ITS-Irvine CAV Developments & the Connected Mobility Living Laboratory

Stephen Ritchie

Director, Institute of Transportation Studies and
Professor of Civil and Environmental Engineering
University of California, Irvine

July 7, 2017

Outline

- ITS-Irvine
- Recent UCI CAV research
- CAVs in the bigger picture
- Transformational Mobility Science
- New ITS-Irvine initiatives and CAVs
- UCI Connected Mobility Living Laboratory (CML2)

The ITS Multicampus Research Unit (MRU)

ITS is a state-legislated unit of the University of California, with branches at Berkeley, Irvine (1974), Davis & UCLA

Mission is to be the premier university-based transportation research and education center in the world, and to provide technology transfer and continuous education to practicing transportation engineers and planners in California.

From inception in 1947 until 2016, California legislature provided about $1M in annual core funding.

The ITS MRU leverages its core funds by over 30:1 per year in sponsored projects from regional, state and federal agencies, and foundations and private industry.

ITS-Irvine: Who We Are

Intellectual headquarters for interdisciplinary transportation education and research at UCI.

Recently ranked 5th in US and & 7th in world for research impact.

25 Faculty Associates from Civil Engineering, Mechanical Engineering, Electrical Engineering, Urban and Regional Planning, Economics, Computer Science, Business, Law, and Public Health

5+ Research Scientists & Postdocs (soft money) plus visiting international scholars

60+ transportation graduate students in ITS, and 30+ urban & regional planning graduate students

Graduate 10-20 Masters & PhD annually from 8 MS and PhD transportation-related degree programs

Total extramural research support
• 2015-16 approx. $26M

What We Do?

Cutting-edge research supported by faculty contracts and grants	• Major sponsors include CEC, Caltrans, CARB, USDOT, NSF, etc.
Stewardship of transportation education and research at UCI	• 8 MS and PhD graduate degree programs • Joint administration of Transportation Science interdisciplinary graduate degree program
Administer & manage the ITS-Irvine research program	• Financially support students with GSR positions, fellowships, conference travel, and office/computing/library support • Employ research staff
Assist in placement of transportation graduates	• Extremely successful in placing MS graduates in professional practice, & PhD graduates in faculty positions & advanced positions in public and private sectors in the US & abroad
Host international visitors	• Routinely host faculty and graduate students for extended stays that support collaborative research leading to cross-fertilization of research ideas
Sponsor seminars and lectures	• For example, recently jointly sponsored and hosted the Hyundai Motor America Seminar series on "Technology Innovations and the Future of Transportation"

Recent UCI CAV Research

- **Autonet** (2003) – pioneering concept for cooperative V2V and V2I communication for traffic management & control, initially based on simulation
- **Persistent traffic cookies** (PTC) (2003) – innovative concept for vehicles to collect and store their own travel history, via "cookies" from roadside controllers, forming a distributed database across vehicles for traffic management & control
- **Inter-vehicle communication systems and vehicular ad hoc networks (VANETs)** (2006-present) - extensive theoretical & empirical research
- **New shared mobility system designs** (2002 – present) – high coverage point to point transit, shared taxi service design, peer to peer ride matching
- **Model robot/autonomous vehicles** (2016-present) – student-project lab & street prototypes
- **Virtual traffic signs** (2016-present) – advanced driver warning & assistance, ultimately for CAVs
- **Connected vehicle cybersecurity** (present)

Connected and/or Automated Vehicles?

Connected Vehicles

- V2I
- V2V
- V2P
- V2X

Both C&A

- Full system integration
- Coordinated and/or collective decision making
- Fleet and system-wide optimization

Automated Vehicles

Six levels adopted by NHTSA:

- 0 – no automation
- 1 – minimal driver assistance

  ..
  thru
  ..

