Imposed vs. chosen change: A vision for the future of the pavement enterprise

Rasmus S. Nordal Lecture

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UCPRC
UNIVERSITY of CALIFORNIA Davis • Berkeley | PAVEMENT RESEARCH CENTER

Outline

- Stationarity?
- Drivers of change
- Responses to change
- Takeaways and summary

Is Stationarity a Good Assumption?

- Stationarity
  - Assumption in time series data that mean, variance and autocorrelation structure do not change over time
  - Should we be designing, constructing and managing pavements assuming that the conditions under which they operate and the functionality desired by the public will be similar to now?
- An exploration of these questions for my state, which may have implications for others

What Causes Institutional Change?

- Changes in institutional choice set
  - Knowledge of ways to organize your enterprise
- Changes in technology
- Long-run changes in relative factor and product prices
- Changes in other institutional arrangements
  - Societal changes that interact with your enterprise

AN ECONOMIC THEORY OF INSTITUTIONAL CHANGE: INDUCED AND IMPOSED CHANGE
Justin Yifu Lin, Cato Journal, 9:1, 1989

What is Chosen (Induced) vs. Imposed Change?

- Change that we choose because it benefits us
- Change that is imposed by others or circumstances
- We are instinctively opposed to making changes that we haven't chosen for ourselves
- Hypothesis: pavement enterprise needs to proactively choose to change or it will be imposed, with negative consequences

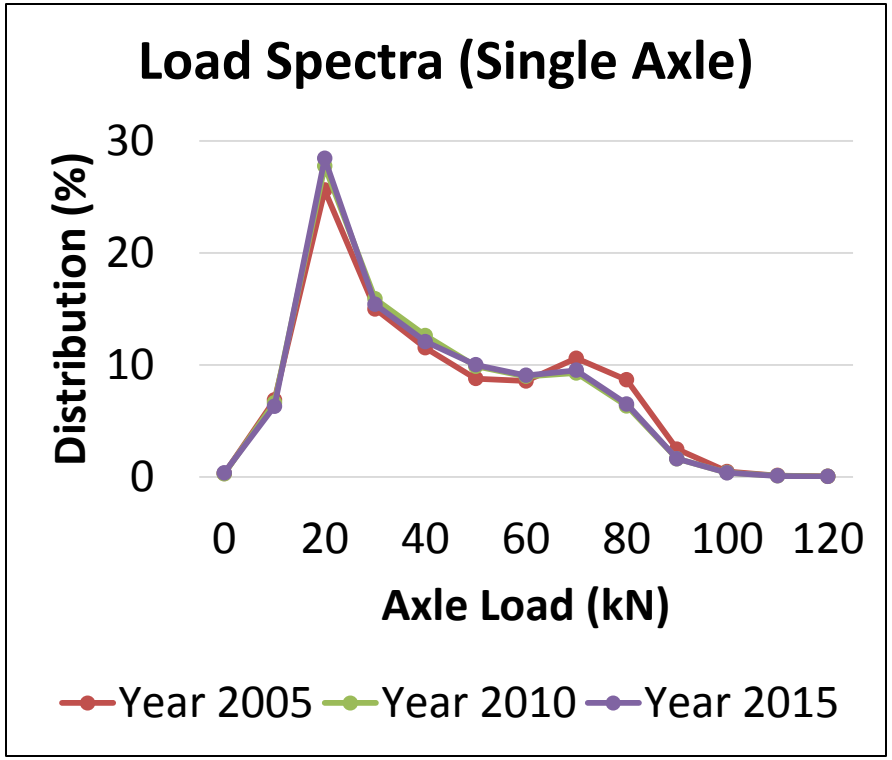
Philip Cox-Hynde, UK Civil Service Training Journal, 2017 https://www.trainingjournal.com/articles/opinion/imposed-vs-chosen-change-managing-change-business ; cartoon: hrdevelopmentinfo.com

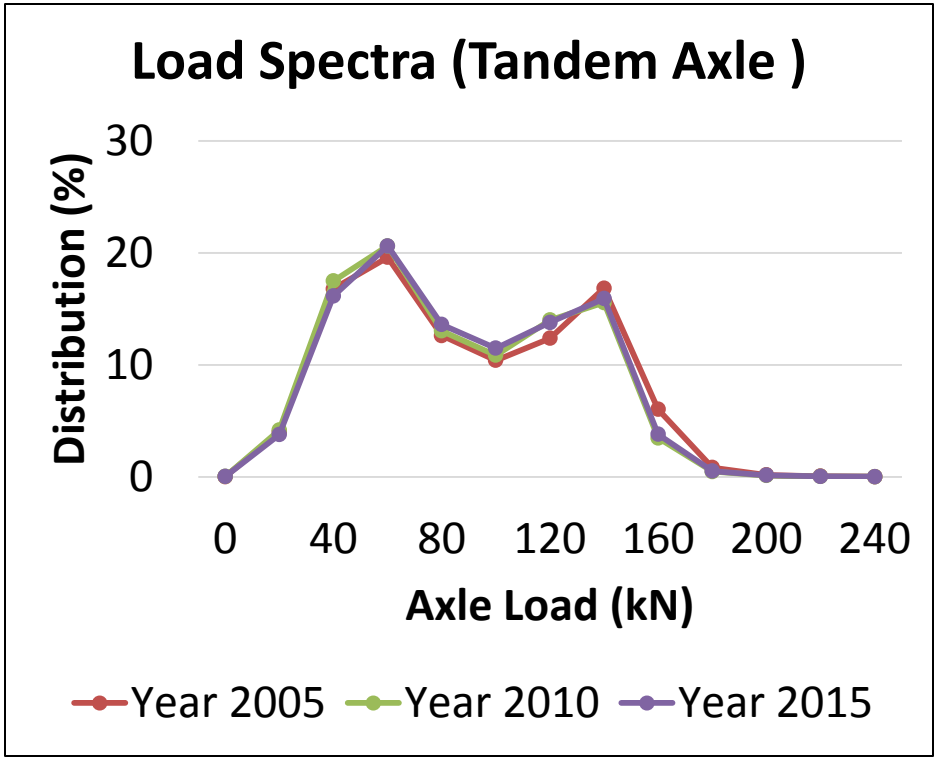
Major Drivers of Change in the Pavement Enterprise:

- Population growth, changes in freight vehicle travel, vehicle ownership, urbanization and de-ruralization,
- Sustainability and population growth
  - Resource depletion, toxicity
  - Climate change, resilience
- Automation and vehicle technology, information technology
- Cost, financing and lack of confidence in government to deliver pavement efficiently
- Jobs, workforce
- The forgotten half
- Pavement values: what do our customers want? Are we communicating with them?

Truck traffic axle weights increasing?

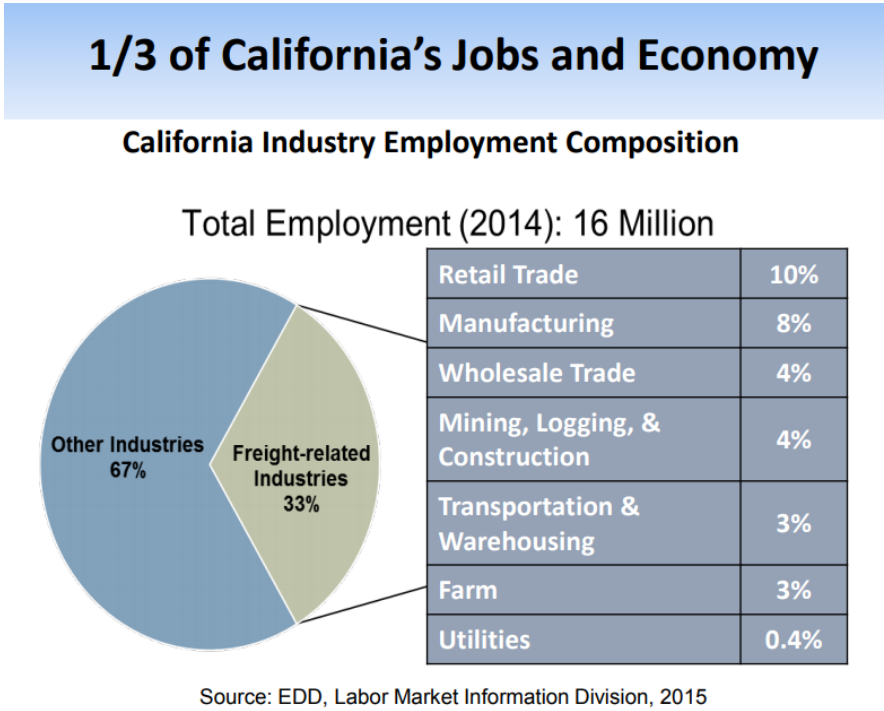
- State-wide average axle loads (115 WIM stations) virtually unchanged in 10 years
- Gross vehicle weights slightly reduced



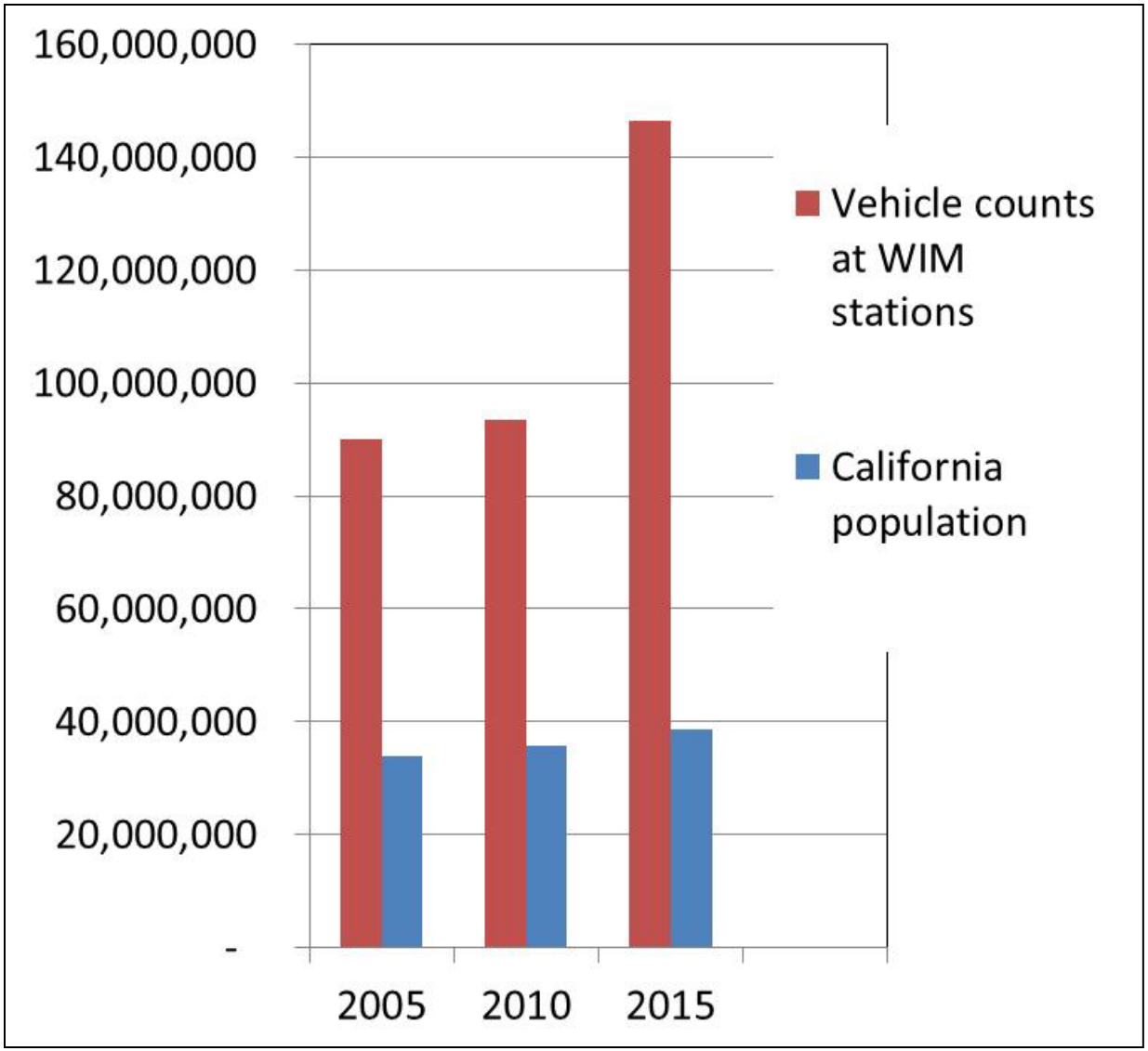


Freight Traffic is Increasing and Changing

- Freight is increasing
  - Economic growth, increasing population
  - Trade-driven economy, good jobs without college
- Changes in patterns of freight:
  - Last mile
    - Increasing household deliveries on local streets of purchases from internet
    - More short-haul delivery trucks in residential areas
    - Will be increasingly natural gas or electric



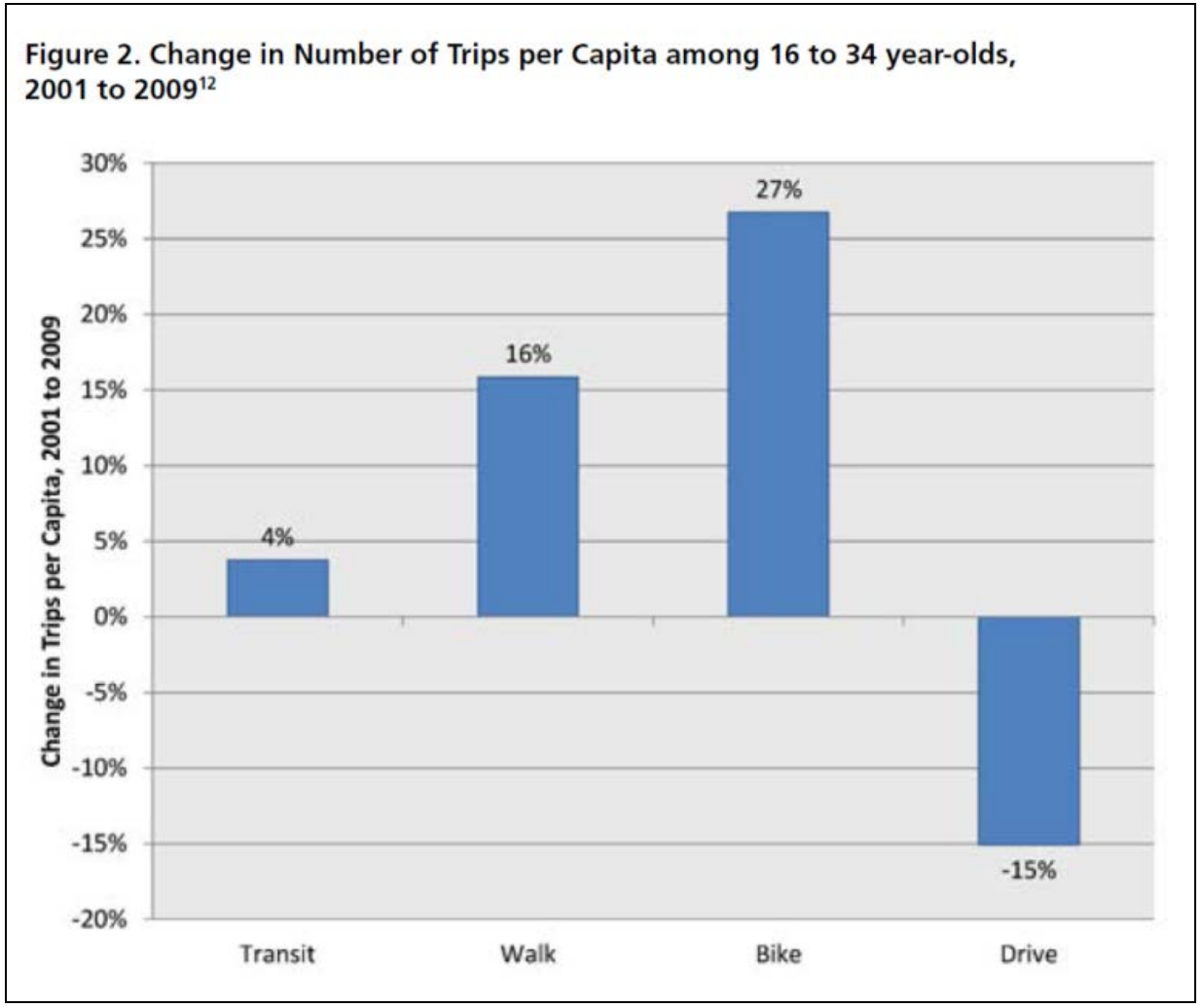
Freight growth: more trucks



- 62% increase in truck counts vs 14% growth in population
- Short-haul: 69% increase
- Long-haul: 59% increase

UCPRC/Caltrans WIM data

What kind of pavement will we need in the future?

