

# **Safety Implications of Lighting**

## **The WSDOT Journey**

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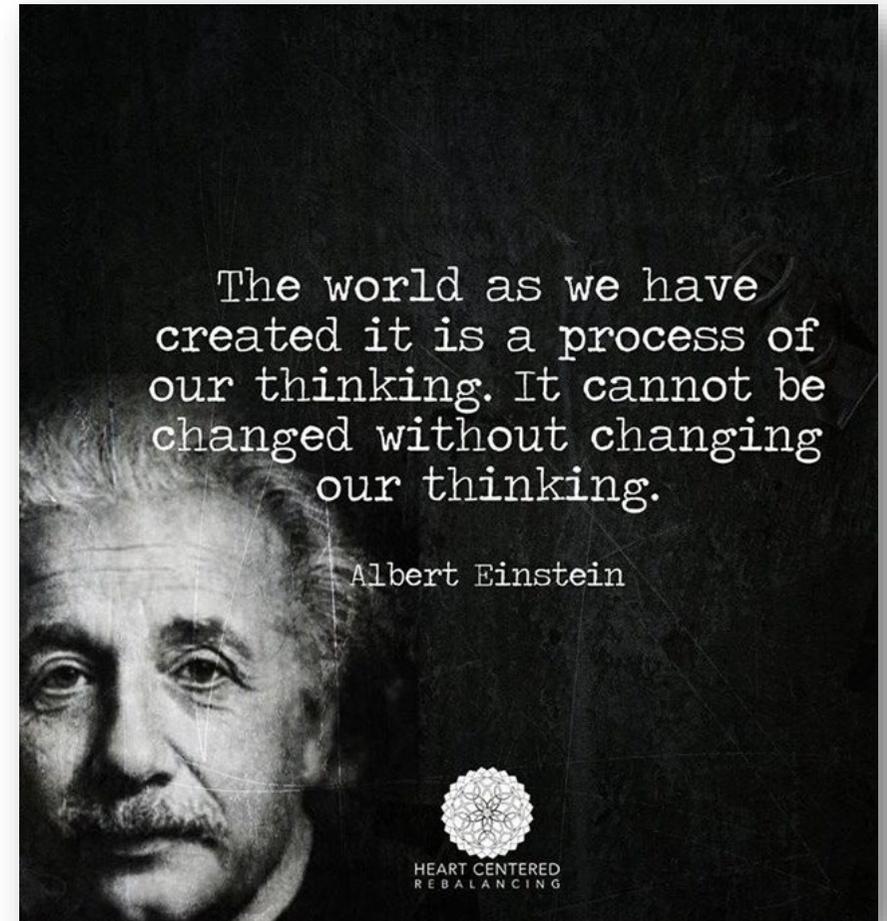
FHWA Evaluation of Low—Cost Safety Improvements Pooled Fund Study: 2019 Technical Advisory Committee Meeting

# Discussion

1. Why focus on lighting?
2. Lighting as an asset
3. A Ph.D. dissertation
4. Consider a performance-based approach with clear understanding of the tradeoffs
5. SHRP2 IAP Safety Illumination Study