- 5 – full automation (no human driver)

- The mobility revolution is fueled by two profound worldwide forces:
  - **Decarbonization** of transportation **-** driven largely by public sector regulations, policies and incentives
  - **Digitilization** of transportation **-** driven largely by private sector advances in information and computing technologies and mobile communications (broadly embraced by consumers and businesses)
- The convergence of these forces is creating a new multidisciplinary field
  - Transformational Mobility Science (TMS)

Transformational Mobility Science

Decarbonization

- Regulation, policy, and incentives
- Reduction of GHG and criteria pollutants
- Air quality and public health
- Alternative & renewable fuels
- Refueling/recharging infrastructure
- Environmental justice
- Sustainable freight transportation
- Data collection, measurement, evaluation
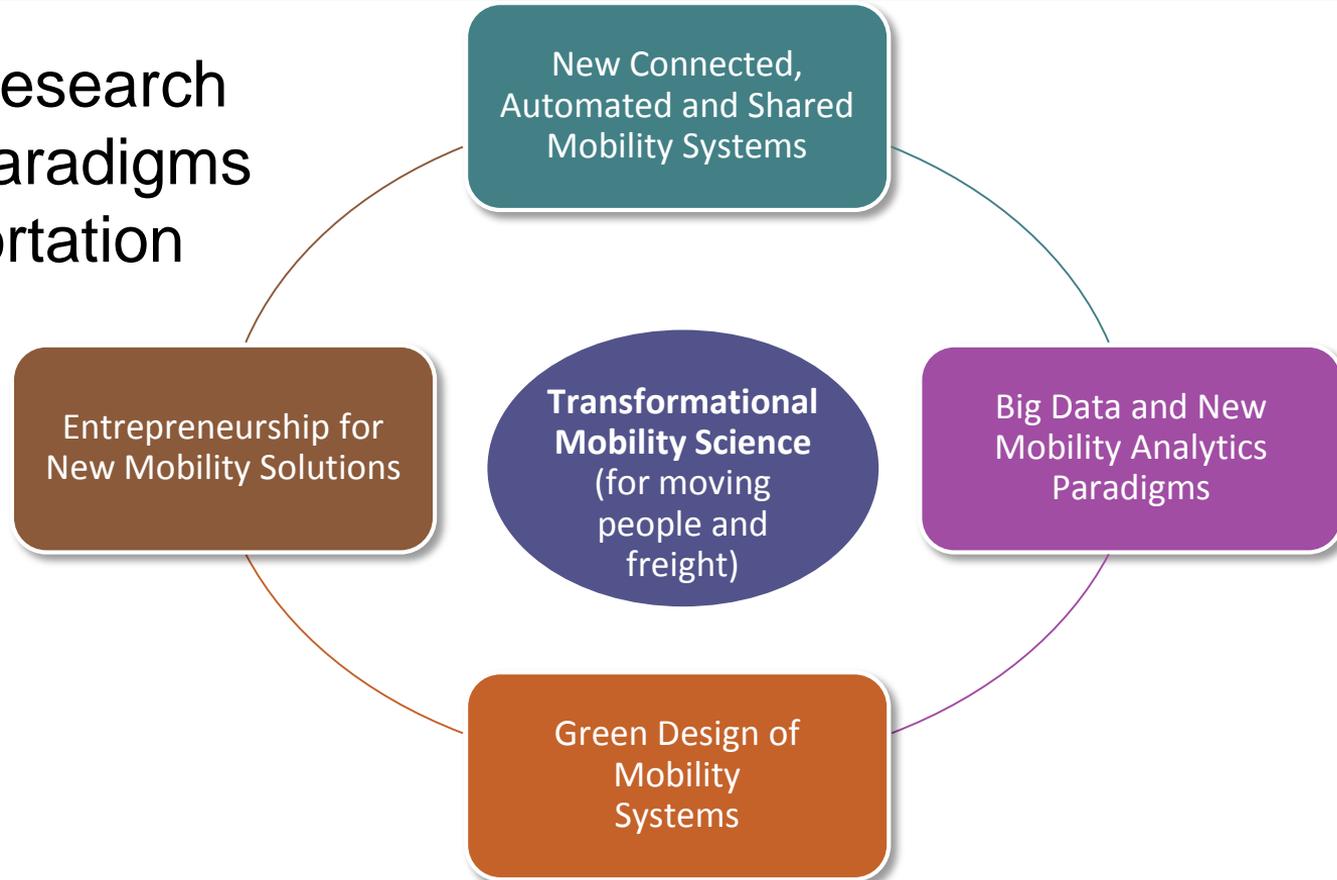- Costs, equity & broader economic impacts
- Policy analysis

Digitalization

- Connected & automated vehicles
- Mobility sharing services
- Integration w/conventional modes
- Regulatory, institutional and legal issues
- Safety
- Communications and cybersecurity
- Smart cities
- Ubiquitous sensing
- Data science
- Impacts on travel demand and urban form