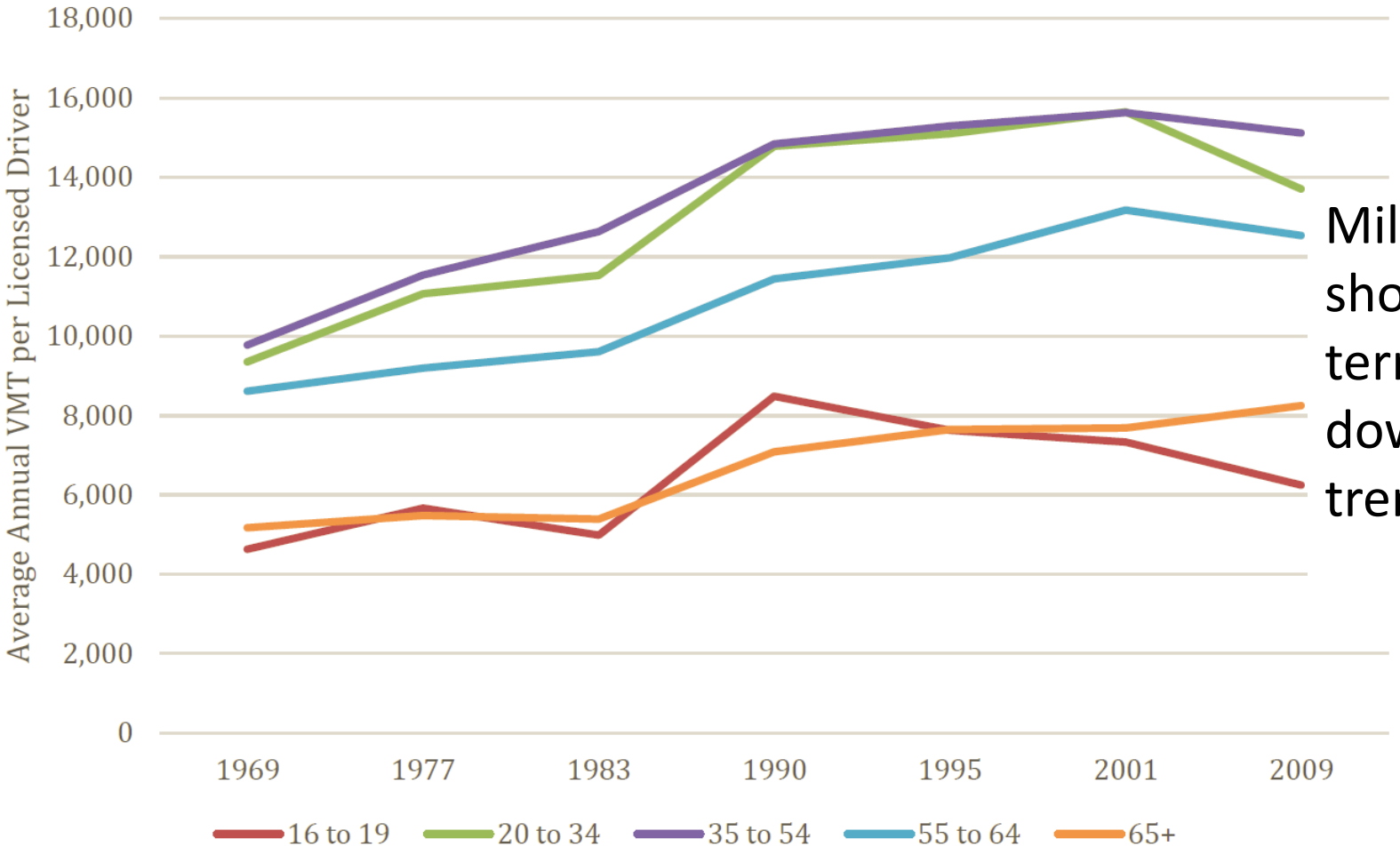


Millennials driving the trend; may not just be recession

Less interested in cars; use of technology to connect instead of travel; more interested in walkable, bikeable cities

NCST white paper, Feb 2016, What affects US passenger travel? Current trends and future perspectives;
US PIRG, Oct 2014, Millennials in Motion

How much pavement will we need in the future? Annual travel per driver by age category

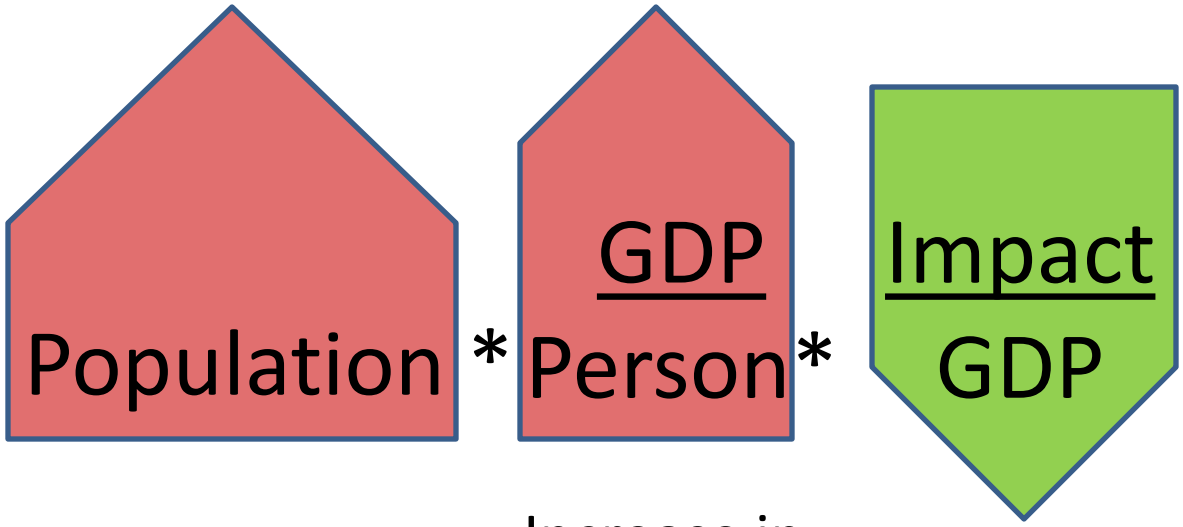


Millennials show longer term downward trend

NCST white paper, Feb 2016, What affects US passenger travel? Current trends and future perspectives;
US PIRG, Oct 2014, Millennials in Motion

Sustainability:
Master equation for environmental impacts

Environmental impact =

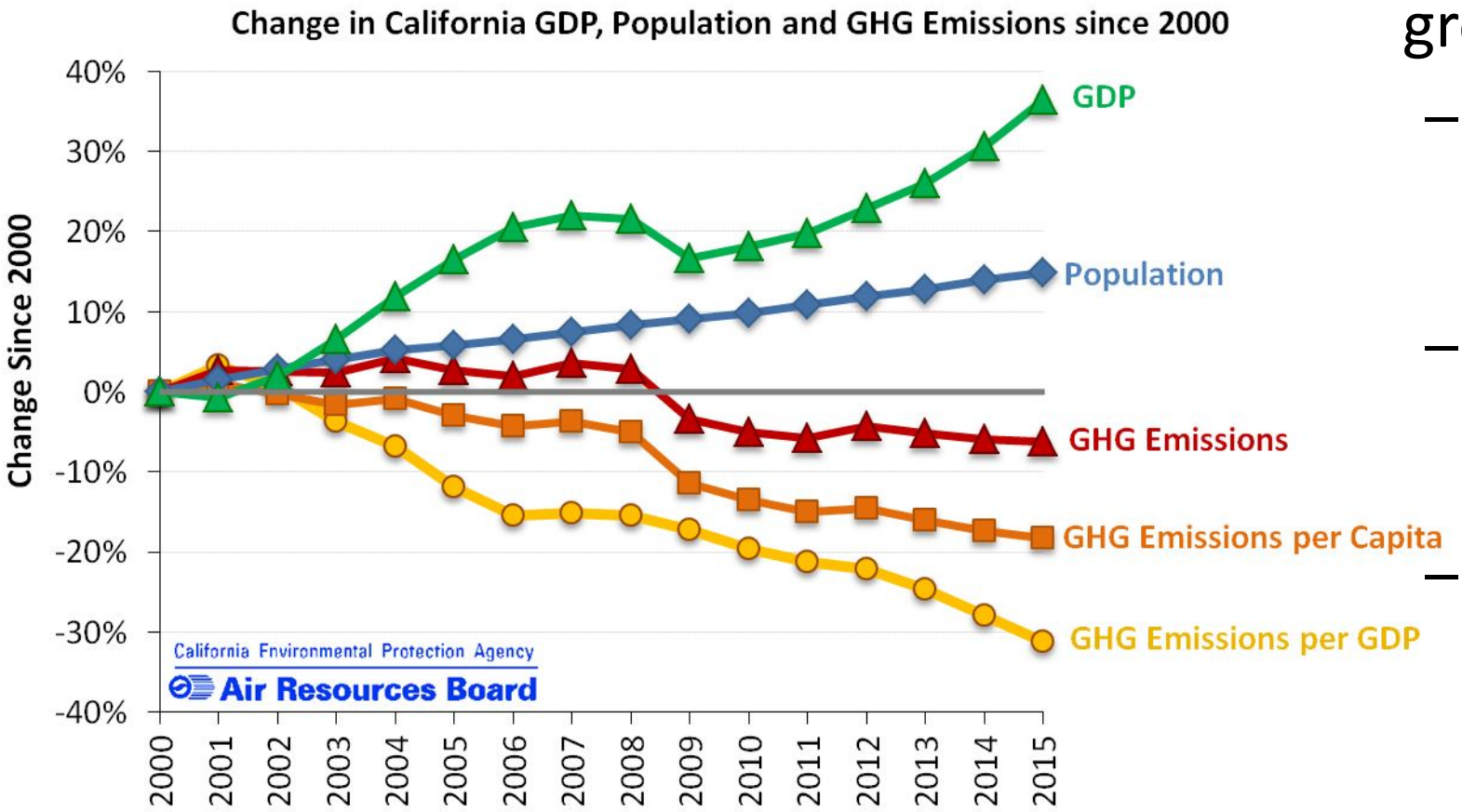


Increase in wealth and economic activity

Technological efficiency

Ehrlich and Holdren (1971) Impact of population growth. e.g. via LCA
Science 171, 1211-1217
Slide adapted from R. Rosenbaum, Pavement LCA 2014 keynote address

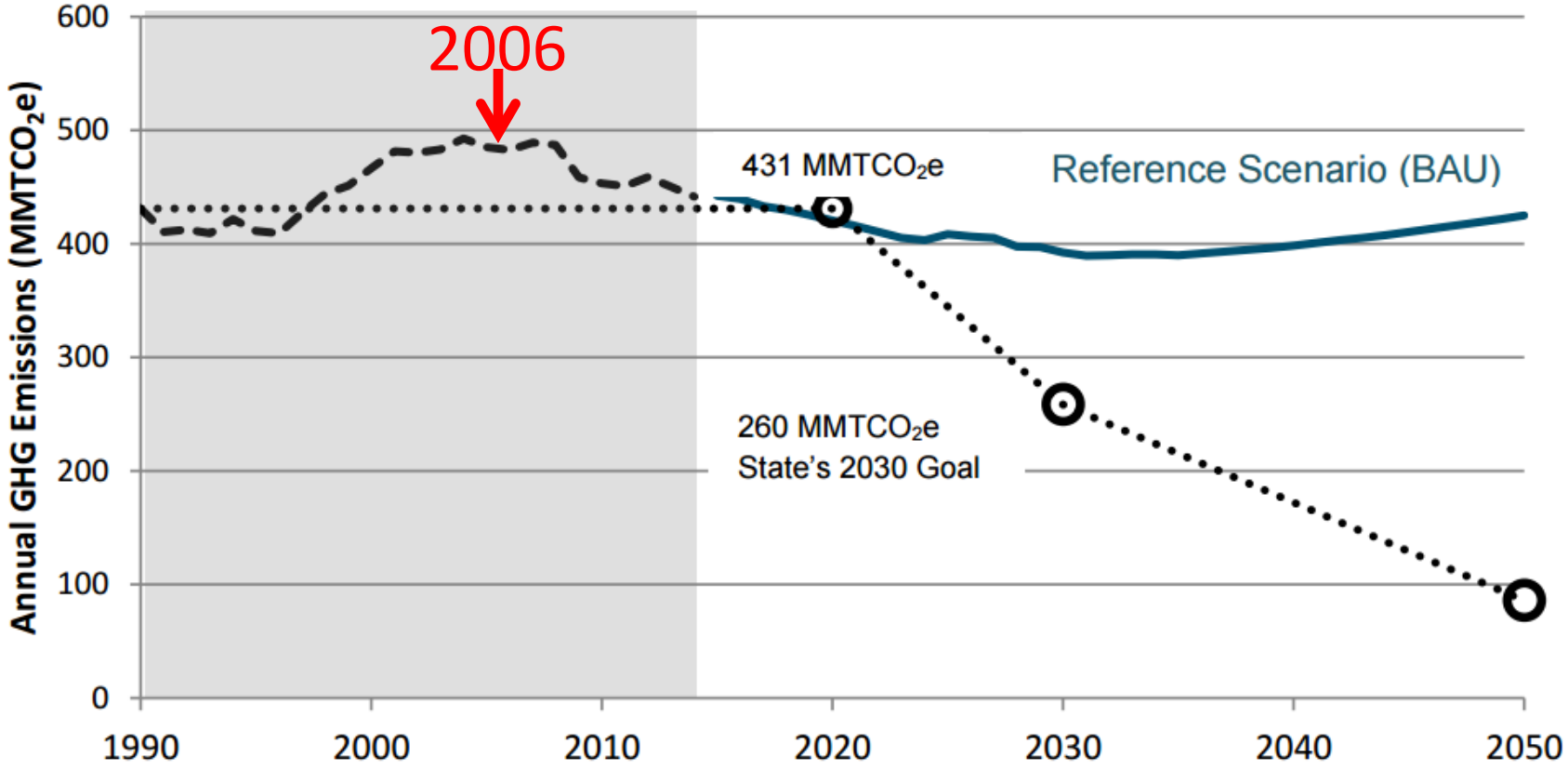
Climate Change: are state goals achievable based on response to climate change law passed in 2006?