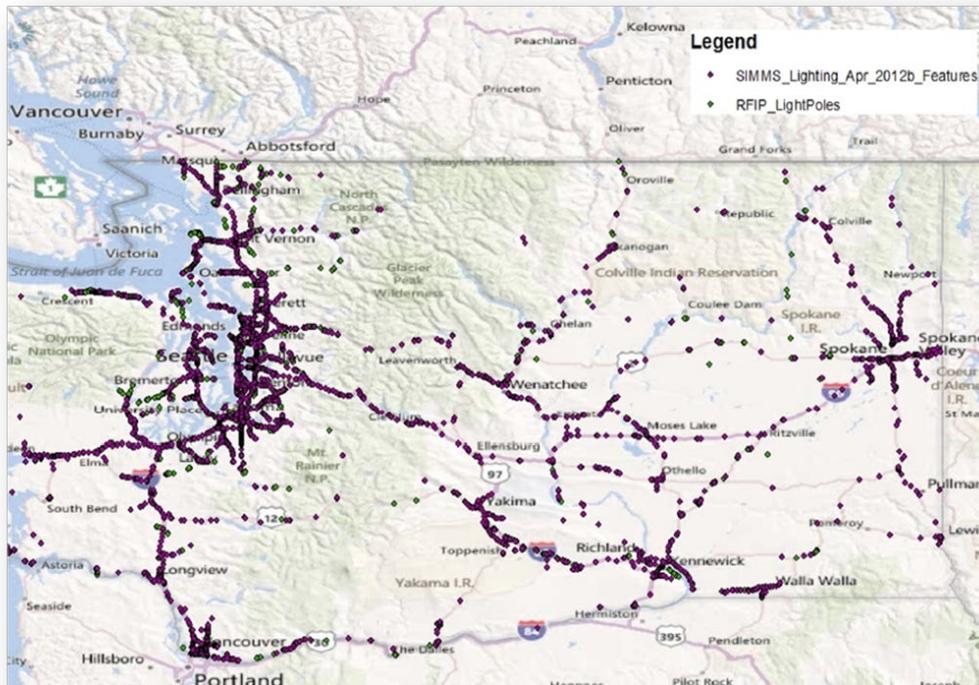
# The nature of DOT business is changing

- Asset investments: performance driven
- Recognition that asset investment choices impact:
  - Ability to invest in other locations that may have a higher need on a statewide basis
  - Future required investments in maintenance
- Requires us to challenge deeply held beliefs



# WSDOT Illumination Systems 2014

- Existing systems: 3,100 (400 installed since 2005)
- Roadway light fixtures: 60,000



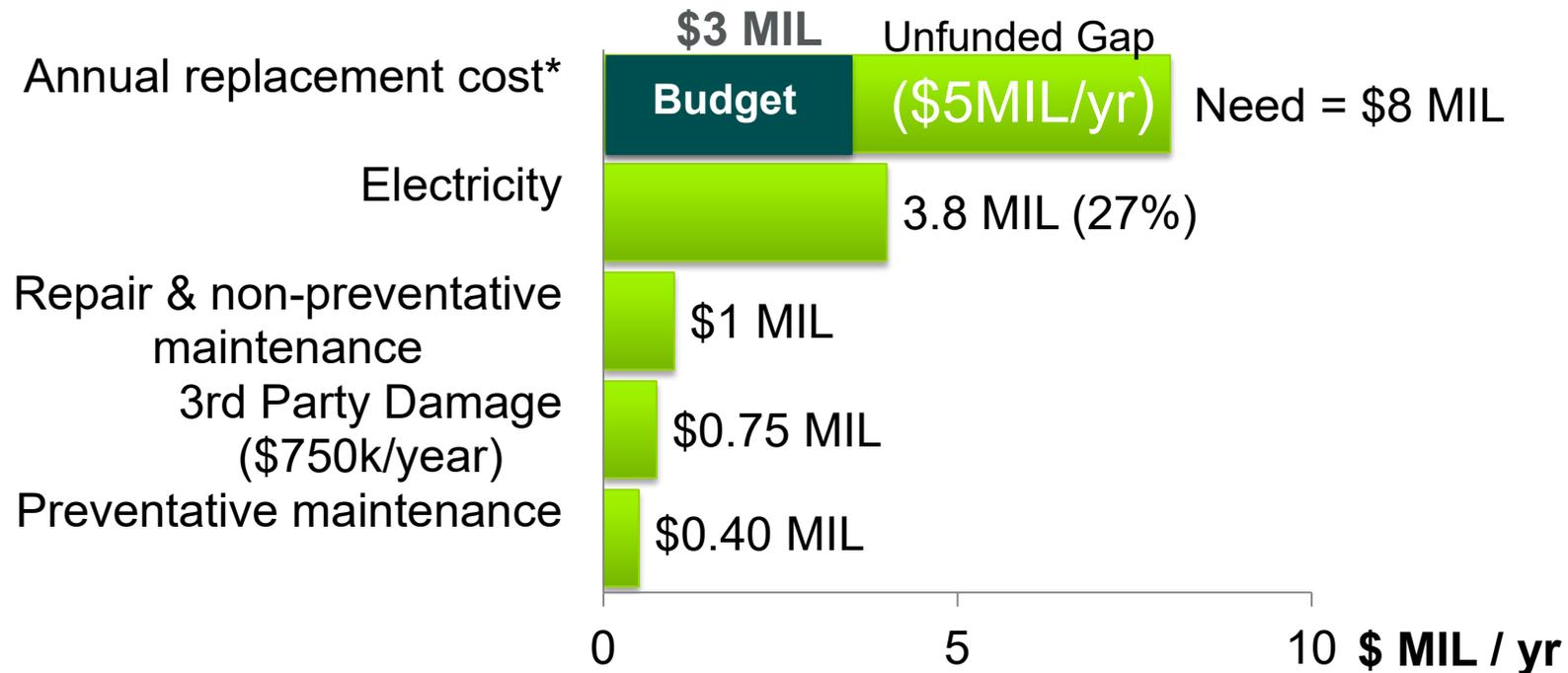
Source: SiMMS & Roadside Features Inventory Program (RFIP) database

