NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Infrastructure Spatial Sensing at Intersections

Stanley Young & Lei Zhu (NREL)
Eric Rask (ANL)
National Renewable Energy Laboratory
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Project ID: eems053

ENERGY EFFICIENT MOBILITY SYSTEMS PROGRAM
INVESTIGATES

MOBILITY ENERGY PRODUCTIVITY

Advanced R&D Projects

Living Labs

THROUGH FIVE EEMS ACTIVITY AREAS

Smart Mobility Lab Consortium

HPC4Mobility & Big Transportation Data Analytics

Core Evaluation & Simulation Tools

Advanced Fueling Infrastructure

Connected & Automated Vehicles

Urban Science

SMART MOBILITY LAB

CONSORTIUM

7 labs, 30+ projects, 65 researchers,
$34M* over 3 years.

Mobility Decision Science

Multi-Modal Transport

*Based on anticipated funding

Overview

Timeline

- Project start date: 10/2017
- Project end date: 10/2019
- Percent complete: 50%

Budget

- Total project funding:
  - DOE share: $50K
  - Contractor share: $0
- Funding for FY17: $0
- Funding for FY18 (if available): $50K

Barriers

- Understand the existing space and literature regarding mobility/energy potential of spatial sensing (such as LIDAR) at critical intersections.
- Explore energy equivalence of improved safety at signalized intersections.
- Industry is primarily focusing on on-vehicle sensing, but on-infrastructure implementations might afford more benefit to a wider set of stakeholders (pedestrians, traffic managers)

Partners

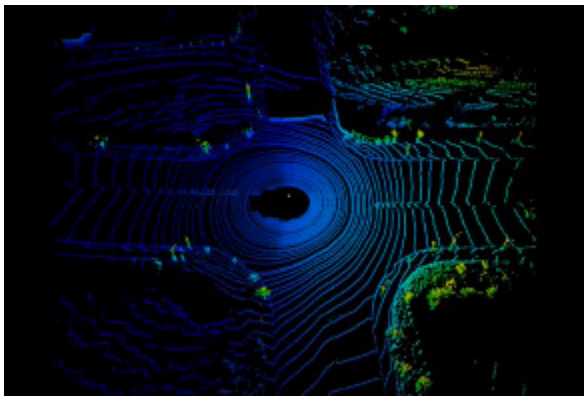
- Argonne National Laboratory (ANL)/NREL
- University of Nevada, Reno (UNR)
- Continental AG (refer to "Continental")
- University of Maryland (UMD)

Relevance

- **Objective**: Explore the mobility/energy impact potential of spatial sensing (such as LIDAR) at critical intersections in the real world.
- Relevant to DOE's Energy Efficient Mobility Systems (EEMS) Program: connected and automated technologies can integrate smart infrastructures to enable drive smoothing and reduce traffic accidents, to decrease energy consumption
- The impact of the project:
  - Potential capability of tracking all objects (conventional vehicles, connected vehicles (CV), automated vehicles (AV), pedestrians, and bikes) for enhancing mobility and energy efficiency
  - CV technology has been studied as enables of more efficient and smooth traffic flow – examine infrastructure sensing provide similar benefits with necessity (and time lags of significant AV fleet penetration).

Approach

- Review state-of-the-art in infrastructure sensing technologies and applications, highlighting gaps and focus areas to enable enhanced mobility energy productivity.
- Milestones
  - FY18:
    - Memorandum of understanding (MOU)/Nondisclosure Agreement (NDA) with industry partner/s
      - *MOU with UNR*
      - *NDA with Continental*
    - Draft assessment of energy equivalence of safety at intersections
    - Establish high-speed, real-time data link with partners (Continental, UNR) for field data
  - FY19: Go/No-Go—move on to FY19 demonstration.



Demo of LiDAR cloud data at an intersection

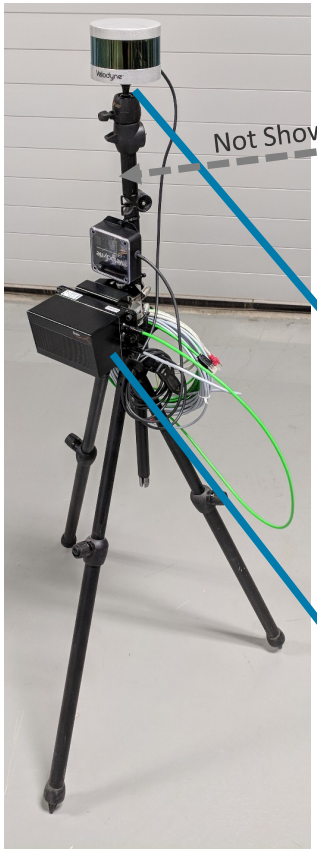
NREL's data visualization facility

Technical Accomplishments and Progress

- **No work previously presented at FY17 AMR**
- Work with partners to explore the maturity of existing spatial sensing technology
  - ANL exploratory portable awareness system and data collection
  - UNR LIDAR sensor mounted at intersections
  - Continental infrastructure spatial sensing system
- Highlighted energy equivalence of safety improvements/crash avoidance

