Charging Mechanisms for Road Use:

An Interface between Engineering and Public Policy

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April 12, 2018

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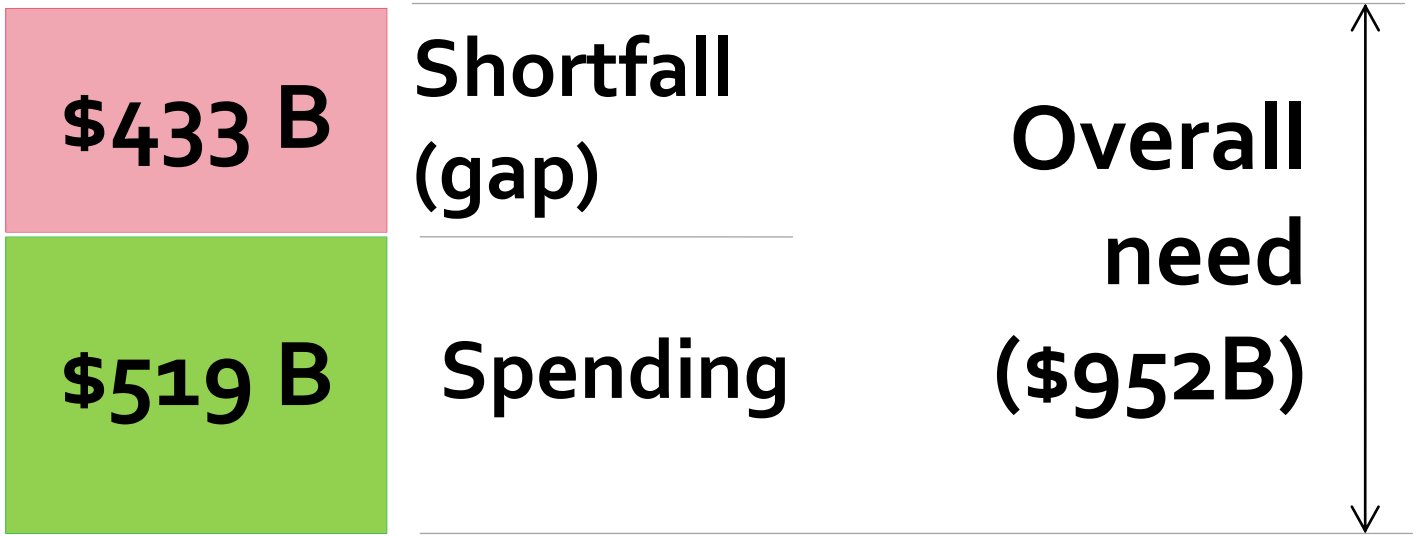
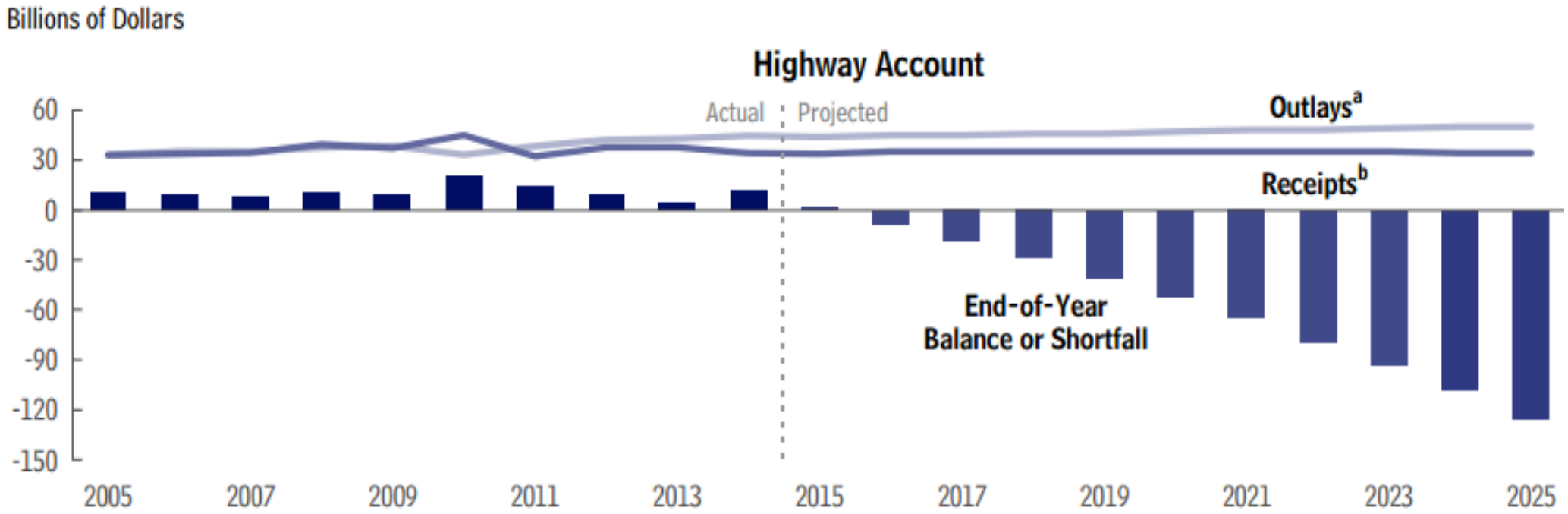
US Highway Infrastructure Assets:
Investment needs and shortfall facts