- Population growth:
  - 1990: 30 million
  - 2017: 39 million
  - 2055: 50 million

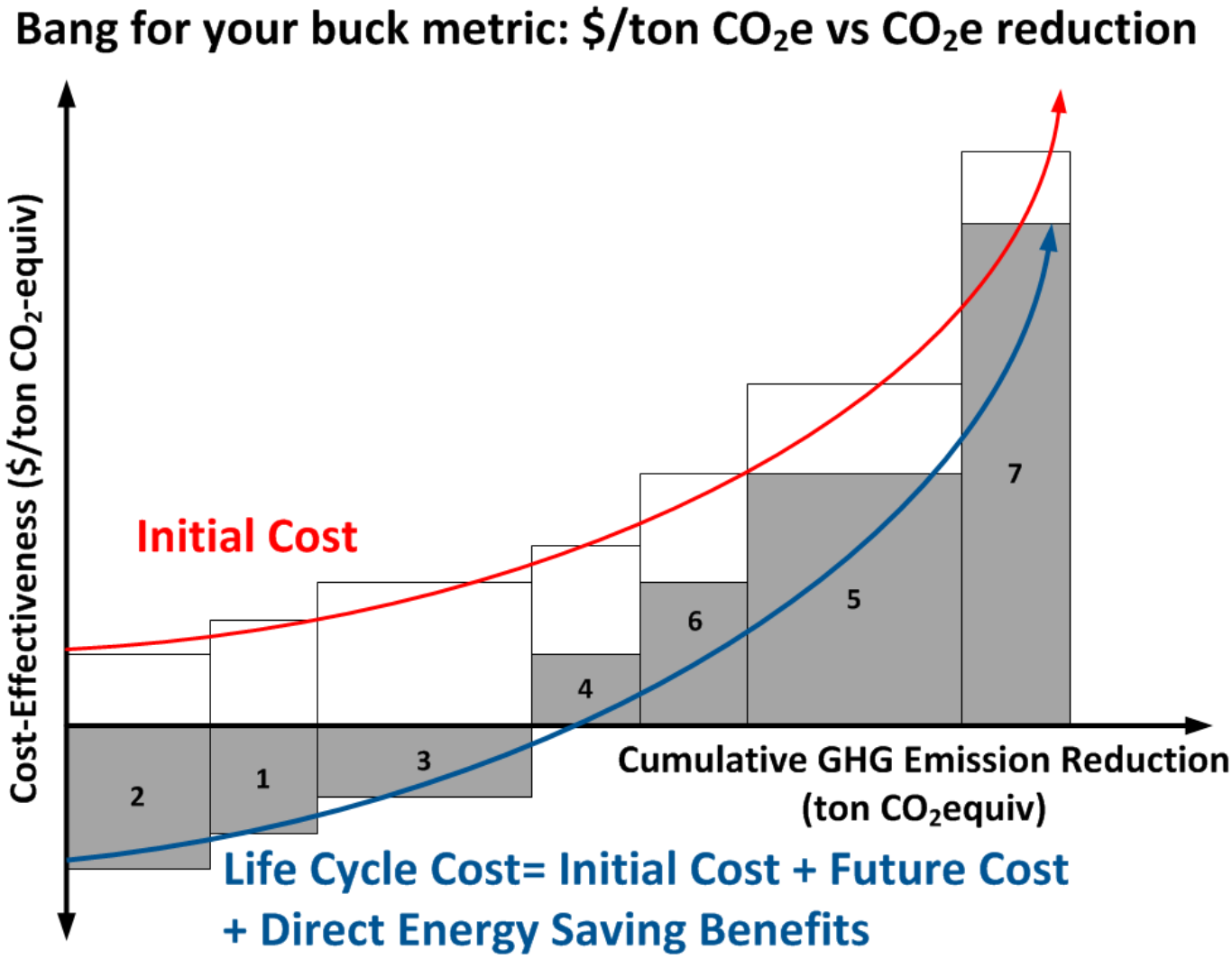
Climate Change: road transport related strategies planning to 2030 and 2050

- Vehicle fuel vehicle changes: Natural gas, Electric
- Complete streets



Air Resources Board Climate Scoping Plan

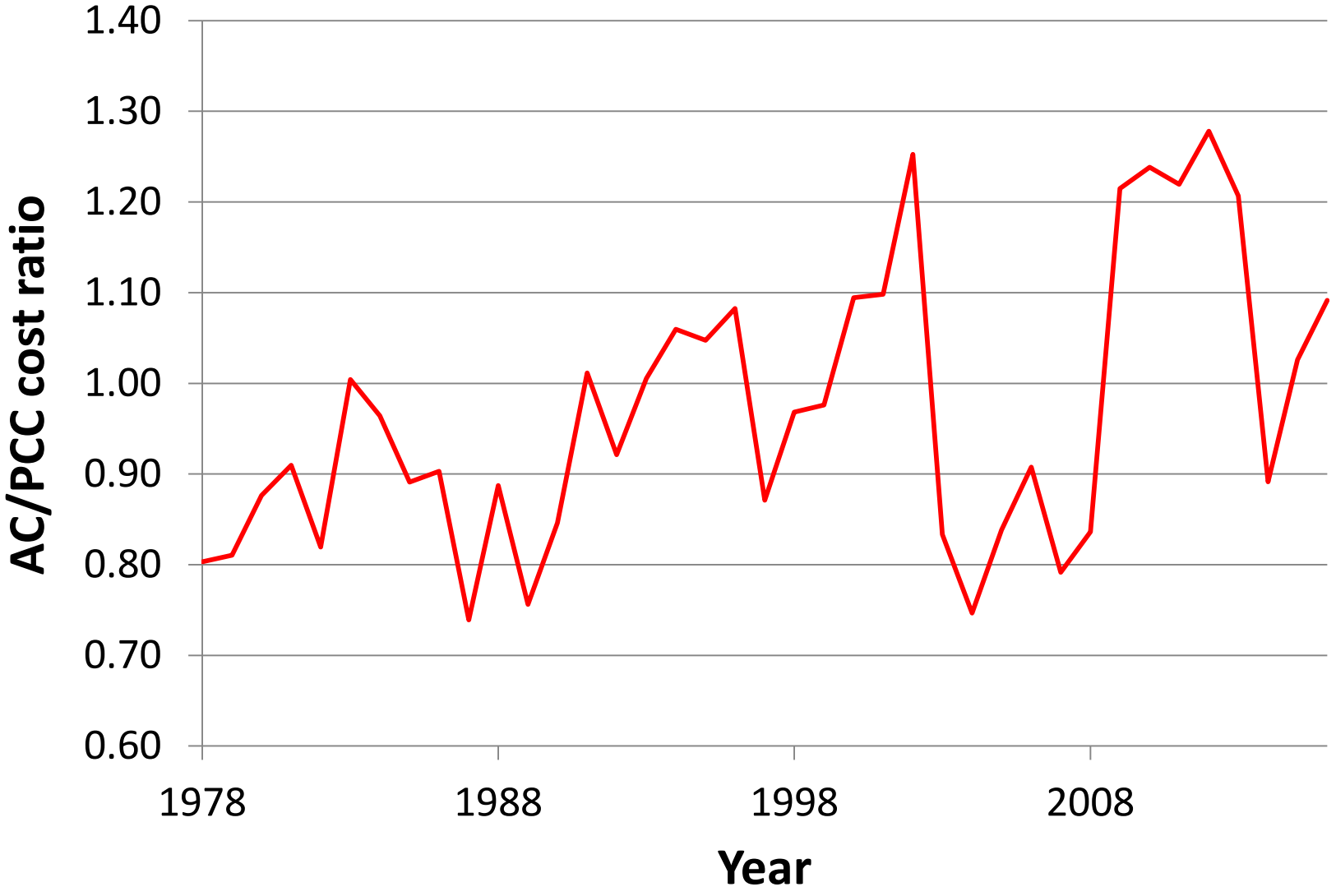
What Should be Done for Sustainability?



Adapted from Lutsey, N (2008) Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-08-15

- Many alternatives to improve sustainability
- How to prioritize?
- Cost from Life Cycle Cost Analysis (LCCA)
- Environment from Life Cycle Assessment (LCA)

Maintaining competition in pavement
California Relative Asphalt and Concrete Costs
1978-2017



Hauling our road materials damages the roads

Projected Growth in Freight Ton and Values 2012 to 2040

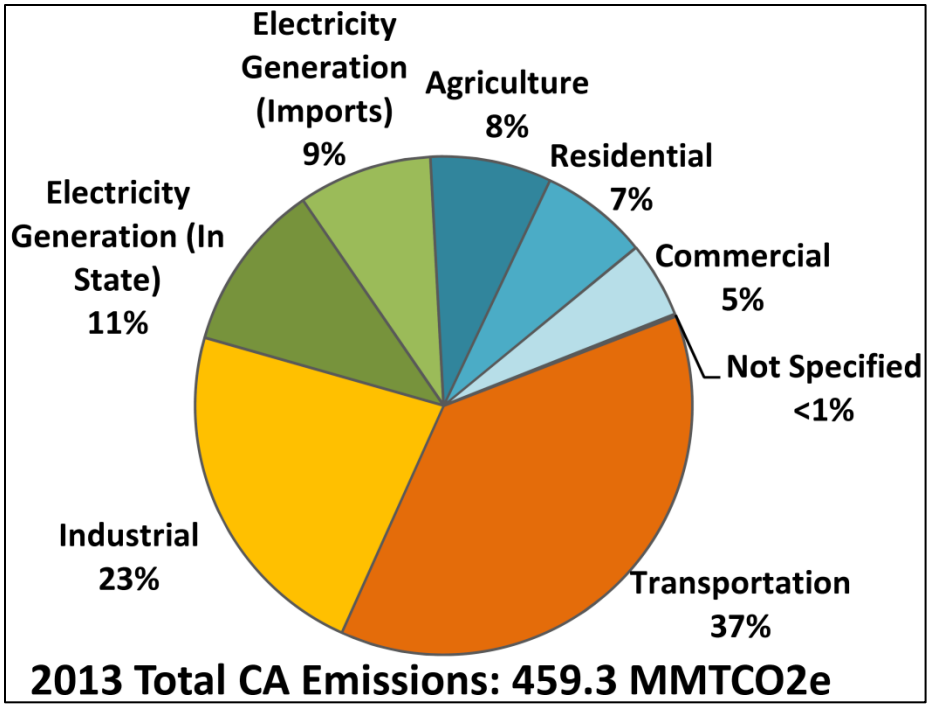
- Freight mass throughput +47%, value +95%
- Demolition, gasoline, gravel and crushed stone, crude oil

Top 2012 Commodities	Weight (in ktons)	Share	Top 2040 Commodities	Weight (in ktons)	Share
Waste and scrap	214,845	15.9%	Waste and scrap	275,456	13.9%
Gasoline	147,106	10.9%	Nonmetallic mineral products	207,374	10.5%
Nonmetallic mineral products	140,453	10.4%	Gravel and crushed stone	168,448	8.5%
Gravel and crushed stone	124,133	9.2%	Gasoline	138,305	7.0%
Crude petroleum	86,022	6.4%	Other agriculture products	126,523	6.4%
Other agriculture products	63,217	4.7%	Crude petroleum	100,427	5.1%
Natural sands	54,886	4.1%	Other foodstuffs	82,896	4.2%
2012 All Commodity Total	1,351,574		2040 All Commodity Total	1,980,491	

Source: FHWA Freight Analysis Framework Summary Statistics

How do Pavements Contribute to California GHG Emissions?

- Out of 459 MMT CO2e in 2013
  - On road vehicles 155 MMT
    - Optimizing smoothness, texture, deflection energy on state network reduces by 1% of this
  - Refineries 29 MMT
    - Paving asphalt about 1 % of refinery production
  - Cement plants 7 MMT
    - Paving cement about 5 % of cement plant production
  - Commercial gas use 13 MMT
    - Very small amounts for asphalt mixing plants
  - Mining 0.2 MMT
    - Large portion for aggregate mining



