Michigan Association of Railroad Passengers (MARP)

Passenger Rail and the Growth of Cities

Why am I here?

- I've invaded your classroom because…
- I want to save the planet!
- I believe rail is ~~the~~ an important key to saving the planet
- Transportation and urbanization fascinated me since I was 12 years old
- I love to travel – I've ridden public transportation in roughly 74 cities around the world

Who are we?

- Today, I'm speaking on behalf of the Michigan Association of Railroad Passengers (MARP)

- My introduction is on the handout page; **now it's your turn!**

- Where did you grow up?

- What career goals do you have?

- What was your most interesting experience related to transportation?

My outrageous claims about cities and trains...

1) Cities cannot grow productively beyond a certain size without rapid, high-capacity transportation

2) Electric urban rail systems are the most effective, efficient, and ecologically sustainable way to provide the transportation large cities need

3) Detroit metropolitan area (Southeast Michigan) has reached the limit of productive growth without urban rail; its stagnating population and productivity is a result

4) Detroit needs many things, but an effective urban transportation system based on rail is one which must be provided if the city is to grow and prosper

5) As planning students and (future) planning professionals, you need to be aware of this. And if you care about Detroit, you need to work to build an effective urban passenger rail system here.

Let's dive in…!

Outrageous Claim 1

Cities cannot grow productively beyond a certain size without rapid, high-capacity transportation

OK, let's unpack that...

Claim 1 – Cities need high-capacity transport

Cities cannot grow productively beyond a certain size without rapid, high-capacity transportation

Cities = metropolitan areas, agglomerations, MSAs (Metropolitan Statistical Areas)

- Metro areas are determined by transportation...
- ...What are the practical limits of how far people can afford to commute from home to work?

Claim 1 – Cities need high-capacity transport

Cities **cannot grow** productively **beyond a certain size** without rapid, high-capacity transportation

- Not necessarily a physical size limit, because…
- The limit depends on many factors, such as…
    - Commute **time**, commute **cost**
    - Availability of transportation **options**
    - **Geography** and **topology**
    - **Social cohesion and history**
    - **Economic ability** of the region to provide **affordable housing AND transport**

Claim 1 – Cities need high-capacity transport

Just a minute...Why **should** cities grow?
Quick answer: *To enhance productivity, lifestyle, world peace*

- **More people working closer together are more productive**
  - This is especially true in the "knowledge economy"
- Cities have the *potential* to provide more ways for people to live happy, comfortable, creative, healthy, productive lives
- Earth's population is growing. Ordered density is a necessity for peaceful coexistence.

PHOTO:
SHINJUKU WARD,
TOKYO

It is by people being in

small spaces together

that

cities work

- Wisdom from Jarrett Walker

The Top 100 of 2017

- Here's a list of the top 100 largest metro areas.
  Biggest first: Tokyo 37,832,892 – 100th : Minneapolis-St. Paul: 4,597,883

  Tokyo, Delhi, Shanghai, Jakarta, Seoul, Guangzhou, Beijing, Manila, New York City, Shenzhen, Mexico City, São Paulo, Lagos, Mumbai, Cairo, Keihanshin (Kyoto-Osaka-Kobe), Wuhan, Los Angeles, Chengdu, Dhaka, Chongqing, Karachi, Moscow, Tianjin, Istanbul, Bangkok, Kolkata, Tehran, London, Hangzhou, Surabaya, Buenos Aires, Xi'an, Paris, Bangalore, Changzhou, Kinshasa, Rio de Janeiro, Shantou, Nanjing, Rhine-Ruhr, Lahore, Jinan, Chennai, Harbin, Chicago, Lima, Washington, D.C. - Baltimore, Zhengzhou, Johannesburg, Qingdao, Bogotá, Chūkyō (Nagoya), Bandung, Boston, Randstad, Busan, Milan, Dallas-Fort Worth, Hyderabad, Riyadh, Shenyang, Wenzhou, Pune, Hong Kong, Nanchang, Yangon, Philadelphia, Houston, Taipei–Keelung, Miami, Santiago, Atlanta, Luanda, Madrid, Ahmedabad, Saint Petersburg, Berlin/Brandenburg, Toronto, Munich, Belo Horizonte, Kanpur, Frankfurt Rhine-Main, Singapore, Barcelona, Ankara, Detroit, Caracas, Dubai-Sharjah-Ajman, Stuttgart, Hamburg, Sydney, Guadalajara, Alexandria, Seattle, Phoenix, San Francisco-Oakland-Hayward, Melbourne, Monterrey, Minneapolis-St. Paul

