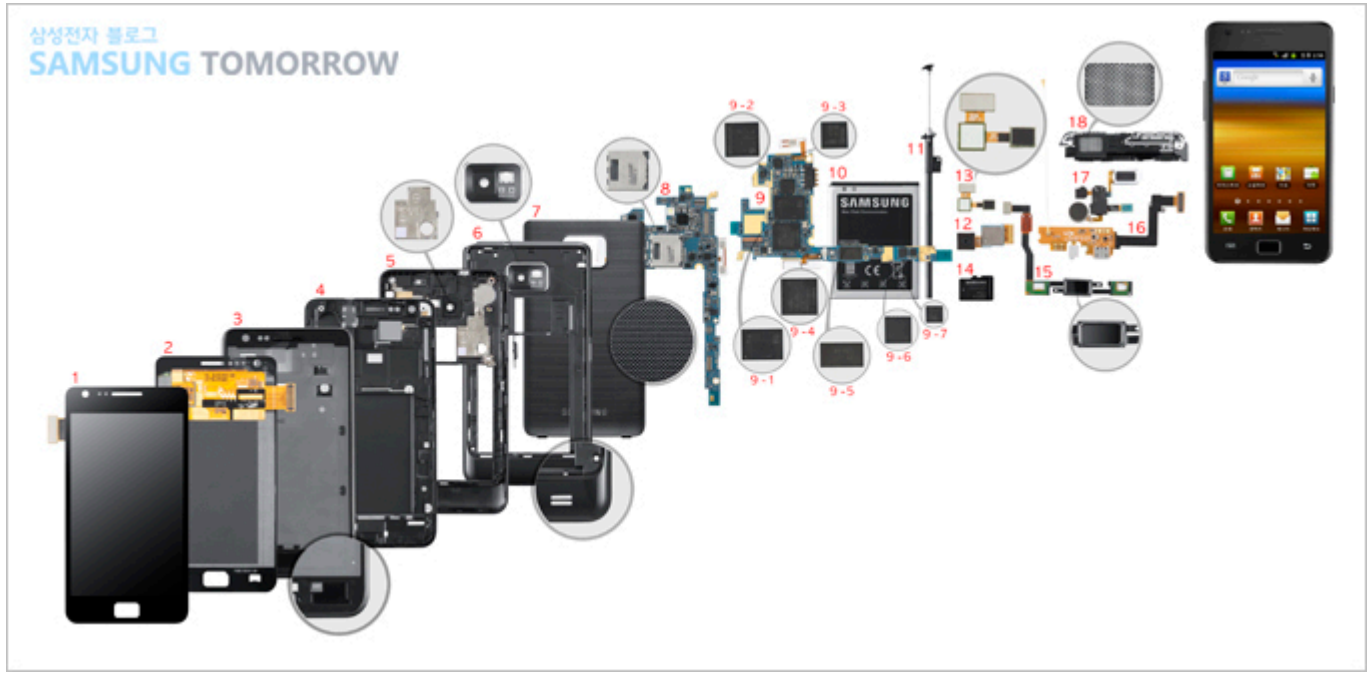
Big Data and Transportation Planning

CASE STUDIES, CONSIDERATIONS, AND CONSEQUENCES

DREW STIEHL
MURP '15
BOULDER COUNTY TRANSPORTATION

What’s inside your smartphone?



Turns out, a lot

Important things:

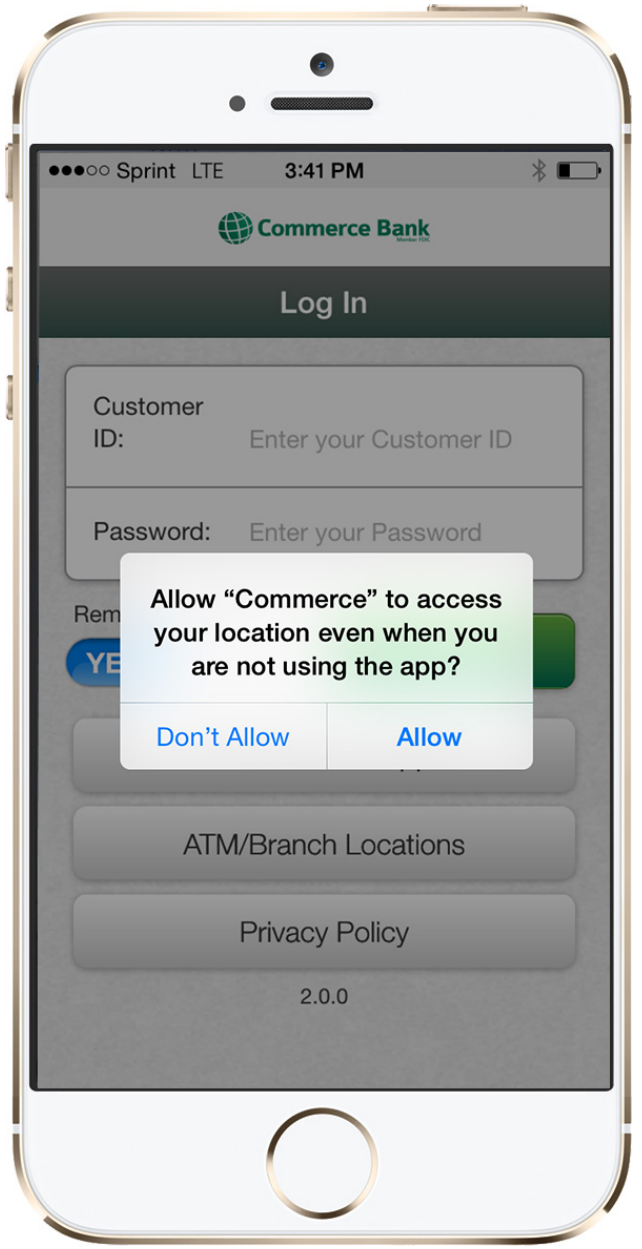
- A-GPS: derives your location using a clock, relativity, at least 3 satellites, wifi, and bluetooth
- Gyroscope: detects very precise changes in movement and direction
- Accelerometer: tracks changes in speed

What does your smartphone know about you?

Turns out, a lot

Important things:

- Your location (as long as it's on your person)
- Changes in speed, direction
- Frequent/favorite locations (e.g. work, home, school, favorite bars/restaurants)
- State of your health
- Which websites you like to go to

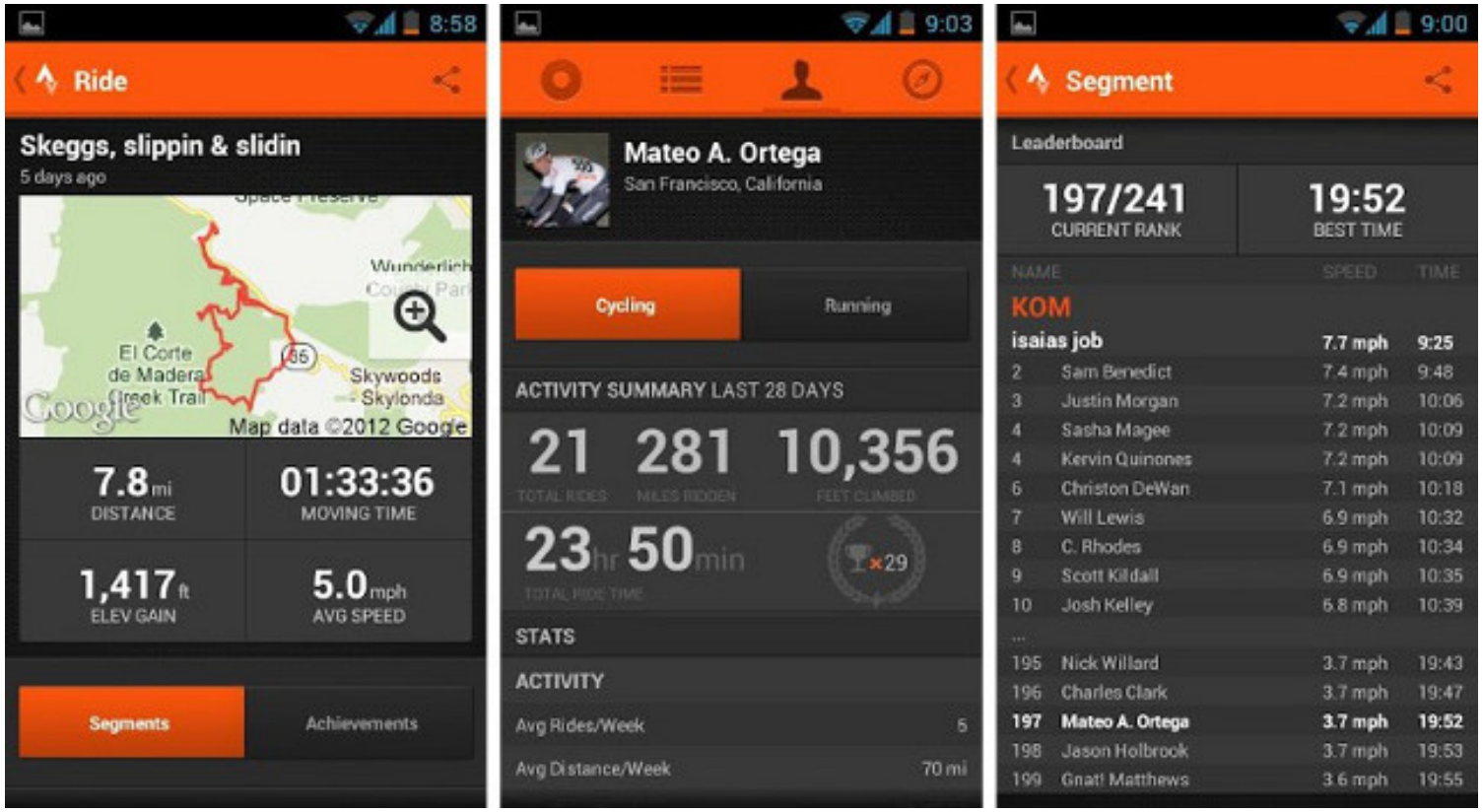


What can we use this data for?

Street Bump

Number and location of pot holes

Strava

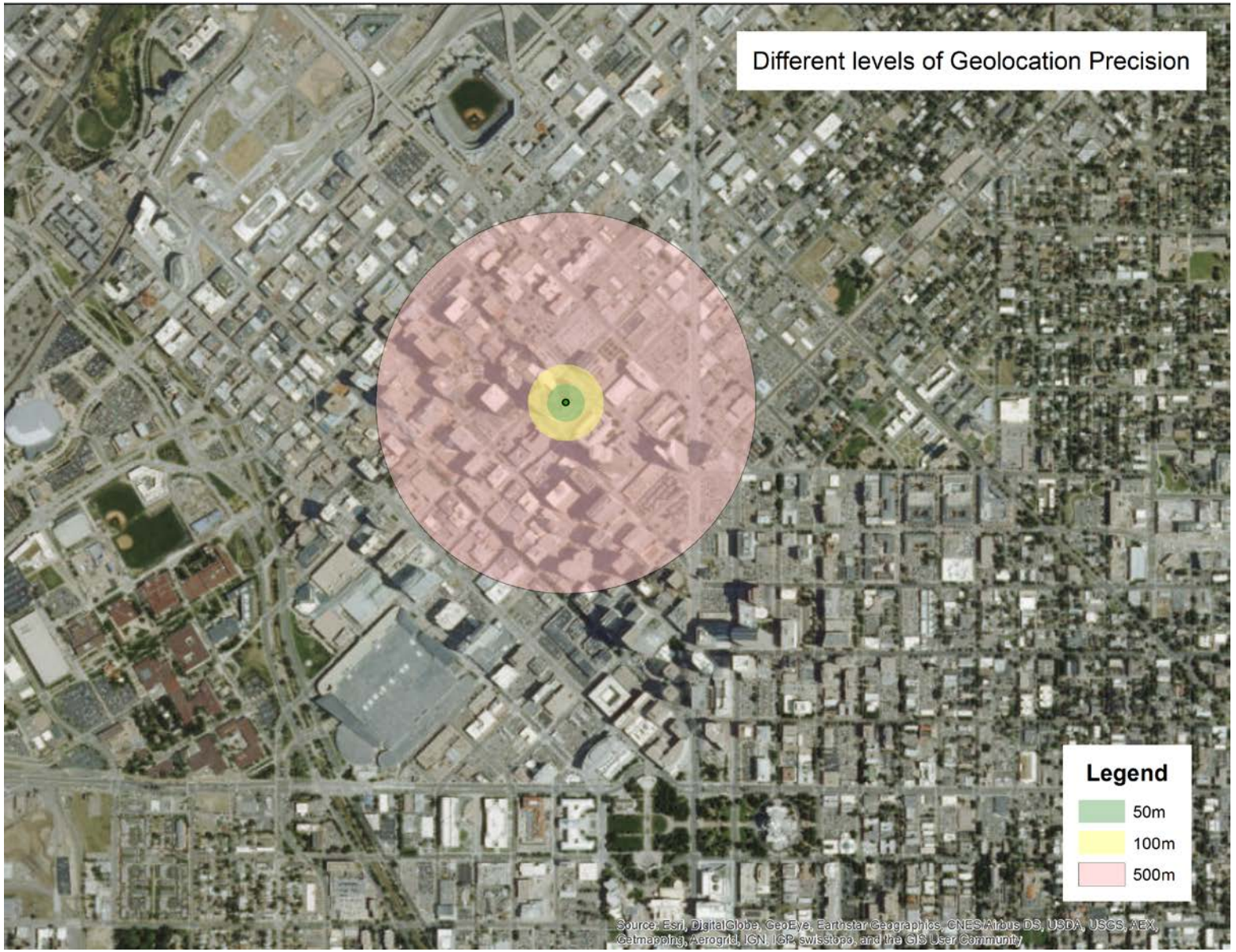


Distance, speed, and elevation gain of bicycle trips.
Race others, or yourself!

