Connected And Autonomous Vehicle Related Research at ORNL

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This presentation does not contain any proprietary, confidential, or otherwise restricted information
ORNL is DOE’s Largest Science and Energy Laboratory

- $1.5B budget
- 4,400 employees
- 3,000 research guests annually
- $750 million invested in modernization
- Nation’s largest materials research portfolio
- World’s most powerful open scientific computing facility
- Nation’s most diverse energy portfolio
- Operating the world’s most intense pulsed neutron source
- Managing the billion-dollar U.S. ITER project
Delivering science and technology: We lead major R&D programs for DOE and other customers
Focusing our energy R&D portfolio on delivering systems-level solutions

Vehicle technologies

Transportation Electrification

Building technologies

Integrated energy systems
ORNL’s vision is to integrate energy science and technology to create a sustainable, livable community.
Internet of Secure Things – Deployed in a Modern Utility

Measuring parameters for a robust, secure electric grid

Advanced Fixed & Mobile Sensors + Fiber Comm Backbone

1: EPB Headquarters
2: EPB Distribution Center
3: Riverside Substation, medium, 6 circuits, 46 kV to 12 kV
4: Dodson Substation, small, 3 circuits, 46 kV to 4 kV
5: Ridgedale Substation, large, 9 circuits, 46 kV to 12 kV

More info? fuhrpl@ornl.gov
Parameters measured include:

- Temp,
- Humidity,
- Pressure,
- Motion (accelerometers),
- Magnetometers,
- Radiation ($\gamma$),
- Coronal arc discharge,
- Thermal imagery,
- Visual cameras,
- Cellphone signals (Verizon, AT&T, T-Mobile, Sprint),
- CH4 (methane),
- CO2,
- H2,
- VOCs,
- CO,
- Alcohol (vapor),
- Chemical “fields”,
- Acoustic “fields”
- Particulates,
- Solar irradiance,
- N2O,
- Fluorinated gases

Residential & Commercial
bldg load monitoring
Electric and Magnetic fields
RFID & QR codes

**Drone Proximity**

**Drone Alert**
Example of Digital Infrastructure - EPB Radial Fiber
Tests of DSRC Units over Chattanooga Network
Chattanooga Department of Transportation – Transit Signal Prioritization
Balancing Fuel Economy and Performance of Signalized Intersection - Assessment of Vehicle-Infrastructure Coordination

• Benefit expected from vehicle-to-infrastructure (V2I) integration
  – Fuel economy
  – Measures of traffic

• Potential conflicts among measures have to be considered
  • Interaction loop between vehicles and infrastructure
  • Measures for vehicle or measures for traffic
  • Measures for drivers
  • Optimal performance

• A solution to interaction loop
  • Prioritization
  • New rules for right-of-way may be needed

Assisting DOT in building safety, security, privacy for connected vehicles

Potential impact: 80% reduction in accidents

- Developed new vehicle-based credential generation system for the National Highway Traffic Safety Administration.
  - Allows messages vehicles broadcast (e.g., BSMs) to be trusted
- Developed metric-based privacy tools for pilot data and operational deployments based on a complete analysis of CVE privacy issues.
  - Trajectory de-identification.
  - System-wide privacy metrics through evaluation of pseudonyms using modeling and simulation.

250+ million vehicles travel on 4 million miles of US roads

Privacy research supported by NHTSA, Federal Highway Administration, and Intelligent Transportation Systems Joint Program Office
Privacy Preserving Data Publishing

Vehicle Travel Data is Valuable

- Connected Vehicle BSMs are high-fidelity (DGPS), and they are transmitted at high frequency (10Hz).
- Pilot studies are being conducted to generate data that will drive innovation
- Individual travel patterns are often unique, and individual privacy should be protected to the extent possible.

**ORNL tools integrate detailed map information, unique detectors for sensitive locations, and a metric-based method to “sanitize” very large vehicle trajectory databases.**
Vehicle-Based Security Credential Management in a Nutshell

A public-key cryptography system for V2V communications (VPKI) where vehicle participants act as a subordinate certificate authority.

• Security
  o Vehicles generate BSM signing and verifying key (certificate) pairs (pseudonyms)
  o BSM recipients are sent pseudonym certificates to authenticate message signatures
  o BSM signatures are authenticated by recipients using sent or cached pseudonym certificates
  o Pseudonym certificates are trusted through group signatures

• Privacy
  o Pseudonyms change often; signing keys are private to each vehicle
  o Group signatures preserve privacy through cryptography
SHRP-2 NDS is a huge resource for transportation research and beyond...

- SHRP-2: The second Strategic Highway Research Program
- NDS: Naturalistic Driving Study
- As in many areas of scientific and engineering research, data is transforming scientific discovery ("The Fourth Paradigm: Data Intensive Science" Microsoft Research)
  - The data itself (volume, need for interpretation) can present challenges
  - Consequently, *automating data extraction from video and other sources* in the NDS can improve effectiveness and reduce the costs of using these data
- Such automation can help answer specific questions as well as lead to new lines of inquiry
SHRP-2 data reconfigured to improve visual analysis and automation

- Auto-detected Head pose
- Rear camera
- Face camera
- Front camera
- Hands camera
- "Birds eye view" transformation

SRI DCODE method of jointly tracking from multiple views
Example video from SHRP-2 NDS with baseline computer vision measurements
Summary of Five Selected Areas Related to Connected and Autonomous Vehicle
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Supplement Slides
Secretary Moniz Test Drives the 3D-Printed Shelby Cobra