The Top 100

- **U.S. cities** in the top 100:

Tokyo, Delhi, Shanghai, Jakarta, Seoul, Guangzhou, Beijing, Manila, New York City, Shenzhen, Mexico City, São Paulo, Lagos, Mumbai, Cairo, Keihanshin (Kyoto-Osaka-Kobe), Wuhan, Los Angeles, Chengdu, Dhaka, Chongqing, Karachi, Moscow, Tianjin, San Francisco-Oakland-Hayward, Istanbul, Bangkok, Kolkata, Tehran, London, Hangzhou, Surabaya, Buenos Aires, Xi'an, Paris, Bangalore, Changzhou, Kinshasa, Rio de Janeiro, Shantou, Nanjing, Rhine-Ruhr, Lahore, Jinan, Chennai, Harbin, Chicago, Lima, Washington, D.C. - Baltimore, Zhengzhou, Johannesburg, Qingdao, Bogotá, Chūkyō (Nagoya), Bandung, Boston, Randstad, Busan, Milan, Dallas-Fort Worth, Hyderabad, Riyadh, Shenyang, Wenzhou, Pune, Hong Kong, Nanchang, Yangon, Philadelphia, Houston, Taipei–Keelung, Miami, Santiago, Atlanta, Luanda, Madrid, Ahmedabad, Saint Petersburg, Berlin/Brandenburg, Toronto, Munich, Belo Horizonte, Kanpur, Frankfurt Rhine-Main, Singapore, Barcelona, Ankara, Detroit, Caracas, Dubai-Sharjah-Ajman, Stuttgart, Hamburg, Sydney, Guadalajara, Alexandria, Seattle, Phoenix, Melbourne, Monterrey, Minneapolis-St. Paul

The Top 100

- In the top 100 metro areas only 6 have no significant urban rail:*

Tokyo, Delhi, Shanghai, Jakarta, Seoul, Guangzhou, Beijing, Manila, New York City, Shenzhen, Mexico City, São Paulo, Lagos, Mumbai, Cairo, Keihanshin (Kyoto-Osaka-Kobe), Wuhan, Los Angeles, Chengdu, Dhaka, Chongqing, **Karachi**, Moscow, Tianjin, Istanbul, Bangkok, Kolkata, Tehran, London, Hangzhou, Surabaya, Buenos Aires, Xi'an, Paris, Bangalore, Changzhou, **Kinshasa,** Rio de Janeiro, Shantou, Nanjing, Rhine-Ruhr, Lahore, **Jinan,** Chennai, Harbin, Chicago, Lima, Washington, D.C. - Baltimore, Zhengzhou, Johannesburg, Qingdao, Bogotá, Chūkyō (Nagoya), **Bandung,** Boston, Randstad, Busan, Milan, Dallas-Fort Worth, Hyderabad, Riyadh, Shenyang, Wenzhou, Pune, Hong Kong, Nanchang, Yangon, Philadelphia, Houston, Taipei–Keelung, Miami, Santiago, Atlanta, **Luanda,** Madrid, Ahmedabad, Saint Petersburg, Berlin/Brandenburg, Toronto, Munich, Belo Horizonte, Kanpur, Frankfurt Rhine-Main, Singapore, Barcelona, Ankara, **Detroit,** Caracas, Dubai-Sharjah-Ajman, Stuttgart, Hamburg, Sydney, Guadalajara, Alexandria, Seattle, Phoenix, San Francisco-Oakland-Hayward, Melbourne, Monterrey, Minneapolis-St. Paul