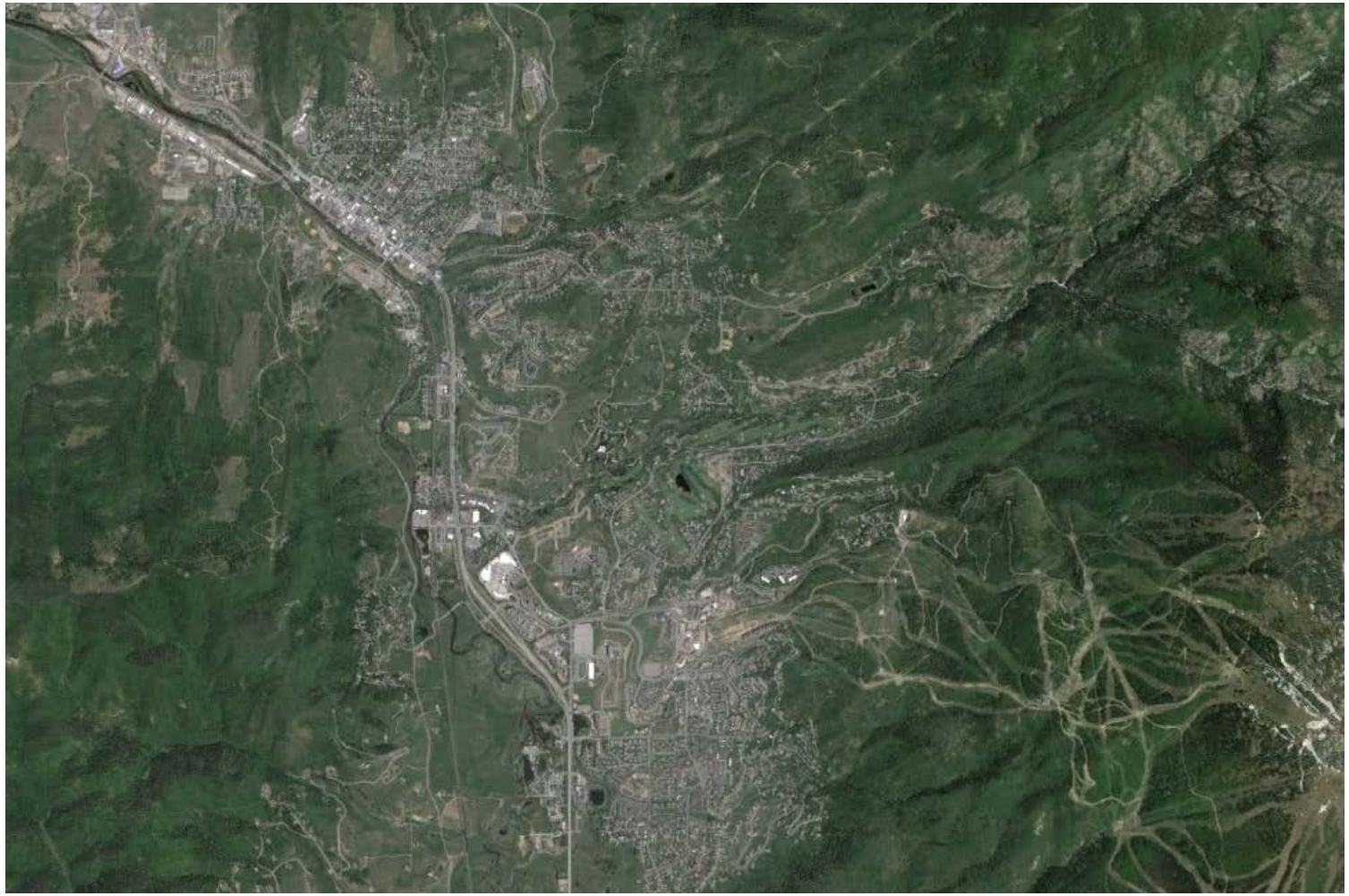
Data cost: roughly $0.80 per user

airsage

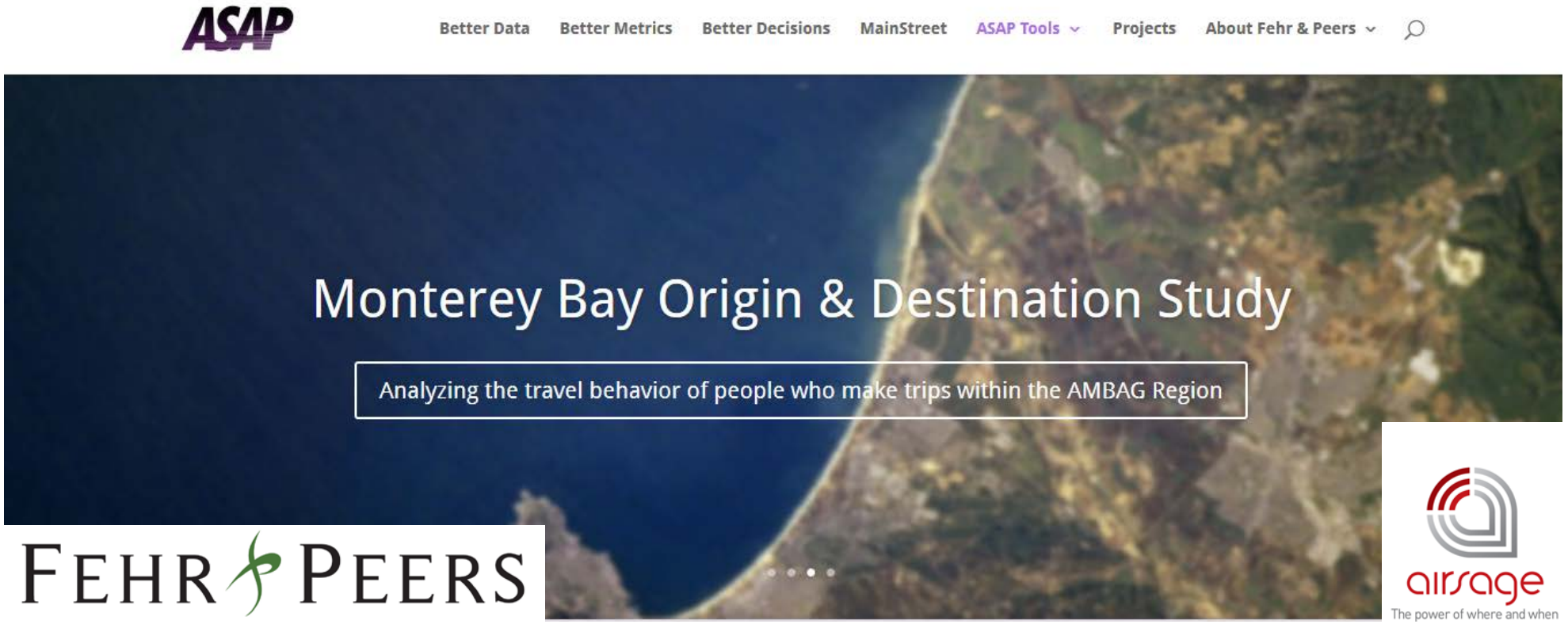
The power of where and when


Different levels of Geolocation Precision
Legend
50m
100m
500m
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Steamboat Springs, CO



Low(er) density, actual canyon effects → low accuracy



Apprx. 1.4 million origin-destination points generated
from cell phone movements within the region over a 30-day period

Contracts start ~$10k, but can be as low as $3500 depending on the sample size

CycleTracks by SFTA

Can’t control your data collection? Collect it yourself!

PROS vs CONS

- Terrabytes of data, obtained quickly
- Relatively cheap data, compared to other data collection techniques
- More complete understanding of travel patterns, "do-it-yourself" sampling
- More data = more power! …

- Can you store this much data? Can you do it securely? Both have associated costs
- Expensive "entry"; e.g. data storage, legal costs, public processes, etc.
- Dubious validity with selective sampling
- But correlation & causation become very muddy with too much data. Sampling is still necessary

THANK YOU

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MURP ‘15

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Electric Vehicles in Colorado: It's not your Dad's Olds

APA Colorado State Conference
October 2015


What are EVs

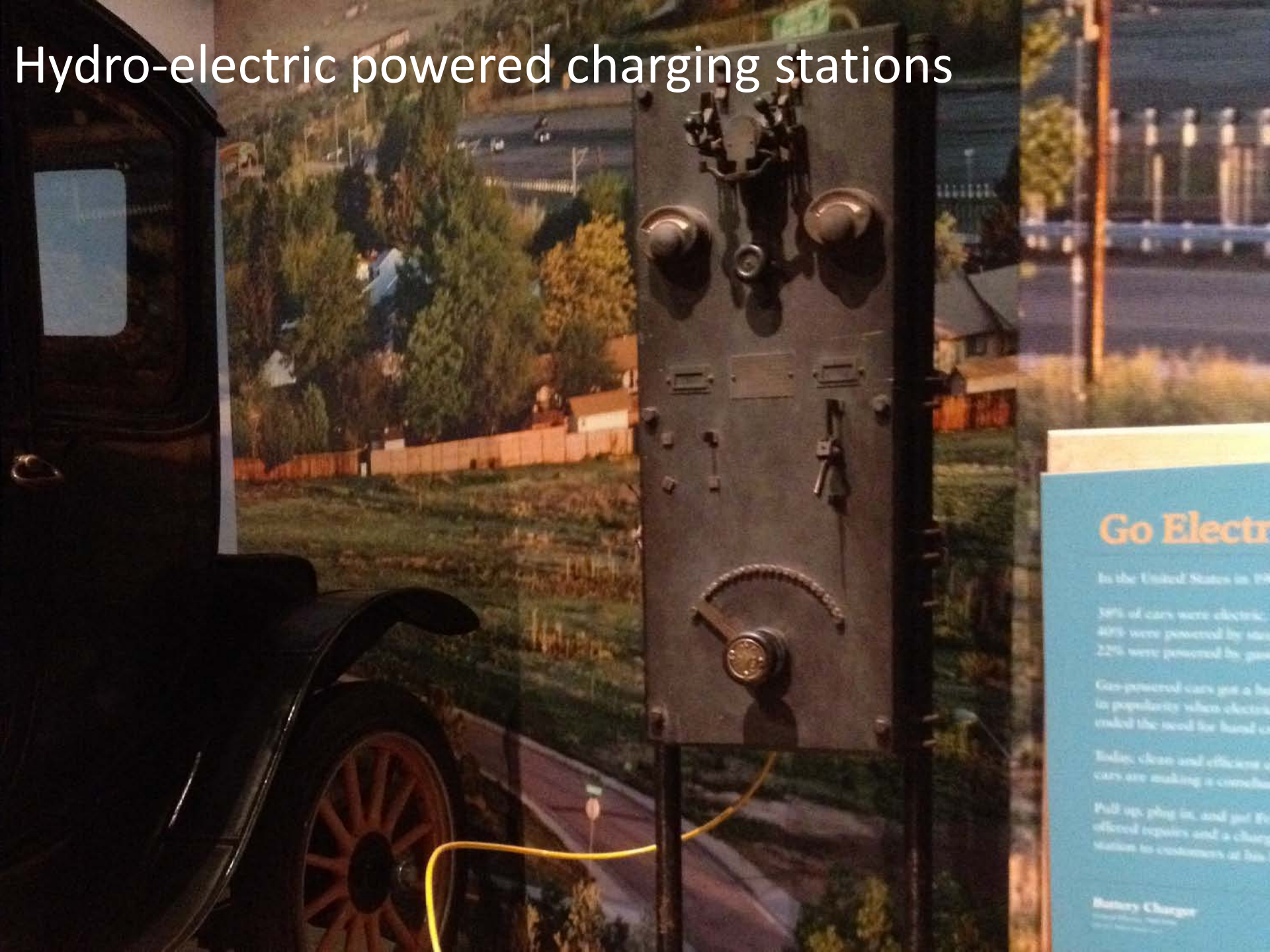
The Fritchle

One hundred miles on a single charge! Engineer Oliver Fritchle built about 500 electric cars in Denver between 1905 and 1920. Two Fritchles delivered goods for the Daniels & Fisher department store in the 1910s. Molly Brown drove one too.

Fritchle made his batteries and most of the car parts in his factory on the corner of Colfax and Clarkson in what's now the Fillmore Auditorium. He got national attention by drivi one of his cars from Nebraska to New York. He opened sal offices in Salt Lake City, Los Angeles, and New York City.