5-Yr Estimates for Roads and Bridges



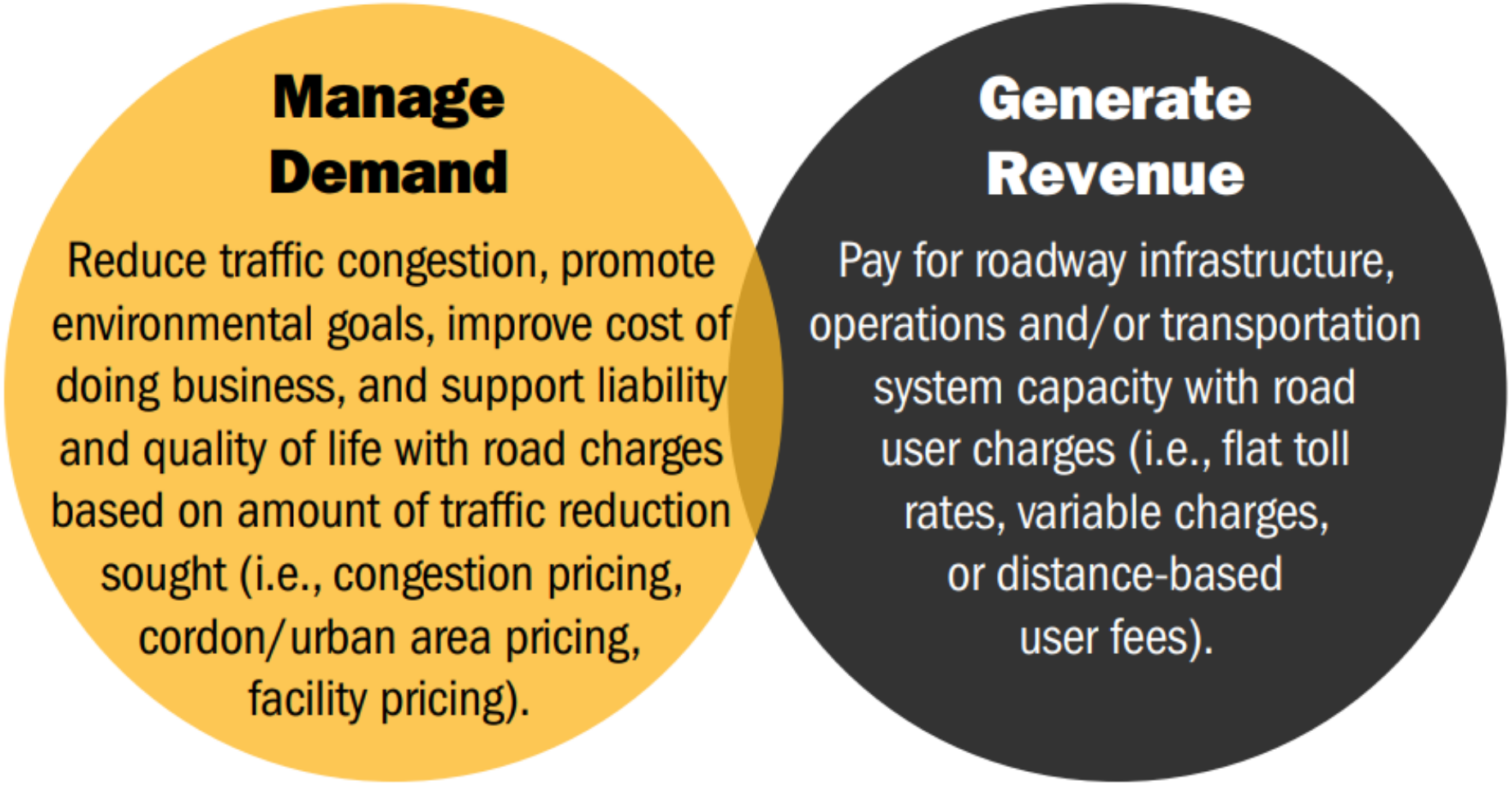
Source: www.infrastructurereportcard.org/bridges/
www.infrastructurereportcard.org/road-infrastructure/ Accessed on 8/26/16

US Federal Highway Trust Fund



Source: https://www.cbo.gov/publication/50298 Accessed on 8/26/2016

Purpose of Road Pricing



Problems with Current Highway Funding Mechanism

- **Inadequate**
  - No change in fuel tax rate in decades.
  - Increasing fuel efficiency.
  - Use of hybrid and electric vehicles.
- **Environmentally unfriendly**
  - Encourages emissions of GHG and other air pollutants.
- **Lack of equity**

Possible Solutions to Revenue Shortfall

- Increase fuel tax rate
- Index to inflation or other measure
- Increase state registration fees
- Adopt local tax for road use
- Impose a sales tax
- Increase local property tax rate
- **Direct charging**

Direct vs. Indirect Road User Charging

- **Indirect Charging**: User is charged for vehicle ownership and usage.
  - Example - license fees, registration fees, fuel tax, and other taxes.