* Jane's Urban Transport Systems

Claim 1 – Cities need high-capacity transport

- Cities cannot grow **productively** beyond a certain size without rapid, high-capacity transportation
- **Productivity** includes several factors and measures…
  - GDP (per capita)
  - Patents (per 100,000)
  - Median income (normalized)
  - Value of manufactured goods
- Productivity influences and extends into
  - Better Health
  - Higher Educational levels
  - Longer Average lifespan
  - Personal fulfillment, happiness
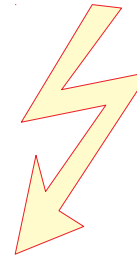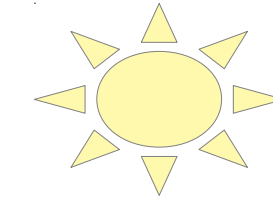
Greater productivity

⬇
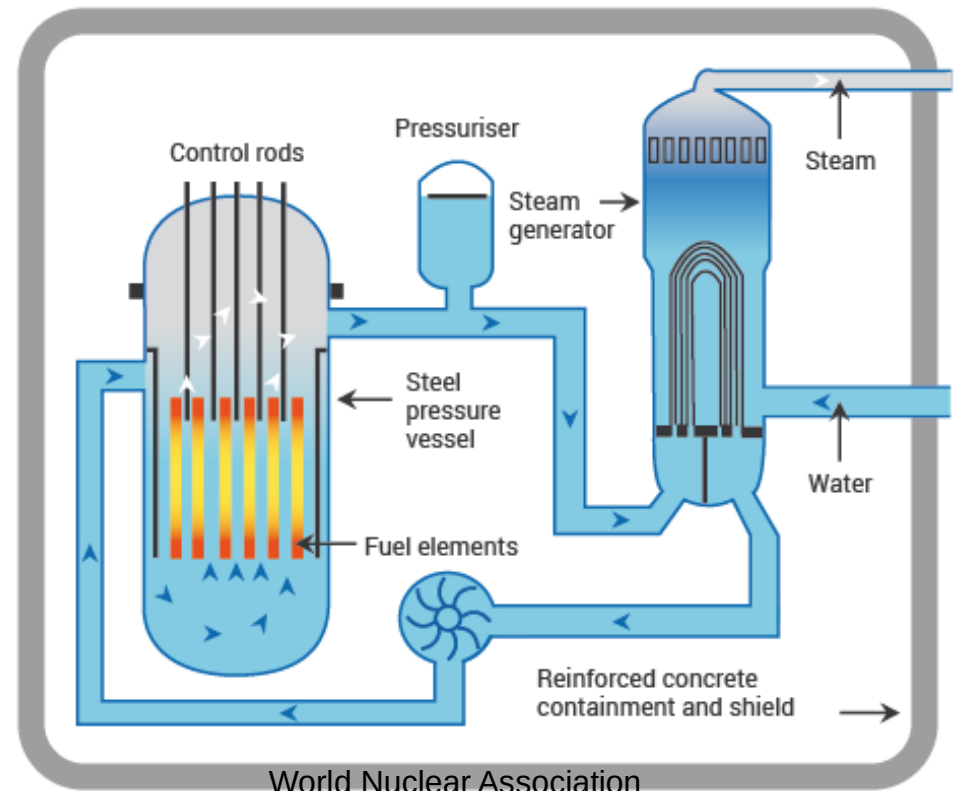
Extra energy

⬇

More amenities

Productivity includes productive use of **land**

- High-capacity transit ► more highly productive land

- Overuse of personal automobiles
    - ► Large parking areas
        - ≈ unproductive land

Claim 1 – Cities need high-capacity transport

- **Parking space** is like control rods in a nuclear power reactor
- Too little, and the too much heat is generated
- Too much, and the reaction no longer generates enough energy