• Cobra Heads	48%
• Sign Lights	2%
• Pole Top	3%
• Underdeck	14%
• Wall Mount	2%
• Shoe Box	4%
• High Mast	3%
• Tunnel	<u>24%</u>
	100%

# WSDOT Illumination Systems

**Annualized  
Life Cycle Cost**

**= \$13.95 MIL/yr**



# Lessons from a Ph.D. dissertation

*Model of Relationship Between Interstate Crash Occurrence and Geometrics: Exploratory Insights from Random Parameter Negative Binomial Approach -*

Venkataraman, N. S., G. F. Ulfarsson, V. N. Shankar, J. Oh, and M. Park, 2011.

Research Record: Journal of the Transportation Research Board, No. 2236, pp 41-48.

- Point lighting proportions and continuous lighting were found to be random parameters
  - In other words: lighting can have both positive and negative crash effects depending on segment characteristics
- Given this finding appropriate design policy modifications can be considered

# ... and Elvik's (1997) words of caution

- Our HSM Predictive Method CMFs for lighting is based on meta-analysis of studies:
  - Ratios that include daytime crashes
  - Limitations of older methodologies in terms of ability to incorporate contextual variables

# What a roadway light pole means

- Roadway light pole = fixed object
- Pole and lighting hardware = asset
- Maintenance cleaning lenses every 2 to 4 years: nature of the work
- Affects on plant and animal life
- Energy consumption

Why are we installing roadway lighting?

If we're doing it for safety performance, it should provide that performance right? (note: discussion is not about security related lighting)

**Once there were light poles...**

# 2 INJURED IN KINGS HIGHWAY CRASH

11:03 46°



#NBC4NY

At least two people were critically hurt when their car smashed into a light pole in Brooklyn so forcefully it was barely recognizable as a vehicle, officials say. The accident shutdown Kings Highway for several hours in East Flatbush. Tracie Strahan reports. (Published Monday, March 11, 2019)