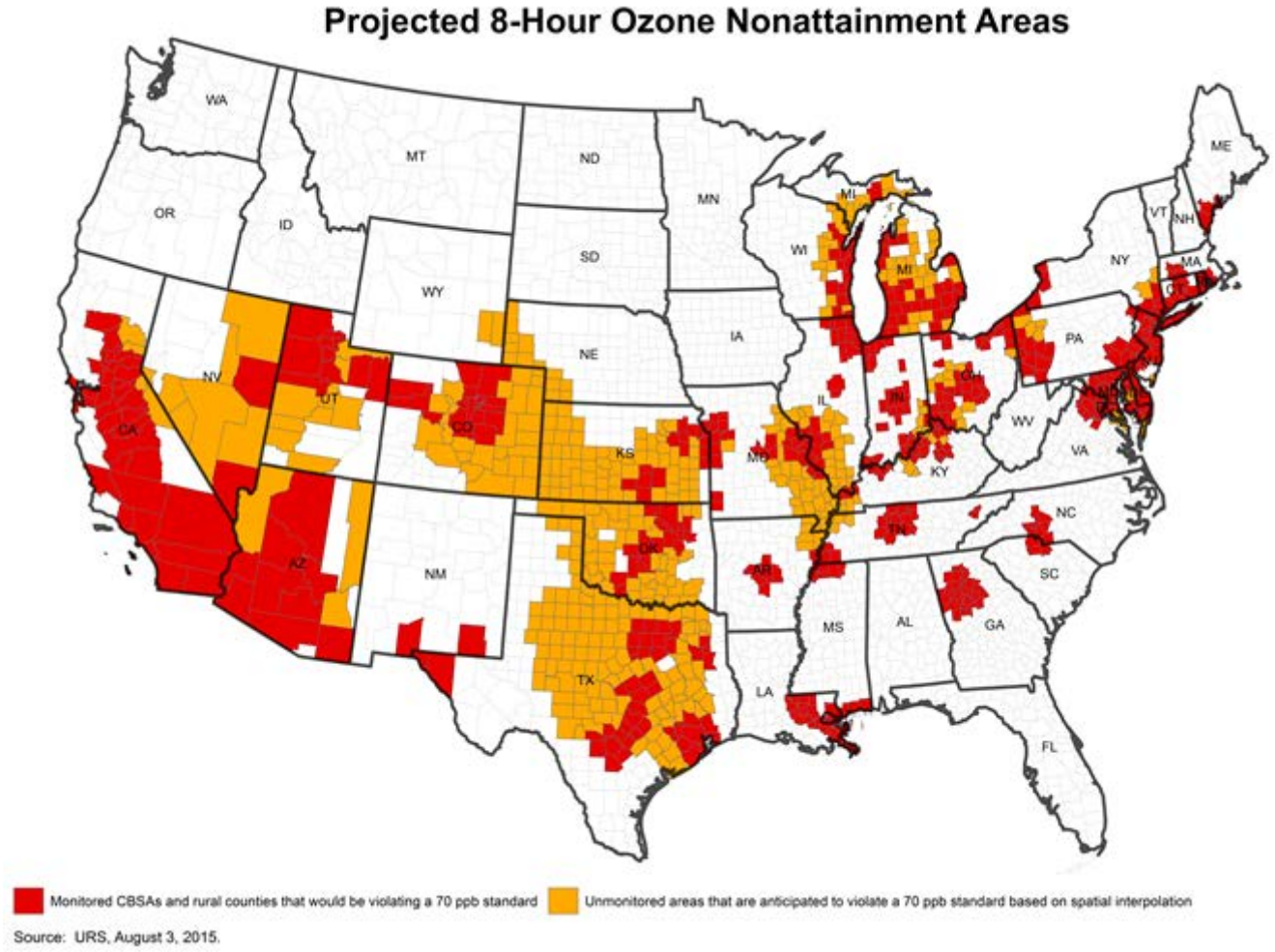
Possible Pavement Reductions	MMT/year
Rolling resist to optimum	1.5
Cement use 50%	0.2
Asphalt use 50%	0.7
Demo, oil, stone haul 10%	0.6
TOTAL	**2.9**

http://www.arb.ca.gov/cc/inventory/data/data.htm

Air Pollution Toxicity

- Transportation related factor of most importance is air pollution, especially diesel trucks

✓ Requiring changes in vehicle fuel sources



http://graphics.latimes.com/responsivemap-pollution-burdens/

https://www.uschamber.com/issue-brief/ozone-national-ambient-air-quality-standards

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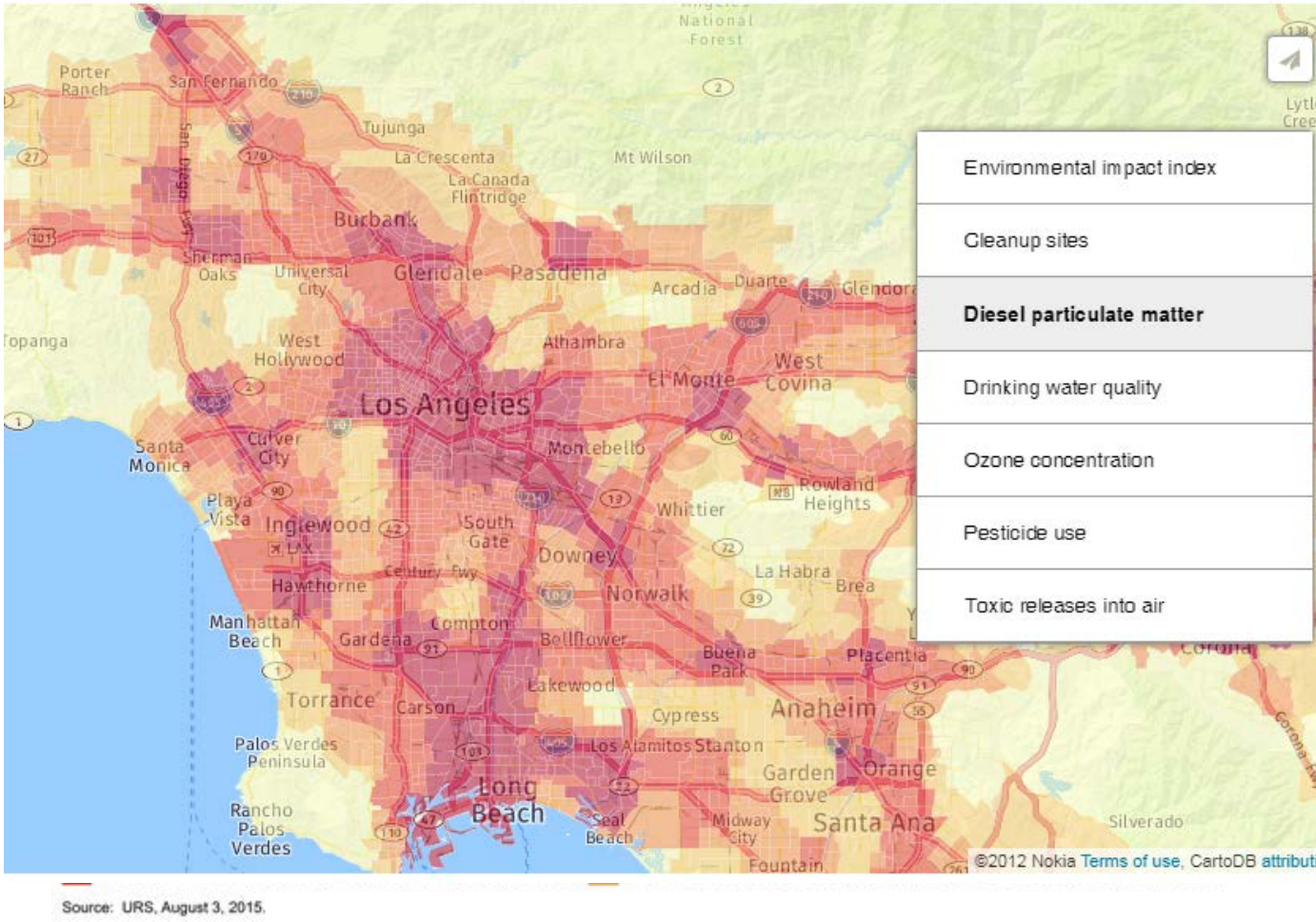

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https://www.uschamber.com/issue-brief/ozone-national-ambient-air-quality-standards

Pavement Materials Resource Depletion and Replacement

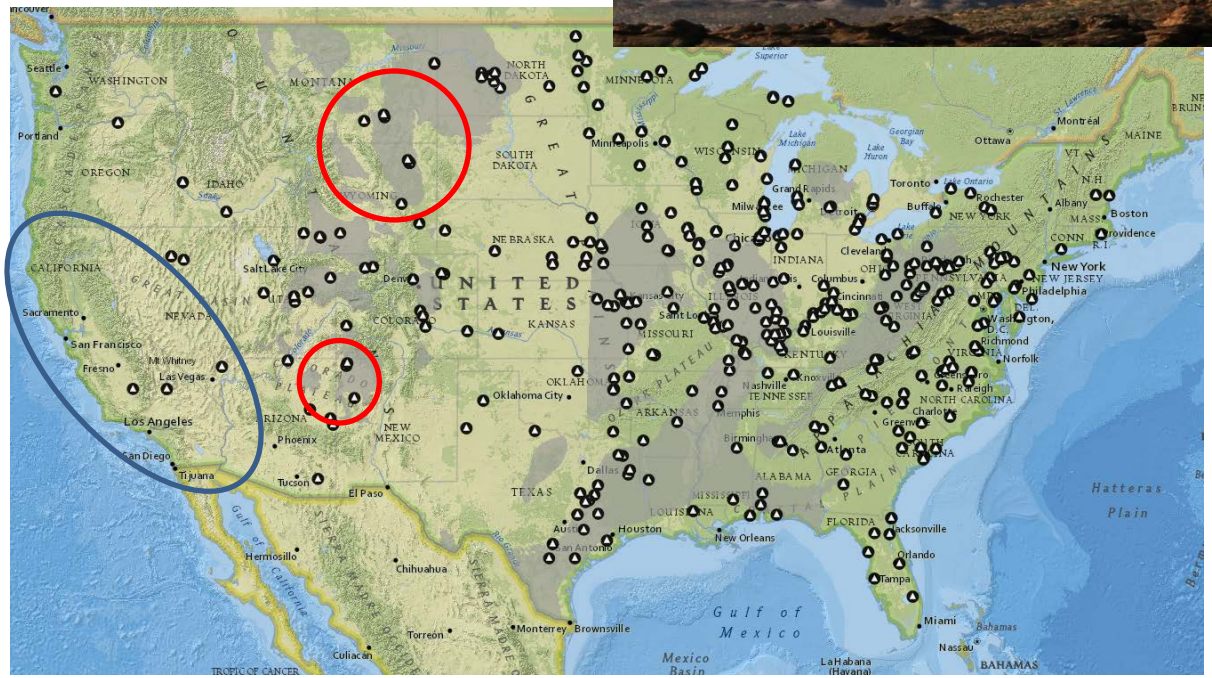
- Aggregate:
  - Local future shortages and quality issues
  - Large quantities of aggregate moved on the roads, lots of fuel, high levels of damage
- Bitumen:
  - US: supply and demand balanced, because large amounts of asphalt are coked for liquid fuels
  - Europe: oversupply of asphalt?
  - If oil demand for transportation fuel diminishes, there is a nearly infinite future supply of asphalt

Pavement Materials Resource Depletion and Replacement

Ross D. Franklin AP

- Cement
  - Fly ash from coal burning reduces CO2 in concrete, reduces ASR
  - Main fly ash sources for California closing
  - Transportation distances long for other sources
  - Market is 0.7 to 1.1 MMT per year
  - Need natural pozzolans with low CaO

Caltrans/industry fly ash shortage report 2016
US Energy Information Agency



Environmental Product Declaration (EPD)

- Pilot Caltrans program for requiring EPDs for concrete, asphalt, steel expected in 2018; many issues to resolve
- Within 5 years expect materials producers will be competing on impact + cost, as in Netherlands, France and soon Sweden, UK

Adapted from N. Santero

Environmental Facts

Functional unit: 1 metric ton of asphalt concrete

Primary Energy Demand [MJ]	4.0×10^3
Non-renewable [MJ]	3.9×10^3
Renewable [MJ]	3.5×10^2
Global Warming Potential [kg CO_2-eq]	79
Acidification Potential [kg SO_2-eq]	0.23
Eutrophication Potential [kg N-eq]	0.012
Ozone Depletion Potential [kg CFC-11-eq]	7.3×10^{-9}
Smog Potential [kg O_3-eq]	4.4

Boundaries: Cradle-to-Gate
Company: XYZ Asphalt
RAP: 10%

Example LCA results

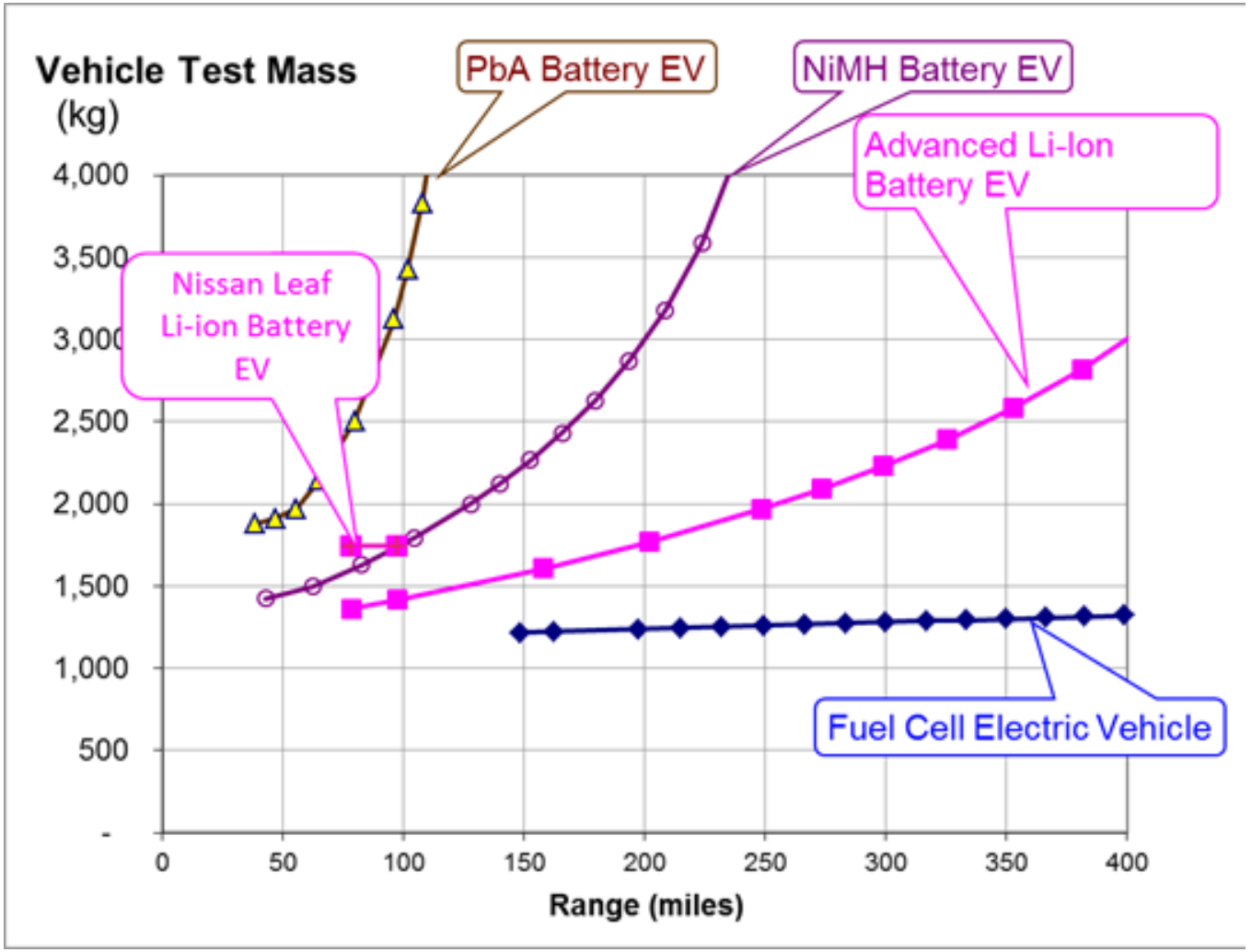
Climate Change and Air Pollution: diesel to natural gas then electric vehicles

- Natural gas trucks as 20 year bridge to electric
  - Trucks: Increase vehicle weight by 250 to 750 kg depending on range
- Electric vehicles
  - Cars: currently about 30% heavier for about 30% of the range
  - Trucks: small trucks available, tractors for semi-trucks under development; likely heavier than diesel