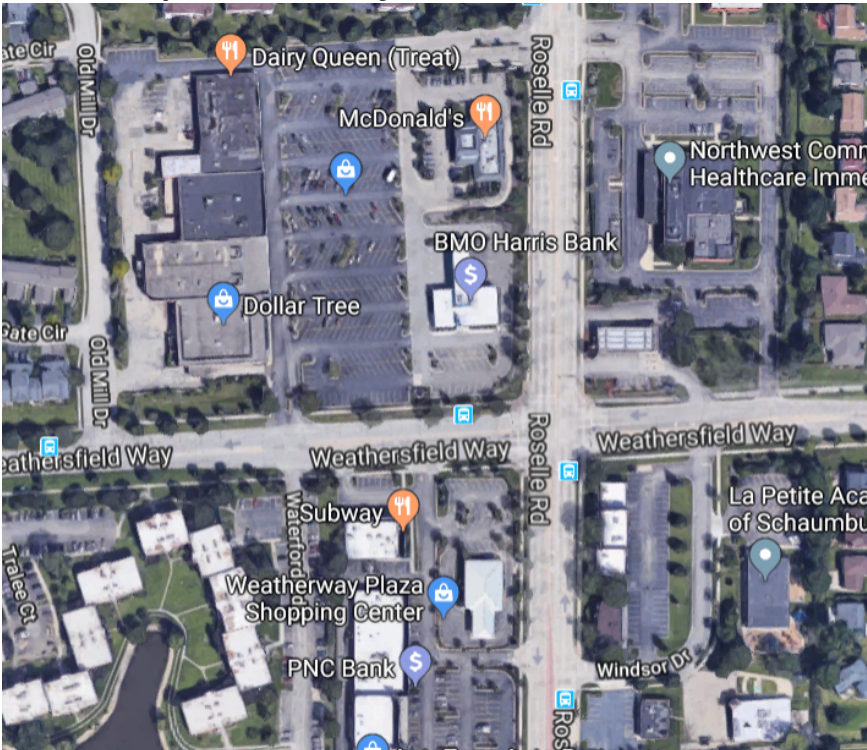A Pressurized Water Reactor (PWR)

Control rods

Pressuriser

Steam generator

Steam

Steel pressure vessel

Water

Fuel elements

Reinforced concrete containment and shield

World Nuclear Association

Claim 1 – Cities need high-capacity transport

Schaumberg, Illinois
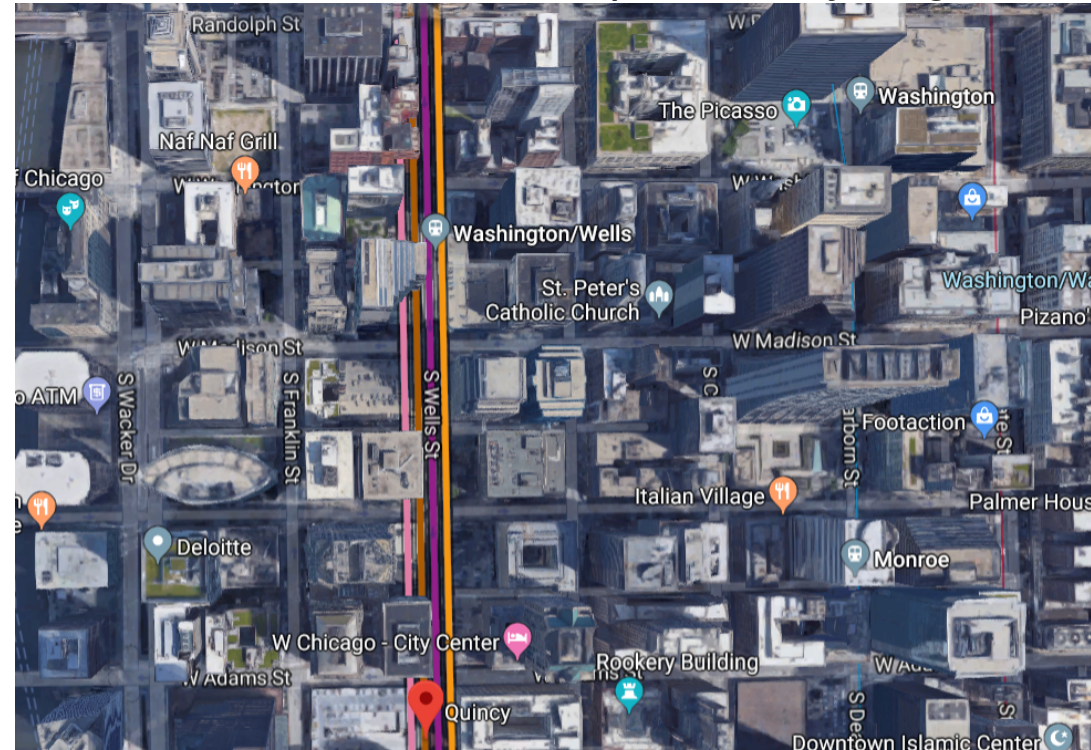Get there by car, plenty of free parking
Land productivity: Low

