traveler Behavior Change

44%
15%
21%
20%

- Original
- Change Route
- Change Departure time
- Change to Transit and Ride Share

Trips taken by mode:

Transit: **2,082**
Drive: **1,584**
Ride Share: **1,076**
Multimodal: **154**
Bike/Walk: **141**

Multimodal   Bike/Walk
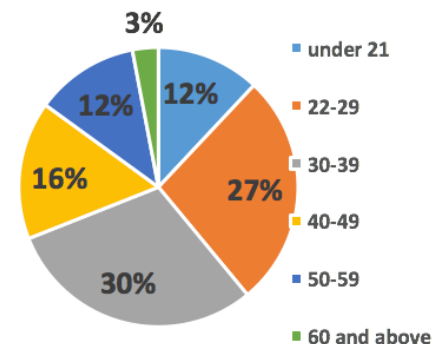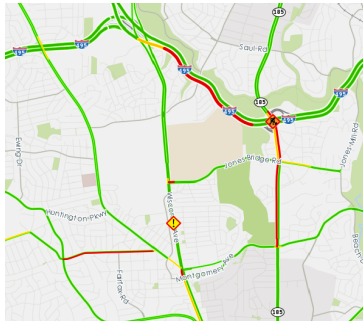Drive
Ride Share
Transit

Incentive Distribution by Home Location

Incentive Distribution by Household Income

22%
37%
23%
18%

- <50,000
- 50,000-75,000
- 75,000-125,000
- >125,000

Incentive Distribution by Age

3%
12%
12%
27%
30%
16%

- under 21
- 22-29
- 30-39
- 40-49
- 50-59
- 60 and above

Model Applications

Demand/Congestion Management

Crowd-Source Solutions
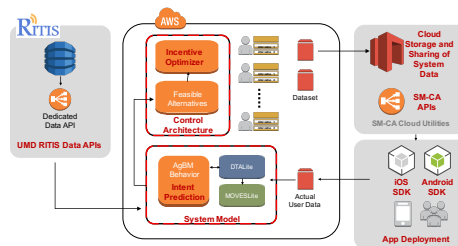
Energy and Emissions

Smart Mobility and MaaS Eco-System