Owned by Denver’s most prominent famlies

Hydro-electric powered charging stations



FROM THE EDITORS OF THE WEEK.com

THE ELECTRIC CAR BOOMLET

THE FIRST ELECTRIC CAR DATES BACK TO 1891

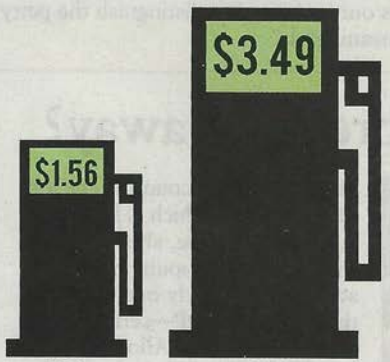
But it had only four horsepower, and topped out at 20 mph.

IT WASN'T UNTIL 2010

THAT THE FIRST MASS-PRODUCED, FULLY ELECTRIC CARS WERE MADE WIDELY AVAILABLE IN THE U.S.

The Nissan Leaf boasted 107 horsepower and a top speed of about 90 mph.

AS GAS PRICES ROSE...



...SO DID SALES OF U.S. PLUG-IN HYBRID AND ELECTRIC CARS

But this was still less than 1 percent of all U.S. vehicle sales.

THE U.S. AUTO MARKET NOW HAS AT LEAST 16 ELECTRIC MODELS, INCLUDING...

MITSUBISHII-MIEV
MSRP: $22,995
Range: 62 miles
Top speed: 80 mph

FOCUS ELECTRIC
MSRP: $35,170
Range: 76 miles
Top speed: 84 mph

TESLA S
MSRP: $69,900
Range: 208 miles
Top speed: 120 mph


GOLDEN
REAL ESTATE
ALL TIMES
$$$$$


CLEARANCE 13' 6"
$$$$


THE ALL-NEW
BMW i3.
BORN ELECTRIC.
$$

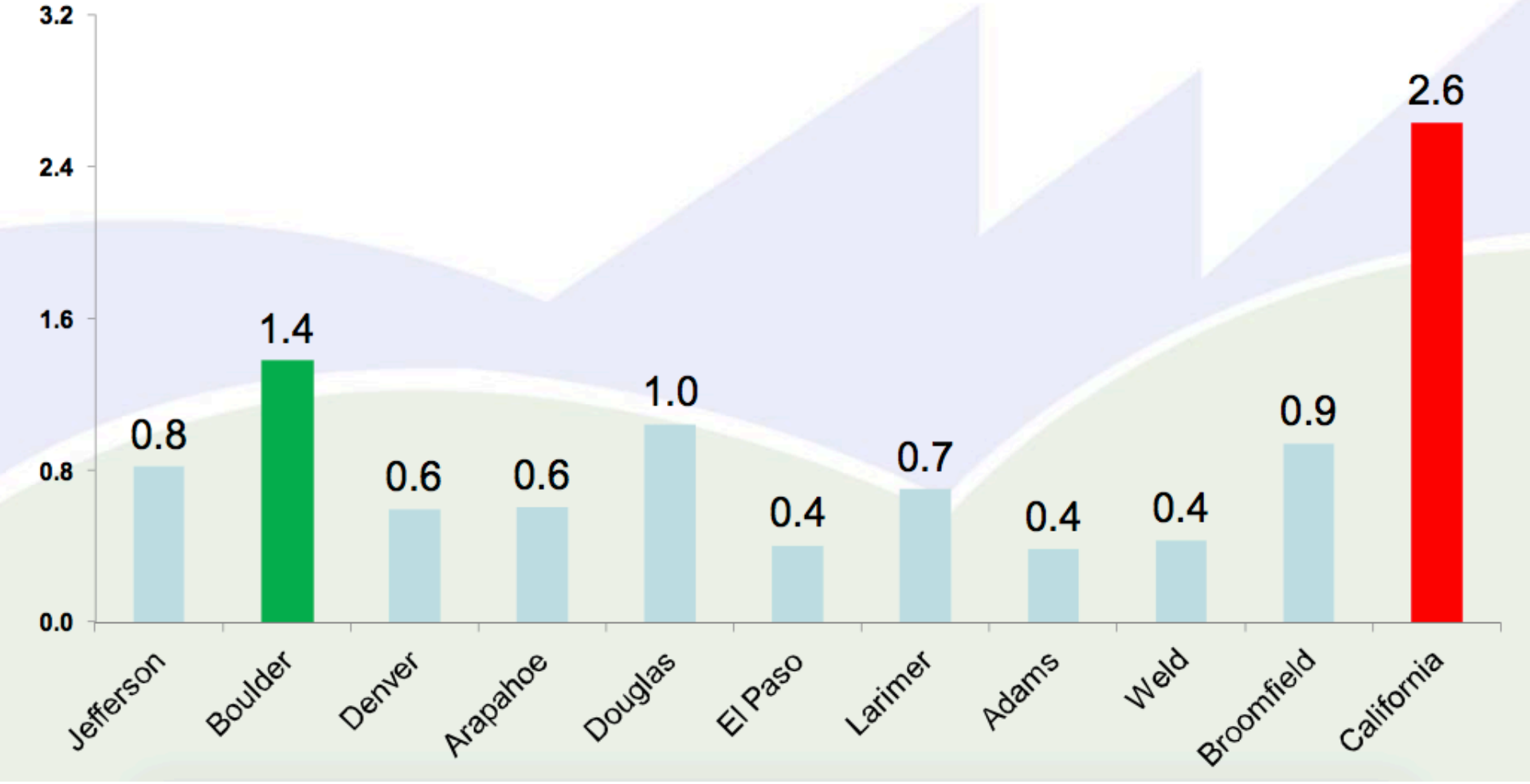

PEAK
GMC

-$


QUICK CHARGE FOR ALL
TYPES OF ELECTRIC VEHICLES
FIRST MOBILE CHARGING UNIT IN COLORADO!
ELECTRIC VEHICLE MOBILE CHARGING UNIT
Level II charge of
240V at 30 Amps
Ask Us About
Convenient Monthly Payment Options
Mobile Battery Service
Bicycle Roadside Assistance
Travel Deals
Insurance Discounts
This truck runs on
Compressed
Natural Gas
800-AAA-HELP
AAA
Colorado

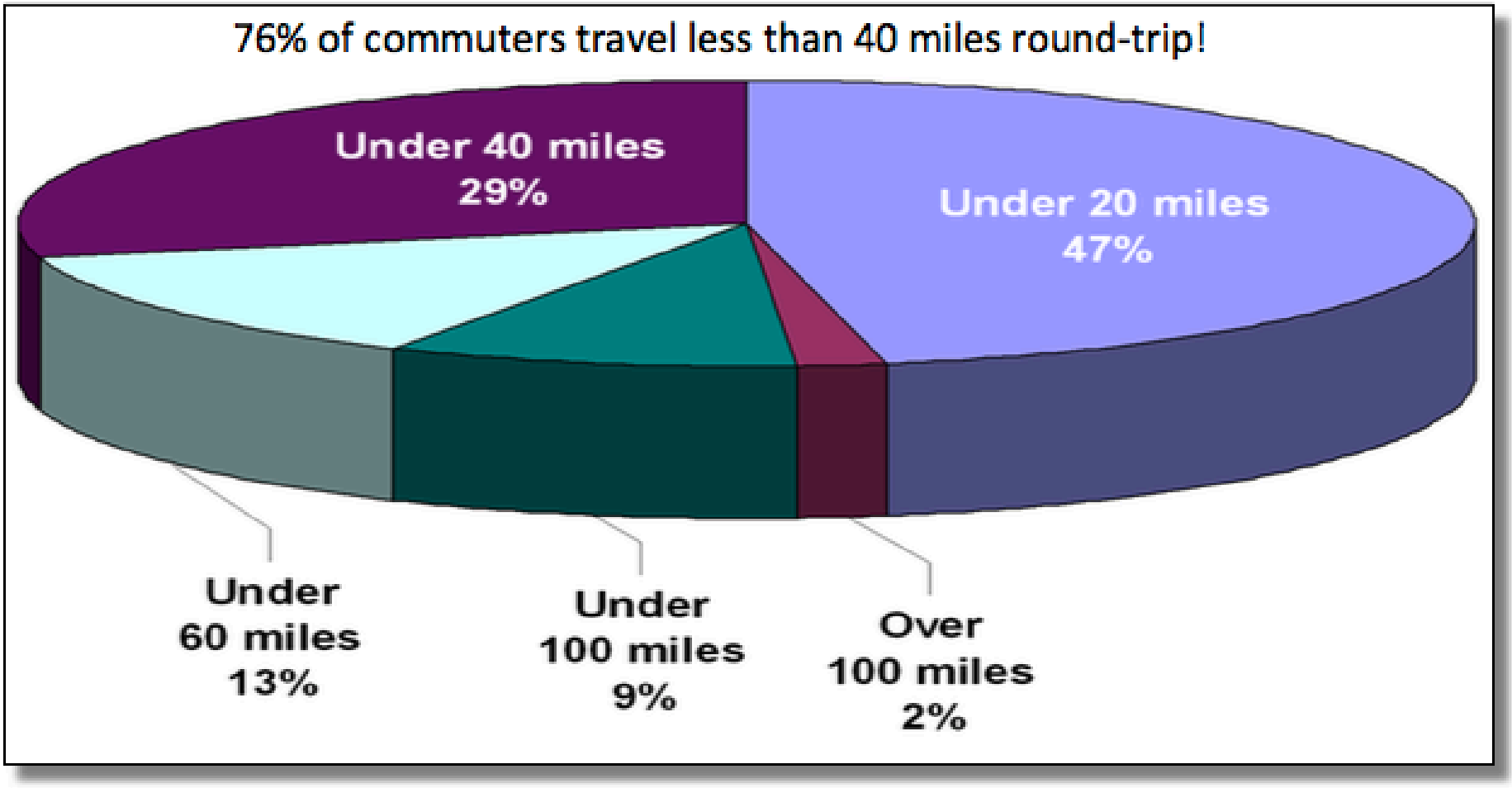

Aspen

Colorado EV ownership



*per 1,000 residents


How do you charge them?



2005 the US Dept. Of Commerce American Housing Survey for the United States


POWER
Driving Distance
3.1 miles
Elapsed Time
14:42
P
37778 miles
B
3.0 miles
1
82
miles
0