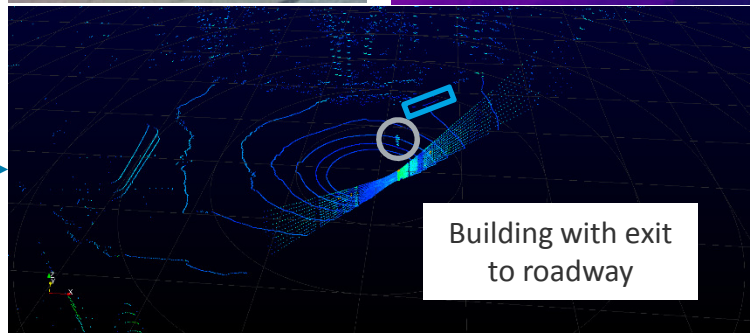
Technical Accomplishments and Progress (1)

- ANL proof of concept exploratory portable awareness system and data collection
  - Platform with multiple various sensors (LiDAR, IR camera, etc.)
  - Exploratory for data collection (It will be further refined)

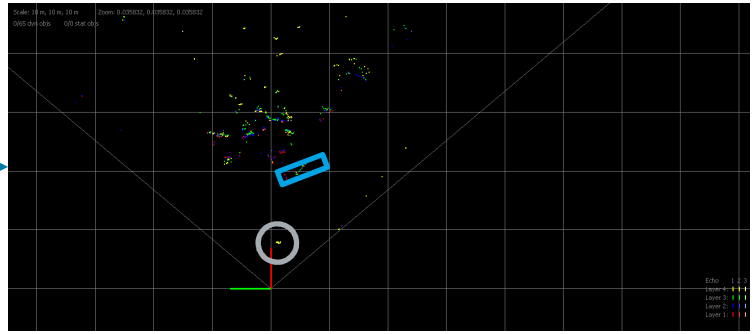


FLIR IR Camera

Velodyne VLP- 16



IBEO LUX



Technical Accomplishments and Progress (2)

- Research team at UNR has installed and networked LIDAR sensors at intersections near the campus
  - Initial installation is moving forward
  - March 2018 -> full data stream to traffic research centers
  - Exploring data transmission to NREL in real-time.

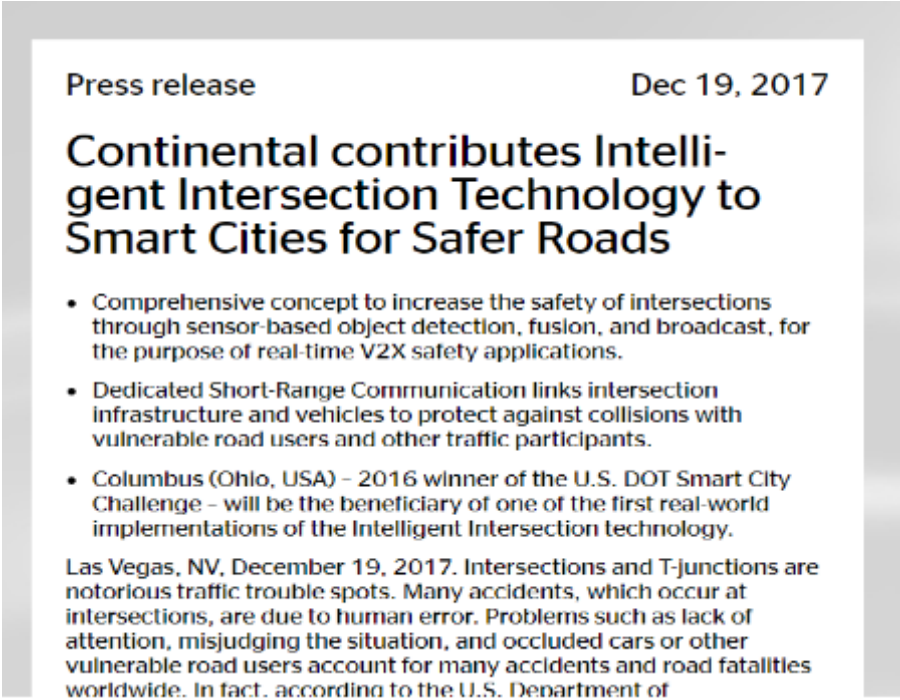
LiDAR sensor mounted at an intersection

LiDAR sensor demo intersection at UNR

Technical Accomplishments and Progress (3)

- Continental Infrastructure Spatial Sensing System
  - A controlled demonstration was conducted in Brimley, Michigan in 2017
  - A demo is planned for the Smart City of Columbus, Ohio in 2019
  - Working on NDA with Continental for data sharing.