Fred Lambert, 7 June 2017
https://electrek.co/guides/tesla-semi/

Electric vehicles and weight

- Range and battery technology control weight
- Trucks use same technologies as cars, more range = add more batteries
- Fuel cells questionable



http://www.cleancaroptions.com/html/ev_weight.html
DeMorro, 2015, https://cleantechnica.com/2015/03/17/lighter-batteries-may-prove-tipping-point-electric-vehicles/

Long-haul truck shown at Tesla shareholders meeting June 2017

Tesla Semi to reach 'scale production' in '18 to 24 months' and will be unveiled with something unannounced, says Elon Musk

Fred Lambert - Jun. 7th 2017 5:26 am ET @FredericLambert

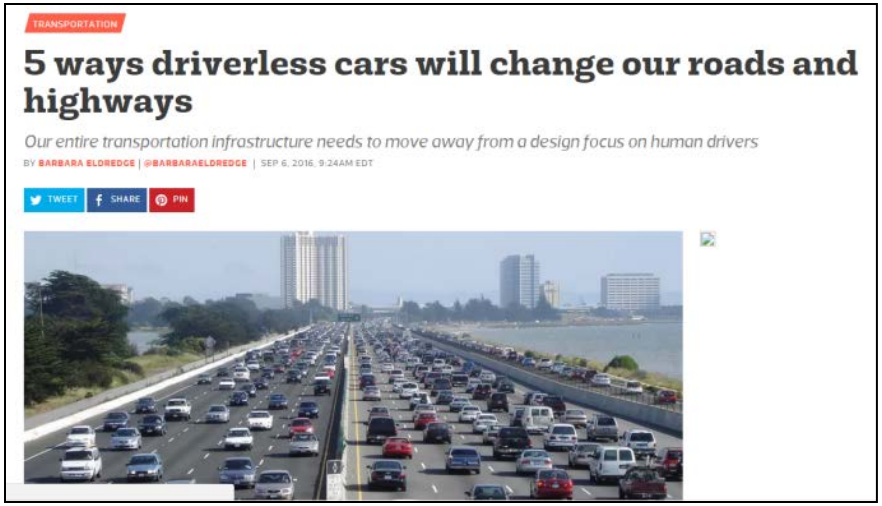
TESLA TESLA SEMI

Autonomous Vehicle Technology

- List of companies with autonomous vehicle testing permits in California (15 June 2017):
  - Volkswagen Group of America,
  - Mercedes Benz,
  - Waymo
  - Delphi Automotive
  - Tesla Motors
  - Bosch
  - Nissan
  - GM Cruise LLC
  - BMW
  - Honda
  - Ford
  - Zoox, Inc.
  - Drive.ai, Inc.
  - Faraday & Future Inc.
  - Baidu USA LLC
  - Wheego Electric Cars Inc.
  - Valeo North America, Inc.
  - NextEV USA, Inc.
  - Telenav, Inc.
  - NVIDIA Corporation
  - AutoX Technologies Inc
  - Subaru
  - Udacity, Inc
  - Navya Inc.
  - Renovo.auto
  - UATC LLC (Uber)
  - PlusAi Inc
  - Nuro, Inc
  - CarOne LLC
  - Apple Inc.
  - Bauer's Intelligent Transportation
  - Pony.AI
  - TuSimple
  - Jingchi Corp

Autonomous Vehicle Technology

- Automated Vehicles Symposium2017
  - One presentation that mentions infrastructure
- Infrastructure focus on detection and guidance, not pavement condition
- Will cause increase in car travel?

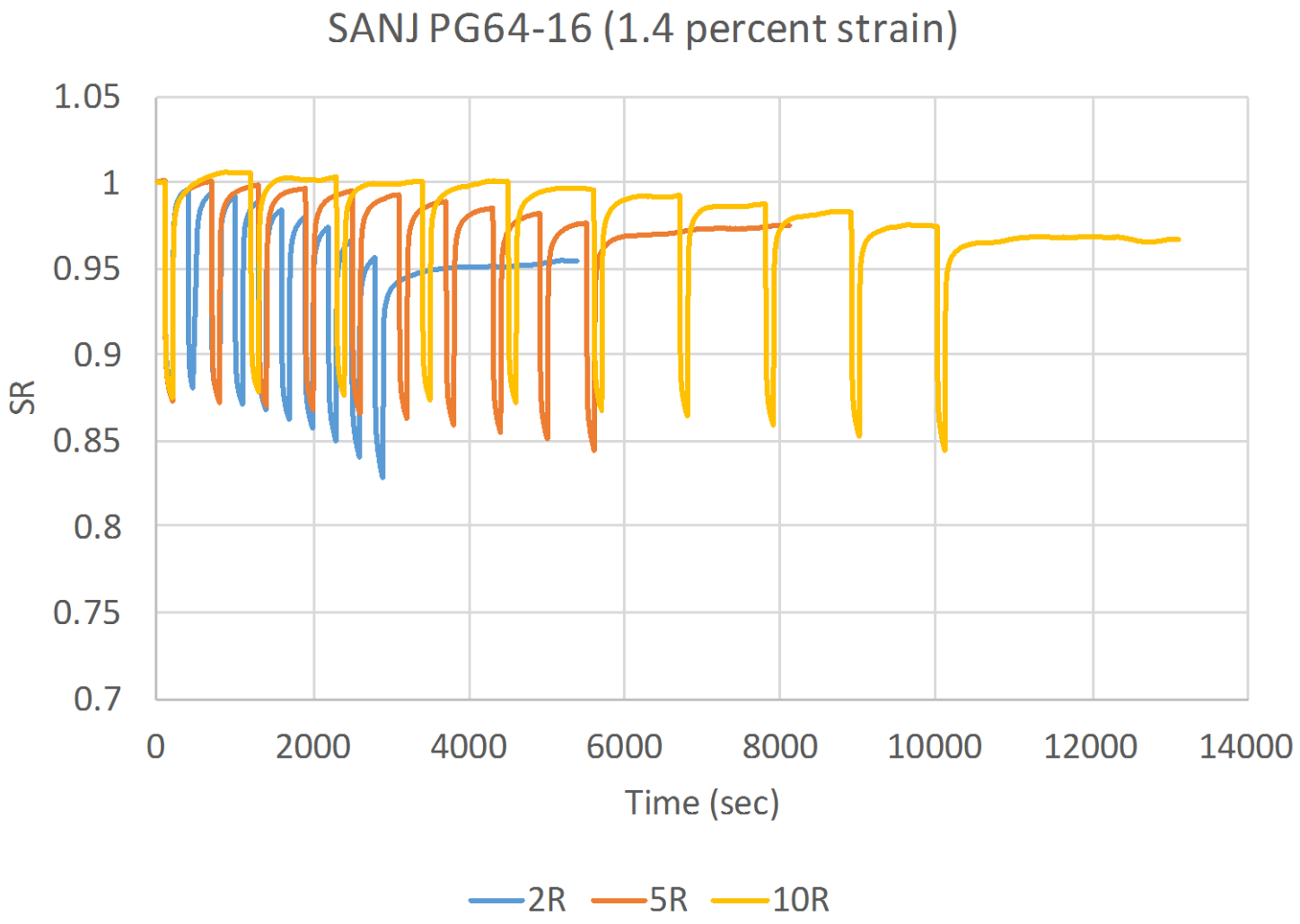


Autonomous Vehicle Technology: effects on pavements

- Fully automated truck platooning expected to deploy starting 2020 and broad implementation by 2030
  - 3 to 13% fuel savings
- Asphalt surfaced pavement
  - Channelized traffic if wander is not programmed into guidance, faster rutting and fatigue
  - Truck platooning will reduce thixotropic recovery times at high speeds, larger strains
- Concrete surfaced pavement
  - Can program trucks off of the slab edge, lower stresses
  - Difficulties discerning marking paint

ATA future truck white paper White Paper:
Automated Driving and Platooning Issues and Opportunities Sept 2015; fuel savings various Freightliner, Volvo,

Recovery time and thixotropy



Rest periods of 2, 5 and 10 times loading period

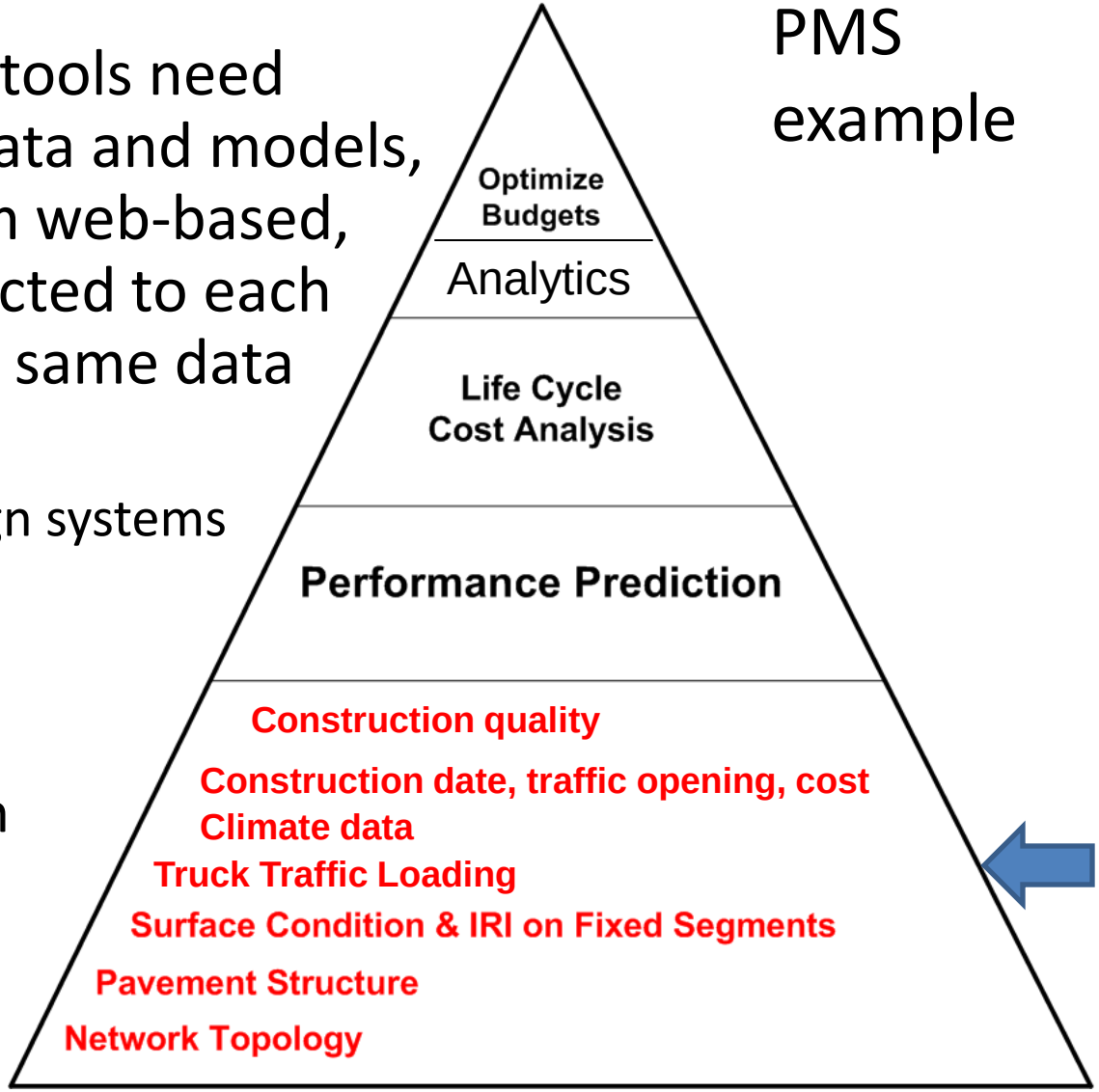
Information technology and pavement

- Freight and personal users will soon have better information about pavement and use it to make route decisions using cell phone apps:
  - Smoothest route
  - Least fuel use route
  - Least freight damage route
- Pavement roughness condition will soon be crowd-sourced to public and road owner with $500 systems
  - Can get IRI using calibrations like Class 1 profilers

Information Technology and Pavement

- Pavement tools need updated data and models, make them web-based, and connected to each other with same data
  - PMS
  - ME design systems
  - LCCA
  - LCA
- Update information routinely

PMS example



Data

Need strong foundation to perform desired operations

Cost, Financing and Confidence in Government to Deliver Pavement Efficiently

CAPITOL ALERT

California gas tax increase is now law. What it costs you and what it fixes

- Tax increase
  - April 4 passed by legislature (2/3 majority)
  - April 28 signed
  - First increase since 1993
- $2.5 billion per year for state highways
- $2 billion for local roads

Cost, Financing and Confidence in Government to Deliver Pavement Efficiently

Gas tax vote prompts recall campaign against Southern California Democrat

Initiative filed to repeal California gas tax increase

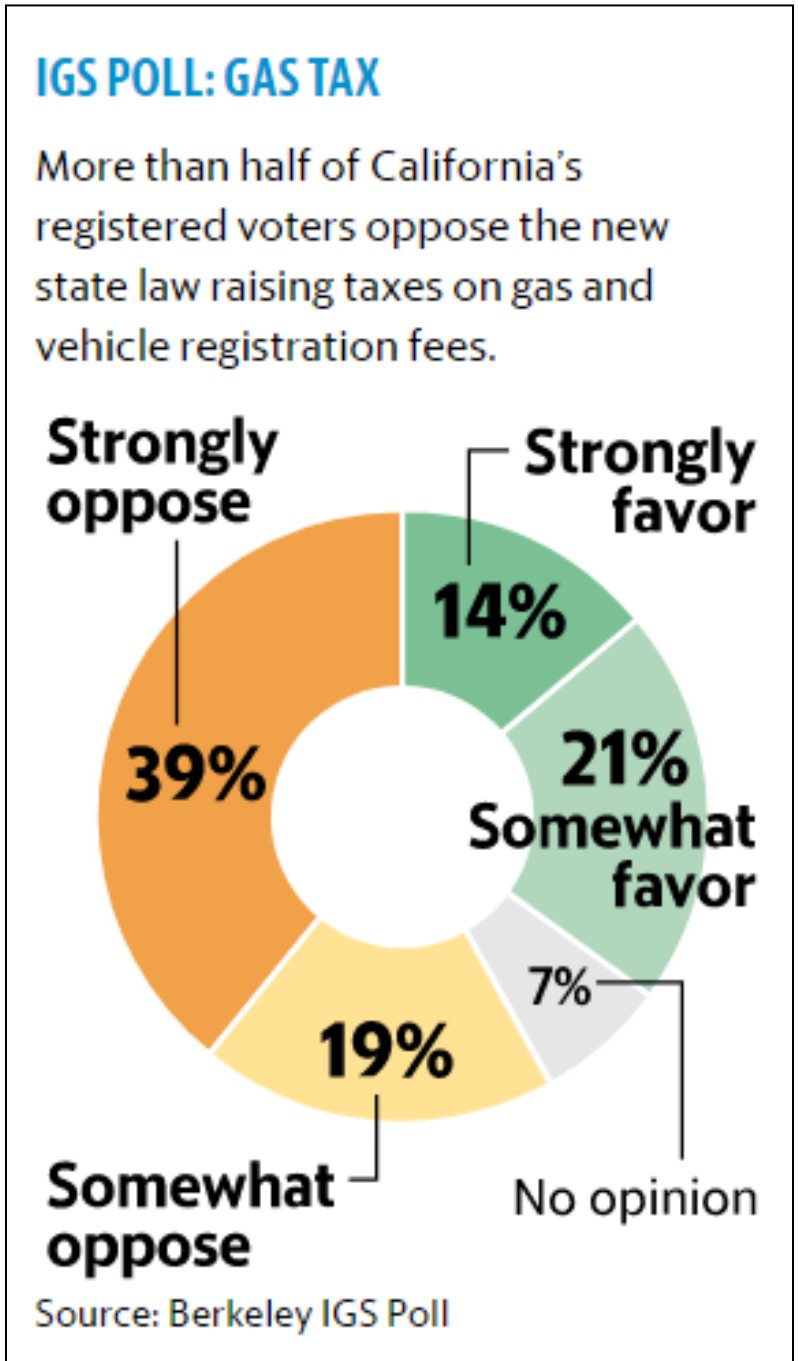
- Negative reaction April 11 to June 15

Main arguments:

- Government is wasteful in road spending
- Road taxes not spent on roads
- “Why can’t roads be made to last longer?”
- “Why are roads so expensive?”

