Overview of the Transportation Secure Data Center (www.nrel.gov/tsdc)

March 2016

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National Renewable Energy Laboratory (NREL) Transportation Center
Transportation Secure Data Center (TSDC) Rationale

High-resolution survey data (e.g., GPS travel profiles, geo-coded trip ends)
- Very valuable for research
- Misuse could violate participant privacy

Secure data center makes data available for legitimate research while preserving privacy
- Maximizes value from limited public funds
- Benefits data providers and users
  - Takes care of archiving and responding to data requests
  - Data accessible from a central location

The TSDC has been supported since 2009 by NREL, U.S. DOT and U.S. DOE
- Department of Transportation, Federal Highway Administration
- Department of Energy, Vehicle Technologies Office

## NREL Transportation Data Centers

**Secure Access, Expert Analysis and Validation Support Decision-Making**

**Alternative Fuels Data Center (AFDC)**  
*Public clearinghouse of information on the full range of advanced vehicles and fuels*

**National Fuel Cell Technology Evaluation Center (NFCTEC)**  
*Industry data and reports on hydrogen fuel cell technology status, progress, and challenges*

**Transportation Secure Data Center (TSDC):**  
*Detailed fleet data, including GPS travel profiles*

**Fleet DNA Data Collection**  
*Medium- and heavy-duty drive-cycle and powertrain data from advanced commercial fleets*

**FleetDASH:**  
*Business intelligence to manage Federal fleet petroleum/alternative fuel consumption*

<table>
<thead>
<tr>
<th>Features</th>
<th>AFDC</th>
<th>NFCTEC</th>
<th>TSDC</th>
<th>Fleet DNA</th>
<th>Fleet DASH</th>
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<tbody>
<tr>
<td>Securely Archived Sensitive Data</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Publicly Available Cleansed Composite Data</td>
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<td>Quality Control Processing</td>
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<td>Spatial Mapping/GIS Analysis</td>
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<td>Custom Reports</td>
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<td>Controlled Access via Application Process</td>
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<tr>
<td>Detailed GPS Drive-Cycle Analysis</td>
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</table>
Related Real-World Analysis Efforts Using TSDC Data

Large distribution of real-world GPS travel profiles, including speed, acceleration, distance, time of day, stop duration, etc. E.g., previous analysis explored fuel economy sensitivity to speed/acceleration characteristics and road grade using hundreds of thousands of GPS drive cycles in NREL TSDC.

GPS = Global Positioning System; CV = Conventional Vehicle
Example Travel Behavior Analysis: Day-to-Day Destination Variation for CA Bay Area Travelers

Consider short- and long-distance work commutes and leisure travel
Able to clearly distinguish patterns of variability in terms of number of trips and type and dispersion of destinations

Developing the TSDC Operating Procedures

Maintain balanced focus on dual priorities
• Privacy protection first and foremost
• Maximize usability (within constraints)

An advisory committee helps support oversight
• Group includes data providers and users
• Represents industry, academia and government

Reference best practice examples
• Experience from other NREL data centers
• And examples external to NREL (e.g., U.S. Census Research Data Center program; virtual data centers on social science\(^1\) and Medicare/Medicaid data\(^2\))

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TSDC Data Archiving Procedures

• Establish MOU agreement with data provider
  – Receive data via mail or secure FTP

• Load onto secure raw data handling server
  – Restricted access
  – On-site security force
  – Established cyber security group

• Maintain data backups
  – Data mirrored on large storage array
  – Maintain backup in separate location for fire/disaster protection

MOU = memorandum of understanding; FTP = file transfer protocol
TSDC Data Processing

- **Standardize formatting**
  - Raw point lat/long, timestamp, precision
  - Trip-level distance and time summary
  - Household/vehicle demographic information

- **Remove explicitly identifying information**
  - Participant names, addresses, contact info

- **Quality control for errant/missing GPS points**
  - Remove, adjust and/or interpolate points
  - Maintain in both processed (filtered) and original (raw/uncorrected) formats

- **Add/link to reference data**
  - Road network, road grade, GIS layers
  - Meteorological, economic, land use data
  - Vehicle and demographic information
Details on GPS Data Filtration

1. Remove duplicate records and data with negative values or differential time steps
2. Replace outlying high/low speed values
3. Remove zero-speed signal drift when vehicle is stopped
4. Replace false zero-speed records
5. Amend gaps in data
6. Repair outlying acceleration/deceleration values
7. Denoise and condition final signal

Sample GPS Vehicle Data

- Raw Speed
- High/Low Filtered Speed
- Zero Drift Filtered Speed
- False Zero Filtered Speed
- Signal Gaps Filtered Speed
- Acceleration Filtered Speed
- Smoothed Speed

Sample GPS Vehicle Data

- Time (s)
- Speed (mph)
Map Matching Illustration

Complex overpasses

- Connectivity can become ambiguous when so many options are available
- Cleaned up post processing during road based analysis
TSDC Data Access: Established two distinct methods