## A fixed object in a crash

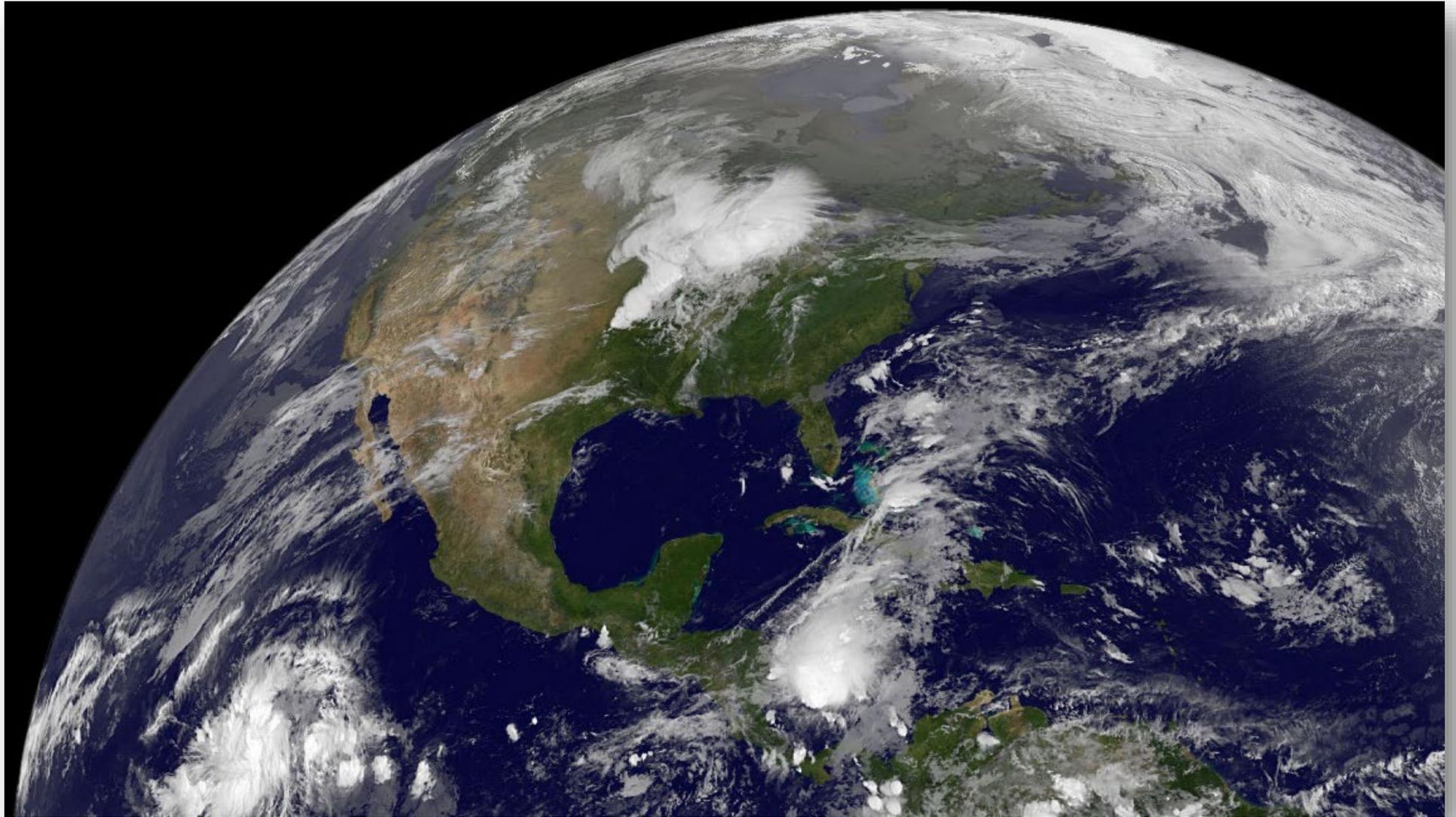
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# Affects plants and animals



<https://www.led-professional.com/resources-1/articles/botanical-light-pollution-red-is-the-new-blue/screen-shot-2016-09-06-at-15-37-20.png/@images/b475486b-2ab0-4adc-8033-f80dbeaa40bc.png>

# Our carbon footprint



**30%** of WSDOT's annualized illumination system life cycle cost is for electricity (\$4MIL/yr)

[https://www.nasa.gov/images/content/358586main\\_Fulldisk-GOES\\_20090608\\_full.jpg](https://www.nasa.gov/images/content/358586main_Fulldisk-GOES_20090608_full.jpg)