Parking
Only While Charging
STUDENT AND GROUP DROP OFF
ChargePoint


ELECTRIC
VEHICLE
PARKING
ONLY

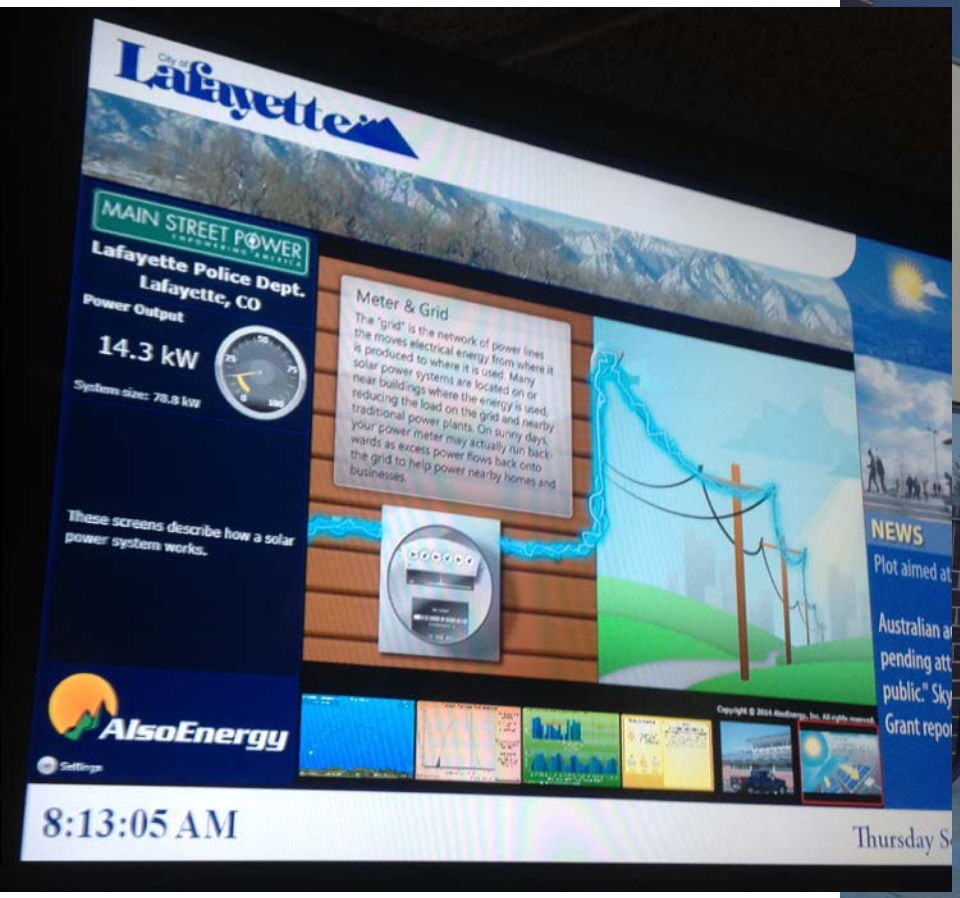
RESERVED PARKING

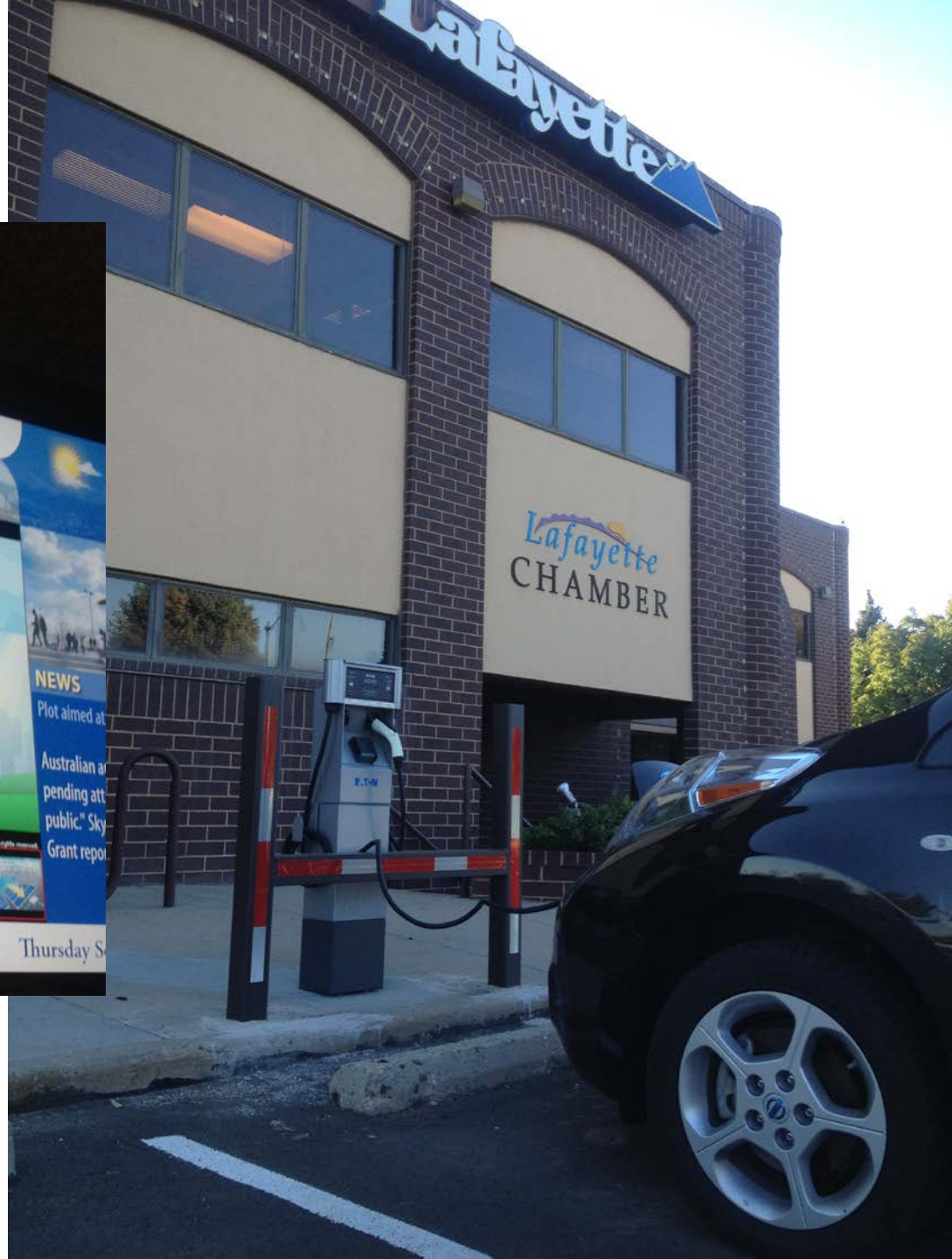
FREE EV CHARGING!

Electric Vehicle (EV) Charging at this station is currently FREE with paid admittance to the garage.

- Compliments of the ***City & County of Denver***


FED FROM NLG5-25,27,29
LEVEL 3
QUICK CHARGER
EV
LEVEL 3 DC QUICK CHARGING
at this station is currently FREE
with paid garage admittance.
- Compliments of The City & County of Denver
LEVEL 3 QUICK CHARGING
is for Short-Term parking guests with
CHAdeMO vehicle connectors
Charging Time Limits:
5 am to 5 pm = 2 hrs.
5 pm to 5 am = 4 hrs.
Please Be Courtious of Your Time at this Charger


City of Lafayette
MAIN STREET POWER
Lafayette Police Dept.
Lafayette, CO
Power Output
14.3 kW
System size: 78.8 kw
These screens describe how a solar power system works.
Meter & Grid
The "grid" is the network of power lines the moves electrical energy from where it is produced to where it is used. Many solar power systems are located on or near buildings where the energy is used, reducing the load on the grid and nearby traditional power plants. On sunny days, your power meter may actually run backwards as excess power flows back onto the grid to help power nearby homes and businesses.
AlsoEnergy
Settings
NEWS
8:13:05 AM


Lafayette
Lafayette
CHAMBER


LEAF
LEGACY


DENVER INTERNATIONAL AIRPORT
TOGETHER WE SOAR
DID YOU KNOW?
DIA is one of the greenest airports in the world!
AIR
WATER
In 2012, DIA collected 64% of the deicing fluid applied to aircraft – one of the highest rates in the country – keeping the fluid out of our local waterways by collecting it for treatment and recycling it for other uses.
ENERGY
WASTE
Do Not Enter
Ground Transportation
telefonix
L1
POWER Post
Station Available
Charging
Connected
Out Of Service
DENVER INTERNATIONAL AIRPORT
TOGETHER WE SOAR


L1
POWER Post
DENVER INTERNATIONAL
AIRPORT
TOGETHER WE SOAR
09 · WUX
NISSAN


#2:FAULT
BLEM (L2CORE)
ChargePoint
DISCOVER
zip
paypass
VISA
Need help? 1-888-758-4389 chargepoint.net


Solar Tree
Under Repair
Expected Repair
Timeframe is First
Week of January 2015
Thank you for your
patience.


Electric
re-charging
lane

Plug In Electric Vehicle Battery Sizes

Toyota Prius	4.4 kWh Battery	11 miles
C-max Energi	7.6 kWh Battery	21 miles
Chevy Volt	16 kWh Battery	38 miles
BMW i3	22 KWh Battery	80 miles
Ford Focus	23 kWh Battery	76 miles
Nissan Leaf	24 kWh Battery	75 miles
Tesla S	54 kWh Battery	208 miles

Charging Levels and Ranges

Level 1 = 5-9 miles of range per hour of charging
Level 2 = 10-15 miles of range per hour of charging
Level 3 = 60-70 miles of range per half hour of charging

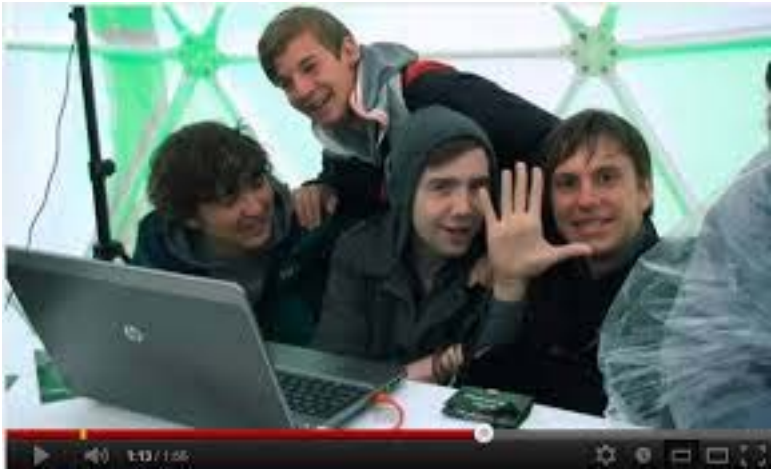
What do they mean for CO's economy?

TECH

Apple Targets Electric-Car Shipping Date for 2019

Car center of the universe changing

Detroit → Silicon Valley



In 2012, the average salary for a software developer was nearly

$90,000

and has risen every year since 2000

APPLICATION DEVELOPERS
average more than $92,000 per year

28% INCREASE IN JOBS BY 2020

TO MORE THAN **691,000** TOTAL JOBS

SYSTEMS DEVELOPERS
average more than $100,000 per year

32% INCREASE IN JOBS BY 2020

TO MORE THAN **500,000** TOTAL JOBS

2013 IS A GOOD TIME TO BE A SOFTWARE DEVELOPER.

This infographic is brought you by Coverity, makers of the industry's leading

SOFTWARE DEVELOPERS ARE **BUSY**

The boom in the amount of code has also produced a massive spike in the output of the average software developer.

6 MILLION DEVELOPERS WORLDWIDE

EACH DEVELOPER AVERAGES ROUGHLY
10 LINES OF CODE PER DAY
WHICH AMOUNTS TO
60 MILLION
TOTAL LINES OF CODE WRITTEN PER DAY
AND
300 MILLION
LINES OF CODE WRITTEN PER WEEK

WITH AN AVERAGE OF 251 WORKING DAYS PER YEAR, THAT'S MORE THAN
15 BILLION
LINES OF CODE WRITTEN PER YEAR

SOFTWARE DEVELOPERS ARE IN **BIG DEMAND**

What do they mean for GHG?

The Path to 2050

The combined efforts of local transportation strategies and federal fleet efficiency standard improvements can have a significant impact in reducing the emissions generated by the transportation sector.

Remaining Emissions from Mobility

73,000mt Transportation Master Plan Actions

120,000mt Federal Efficiency Standards

125,000mt Electric Vehicle & Other Innovations

\+

Total Projected Emissions Reduction = 318,000mt or 16%

How 'green' are electric cars?

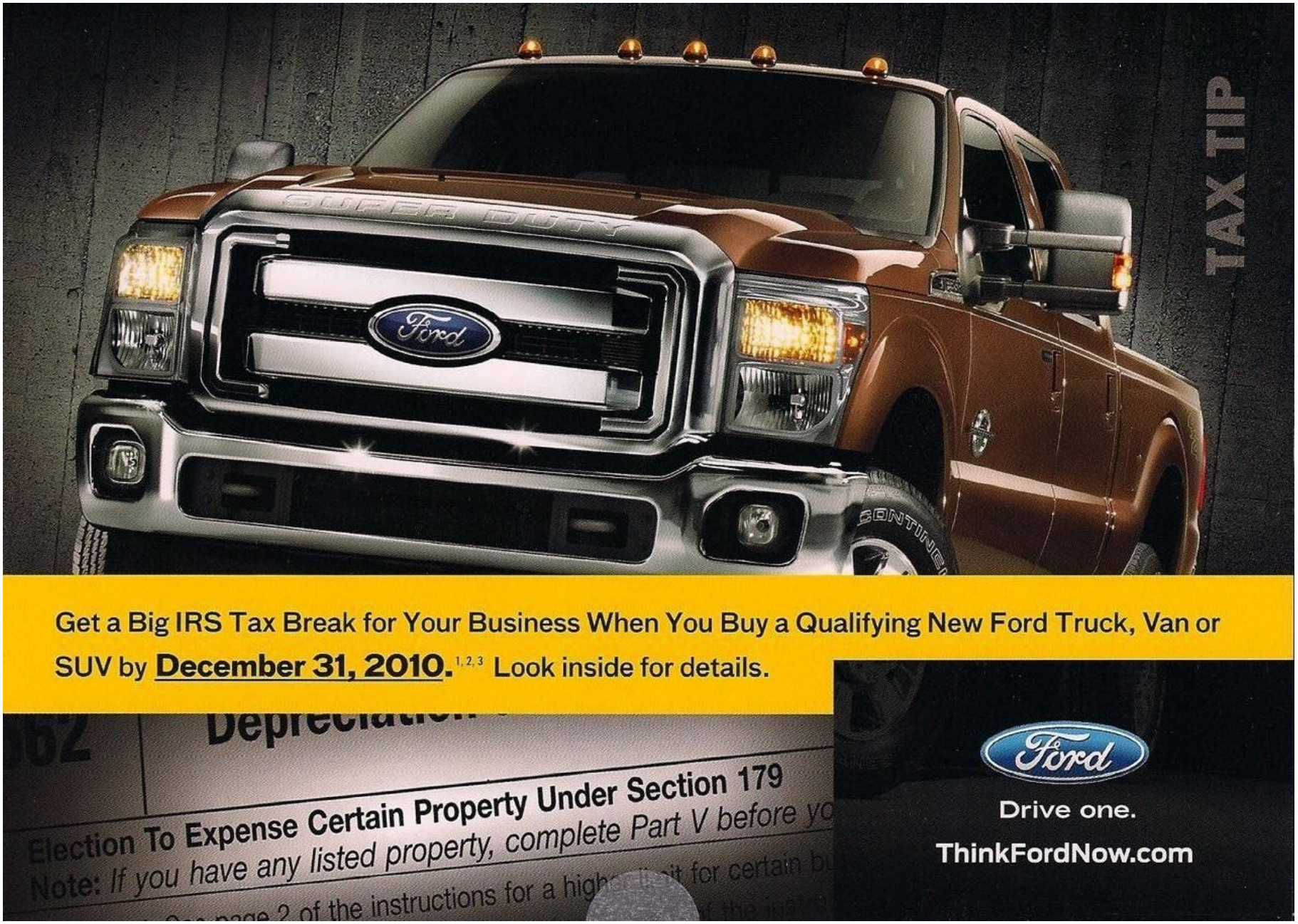
The cars themselves give off no emissions, so they are vastly cleaner than carbon-dioxide-spewing, gas-powered vehicles. But the question gets complicated when you consider the source of electric cars' energy. A recent MIT study found that electric cars charged in states with strong nuclear or renewable energy sources are indeed greener than normal cars, but those in states that rely on coal plants can be *worse* for the environment than gas-powered vehicles. There is also the question of how to recycle the dead lithium-ion batteries, which, though containing none of the caustic chemicals of conventional car batteries, can weigh hundreds of pounds and aren't suitable for landfills on a large scale.