Chicago, Illinois
Get there by transit, parking very expensive
Land productivity: High

Capacity vs. space required

Seen

This

One?

Claim 1 – Cities need high-capacity transport

Cities cannot grow productively beyond a certain size without rapid, high-capacity transportation

- Rapid = "relatively short" time required to get where people need to go – especially from home to work

- Time spent commuting is generally **unproductive**

- Unproductive time = lowered productivity (duh!)

Claim 1 – Cities need high-capacity transport

- Long commutes ► increased value of housing near work
- *World-wide phenomenon in large, productive cities:* **housing** within short commuting time of major employment centers is **unaffordable** except to people with very high salaries (≈ the most productive people)
- *But...* Lower-paid support workers are needed in **all** parts of a city
- Without support workers, productive workers become less productive
- *So...* **Affordable housing not only helps "poor people", it keeps cities productive.**

Sidebar – "Time is money" but…
Time is worth **more** to low-income people

"Time is money" not just to high-wage workers

- What is a "living wage"?
  - enough money to pay basic expenses?
  - Let's say it's $15/hour
- If working poor earn $15/hr and middle class earn $20
- …Middle class earns "living wage" in 45 minutes
- If both classes require 60 minutes to get to work,
  - Working poor loses **100%** living wage earning power, **$15.00**
  - Middle class loses only **75%** living wage earning power, **$11.25**
- **Commute time reduces "working Poor" earning power more than "Middle Class" earning power**

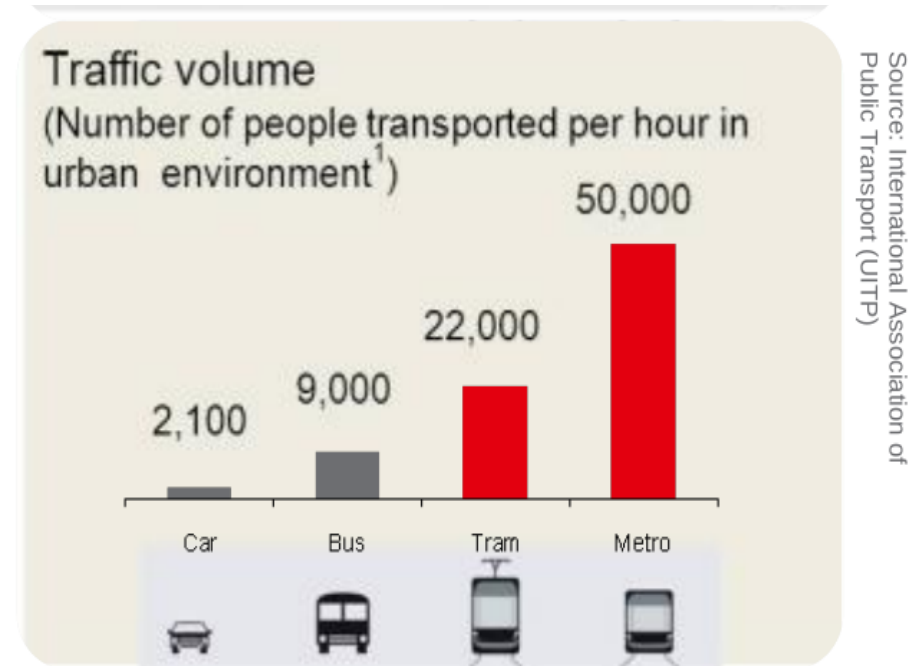# Claim 1 – Cities need high-capacity transport

Cities cannot grow productively beyond a certain size without rapid, high-capacity transportation

- Not so much capacity of the *vehicles*, as capacity of the **corridors**.