- Cleansed/public download data area
  - Streamlined access for cleansed data; helps limit accounts in secure portal to those with a legitimate need to work with the detailed data
  - Excludes latitude/longitude and other potentially identifying details (e.g., vehicle model)
  - Includes useful supplemental information (e.g., distance traveled by road type)
  - Requires point-and-click user registration and usage agreement

- Secure portal for detailed/spatial data
  - Virtual access (rather than requiring travel)
  - Details on next slide
Secure Portal Environment Access Process

- Application packet at [www.nrel.gov/tsdc](http://www.nrel.gov/tsdc)
- Data Use Disclaimer Agreement
  - Includes confidential data protection legal language and explicit pledge not to attempt identifying individual participants
  - Required for each individual user—no data removal or account sharing
  - Requires signature from both applicant and their supervisor
- Analysis Description Document
  - Explain proposed analysis, why secure portal access needed
- Condition of Use for NREL Cyber Resources (on-line form)
- Advisory group reviews application and provides recommendation
  - Data providers included on review if desired
- Approved users only access data within the secure portal environment
  - Data transfer prohibited (clipboard sharing, local drive access, & internet disabled)
  - Use software packages provided within the environment
  - NREL audits aggregated results a user wishes to remove before providing them to the user
TSDC Secure Portal Snapshot

SOFTWARE

TSDC DESKTOP

DATA STORAGE

POSTGRESQL/POSTGIS DATABASE

SHARED DRIVE STORAGE
### Included Datasets and Request Frequency

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Sec-by-Sec Veh. GPS</th>
<th>Sec-by-Sec Wear. GPS</th>
<th>Orig./Dest. Travel Diary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Vehicles</td>
<td># Days</td>
<td># Persons</td>
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<tr>
<td>2014 Southern Nevada Household Travel Survey</td>
<td>-</td>
<td>-</td>
<td>1,694</td>
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<tr>
<td>2002-14 Texas Regional Travel Surveys (10 total)</td>
<td>3,561</td>
<td>1</td>
<td>-</td>
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<tr>
<td>2013 Mid-Region Travel Survey - Albuquerque</td>
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<td>-</td>
<td>1,023</td>
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<td>2012-13 Delaware Valley Household Travel Survey</td>
<td>-</td>
<td>-</td>
<td>811</td>
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<tr>
<td>2010-12 California Household Travel Survey</td>
<td>2,910</td>
<td>7</td>
<td>7,574</td>
</tr>
<tr>
<td>2012 California Household Survey Supplement</td>
<td>625</td>
<td>7</td>
<td>244</td>
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<tr>
<td>2011 Tolling Impact Survey - Atlanta &amp; Seattle</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>2011 Atlanta Regional Commission Travel Survey</td>
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<td>7</td>
<td>797</td>
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<tr>
<td>2010 Travel Behavior Inventory - Minneapolis</td>
<td>-</td>
<td>-</td>
<td>278</td>
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<tr>
<td>2007 Chicago Metropolitan Regional Travel Inventory</td>
<td>408</td>
<td>7</td>
<td>209</td>
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<tr>
<td>2004-2006 Traffic Choices Study - Seattle</td>
<td>481</td>
<td>540</td>
<td>-</td>
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<tr>
<td>2004 Mid-America Regional Travel Study - Kansas City</td>
<td>408</td>
<td>2</td>
<td>-</td>
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<tr>
<td>2001-02 Southern California Regional Travel Survey</td>
<td>583</td>
<td>2</td>
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<tr>
<td><strong>Total Vehicle-Days of Travel</strong></td>
<td></td>
<td></td>
<td>300,894</td>
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<tr>
<td><strong>Total Person-Days of Travel</strong></td>
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<td>39,838</td>
</tr>
</tbody>
</table>

Caltrans sample also includes some OBD data, and geocoded trip ends from the full survey.
Questions?

For More Information on the TSDC…

Visit the website:  www.nrel.gov/tsdc

• Read about the project
• View fact sheets and publications
• Download cleansed public data
• Apply for secure portal access
• Sign up to receive e-mail updates

Contact:  Jeff.Gonder@nrel.gov or tsdc@nrel.gov

• If interested in partnering on the project
• For user support
• For help answering questions
Appendix
Integration with Other Large Datasets

- GPS Travel/Drive Cycles
- Digital Street Maps
- Traffic Speeds
- Elevation / Grade
- Ambient Temperature
- Freight Volumes
- Vehicle Registrations
- Solar Intensity
- Overall Road Volumes
Example TSDC-Enabled Studies

- Extensive NREL analyses working with large GPS datasets
  - Multi-powertrain real-world fuel economy distributions/sensitivities
  - Comparing real-world driving and standardized test profile results
  - Enabling road grade simulation and quantifying impacts
  - Synthesis with national climate data for thermal technology evaluation
  - Investigating PEV charging and alternative fuel station locations
  - Developing green routing and adaptive control algorithms
  - Assessing fuel saving opportunities from driver feedback...