# Night sky darkness

Effects on circadian  
rhythms



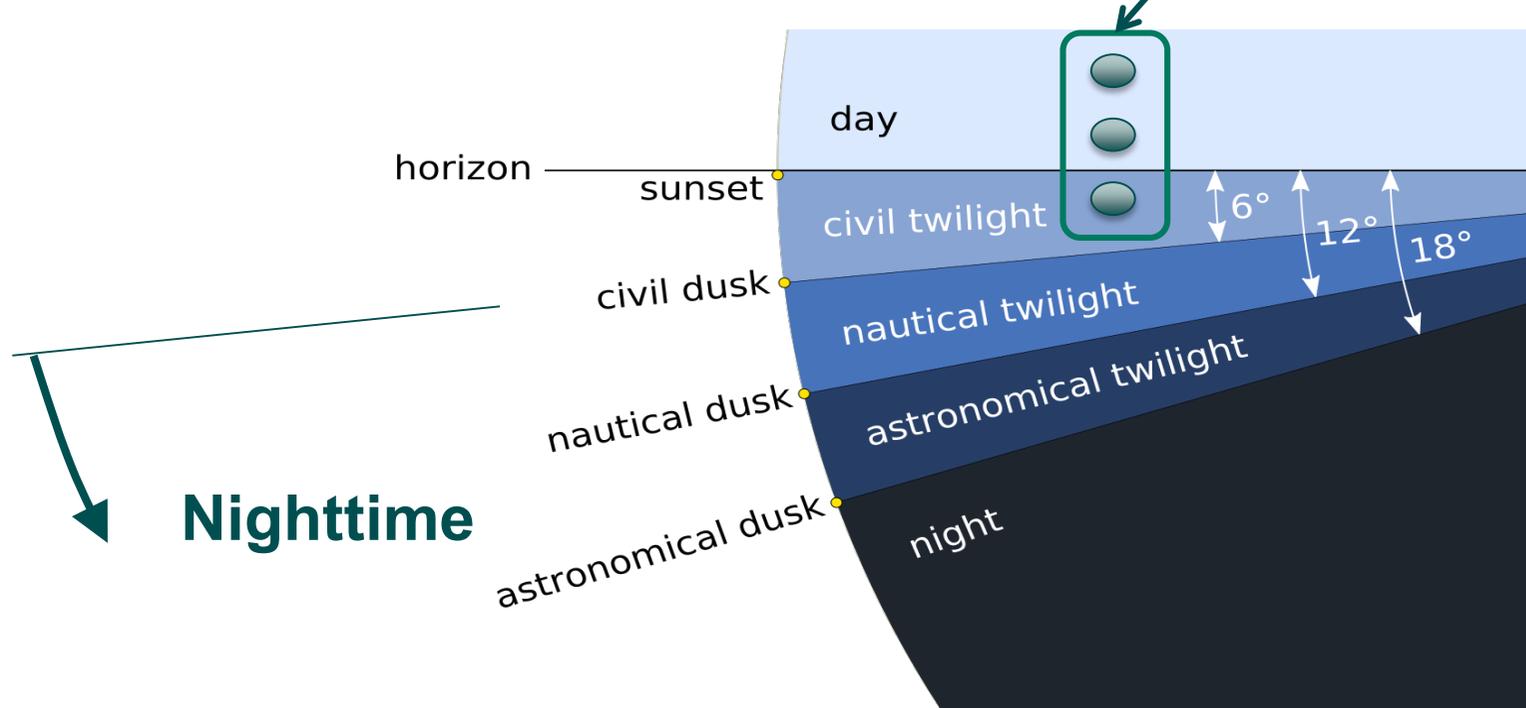
[https://www.nasa.gov/sites/default/files/images/712129main\\_8247975848\\_88635d38a1\\_o.jpg](https://www.nasa.gov/sites/default/files/images/712129main_8247975848_88635d38a1_o.jpg)

# **Continuous lighting on limited access freeways in WA**

# Definitions matter

- What is a nighttime crash?
- What is our source for this information?

Crashes during these times are not typically corrected with lighting  
(small target visibility unaffected by roadway lighting during daytime and civil twilight)



Nighttime definition (for lighting) excludes civil dusk and civil dawn

# Challenging our assumptions

## Using science: robust modeling approaches

- Evaluate impact of continuous roadway lighting on nighttime crashes
- Random parameter modeling of continuous lighting on freeways in WA, incorporates multiple variables and account for unobserved heterogeneity across segments
- Proven approach to consider multiple factors at the same time – get closer to comparing ‘apples to apples’, and allow for differences among the similar locations (other than those modeled), to be quantified
- 5 years of crash data – isolating nighttime crashes
- Linked data used in the modeling:

### Geometry, volumes and urban/rural character

- Traffic volume
- Number of lanes
- Shoulder widths (left and right)
- Horizontal curvature
- Presence of interchange
- Urban/ rural character