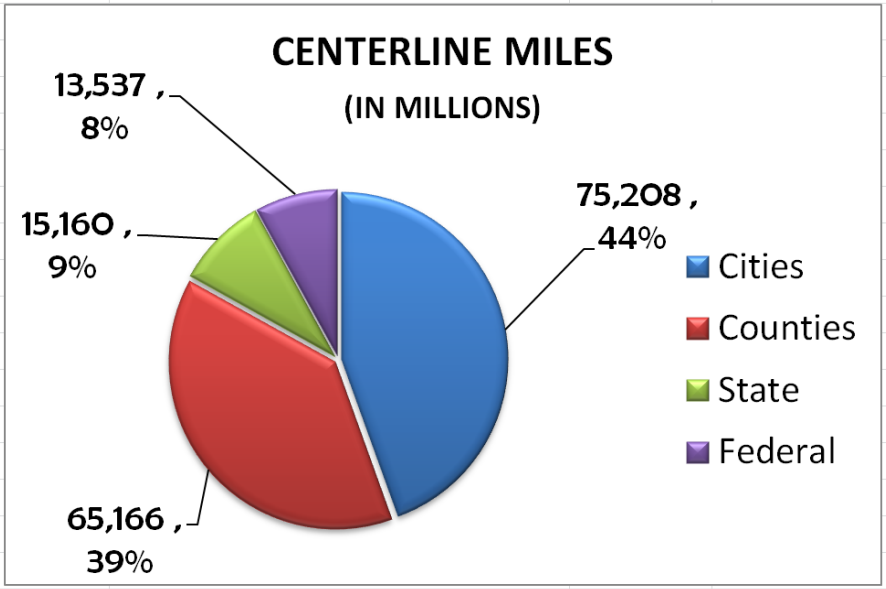
Cost, Financing and Confidence in Government to Deliver Pavement Efficiently

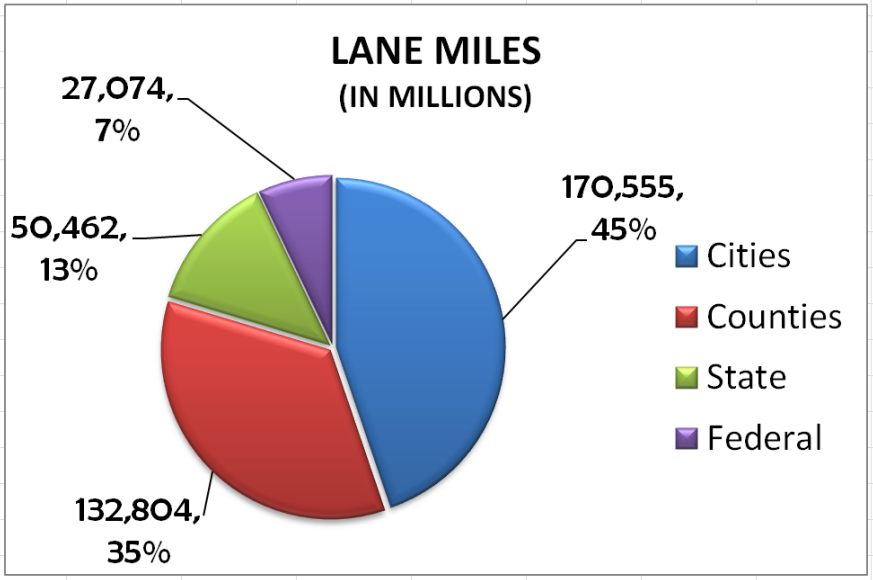
- Poll taken June 8

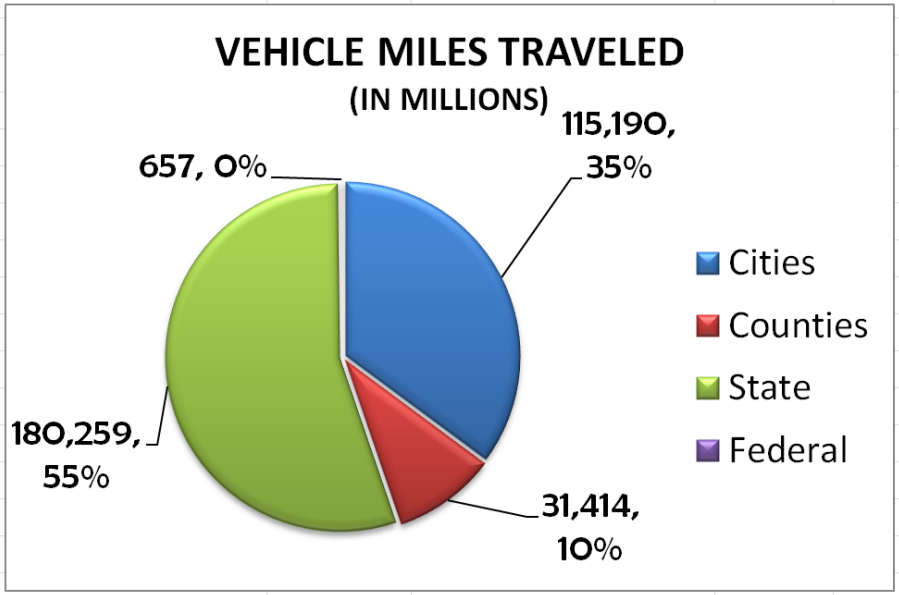


If you don't like California's gas tax increase, you're not alone

The Forgotten Half of Our Pavements







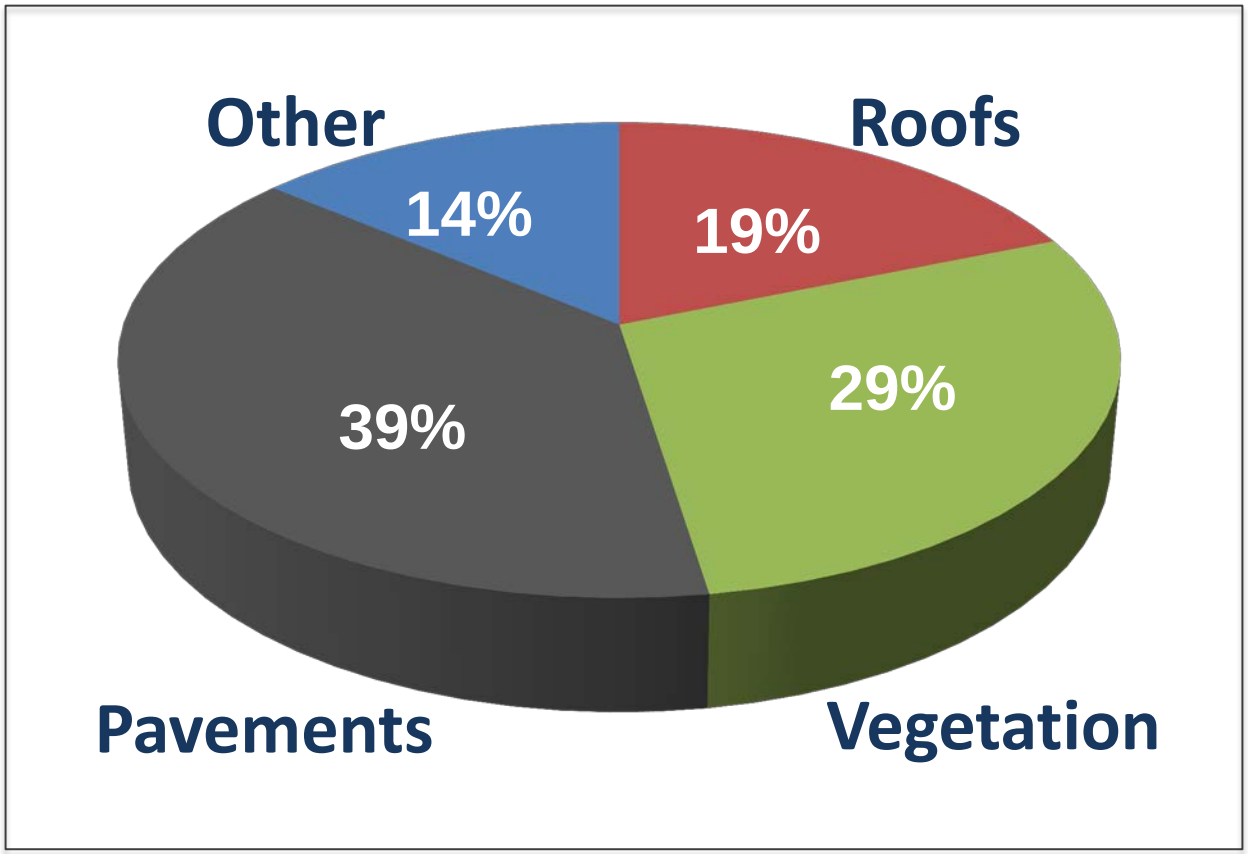
National $ Spent on Transportation in 2008 (US Census Bureau)

STATE GOVERNMENT	LOCAL GOVERNMENT
97,508,989	61,053,150

Urban pavements fail because of utilities

- Most urban pavements are scaled down highway pavements
- Invent new materials and structures to handle utilities?

Pavements are an important part of the urban environment



Sacramento

Akbari et al. 2003 <doi:10.1016/S0169204 6(02)00165-2>

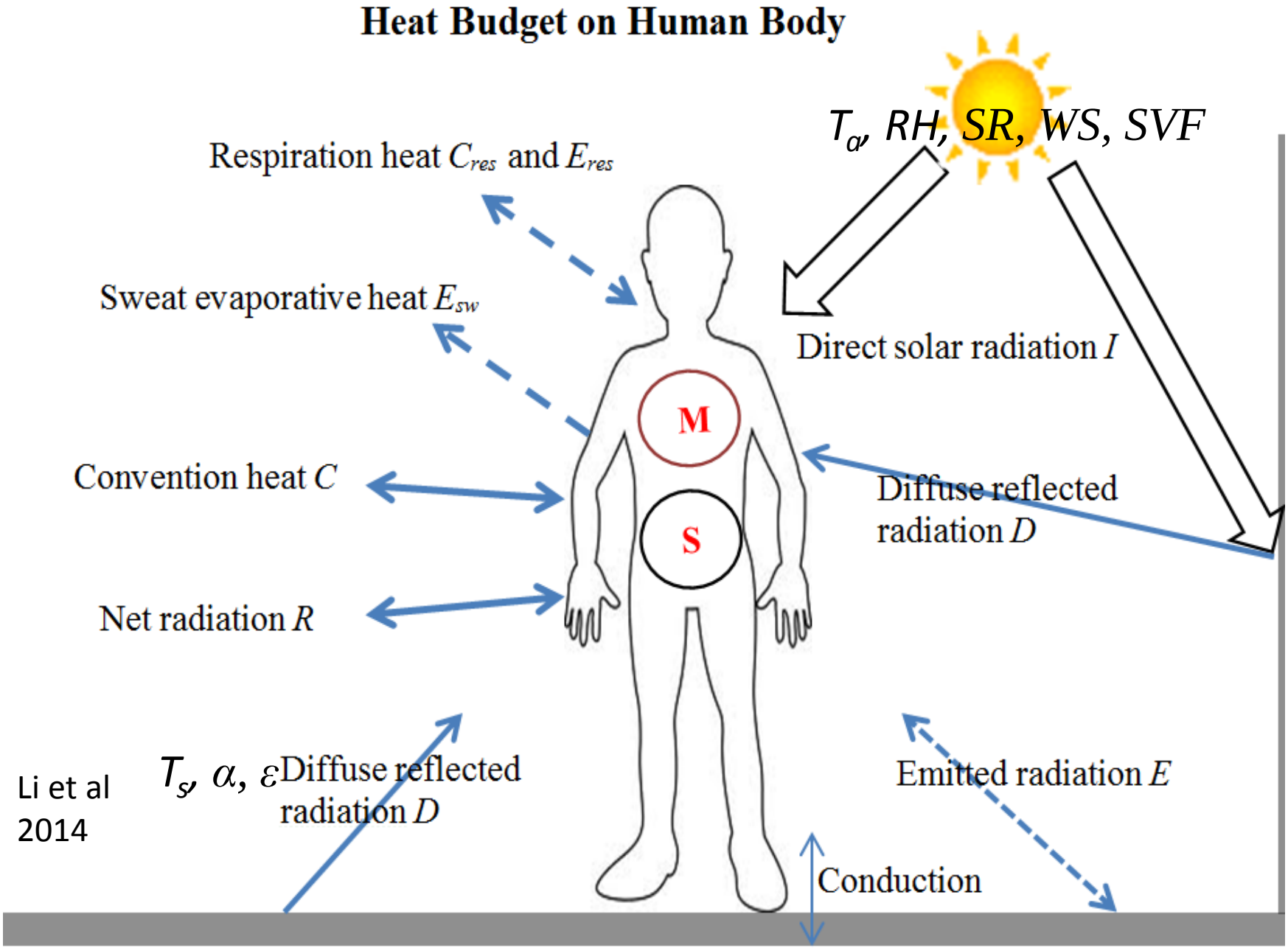
Other issues with current approach to urban pavement

- Active transportation
  - Street geometric and surface designs generally don't consider it
  - Bike path and trails are scaled down highway pavement designs
- Urban forests
  - Impermeability
  - Pavement and root growth
- Noise
  - Tire pavement noise at higher speeds
  - Non-absorptive for noise