EV recycling market
is just emerging

Less to leak over time and during crashes

Lowers the “silent oil” spill


What is the government doing?

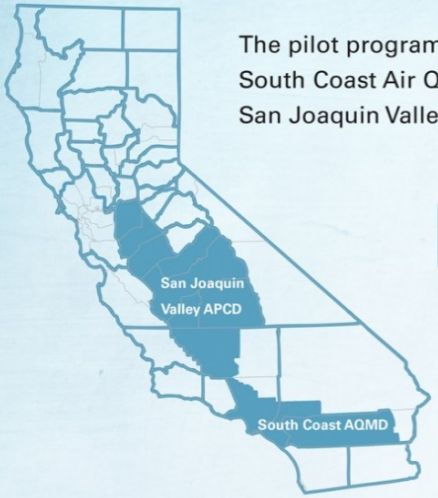

TAX TIP
Get a Big IRS Tax Break for Your Business When You Buy a Qualifying New Ford Truck, Van or SUV by December 31, 2010.[1,2,3] Look inside for details.
Election To Expense Certain Property Under Section 179
Note: If you have any listed property, complete Part V before yo
page 2 of the instructions for a high
Ford
Drive one.
ThinkFordNow.com

Sad but still true…

Making the Cleanest Cars Affordable

EFMP Plus-Up is helping low-income families save money with fuel-efficient and ultra-clean cars*

STEP 1
Where do you live?



The pilot program is available in the South Coast Air Quality Management District & San Joaquin Valley Air Pollution Control District.

STEP 2
Scrap your old vehicle.

Turn in your dirty old vehicle. (Check with your Air District for eligibility requirements.)

STEP 3
What type of vehicle are you interested in?

Eligible vehicles must be less than 8 years old.	Hybrid 20 MPG +	Hybrid 35 MPG +	Plug-in Hybrid	EV
Low Income *≤ 225% of the federal poverty level*	$6,500	$7,000	$9,500 + $1,500**	$9,500 + $2,500**
Moderate Income *226% - 300% of federal poverty level*		$5,000	$7,500 + $1,500**	$7,500 + $2,500**
Above Moderate Income *301% - 400% of federal poverty level*			$5,500 + $1,500**	$5,500 + $2,500**

CALIFORNIA CLIMATE INVESTMENTS

** Enhanced Fleet Modernization Program*
*** Clean Vehicle Rebate Project for new vehicle purchases*


Colorado
EV
ELECTRIC VEHICLE

REFUEL COLORADO

http://cleanairfleets.org/programs/charge-ahead-colorado


COLORADO DEPARTMENT OF TRANSPORTATION
09/25/13
ISSUE DATE
3253A
PERMIT NUMBER
HOV EXEMPTION
NISSAN
AGC AUTOMOTIVE
DOT-375 M3H4 AS1
B
ExpressToll

vehicle miles traveled

estimating and forecasting

VMT 101

X

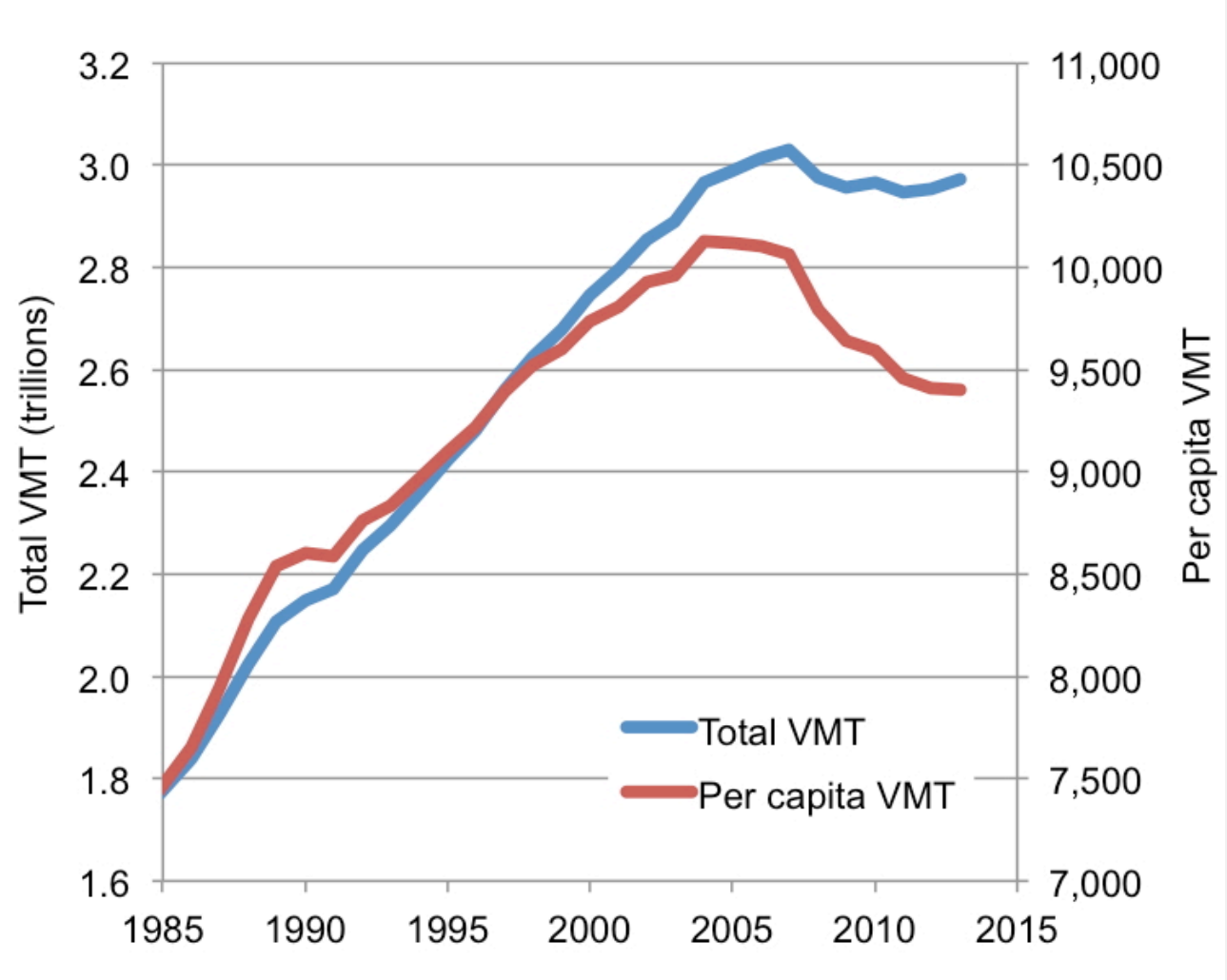
xx miles

[traffic volume] x [roadway length] = VMT

why is VMT useful

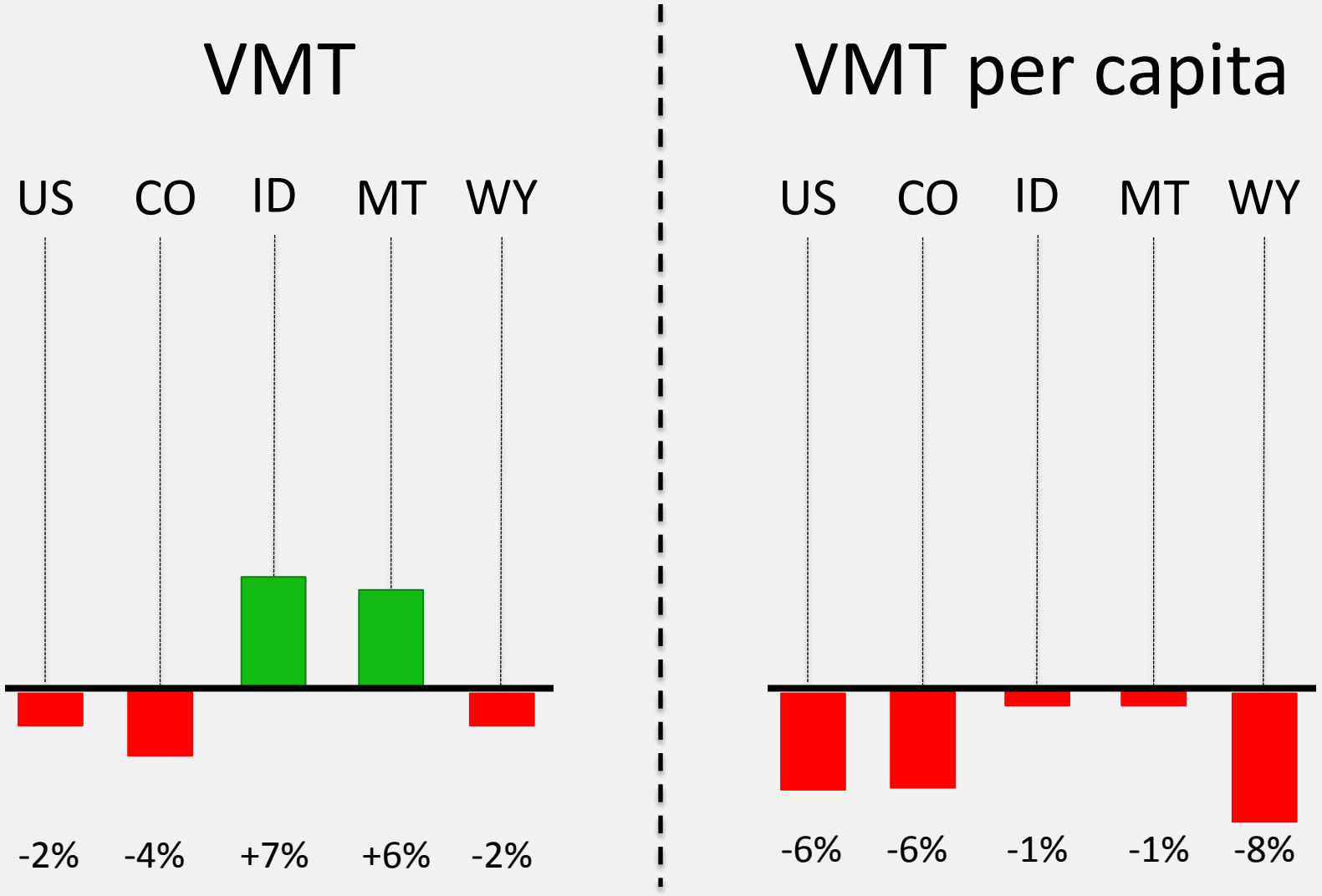
- performance monitoring indicator
  - amount of driving
  - mode share
  - GHG and other vehicle emissions
  - roadway capacity
- track trends
- compare to other locations

national VMT trends



source: State Smart Transportation Initiative (FHWA and Census Bureau data)

western states 2006-2012



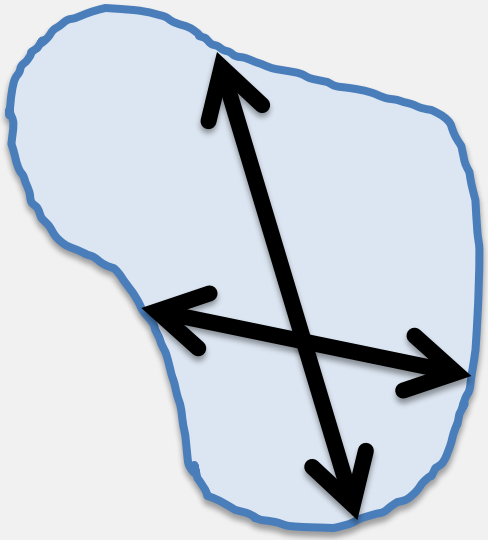
Source: FHWA and US Census Bureau

measuring VMT

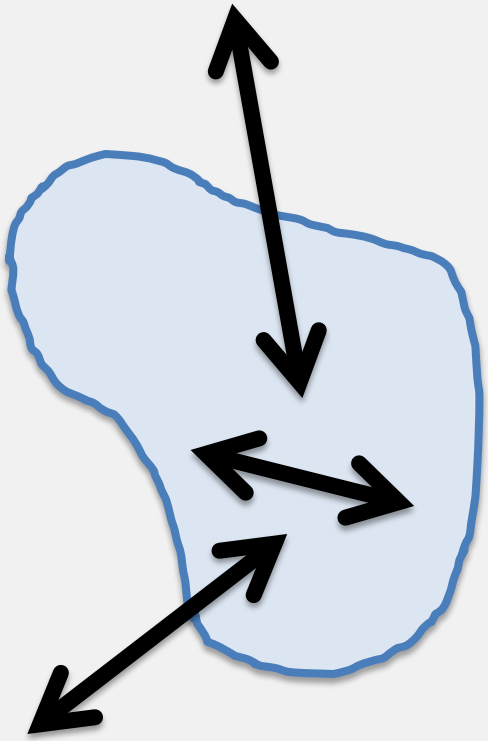
image credit: flashreport.org

define area being measured

corridor



internal



attributable

polygon model

miles of street	x	traffic volume	=	vmt
(GIS)		(counts)		