Shaping research
for new paradigms
in transportation

New Connected, Automated and Shared Mobility Systems

Entrepreneurship for New Mobility Solutions

Transformational Mobility Science (for moving people and freight)

Big Data and New Mobility Analytics Paradigms

Green Design of Mobility Systems

Current ITS-Irvine Initiatives

New UC ITS Mobility Research Program (funded by 2017 California Senate Bill 1)

- Enable ITS researchers to actively support the state in developing policies, rules, and strategies that are grounded in science
- Address critical state prioritiy areas identified by the Legislature and the Governor: Climate Change, Urban Sustainability and Air Quality, Infrastructure and Energy, Transportation System Performance, and Taxation and Finance

New ITS-Irvine Center for Transformational Mobility Science

- Integrate and leverage campus and external resources
- Cutting edge education and research in TMS
- Educate a new generation of future transportation leaders
- Position UCI as a global leader in TMS

Establishing new ITS-Irvine Leadership Council

- State & National transportation leaders based in SoCal with special interest in Orange County and advancing transportation education & research at UCI
- Advocacy role for our program and region
- Advice on setting priorities, new initiatives and program direction & success

Current ITS-Irvine & Campus Initiatives

New campus Traffic Management System & Command Center

- UCI Transportation & Distribution Services is installing a new campus Traffic Management System & Center for dynamic transportation mangement
- Components include new signal controllers, fiber optic communications, CCTV, centralized software and control capabilities
- Virtual TMC in ITS-Irvine, and data sharing for education and research

Proposed UCI Connected Mobility Living Laboratory

- Build upon the new campus TMC
- Unique "live" Testbed on the UCI campus
- Support cutting-edge research, education, and information dissemination in connected mobilty technology and policy (ultimately CAVs)
- Scalable, beyond just UCI campus

- Twofold focus:
  - technological feasibility
  - but also more importantly, how to harness connected mobility for the benefit of society
- Initial users:
  - UCI students
  - UCI Staff
  - UCI Faculty
  - Visitors
- Leading universities worldwide engaged in CAV research, but few have the advantage of a campus-wide testbed as well as a multidisciplinary research capability e.g. Nanyang Technological University (Singapore) Smart Mobility Testbed
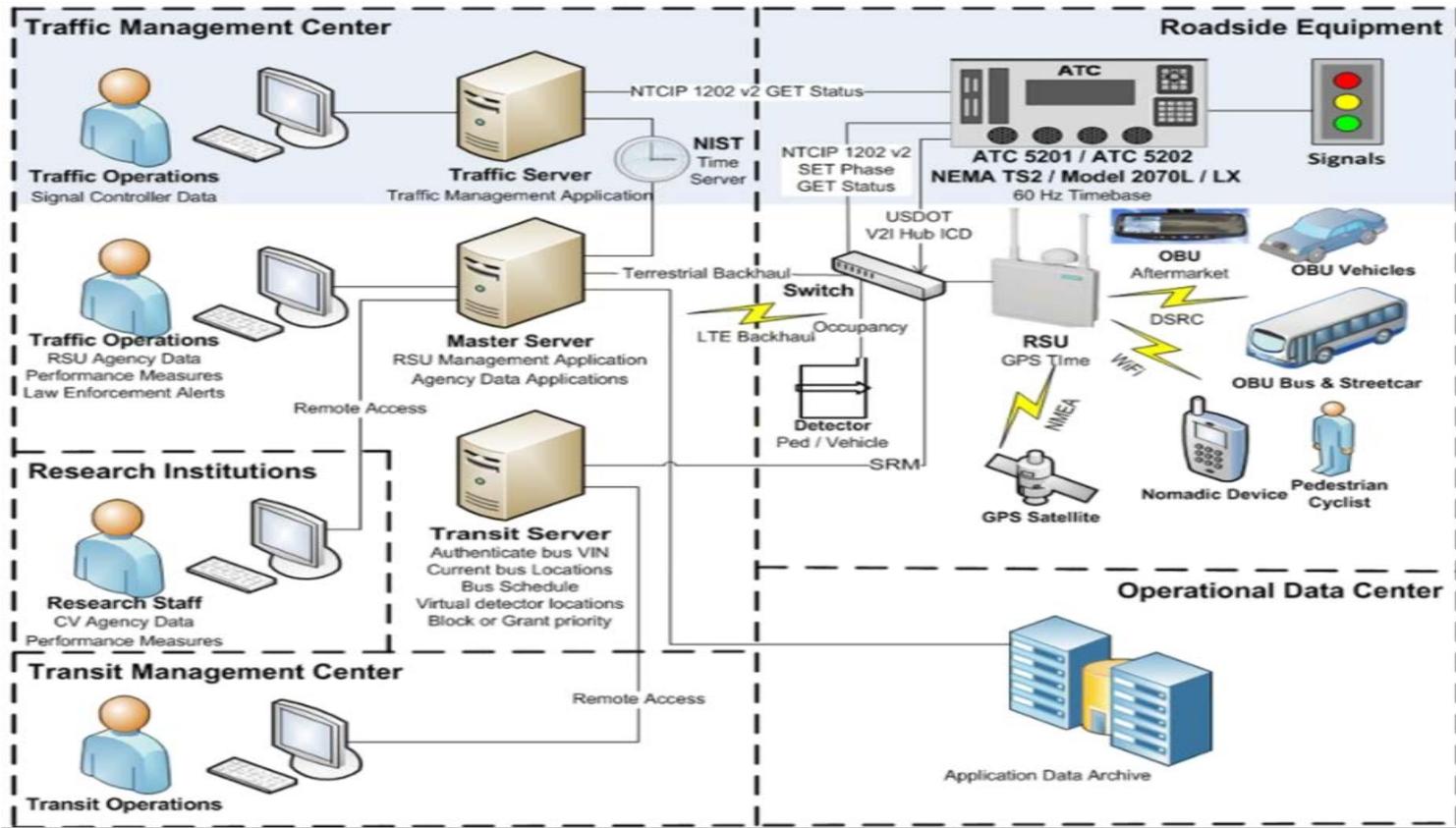
- Connected infrastructure
  - Traffic signals
  - Roadways
  - Parking for vehicles and bicycles
  - EV charging spaces
  - H_2 refueling status
  - Campus TMC command center and virtual TMCs (as in ITS)
- Mobile instrumentation:
  - UCI Anteater Express transit buses (30, with 20 new BEVs in August, 2017)
  - UCI fleet services vehicles
  - UCI Police vehicles
  - UCI Zotwheels bike-share program
  - UCI student/staff/faculty/visitor vehicles
  - Pedestrians & Cyclists