- How many people can a transportation corridor deliver in a given time (an hour)?

- Remember, successful cities bring millions of people together to increase their productivity.

Capacity of Urban Transport Modes

- **General overview**
  - Car: 1 lane ltd access
  - Bus: typical BRT
  - Tram = light rail
  - Metro = heavy rail

Traffic volume
(Number of people transported per hour in
urban environment[1])

50,000

22,000

9,000

2,100

| Car | Bus | Tram | Metro |

UITP
(Tram and Metro seem a bit high, but
proportions are certainly correct)

Capital Cost Advantage

Building new roads and railways isn't happening much in North America. Instead, existing rights-of-way are being refurbished and sometimes expanded.

However, refurbishment and expansion are too complex to provide comparative figures, so here are the new-build costs:
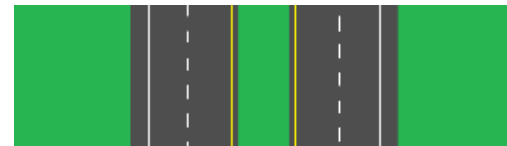

New 2-Track Railways
$3.6 million per country mile
$4.0 million per city mile
Peak capacity: 20,000 per hour*

* Does NOT include the cost of the trains themselves
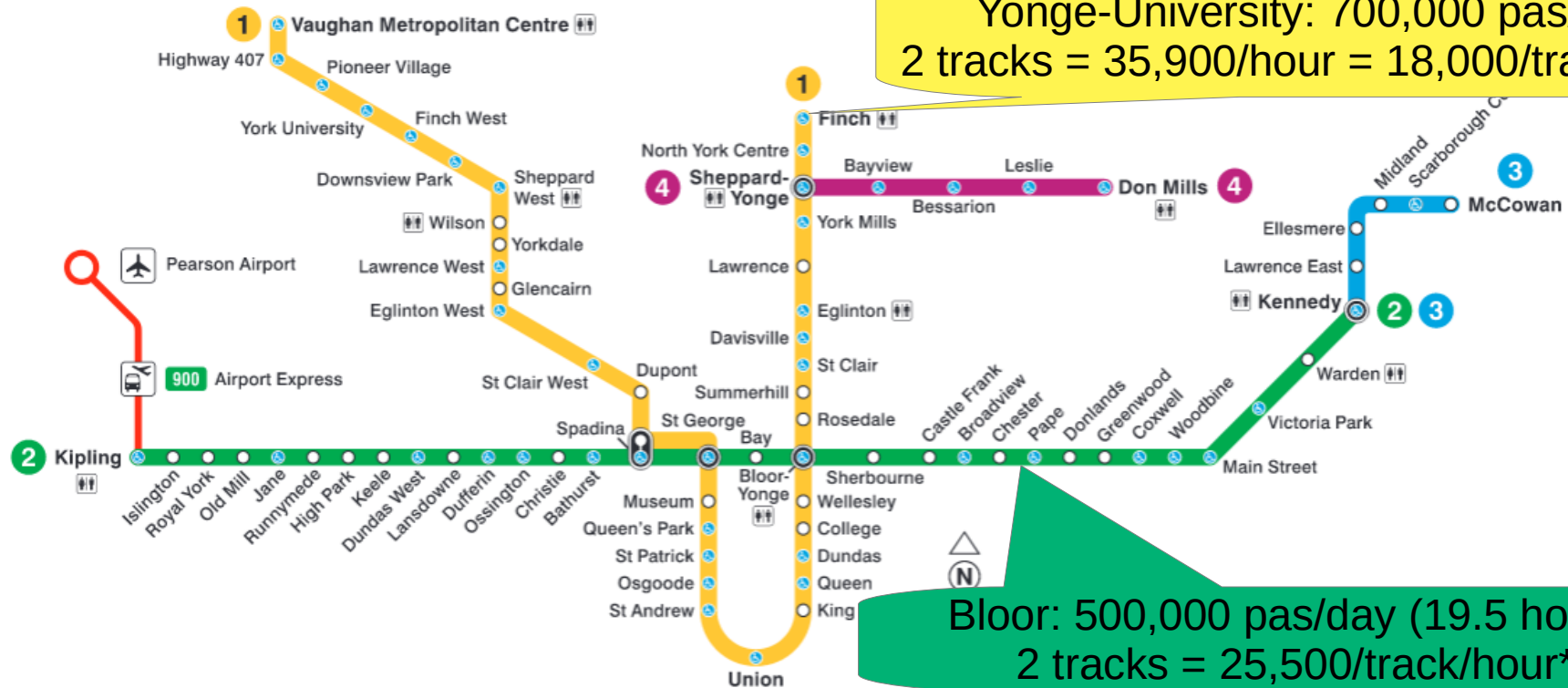