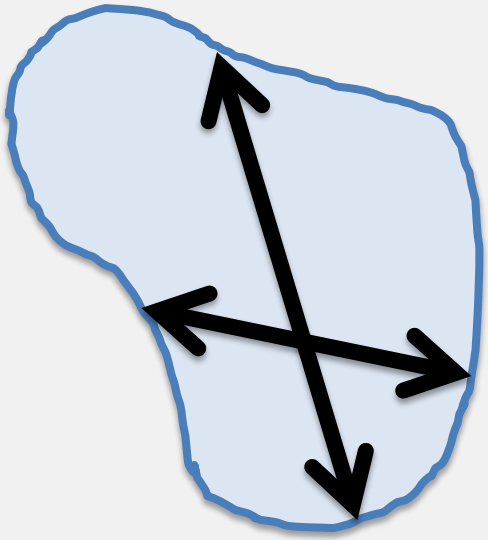
- biased toward higher volume streets
- does not account for external travel
- includes pass-through traffic
- good reality check
- provides no analytics (trip purpose, traveler type, etc.)

activity model

vehicle trips	x	trip length	=	vmt
(survey data)		(survey data)		

- aggregated from behavioral data
- draws from studies
- combined with demographic data
- supports estimation of external travel
- provides some data on trip purpose, traveler type
- provides some data on seasonality

case study: Teton County, WY



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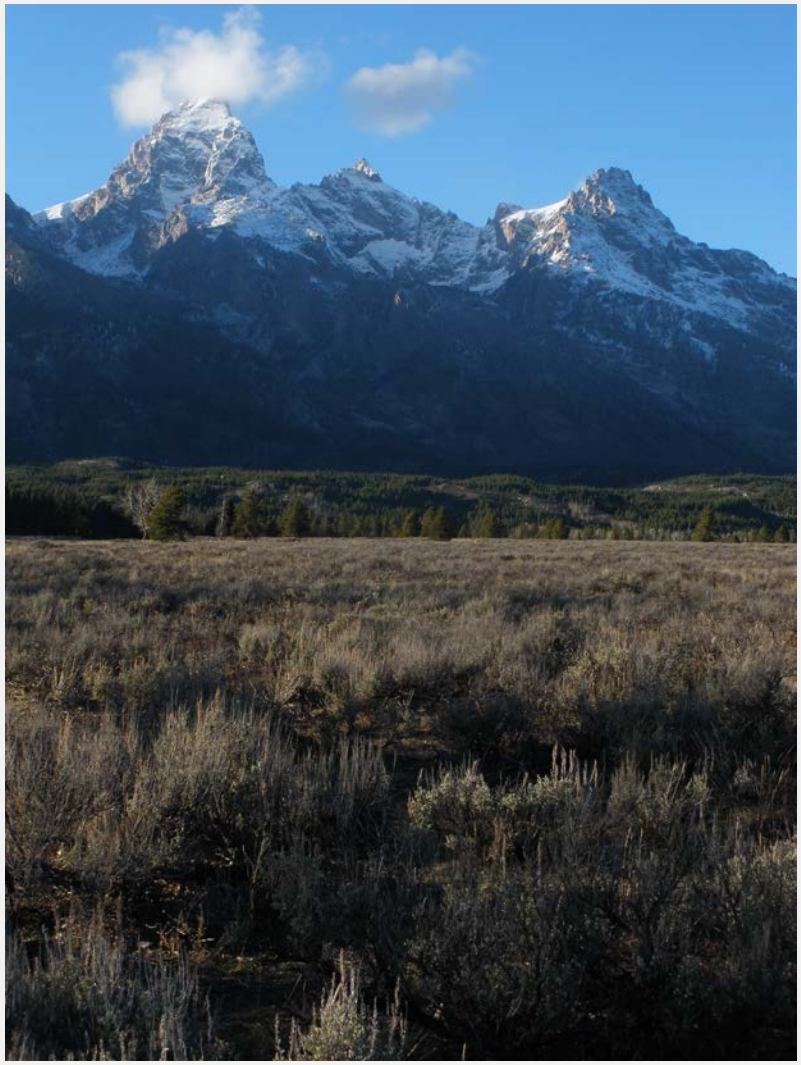
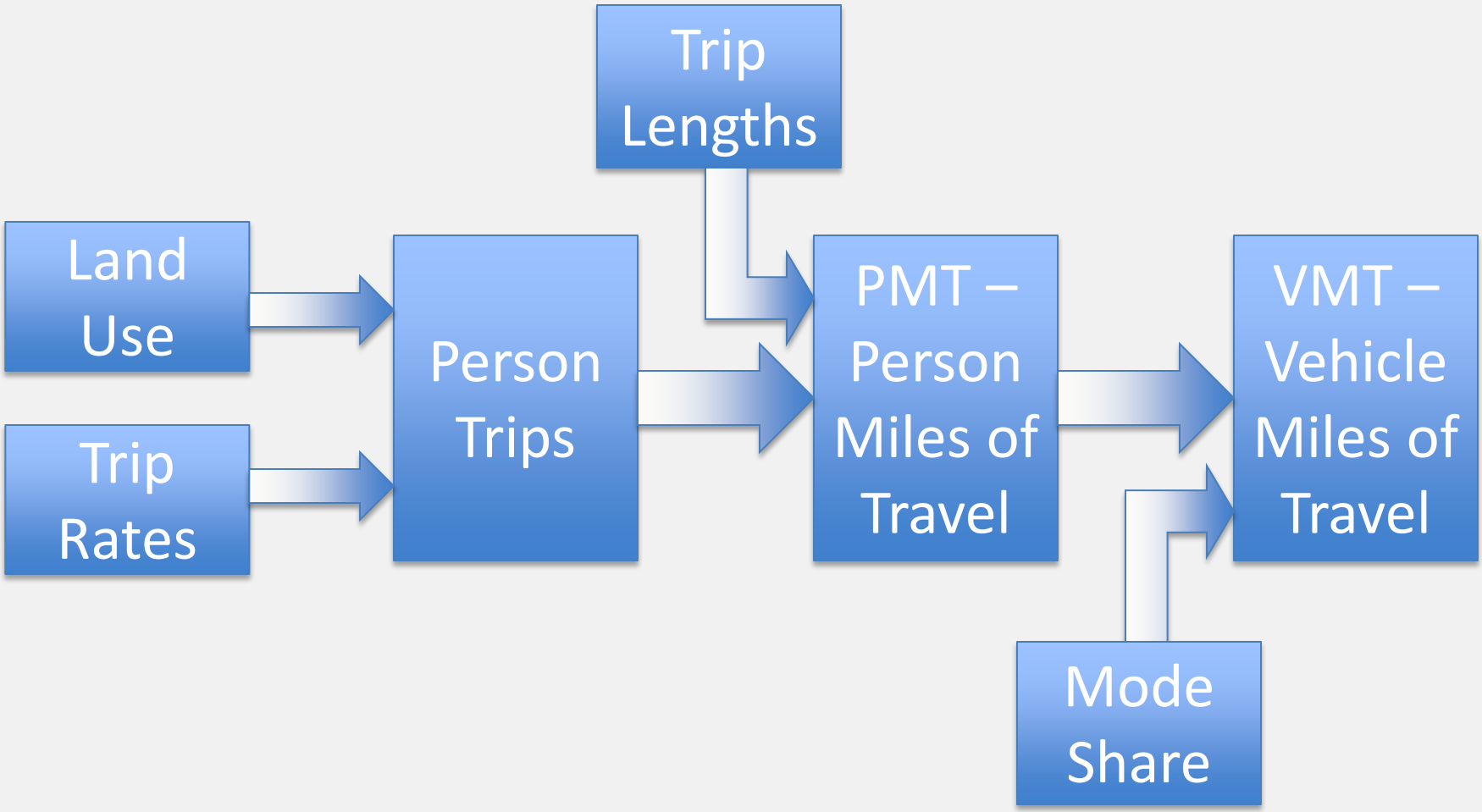
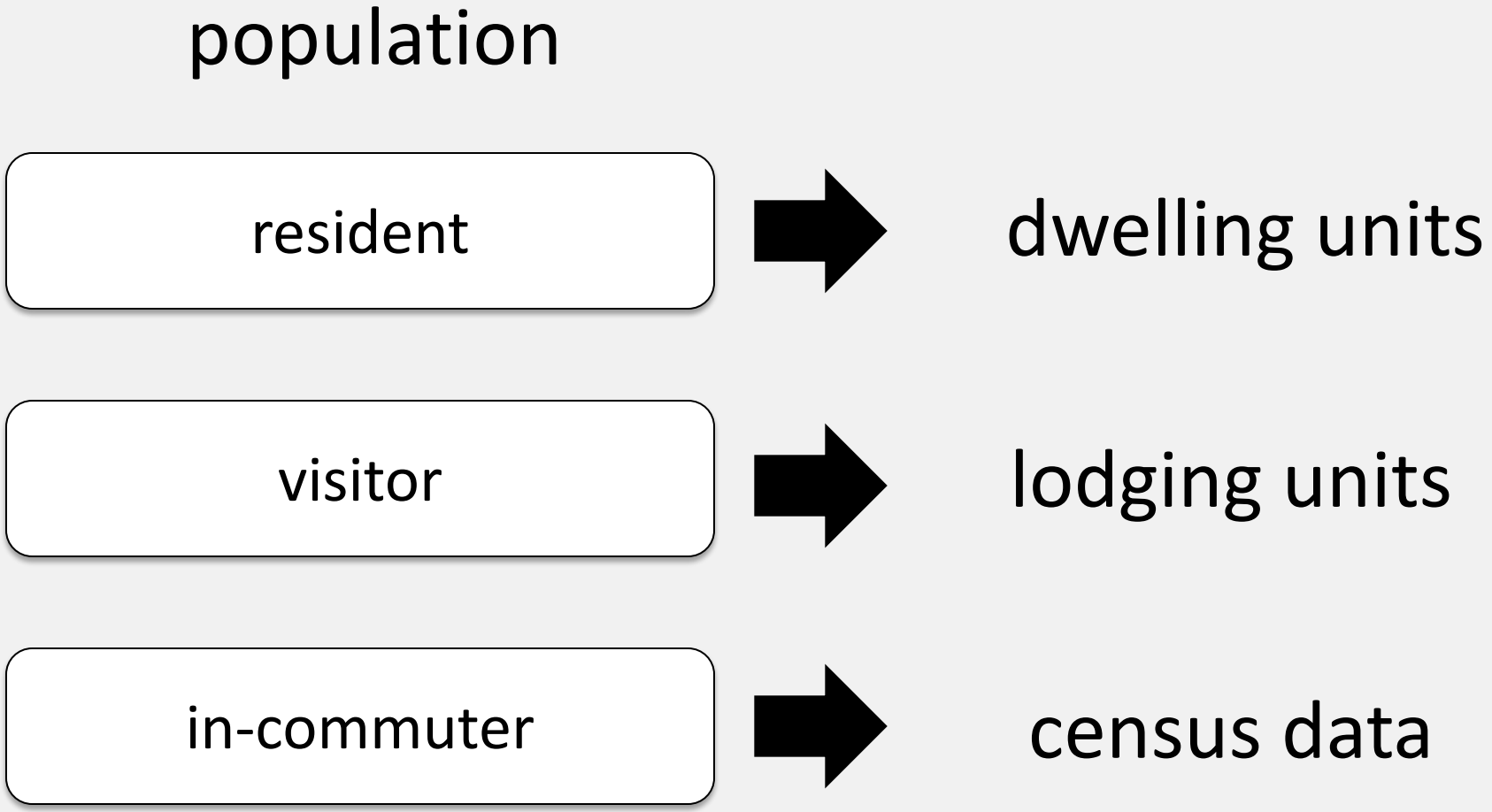