Continental website snapshot



Press release Dec 19, 2017

Continental contributes Intelligent Intersection Technology to Smart Cities for Safer Roads

- Comprehensive concept to increase the safety of intersections through sensor-based object detection, fusion, and broadcast, for the purpose of real-time V2X safety applications.
- Dedicated Short-Range Communication links intersection infrastructure and vehicles to protect against collisions with vulnerable road users and other traffic participants.
- Columbus (Ohio, USA) – 2016 winner of the U.S. DOT Smart City Challenge – will be the beneficiary of one of the first real-world implementations of the Intelligent Intersection technology.

Las Vegas, NV, December 19, 2017. Intersections and T-junctions are notorious traffic trouble spots. Many accidents, which occur at intersections, are due to human error. Problems such as lack of attention, misjudging the situation, and occluded cars or other vulnerable road users account for many accidents and road fatalities worldwide. In fact, according to the U.S. Department of

Technical Accomplishments and Progress (4)

- Highlighted energy equivalence of safety improvements/crash avoidance
  - The excess **fuel per fatal crash** for urban arterials estimated by National Highway Traffic Safety Administration (NHTSA) in 2015 was **504 gallons** (incorporating all delays, subsequent vehicle idling, and rerouting of traffic)
  - 102 gallons per injury crash
  - 68 gallons of fuel per "property damage only" (PDO) crash
  - In 2016, the United States Fatal Accident Reporting System (FARS) reported:
    - 5,765 urban intersection related crashes
    - An estimated of 2,905,000 gallons of excess fuel
    - Does not include:
      - Lost productivity
      - Life cycle and vehicle energy loss
      - Health, repair, etc., and associated activities.

Responses to Previous Year Reviewers' Comments

- **The project was not reviewed last year (FY17)**

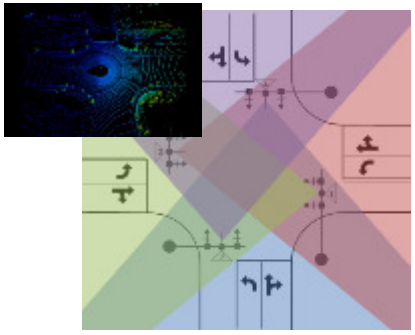
Collaboration and Coordination with Other Institutions

- Within VTO:
  - ANL
- Outside VTO:
  - UNR
    - Department of Civil and Environmental Engineering
    - Nevada Center for Applied Research
    - MOU for research and funding opportunities
  - Continental
    - A leading German automotive manufacturing company, based in Hanover, Germany
    - World's third ranked original equipment manufacturer (OEM) automotive parts provider and fourth largest tire manufacturer
    - NDA for intersection spatial sensing data sharing
  - UMD
    - Center for Advanced Transportation Technology (CATT)
    - Energy equivalence of accident research.

Remaining Challenges and Barriers

- Remaining challenges and barriers
  - Data transmission bandwidth from roadside to data center
  - Large-scale cloud sensing data processing and machine learning technologies for moving objects recognition, analysis, and communication
  - Research on energy equivalence of safety improvements/crash avoidance
- Justification and support for the future plans
  - NREL experts on intelligent transportation system (ITS) and big data analytics
  - Working with partners for data sharing and analysis

1. Instrumented intersection



2. Data fusion for Visibility

3. Communication Strategy

4. Knowledge → Research

Proposed Future Research

- FY18:
  - Establish high-speed, real-time spatial data link with partners
  - Perform energy equivalence of safety research
- FY19:
  - Create machine-learning approaches with high-performance computing (HPC) to recognize, analyze, and communicate spatial information
  - Map spatial infrastructure sensing to applications that enhance mobility/energy efficiency and safety, including (not all those will be considered):
    - Traffic signal control strategy
    - Near-misses detection and prevention
    - Cybersecurity applications for connected vehicles (CV)/V2I/I2V.

Any proposed future work is subject to change based on funding levels.

Summary

- **Objective**: Assess the mobility/energy performance potential of placing spatial sensors (such as LIDAR, RADAR, and video/image processing) at critical intersections in real-world.
- Cooperating with leaders/experts (UNR/UMD/Continental):
  - MOU/NDA data sharing
  - Spatial data analysis/transmission/abstraction
- Estimate the energy impact of foreseen enhancements on safety, such as the energy equivalency of improved safety from crash prevention, near-misses detection and prevention.

Thank You

www.nrel.gov

Project ID: eems053

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Technical Back-Up Slides