- **Direct Charging**: User pays directly, in a manner that reflects the instance, amount of time or mileage of highway use.
  - Example – tolling.

Direct User Charge (DUC) Mechanisms – The Dimensions

- Highway facility type or coverage for which fee is charged
- Point at which payment is made
- Quantitative basis for the charge
- Technology applied to monitor the use and collect the payment

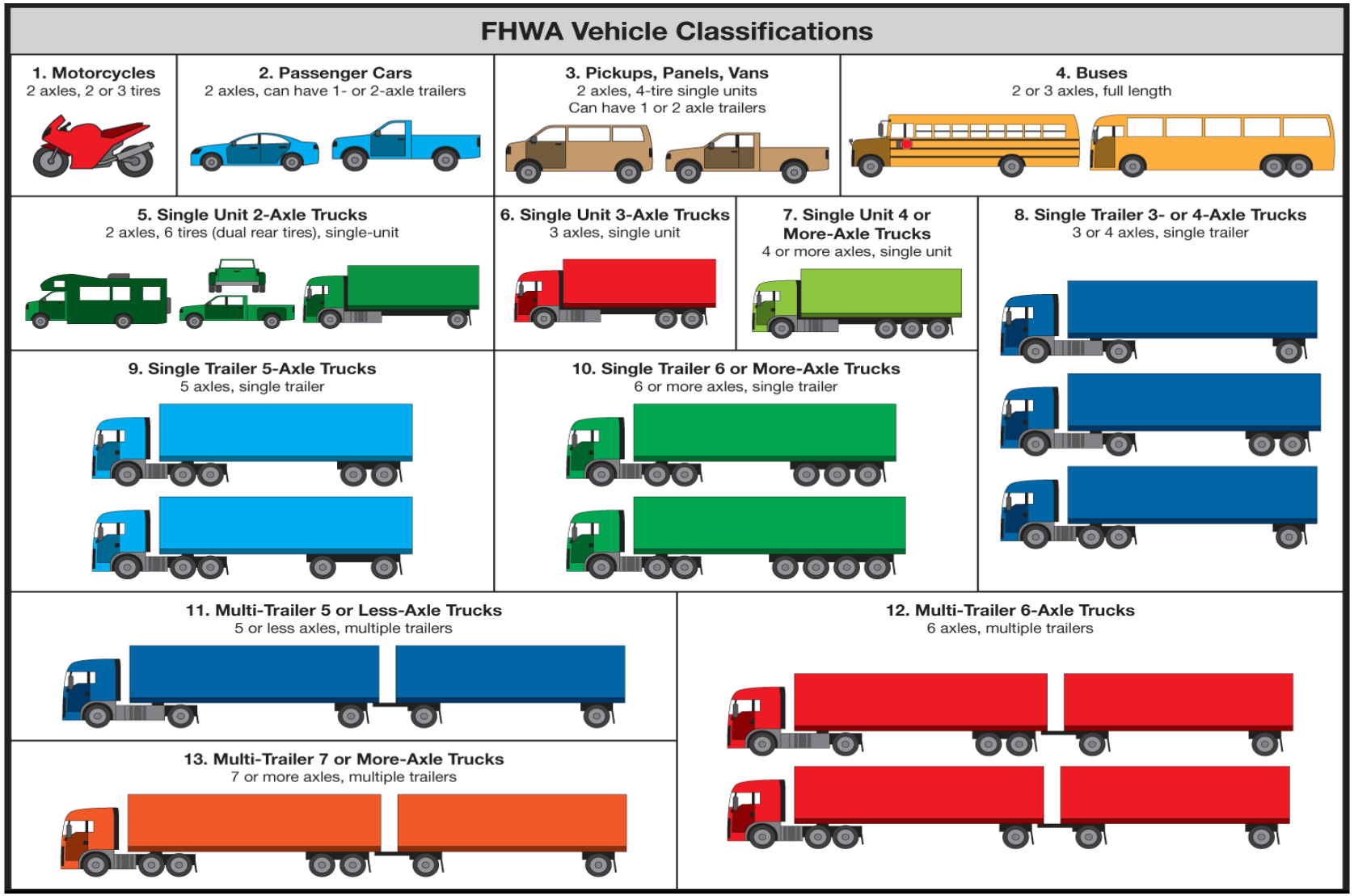
Types of DUC

Name	Description
Road Toll	A fixed fee for using a specific road at a specific time
Congestion Pricing (Time-variable)	Fixed or variable fee for road use at a specific time
Cordon Fees	Fees charged for driving in particular area of highway network, i.e., a CBD
HOT Lanes	HOV lanes that allow a limited number of low-occupancy vehicles for a fee
Distance or Weight-based Fees	Fee based on number of miles driven, or number of miles a certain weight is hauled