PMT* Model

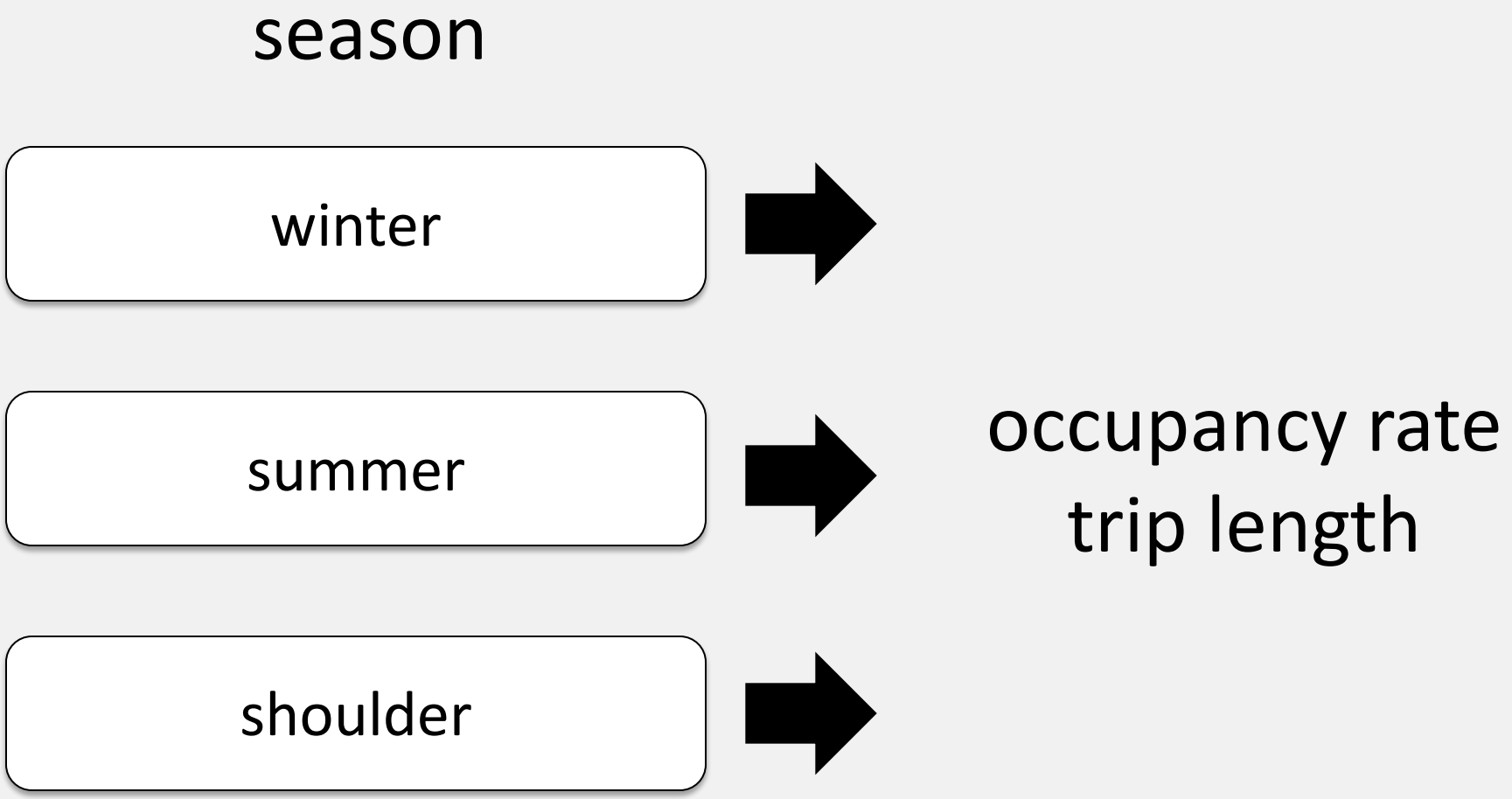


*person miles of travel

VMT by group

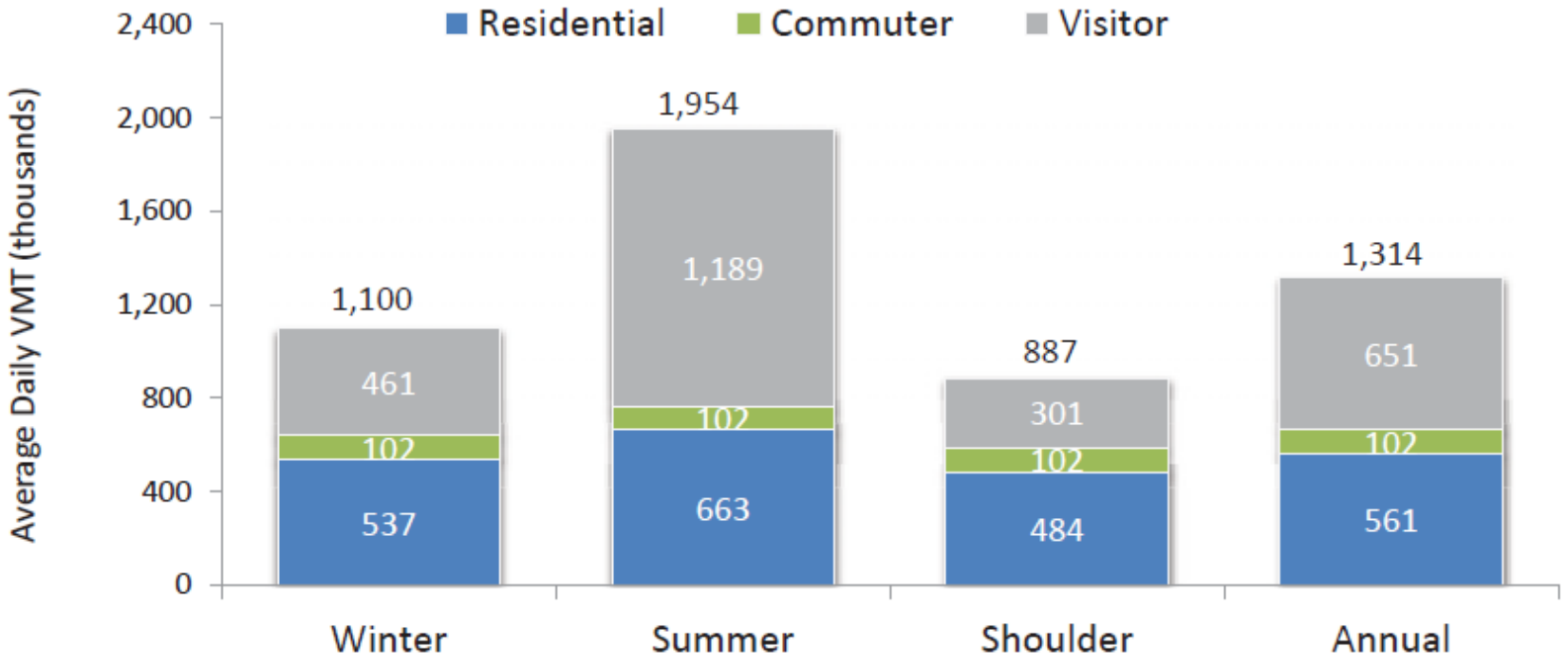

population
resident
dwelling units
visitor
lodging units
in-commuter
census data

VMT by group



2013 Countywide VMT

(estimated average daily vehicle miles traveled - thousands)



forecasting VMT

baseline scenario: no change in travel behavior

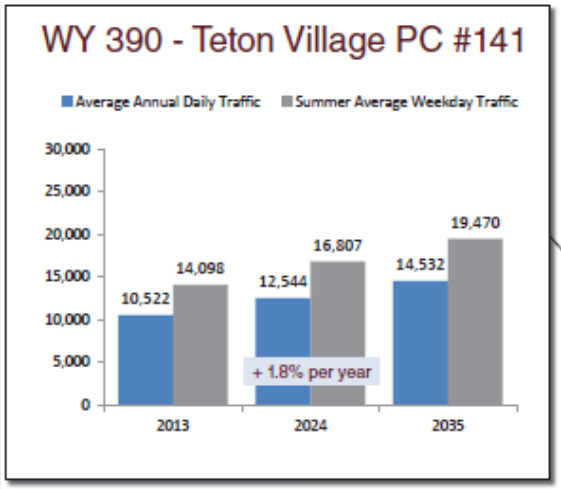
plan scenario: 5% mode shift from SOV

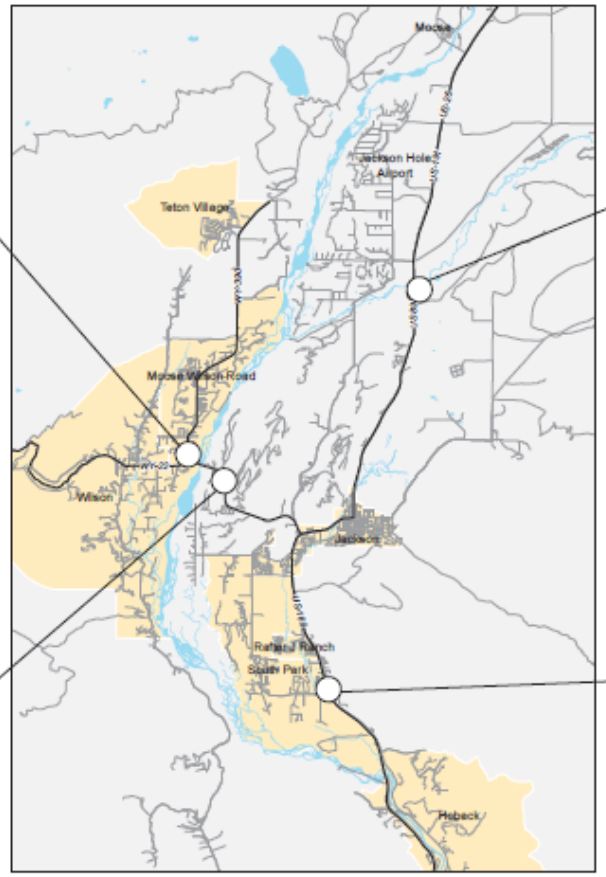
Indicator		Base Year	Baseline Scenario		Plan Scenario	
		2013	2024	2035	2024	2035
Mode Share (of total annual trips)	SOV (single occupant vehicle)	54%	54%	54%	51%	48%
	MOA (multiple occupant auto)	29%	29%	29%	29%	29%
	Walk	9%	9%	9%	10%	11%
	Bicycle	7%	7%	7%	8%	9%
	Transit	1%	1%	1%	2%	3%
Annual vehicle miles traveled (VMT)		480 million	550 million	610 million	525 million	560 million
% Growth in VMT from 2013		-	14%	28%	9%	17%
Annual transit ridership		0.9 million	1.1 million	1.2 million	1.8 million	3.6 million

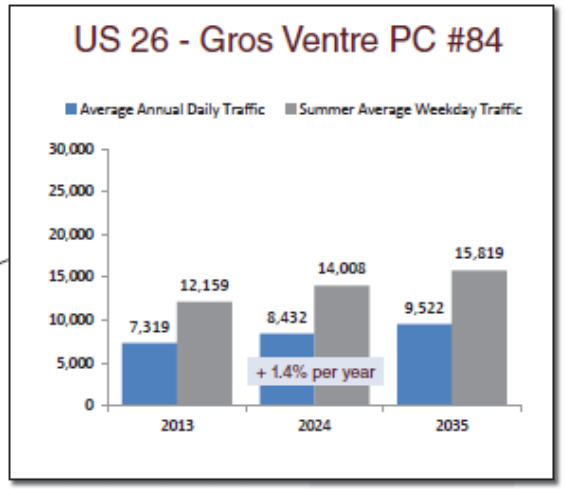
informing cost estimates

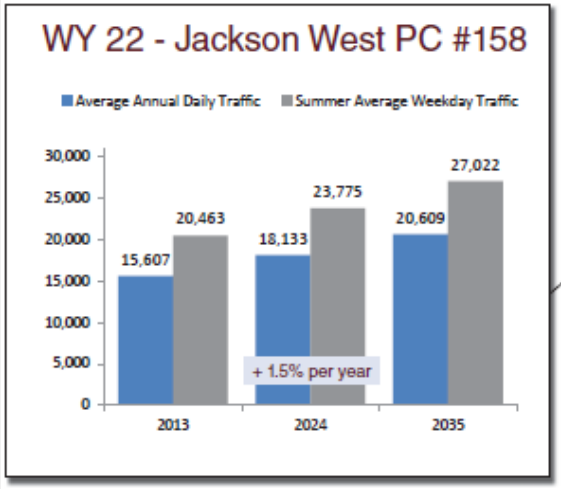
Plan Scenario	2013	2018	2024	2035
Assumptions				
Annual ridership	899,318	1,259,045	1,798,636	3,597,272
Annual bus revenue hours	39,731	55,623	79,461	158,922
Bus fleet size	30	42	60	120
Farebox revenue (23% of O&M)	$674,399	$944,158.33	$1,348,798	$2,697,595
Cost Estimates				
Operation and maintenance (O&M) cost	$2,913,229	$4,369,843	$6,554,765	$14,566,145
Capital cost - bus fleet replacement	$750,000	$1,125,000	$1,687,500	$3,750,000
Capital cost - other	$600,000	$840,000	$1,200,000	$2,400,000
Capital cost - transit facility completion*		$30,000,000*		
Total cost (O&M + capital)	$4,263,229	$6,334,843	$9,442,265	$20,716,145
Total cost (O&M + capital) less revenue	$3,588,830	$5,390,685	$8,093,468	$18,018,550