New 4-Lane Highway
$**13.2** million per country mile
$**17.6** million per city mile
Peak capacity: 8,000 per hour°

° Does NOT include cost of parking structures or the autos themselves

Efficiency and Capacity example:
Toronto subway (vs highway)

Yonge-University: 700,000 pas/day
2 tracks = 35,900/hour = 18,000/track/hour

Bloor: 500,000 pas/day (19.5 hours)
2 tracks = 25,500/track/hour*

* Christopher MacKechnie, https://www.liveabout.com/passenger-capacity-of-transit-2798765

Efficiency and Capacity example: Toronto subway and highway

Equivalent highway capacity cost (not counting parking cost and cost of demolition of existing structures):

Average passengers per hour	25,641.026	35,897.436
Passengers each direction per hour	12,820.513	17,948.718
Vehicles per lane per hour	2,100	2,100
Lanes needed each direction	6.105	8.547
Total number of lanes needed	12	18
Length of corridor (miles)	16.3	24.1
Lane miles needed	195.6	433.8
USD / city lane-mile	$17,600,000	$17,600,000
USD cost per line	**$3,442,560,000**	**$7,634,880,000**
USD cost total	**$11,077,440,000**	

Wisdom from Jarrett Walker

"Cars are instruments of freedom in rural areas...

and of tyranny in cities."

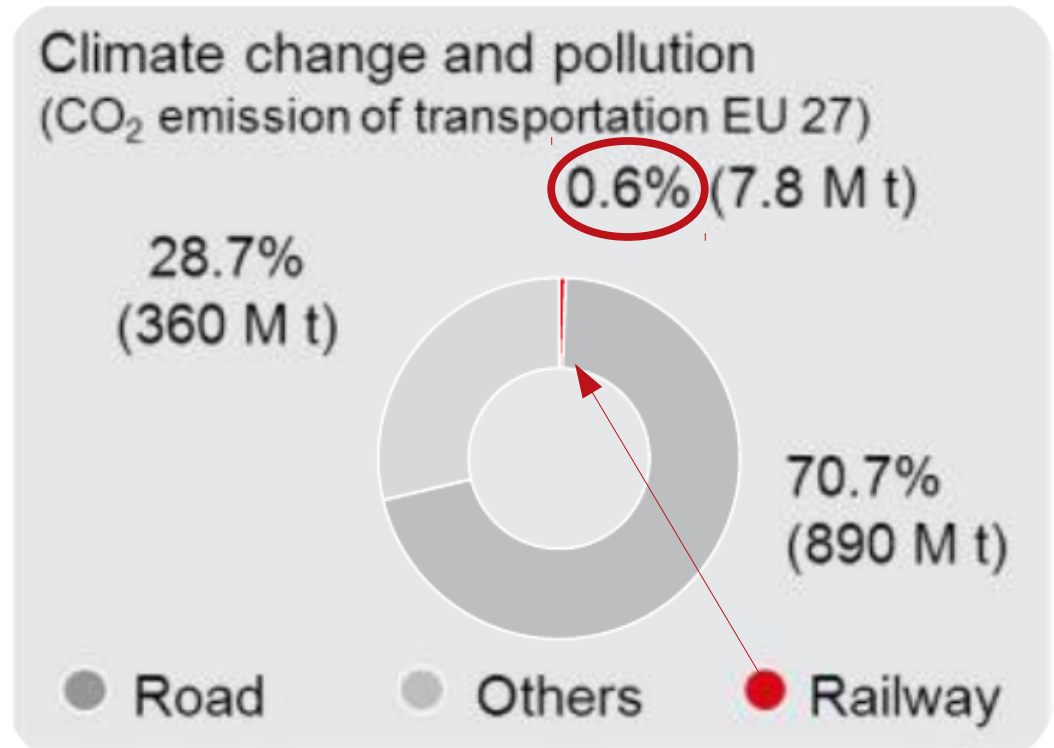"Transit planners are freedom planners!"