### Roadway lighting (proprietary dataset)

- Median roadway lighting proportion
- Right roadway lighting proportion
- Both-side roadway lighting proportion
- Point lighting proportion
- No roadway lighting proportion

# Findings & immediate implications

## Findings

Continuous lighting on freeways in WA State: *no measurable impact on nighttime crash performance*

## Immediate implications

- LED conversions: focus on only where lighting is needed (\$4MIL project incl. adaptive lighting) & removal of 500 poles (Phase 1), 10k poles (Phase 2)
- In practical solutions: A 2-mi segment under design: \$550k savings by eliminating unnecessary continuous lighting

## Are we the only team evaluating illumination?

No, others are finding similar anomalies to deeply held beliefs about lighting

Thou has a brain, therefore  
thou is biased –

## **Confirmation bias**



# **SHRP2 IAP Safety Illumination**

# Project Motivation

- WSDOT reviewed design practices across the country – design approaches vary greatly
- Evidence indicates that a “one size fits all approach to lighting design requirements unlikely to maximize benefits from illumination installations”
- The primary design question: “Where would lighting support safety performance and at what level?”
- Focus:
  - **Mainline** limited access freeway segments **at on and off ramp locations**
  - To a limited extent a small sample of intersections

# Project Overview

- Project objective
  - To study effects of lighting on nighttime safety performance
    - Freeway mainline at ramp locations
    - Intersections
  - Recommend lighting designs to target safety performance
- Research questions to address
  - Effects of roadway lighting on driver behavior as it relates to safety performance
  - Effects of roadway lighting on safety performance in different roadway settings
  - Lighting design practices based on safety performance
- Three-phase research (Phase I and II complete, III underway)

# Phase I & II

- Phase I: proof of concept with limited sample
- Phase II
  - Findings: found statistically significant correlations between lighting variables **but the effect sizes were negligible**
    - For example: acceleration change scale 0.001-0.01m/s<sup>2</sup> per unit increase → measuring precision of equipment, practical value, likelihood of findings being reproducible
    - How could this happen? Isn't statistical significance meaning that we can then say there is a relationship? *The p-value discussion.*

**“big data.. can make any finding look significant in the traditional statistical sense, but they may have an effect size that might not be critically meaningful”**

Chris Gennings from the Icahn School of Medicine at Mount Sinai (2018) – Informing Environmental Health Decisions Through Data Integration: Proceedings of a Workshop in Brief, p.1, National Academies of Sciences, Engineering, and Medicine, <http://nap.edu/25139>, Accessed June 2018.

**SHRP2 Naturalistic Driving Data = Big Data**

# Phase III

- Additional data requests & analysis:
  - extend crash analysis to CA locations & re-categorize existing WA and NC lighting conditions into smaller illuminance ranges
- Time Series Analysis
  - Time Series analysis scenarios:
    - Ramp type, including entrance ramp and exit ramp locations.
    - Ramp complexity, including complex ramp locations and non-complex ramp locations (speed differences between ramp and mainline, single or dual lane ramps, weaving lane presence)
    - Traffic type, including merging and diverging traffic.
    - Illuminance ranges, including 0-3lux, 3-6lux, 6-9lux, 9-12lux, 12 -15lux, and 15 and higher.
    - Driver age, including older drivers (65 and older) and younger drivers (younger than 65).
  - Explore both Weibull & multiple linear regression (reducing collinearity effects)



# We leave you with a challenge

Research on countermeasures, predictive methodologies, and other safety analysis tools will challenge us in ways we may not expect

- Will we allow for **truly data-driven and science-based** decisions OR
- Will we allow confirmation bias to impact what we believe and are willing to consider to be true?

# Our commitment

- WSDOT is committed to the safety of our traveling public - we see no choice but to move ahead with data-driven and science-based methods.
- The public expect us to spend money wisely – so if we determine that particular applications do not provide measurable safety performance benefits → such installations:
  - takes money away from *other higher priorities*
  - has significant impacts on the *environment* (plants, animals, night sky darkness, carbon footprint)
  - unnecessarily exposes our *maintenance staff* to traffic for routine maintenance and repair
  - represent *fixed objects within the public right of way*

**Questions?**