Land8.com

Pavements = urban hardscape not just roads and streets

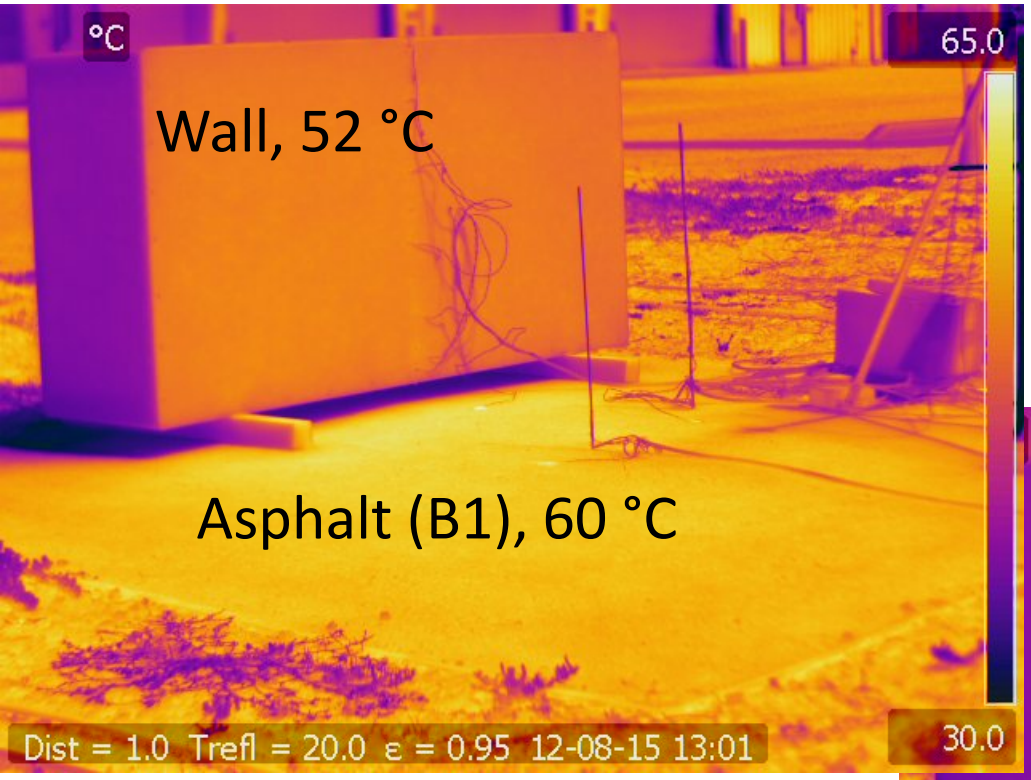
- Stormwater management, groundwater infiltration
- Tire pavement noise
- Human thermal comfort
- Pedestrian and bicycle functionality
- Better interaction with urban forestry

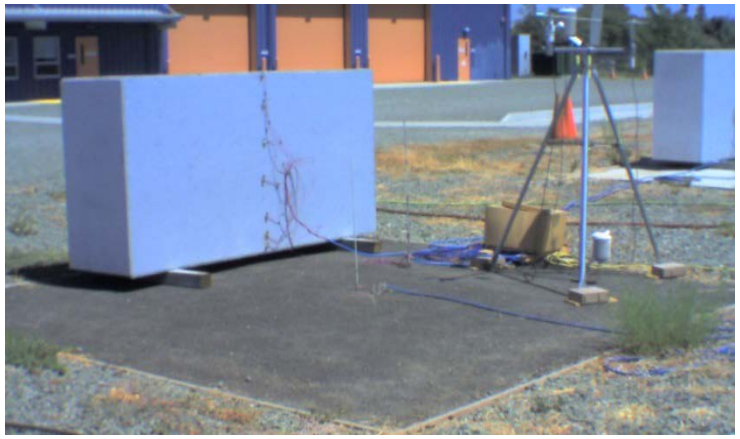


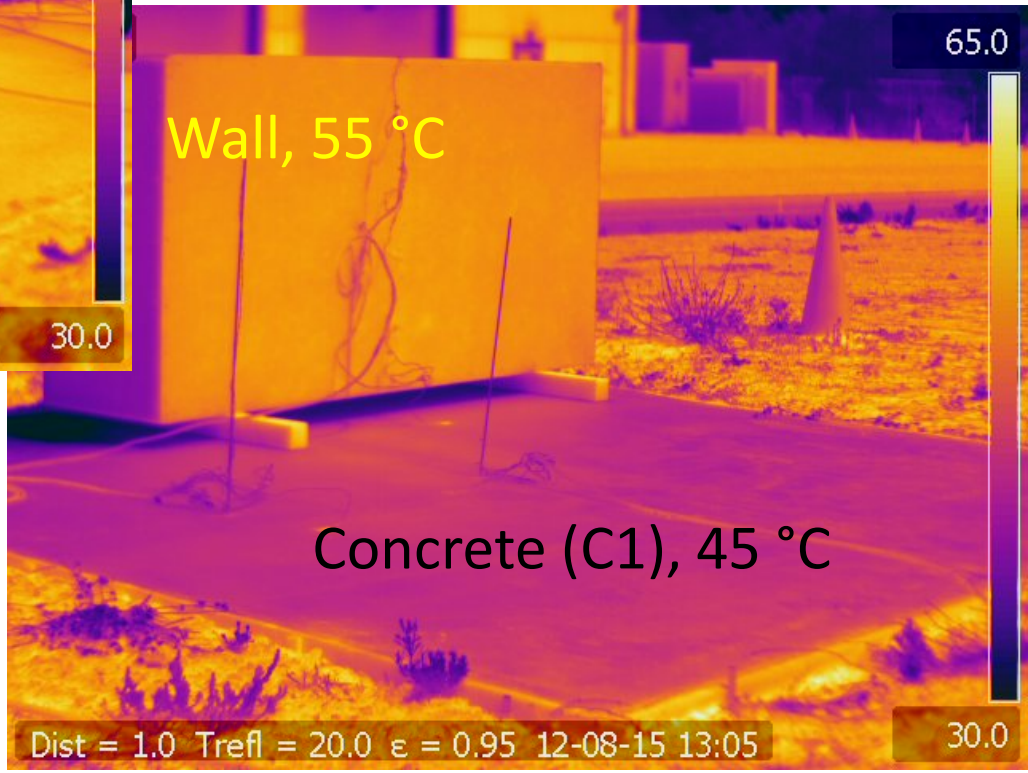
Li et al 2014

M is the metabolic rate (W/m^2). *W* is the rate of mechanical work (W/m^2). *S* (W/m^2) is the total storage heat flow in the body.

Thermal Impacts of Albedo and Reflection







13:00 8/15/2012

More reflective asphalt?
Thin reflective coatings for asphalt?
Thin concrete with high SCM?

Status of local government pavement knowledge in California

- Agencies
  - Some agencies have some staff with university training in pavement; other agencies have no staff with university or other formal pavement training
  - Heavy reliance on consultants
- Consultants
  - Some have excellent staff
  - Many have no staff with university or other formal training
- Issues:
  - Old, poorly understood specifications, design methods
  - Construction quality control for most important issues: compaction, concrete mix designs

Jobs and Workforce

- Supply:
  - Are we producing enough pavement students?
  - Are students interested in pavement?
  - What today's students want:
    - Solve important problems
    - Be able to use their creativity and skills
    - Have positive impact
    - This is same as other generations
- Demand:
  - Are government and industry prioritizing hiring students with pavement training, or generalists?
  - Are we making use of and rewarding pavement training?
  - Are we providing the environment to attract people?

Takeaways: do we have stationarity?

- Stationarity is not always true
  - Demands on pavements can change, potentially rapidly
  - People want more from pavement, and more people are involved in decision-making
- Changes in California
  - Number of trucks increasing rapidly
    - Especially last mile due to internet purchase deliveries
  - Electric vehicles and natural gas may increase loads some
  - Autonomous vehicles may cause important loading patterns in space and time
  - Increasing attention to local roads, multi-functionality
  - Users will soon have much better information about pavement and make decisions with it
  - Low willingness to pay for state-wide tax for pavement

Takeaways: what do our customers want?

- Pavements we deliver must do more:
  - More sustainable
    - Cost
    - Smooth
    - Construction delay
    - Small CO2e impacts, more important local effects
- Handle multiple modes and purposes in urban areas
  - Think of pavement as hardscape, not just for vehicles
    - Active transportation (bikes, walking)
    - Local thermal environment, tree-compatible pavement
    - Stormwater
    - Utilities

Takeaways: what do we need to do differently?

- Make pavement last longer for same cost, faster repairs
- Make all tools and data web-based for continuous update
- Deliver innovation and training that is developed to match the capabilities of the workforce
  - Do $5 of development for each $1 of research
  - Find solutions for local government
- Increase the capabilities of the work force, and put value on pavement knowledge in employment
- Think beyond asphalt vs concrete, think pavement
- Find a way to communicate to public about pavement
  - Rightly or wrongly, government is not seen as cost-effective deliverer of these services
  - Communicate the science and technology innovations
  - They are interested!

Change Management in Government: Obstacles

- Leaders are chosen based on command of policy, technical expertise, or political connections, not ability to lead change
- Leaders usually have limited time in office
- Rules in place to limit corruption also tend to limit flexibility
- Penalties for failure are always larger than any rewards for success
- In a democracy there are many stakeholders with different goals to manage

Frank Ostroff, Harvard Business Review, 2006
https://hbr.org/2006/05/change-management-in-government

Change Management in Government: Steps to Success

- Identify improved performance against mission as the fundamental objective of the transformation effort
- Win over internal and external stakeholders
- Create a road map
  - Vision, priorities, program
  - Make the road map a part of the culture of the organization
- Take a comprehensive approach
  - leadership, structure, processes, infrastructure (including technology), people, and performance management
- Need leaders
  - Reward their efforts

Adapted from Frank Ostroff, Harvard Business Review, 2006

Change Management in Government: Communicating with the Public

- What is our message about what is being done that is positive and better
- Livability and Quality of Life, relate to people's lives
  - Access by different modes, shared prosperity, environmental impact, public participation, safe and healthy communities, wise use of resources
- Relate to people's pocketbooks
- Set goals and measure and report progress
- Have the right messengers
  - Trusted messengers who are informed about pavement progress, not necessarily pavement engineers!

California Pavement Research Road Map Areas

- Design, materials and construction
  - Mechanistic-empirical design
  - Performance based specifications
  - Construction quality
- Environmental, maintenance
  - Recycling technologies
  - Life cycle assessment (LCA)
- Maintenance
  - Preservation technologies
  - Pavement management
    - Pavement management system (PMS)
    - Life cycle cost analysis (LCCA)

Communication of pavement road map

- Entire program communicated in plain language on two A3 pages

Pavement Research Roadmap (2014 - 2017)
Caltrans Division of Research, Innovation and Systems Information and UC Pavement Research Center