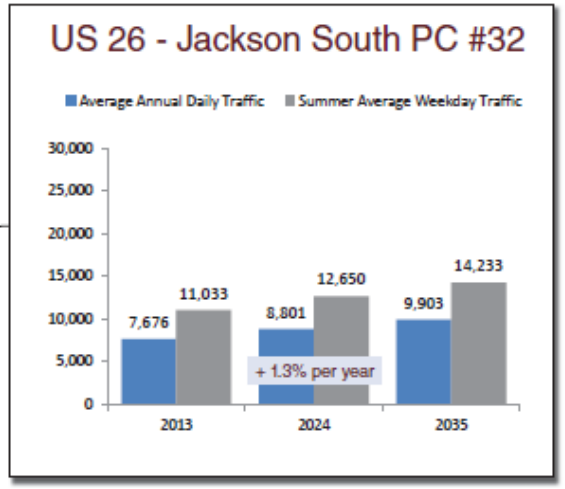
monitoring VMT overtime



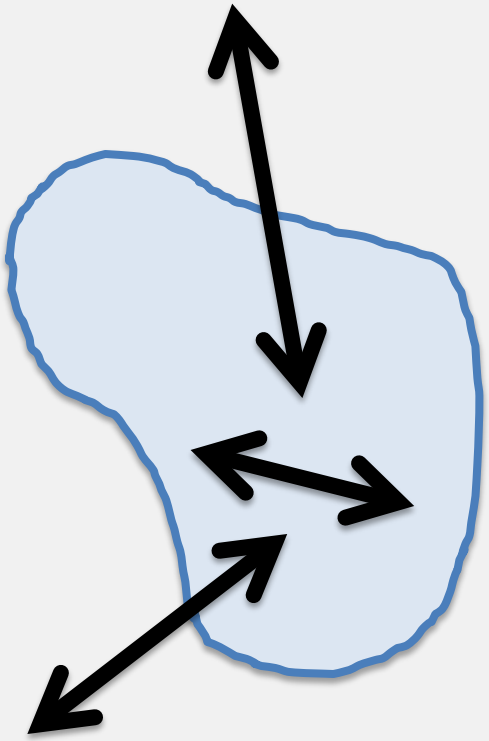








case study: Aspen, CO



attributable

VMT activity model

Season	Summer								
Data	Effective Popu-lation	SOV Mode Share	MOA Mode Share	MOA Vehicle Occ.	Daily Trips	Trip Length	SOV VMT	MOA VMT	Daily VMT
~~Residents~~	~~7,792~~	~~29%~~	~~18%~~	~~2.6~~	~~3.7~~	~~3.8~~	~~31,911~~	~~7,503~~	~~39,414~~
Commuters	5,821	45%	13%	2.5	3.3	4.5	39,588	4,379	43,967
RFV Visitors	2,386	39%	20%	2.6	3.7	4.5	15,434	3,062	18,496
Other Visitors	12,885	15%	59%	2.6	3.7	4.5	32,456	48,445	80,901
RFTA Bus									2,667
Single Unit Truck									965
Comb Truck									1,954
TOTAL	28,884						119,389	63,390	188,364

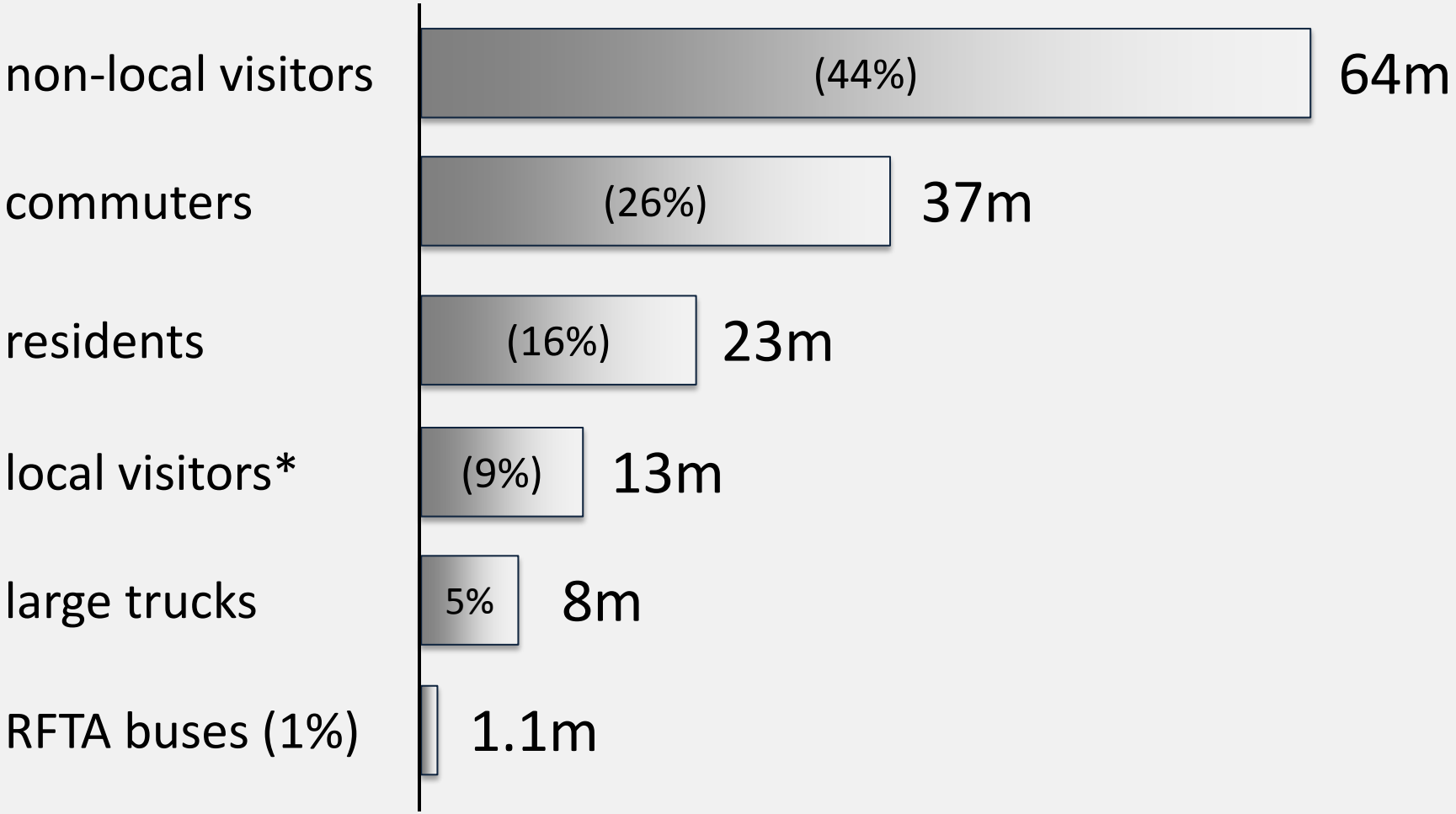
example: commuter travel behavior

Commuters

Definition: Workers who work in the Aspen EIB and live outside the EIB

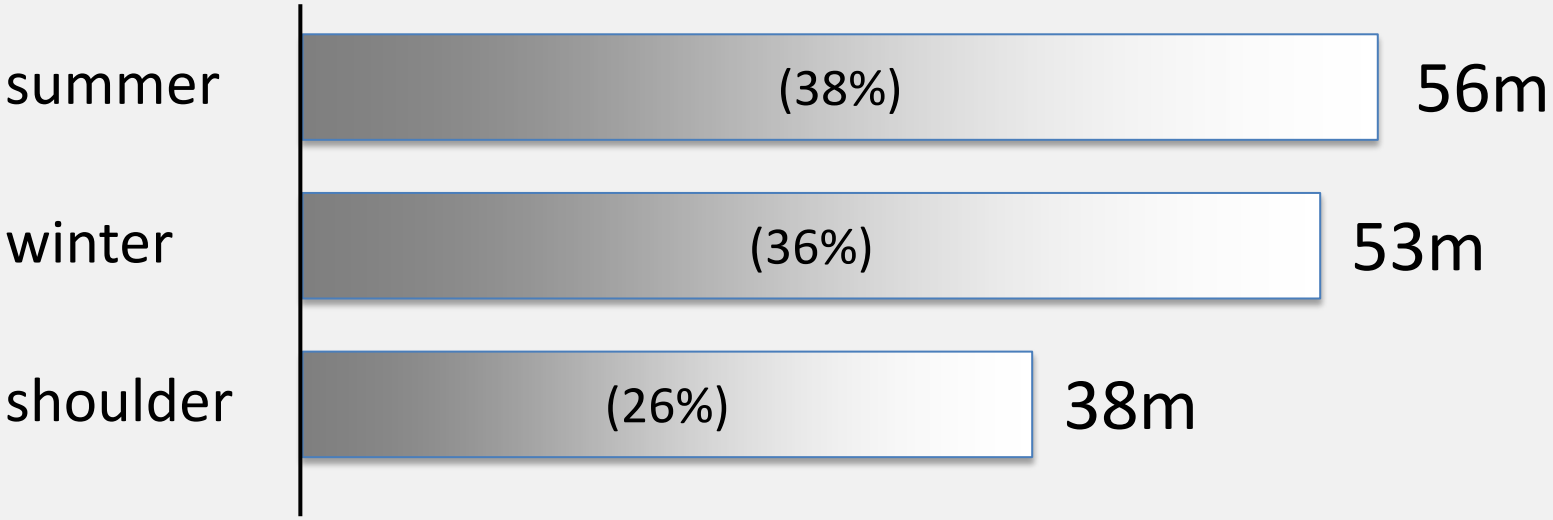
Description	Summer	Winter	Shoulder	Annual	Source
Commuter Population					
Pitkin County jobs	15,597	17,594	13,930	15,707	Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2013)
Seasonal variation	-0.7%	12.0%	-11.3%	0.0%	
Pitkin County workers	16,660	18,793	14,879	16,777	2013 American Community Survey Workers by Workplace Geography
% working in Aspen TAZ	78%	78%	78%	78%	2014 Regional Travel Patterns Survey
Aspen EIB workers	12,935	14,591	11,552	13,026	
% commute	70%	70%	70%	70%	2014 Regional Travel Patterns Survey
Aspen EIB commuters	9,055	10,214	8,087	9,118	
Days per week commuting	4.5	4.5	4.5	4.5	Estimate
Average daily commuters	**5,821**	**6,566**	**5,199**	**5,862**	
Commute Mode Share					
Aspen employee SOV	36%	38%			2014 Regional Travel Patterns Study
Aspen employee MOA	10%	16%			2014 Regional Travel Patterns Study
Aspen employee Bus	35%	38%			2014 Regional Travel Patterns Study
Aspen employee Walk/Bike	20%	10%			2014 Regional Travel Patterns Study
In-commute SOV	**45%**	**42%**	**44%**		
In-commute MOA	**13%**	**18%**	**15%**		
In-commute bus mode share	44%	42%	43%		
Vehicle Occupancy of Carpool Trips					
Average MOA vehicle occupancy (per trip per vehicle)	2.51	2.51	2.51	2.51	2013 American Community Survey Means of Transportation to Work by Workplace Geography (Aspen)
Trip Rate					
Average daily trips per person	3.3	3.3	3.3	3.3	Assumed to be 90% of resident trip rate
Trip Length					
Trip length from EIB boundary to downtown Aspen	5.0	5.0	5.0	5.0	
Average commute trips per commute day	2.0	2.0	2.0	2.0	
Average Trip Length by Commuters in EIB	4.5	4.5	4.5	4.5	

by travel group



*from Roaring Fork Valley outside Aspen

by season



summer = Jun - Sep
winter = Dec - Mar
shoulder = Apr - May & Oct - Nov

by vehicle and fuel type

Vehicle Type	Fuel Type	Miles per Gallon	% of Total VMT	Annual VMT	Gallons of Fuel Consumed
Car (sedan, wagon, small SUV, crossover)	Gasoline	24.4	38.1%	55,791,068	2,287,611
Car (sedan, wagon, small SUV, crossover)	Diesel	25.0	0.4%	514,322	20,593
Car (sedan, wagon, small SUV, crossover)	Electric	n/a	0.03%	39,406	0
Truck (med/large SUV, pickup, van, minivan)	Gasoline	17.9	50.0%	73,273,931	4,082,787
Truck (med/large SUV, pickup, van, minivan)	Diesel	17.6	4.4%	6,518,415	370,400
Motorcycle	Gasoline	43.5	1.0%	1,508,814	34,650
RFTA Bus (standard)	B5 Biodiesel	4.3	0.6%	874,468	205,757
RFTA Bus (BRT)	CNG	5.8	0.1%	196,641	34,199
Single-Unit Truck (& other bus)	Gasoline	7.3	0.4%	617,226	83,982
Single-Unit Truck (& other bus)	Diesel	7.3	0.6%	837,532	113,958
Combination Truck (semi, tractor-trailer)	Diesel	5.8	4.4%	6,384,608	1,091,479
Total			100%	146,556,433	8,325,416