Road Pricing to Meet Highway Needs

- Accounting of Costs and Revenues
- Inventory of Road Use
- Allocate Costs and Revenues to User Groups
- Estimate Cost Responsibility and Revenue Contribution for Each User Group
  - Target: Revenue/Cost → 1.0 for Each User Group

Highway User Groups
(FHWA Vehicle Classes)



Federal Highway Administration (FHWA) 13-category vehicle classification. Reprinted with permission from Randall (2012).

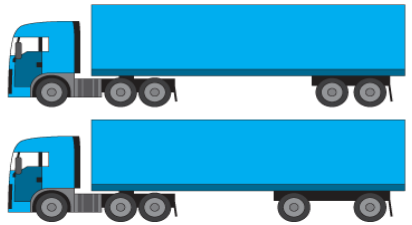
Costs Occasioned by Road User/Vehicle Class

From Class 1 to Class 13:

- Increasing **physical degradation** of pavement and bridges
  - related to vehicle weight and axle configuration.
- Increasing **operational impairment** of traffic flow in terms of safety and mobility
  - affected by vehicle size.

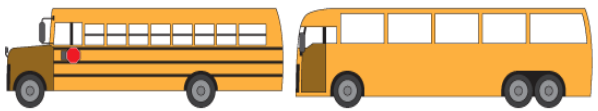
Highway System Use by User/Vehicle Class

1%



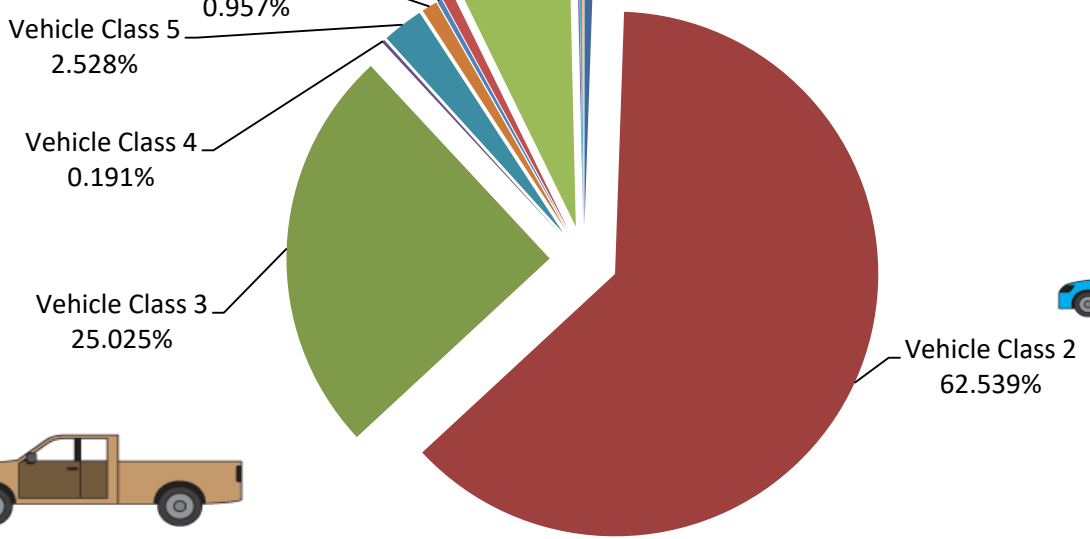
6.8%

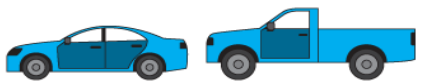
2.5%



0.2%

25%





63%

Vehicle-miles travelled (VMT) distributions by vehicle class in a typical state (Klatko et al. 2015).

Allocation of Pavement Costs

- For new construction, minimum base facility (VMT) vs. additional layers to heavier loads (ESAL-miles).
- For maintenance and rehabilitation, load (ESAL) and environment (VMT).