Caltrans Roadmap for Pavement Research

UCPRC UNIVERSITY of CALIFORNIA PAVEMENT RESEARCH CENTER

	CALTRANS PROGRAM AREAS						
	DESIGN, MATERIALS & CONSTRUCTION			ENVIRONMENTAL		MAINTENANCE	
PRIORITY TOPICS	Mechanistic-Empirical Design	Performance Based Specifications	Construction Quality	Recycling	Sustainability	Preservation	Pavement Management
PROJECT TITLES and description	• **Standard Materials Library and Guidance (SPE3.30, TID 2667)** - Test and include additional regional materials in the Caltrans ME Standard Materials Library, including base, subbase and new recycled materials. Implement procedures to simplify the selection of material types for ME design by district designers, and develop guidance for asphalt mix designers to meet performance related mix design requirements. Support implementation of CalME and use of MEPDG. • **Improved ME Design and Reliability Approach (SPE 3.31, TID 2668)** - Improve the ability/reliability of Caltrans and national ME procedures to predict pavement distresses. Address upcoming changes in AASHTO test methods for asphalt fatigue cracking and translation of data from repeated shear to the new Asphalt Material Performance Tester (AMPT) equipment. Update calibration of Mechanistic-Empirical Pavement Design Guide (MEPDG) methods for jointed plain concrete (JPC) transverse cracking and faulting using new condition survey data. Complete study investigating range of coefficient of thermal expansion (CTE) values in state testing procedures.	• **Performance-Related Specifications for Rubberized Asphalt Binder (SPE 4.50, TID 2671)** - Develop supporting data/information for the writing of performance related QC/QA specifications for mix design and mix placement of terminal blend and wet process asphalt rubber mixes. This project will use recently developed dynamic shear rheometer (DSR) test methods for assessing rubber binders and will include laboratory mix tests and field evaluations on new and recent projects. • **Support for Superpave Implementation (SPE 3.32, TID 2672)** - Establish annual state-wide round robin (to be taken over by METS IA program) for Hamburg Wheel Track Test (HWTT) study to determine precision and bias, and incorporate results in revised specifications. Assess differences between laboratory and plant produced mix, and continued development and implementation of performance related tests. Review appropriateness and applicability of QC/QA testing on Superpave projects and make recommendations for revised specifications if justified. Monitor performance of Superpave projects constructed to date. • **Simplified Performance Based Specifications for AC Long Life Projects (SPE 3.33, TID 2673)** - Complete the development of simplified asphalt mix design procedures and specification preparation for AC long life projects that are easier for contractors and districts to understand and communicate on, but do not increase the risk of poor performance to Caltrans. Evaluate revised specifications and procedures on new AC long life projects. Support Caltrans on implementation and training. • **Improved Screening Tests for Alkali-Silica Reaction (SPE 3.34, TID 2702)** - Evaluate Caltrans historical risk for ASR for pavements and structures. Determine appropriate testing methods and criteria for assuring Caltrans low risk.	• **Quieter Pavement Long-term Monitoring (SPE 3.35, TID 2710)** - Continue noise, smoothness (IRI), and friction monitoring of a few selected grind and groove (GnG) and continuously reinforced concrete pavement (CRCP) pilot sections for which monitoring began in 2012/13.	• **Binder Replacement in High RAP/RAS Asphalt Mixes (SPE 4.51A&4.51B, TID 2676&2677)** - Continuation of a study investigating determination of binder replacement rates in high RAP/RAS mixes without the need for binder extraction. This is a phased study starting with binder testing and analyzing, followed by laboratory mix and field testing, and then APT if justified. The effects of asphalt modifiers (polymer and rubber), warm mix technologies, and rejuvenators will also be investigated. • **Improved Guidance and Specifications for Full-Depth Reclamation (SPE4.59, TID 2707)** - Continuation of a study to develop project selection and design guidelines and specifications for different full-depth reclamation (FDR) strategies. This phase of the project will assess performance of different FDR stabilization treatments under wet conditions using accelerated pavement testing on existing test sections. This phase will also monitor performance of completed field projects that used the different strategies, including comparing as-built properties with laboratory design properties. • **Microcracking for Cement Stabilized Layers (SPE 4.52A&4.52B, TID 2708&2709)** - Develop laboratory design and construction procedures/specifications for microcracking/ precracking of new or in-place recycled cement stabilized layers to limit the effects of shrinkage related cracking, taking into consideration material properties, climatic factors, and cement contents. Consider interactions of different cement contents with microcracking and layer thickness design.	• **Validation of Greenhouse Gas Emissions from Pavement Deflection (SPE 4.53, TID 2691)** - Follow up to 13/14 project to review mechanistic equations from MIT and other research centers to calculate viscoelastic energy dissipation from vehicle operation for different pavement types, climate regions and vehicle types. Perform field validation of fuel economy differences, compare results with researchers, and then perform comprehensive assessment for state network implementation. • **Environmental Life Cycle Assessment Updates and Applications (SPE 4.54, TID 2718)** - Address additional issues required for Caltrans to meet AB32 greenhouse gas emission targets and category pollutant regulations using environmental life cycle analysis (LCA) following the Pavement LCA Roadmap. Develop additional/improved methods for LCA for the range of design, construction, maintenance, and rehabilitation strategies used in California. • **Updated Greenhouse Gas Emission Evaluations (SPE 4.55, TID 2719)** - Update Greenhouse Gas Emission methodologies for pavement management based on validation and calibration of LCA methods for pavement effects on vehicle emissions, including results of proposed projects Sus-A and Sus-B. Provide recommendations for improved simplified LCA GHG evaluations.	• **Effects of Pavement Roughness on Freight Movement (SPE4.56, TID 2723)** - Continue study to assess effects of roughness on cost of freight transport, choice of routes by haulers, and on emissions. Additional types of freight, districts, and routes will be assessed. • **Guidelines for Preservation Treatments for Bicycle Routes (SPE 4.57, TID 2693)** - Use results of recent cyclist comfort study for chip seal textures to test more Caltrans treatments for texture, and prepare guidelines for selection of preservation treatments that can be used on bicycle routes on state highways. • **Evaluate Early Age and Premature Cracking for LCCA (SPE 4.58, TID 2713)** - Complete work evaluating early age and premature cracking of slab replacements and concrete lane replacements to determine risks and likely causes of failures, to develop recommendations for reducing risks. Prepare design life estimates for use in LCCA.	• **Evaluate Traffic Speed Deflection Measurement (SPE 4.60, TID 2686)** - In conjunction with an FHWA pooled fund study on traffic speed deflection measurements, determine whether this method of pavement structural condition assessment is appropriate/will add value to network level assessments in California. • **Improved Smoothness and Distress Models and Benefits Equations for PaveM (SPE 5.01, TID 2703)** - Develop performance models for pavement smoothness and distresses based on the percentage of segment worse than the threshold values instead of the current approach, which uses average condition values. Review impact of these models on calculation of benefits. • **Performance Models for Seal Coats in PaveM (SPE 5.02, TID 2674)** - Develop pavement distress performance models for specific preservation treatments currently grouped under "Seal Coat" to provide more detailed treatment selection in PaveM, including slurry seals, aggregate seal coats with different binders and gradations, fog seals, and others identified by Caltrans. • **Evaluate Composite Pavement Performance and Decision Trees (SPE 5.03, TID 2704)** - Evaluate performance of composite pavements built in California (typically performed as crack, seat and overlay) to determine whether they should have a separate decision tree in PaveM. • **Algorithms for Grouping Segments into Projects in PaveM (SPE 5.04, TID 2705)** - Complete development of an algorithm to combine multiple management segments selected for treatment into potential construction projects and design graphic user interface for coding in PaveM. • **New Life Cycle Cost Optimization Models for PaveM (SPE 5.05, TID 2687)** - Apply new life cycle cost optimization models to PaveM decision trees. Use results to advise the implementation and evaluation of incremental benefits (Ino-Ben) option in PaveM software by Caltrans. • **Evaluate APCS Data Collection and PaveM Engineering Configuration (SPE 5.06, TID 2688)** - Evaluate how distresses collected by the Automated Pavement Condition Survey (APCS) are being used in PaveM decision trees and develop recommendations for changes in APCS and/or decision trees, performance equations and benefits equations. • **Evaluate Linear Reference System (SPE 5.07, TID 2722)** - Compare Caltrans's current Linear Reference System (LRS) with approaches used by other states and system needs for MAP-21, and identification of pros and cons of retaining current system or changing to a county and state odometer system. • **Document PaveM Traffic Updating Processes (SPE 5.08, TID 2706)** - Document processes for updating traffic used in PaveM and in bridge and pavement design. The study will also characterize truck traffic with unregulated loads for ME design for state highways near heavyload facilities. • **Update PaveM Engineering Configuration (SPE 5.09, TID 2689)** - Update engineering configuration (data aggregation, decision trees, benefit equations) as experience is gained during initial use by districts and HQ. Address additional data collection, materials design and policy questions developed by Caltrans. • **Update Guidance and Calculations for Life Cycle Cost Analysis (SPE 5.10, TID 2690)** - Develop LCCA information and guidance for new pavement structures, rehabilitation and preservation treatments. • **Update project level asphalt surface design (SPE 3.36 TID 2675)** - Update California mechanistic-empirical project level pavement management design method and process.

Caltrans Roadmap for Pavement Research

PRIORITY TOPICS

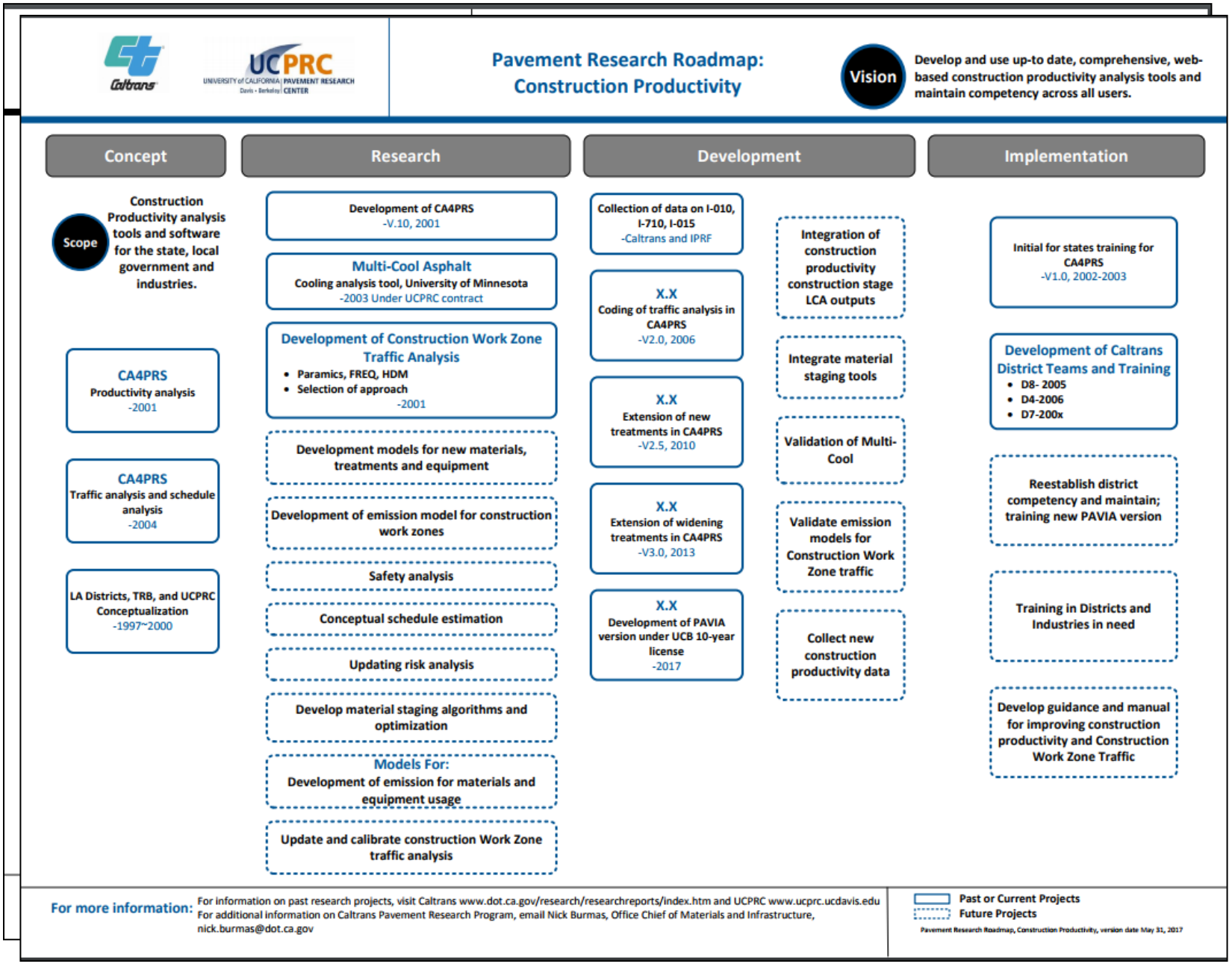
STRATEGIC PROBLEMS

STRATEGIC OBJECTIVES

RESEARCH APPROACH

PROJECT TITLES and description

Research arc in detailed road maps for each subject area



Local Government: the forgotten 50%

Technical Advisory Group:
League of Cities,
Association of Counties

Modeled on Minnesota, Iowa programs

State and federally funded research and development for highways

UCPRC
UNIVERSITY of CALIFORNIA Davis • Berkeley | PAVEMENT RESEARCH CENTER

City and County Pavement Improvement Center

Training, development of appropriate technology, specialized research for local governments

Partnered with teaching universities

CALIFORNIA STATE UNIVERSITY LONG BEACH 1949

CALIFORNIA POLYTECHNIC STATE UNIVERSITY 1901 DISCERE FACIENDO

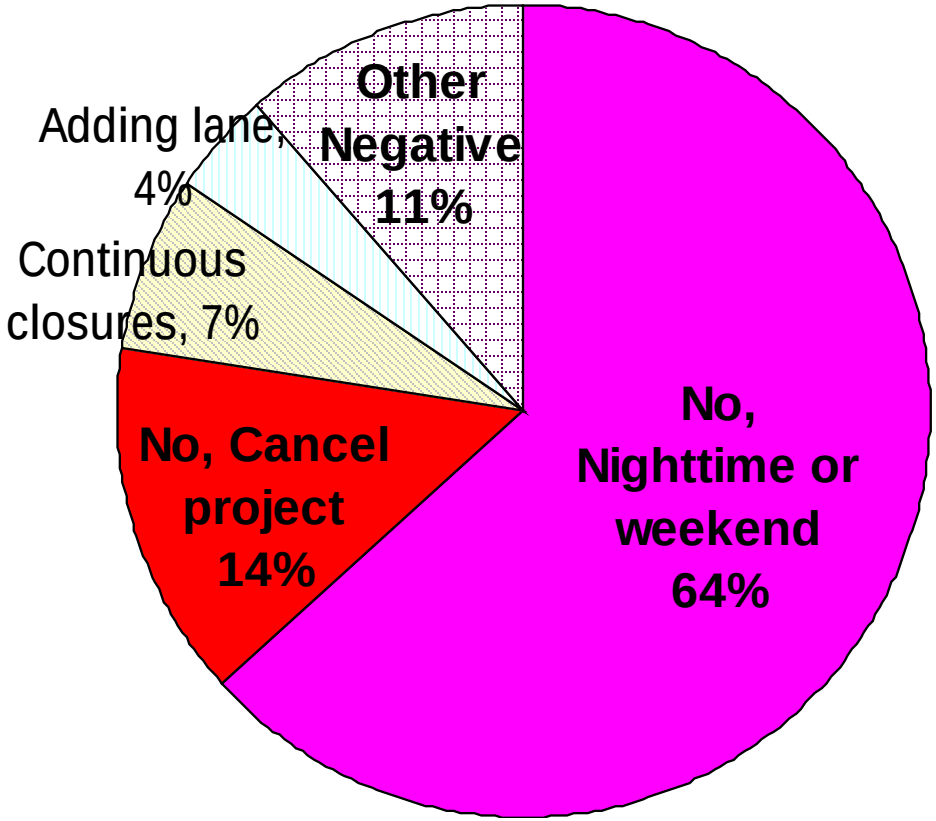
San José State UNIVERSITY

Selection of Closure Type for Concrete Freeway Reconstruction using CA4PRS

Construction Scenario	Schedule Comparison		Cost Comparison ($M)			Max. Peak Delay (Min)
	Total Closures	Closure Hours	User Delay	Agency Cost	Total Cost	
1 Roadbed Continuous	2	400	5.0	15.0	20.0	80
72-Hour Weekday Continuous	8	512	5.0	16.0	21.0	50
55-Hour Weekend Continuous	10	550	10.0	17.0	27.0	80
10-Hour Night-time Closures	220	2,200	7.0	21.0	28.0	30

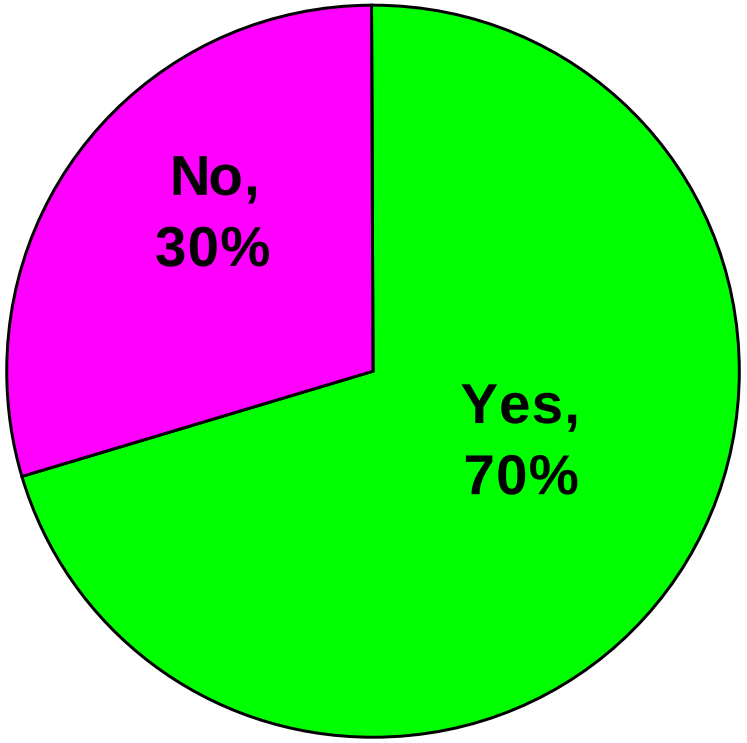
I-15 Devore Web-Surveys
Public Perception Changes

Before- construction



Do you support 72-h (3-weekday) Weekday closures?

After-construction



Do you support future "Rapid-Rehab" projects?

Expectations for Transportation Segment of the Economy

S. David Freeman

UCLA Seminar: Infrastructure Investment for Sustainable Growth (October, 2010)

- Transportation sector about to enter a period of profound change similar to energy sector in 1970s and 1980s
- Regulations will be implemented requiring increasing energy efficiency and environmental performance
- Transformation necessary to maintain economic competitiveness of US
- **We are no longer rich enough to make many mistakes and still be able to achieve our goals**
- **I would add: we need to better focus our research, translate our results into practice, and communicate to the public to achieve our goals**


Thanks to many colleagues
Questions?