Current Vision

- Research focus:
  - Safety, security and resilience
    - e.g., SPaT Challenge research support, cybersecurity, driver/vehicle safety-related information, ped & cyclist & work zone detection
  - Efficiency and equity
    - e.g., Intelligent signal applications post SPaT (signal timing, transit/freight/emergency vehicle priority), traveler information for destination/parking/EV charging/special events, shared mobility services support, capital & O&M cost analyses etc
  - Emissions and energy
    - e.g. air quality (GHG & criteria pollutant) and energy impacts, UCI microgrid integration etc
- Now developing:
  - Basic and applied research agenda
  - Infrastructure elements (e.g. DSRC, wifi, Bluetooth, 5G etc)
  - Concepts for scalability to surrounding areas & roadways & transit services
- Implementation
  - Multiple phases, Phase 1 operational by end of 2017.

Courtesy: Econolite, Inc

Why Locate a CV Testbed at UCI?

- Strategic location in S. CA at the forefront of automotive technology and mobility innovation
- Strong relationships with transportation leaders in public & private sectors
- Major activity center with many multimodal internal and external trips, its own residential area, and operates its own power microgrid
- Existing excellence, capability and commitment to succeed & provide leadership:
  - New Campus TMC & infrastructure, and enthusiasm & support of campus leadership
  - UCI is 9th ranked public university in the US
  - ITS-Irvine is 5th ranked transportation research program in US
  - UCI is first 2-time winner of US Sierra Club's Top 10 Coolest, Greenest campus, nationwide!
- Large, diverse student body:
  - Technologically-literate
  - Our students are likely early CAV adopters, and the commuters & travelers of the next 40 years, especially in S. CA!
  - UCI is now federally designated as both a Hispanic-Serving Institution, and an Asian American and Native American Pacific Islander-Serving institution (one of only two universities in the prestigious 62-member Association of American Universities having an HSI designation)
  - UCI is (again) 1st on *The New York Times'* College Access Index, recognizing the U.S. university "doing the most for the American dream," and the upward mobility of its graduates
- A unique combination of attributes, unmatched elsewhere in California, or the US!