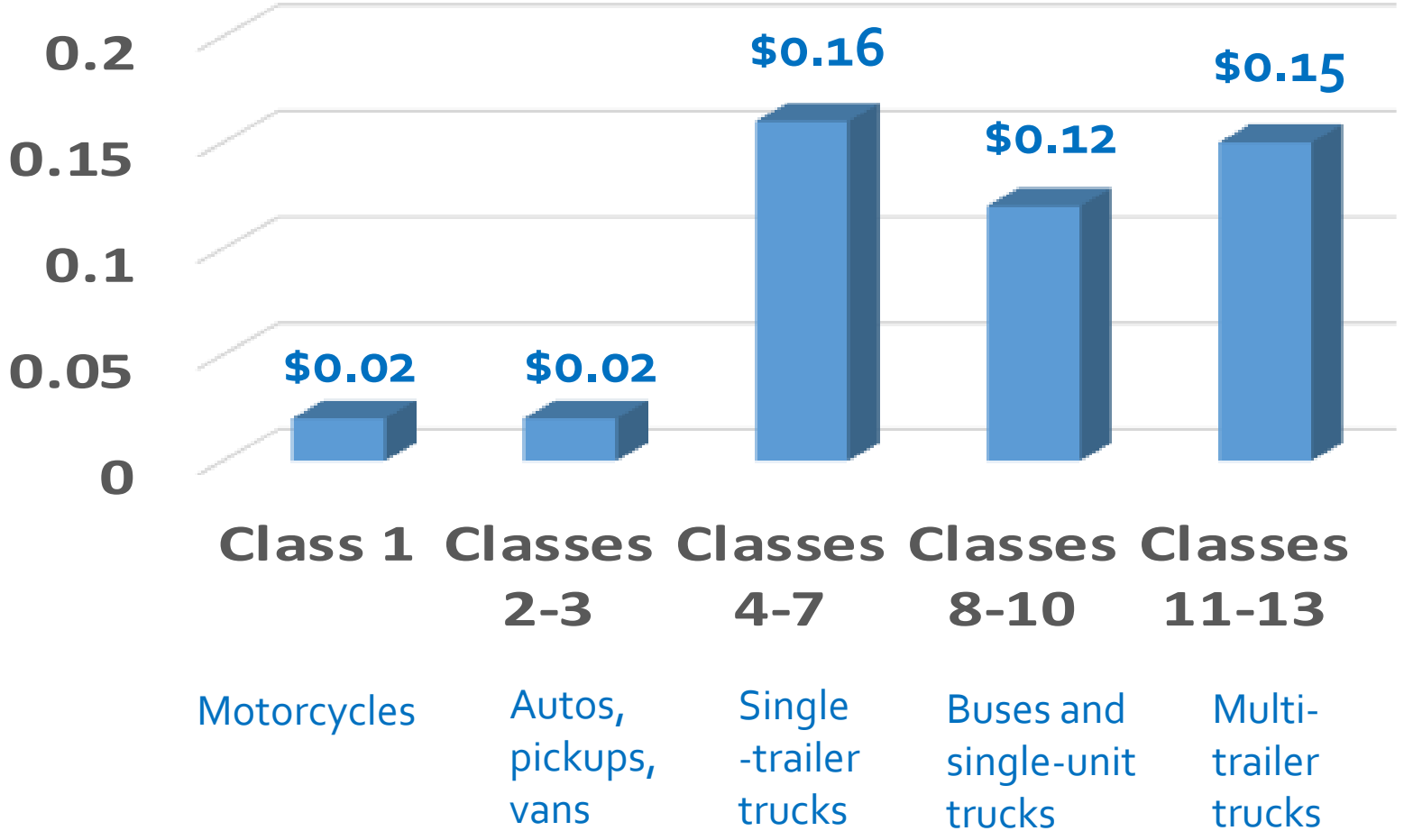
Allocation of Bridge Costs

- Costs allocated proportionally by vehicle class (stress levels): AASHTO design vehicles.
- Statistical correlation of critical stress levels caused by AASHTO design vehicles and FHWA operating vehicles.

Allocation of Common Cost

- VMT

Cost Responsibilities by Vehicle Class in Indiana



VMT=vehicle-miles travelled.
Based on data from Volovski et al. (2016)

Comparison

Direct User Charging to Self-finance Highway Infrastructure

- Funding needs by work category
- Administrative costs
- Costs for implementation of DUC
- Need vs. expenditure
- Periodic updates in cost allocation

Technologies, Costs and Benefits of DUC

Technologies for Road Use Monitoring & Fee Collection

- Automated Number Plate Recognition (ANPR)
- Dedicated Short Range Communications (DSRC)
- Satellite Systems
- Cellular Networks
- In-Vehicle Equipment

Technologies: ANPR

- Roadside infrastructure and digital cameras used with optical character recognition (OCR) software
  - Purpose: to record and process images of vehicles and their license plates.

Technologies: DSRC

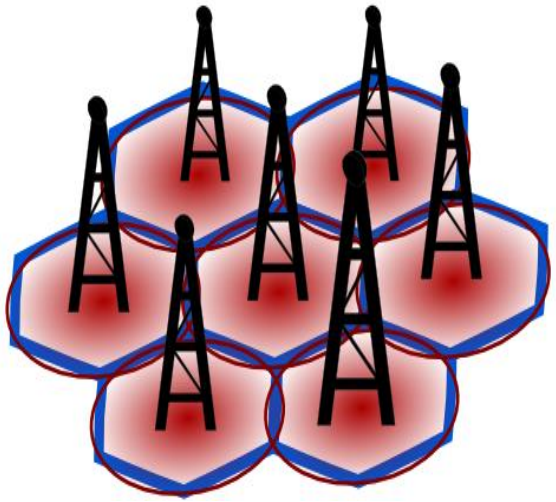
- A means of Automated Vehicle Identification (AVI), an example of "tag & beacon" recognition systems.
- As vehicle passes beneath/near overhead gantry, antennas mounted on gantries communicate with vehicle-mounted tags or transponders.

Technologies: Satellite Systems

- Satellite-based locationing systems, e.g., Global Positioning System (GPS).
- Does not require roadside infrastructure.

Technologies: Cellular Networks

- Advantages:
  - increased communication capacity
  - reduced power use
  - larger coverage area,
  - reduced interference from other signals.



- Does not require roadside infrastructure.

DUC Payment Procedures

- Use of smartphones
- In-vehicle vs. out-of-vehicle
- Electronic payment
- Periodic reporting

Agency Costs

- Infrastructure and Equipment Capital Costs
- Operation and Administration
- Upgrade and Maintenance
- Oregon DOT Estimates:
  - 10% of revenue ($4 million) for 100,000 use
  - 5% of revenue ($2 million) for 1 million use

Collection Costs

- Estimated collection costs as a fraction of toll revenues are:
  - 21% in Singapore
  - 22% for the Stockholm Trial, and
  - 50–60% for London

User Costs

- OBU: $50-$80 per user
- Initial intangible costs
- Mileage fee (passenger vehicles)
  - Oregon (ODOT, 2014)
    - 1.56 cents/mile
  - Minnesota (Baker, 2014)
    - 1 cent/mile (off-peak)
    - 3 cents/mile (peak)

Benefits of DUC

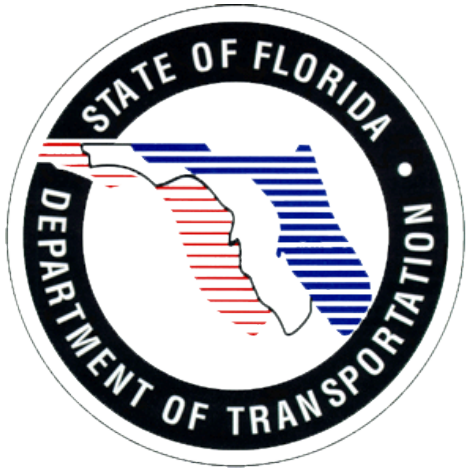
- **Primary benefit:** a stable pricing mechanism
- **Secondary effects:**
  - travel reduction
  - lowering road and parking facility costs,
  - increasing road safety
  - protecting the environment
  - encouraging more efficient land use, and
  - improving community livability.

Requirements For Road User

- Easy to understand.
- Convenience.
- Availability of alternative modes or routes.
- Multiple payment options.
- Transparency – charges must be known before trip is undertaken.
- User privacy must be assured.

Requirements For Highway Agency

- Minimal traffic impacts
- Efficiency and equity
- Effectiveness
- Flexibility
- Scalability
- Reliability
- Security and enforceability
- Cost effectiveness
- Implementability



Transport for London

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Requirements For General Public

- Economic efficiency
  - Should reflect positive net benefits
- Political acceptability
- Environmental compatibility
- Integration

Selected Instances of DUC: HOT Lanes

I-15 /San Diego, California (2009)

Singapore (1998)

Electronic Road Pricing Gantry at North Bridge Road, Singapore

Selected Pilots for Distance-based DMC

- Oregon (2004-2006)
- Puget Sound (2002-2008)
- Iowa (2005-2010)
- FHWA Grants to 12 DOTs (2016)

Threats to DUC Implementation

- Institutional
- Equity
- Financial
- Technology and Operations
- Public Acceptance
- Several attempts have been aborted due to public outery or political opposition. (Edinburgh/ Manchester/ New York/ Netherlands)

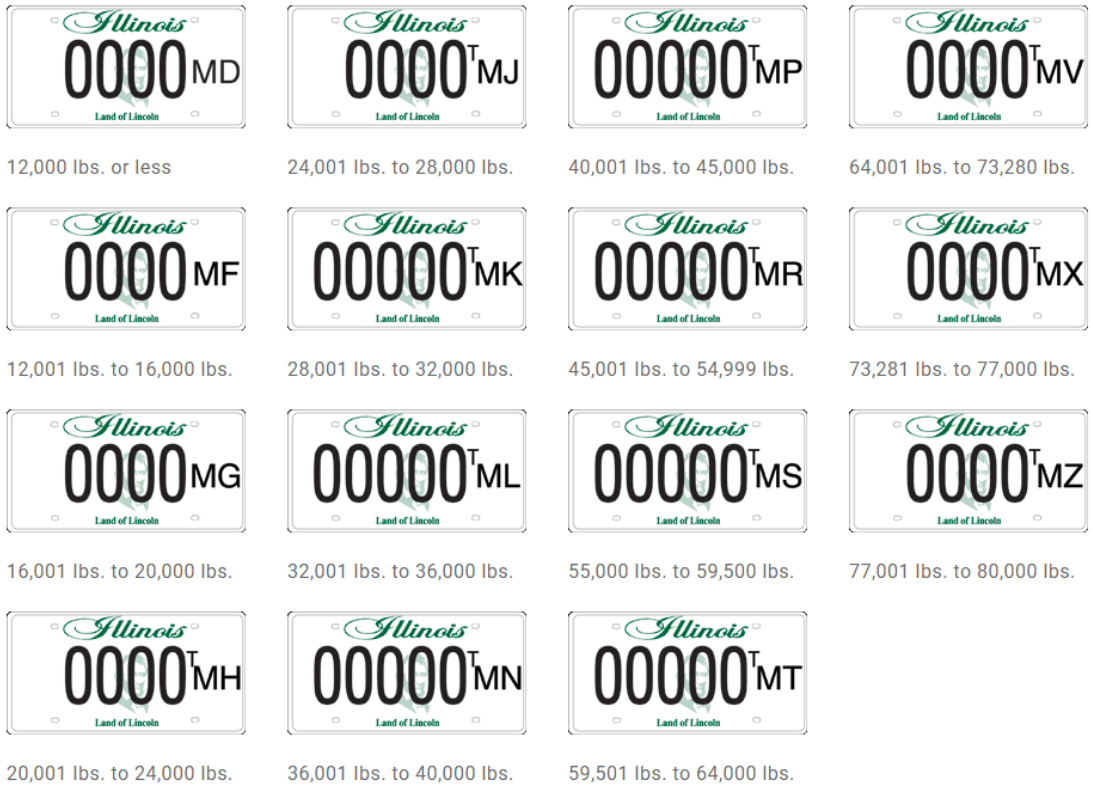
Estimated VMT Elasticity w.r.t VMT Fees

Vehicle Category	Elasticity

FHWA Grants

- Pilot basis in Oregon for the first time (2 projects)
  - 2007: Road User Fee Pilot Project
  - 2012: Road Usage Charge Pilot Project
- Implemented: 5,000 volunteer motorists in Oregon (started in July 01, 2015)
- For trucks in Illinois and Germany
- 12 cities in the U.S as part of a **National Evaluation of a Mileage-Based Road User Charge study** conducted by the University of Iowa

Mileage Trucks



Mileage Trailers

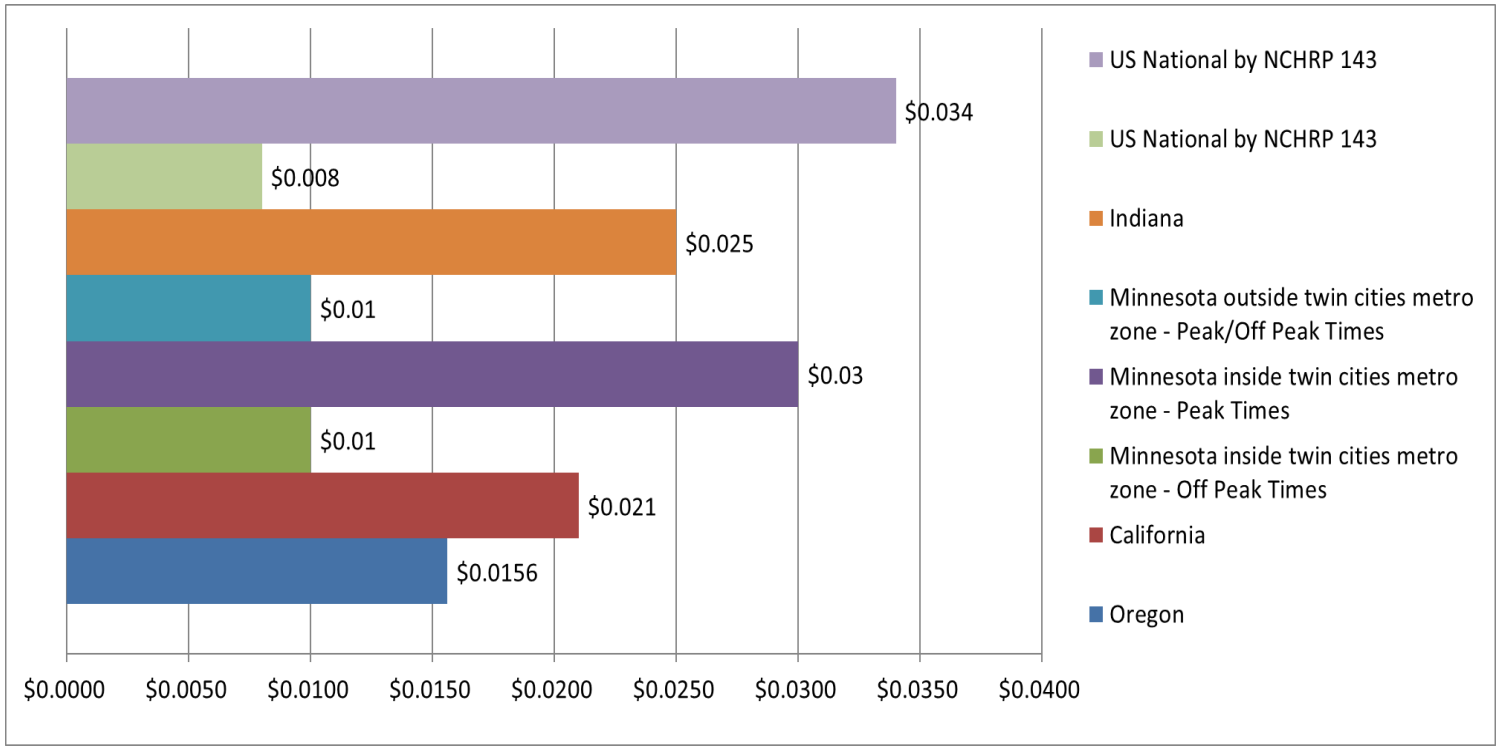
National Evaluation of a Mileage-Based Road User Charge study

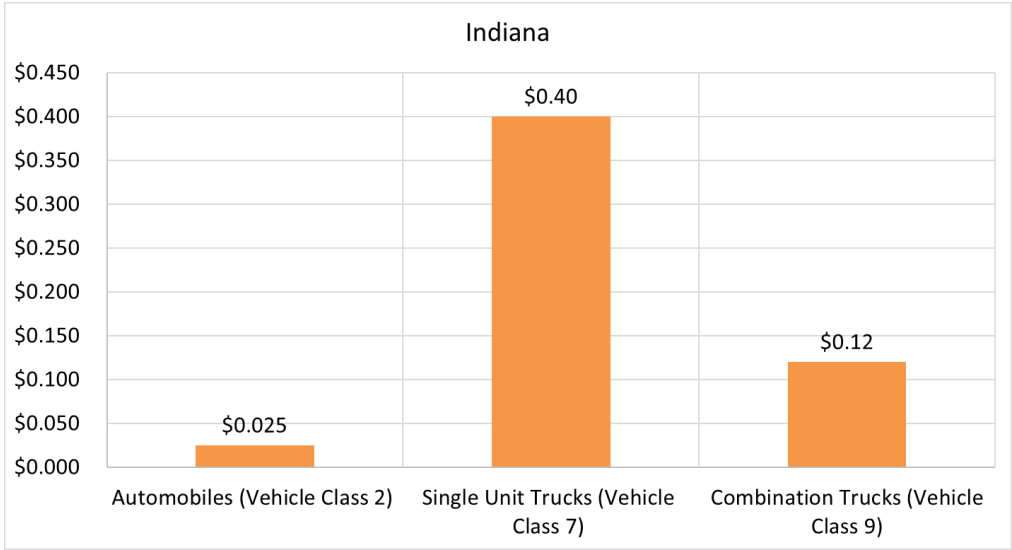
- Four-year study
  - investigating and testing a new approach to assessing and collecting road user charges
  - 2-year field study conducted by the University of Iowa Public Policy Center
  - 2,650 volunteers from 12 areas throughout the country participated in the study
- Study involves two major issues:
  - testing the appropriateness of the technology and
  - looking at user accessibility and acceptability.

National Evaluation of a Mileage-Based Road User Charge study

- System mileage charges totaled and apportioned to the federal, state, and local levels .
- Average participant drove approximately 9,000 mi during the study (the study totaled more than 21 million miles).
- 92.5 percent of all driven miles were successfully measured by both the GPS and the onboard diagnostics system
- 71 percent had a highly or somewhat positive view, and 17 percent held a highly or somewhat negative view.
- Participants consistently (but to varying degrees) preferred audit ability, which consisted of receiving detailed monthly invoices, over maximum privacy protection.

Distance based Charging





Research Issues

- / New York/ Netherlands)

Research Issues

- / Netherlands)

Conclusions

- DUC is the most appropriate and sustainable road pricing mechanism.
- Success depends on how well concerns of key stakeholders are resolved.
- Challenge is to keep up with rapidly changing technologies.
- Logical integration with autonomous transportation.