Outrageous Claim 2:

- **Electric urban rail systems are the most effective, efficient, and ecologically sustainable way to provide the transportation large cities need**

Claim 2: Electric trains do the job best

Electric urban rail systems are the most effective, efficient, and **ecologically sustainable** way to provide the transportation large cities need

- Electricity can be generated in many ways...clean and dirty
- As more clean sources come online, electric vehicles become cleaner without having to be re-designed and re-engineered
- Europe has a high % of electric trains + high % of clean power
- The graph at right (2011) illustrates what a big difference this makes →

Climate change and pollution
(CO_2 emission of transportation EU 27)

0.6% (7.8 M t)

28.7% (360 M t)

70.7% (890 M t)

Road   Others   Railway

Claim 2: Electric trains do the job best

Electric urban **rail** systems are the most effective, efficient, and ecologically sustainable way to provide the transportation large cities need

- Rail's great advantage: steel on steel. "Railroad wheels and rails are made of high strength steel. **A steel wheel requires very little energy to roll on a steel rail;** indeed, care must be taken that a car does not run away on level track on a windy day. This is **because wheel and rail deform very little under load, unlike a rubber tire rolling on asphalt.**" - Transportation Technology Center, Inc., of the American Association of Railroads. https://aar.com/ pdfs/Part1_WRI_Management.pdf

Claim 2: Electric trains do the job best

Electric urban rail systems are the most effective, efficient, and ecologically sustainable way to provide the transportation large cities need

- Hertzian Contact (1882) describes the pressures, stresses and deformations that occur when curved elastic bodies are brought into contact.

- "Contact Patches" tend to be **elliptical**

- This yields **parabolic** contact pressures

$$P_o = ^3/_2 P_{avg}$$

P_{avg}
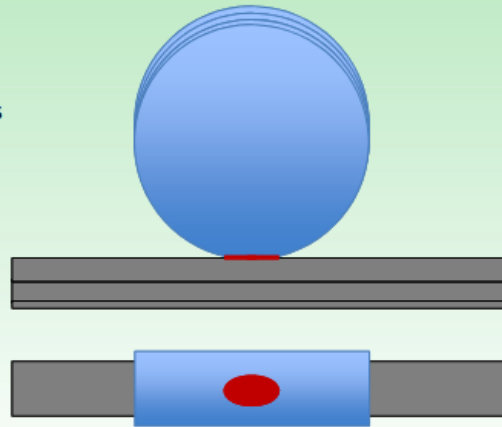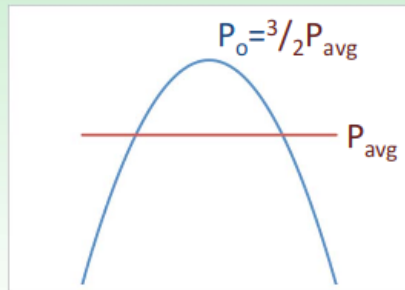
- Contact theory was subsequently broadened to apply to rolling contact (Carter and Fromm) with non-elliptical contact and arbitrary creepage (Kalker; *more on this later…*)
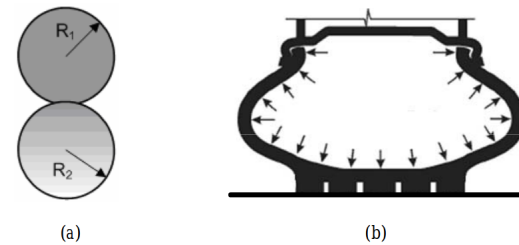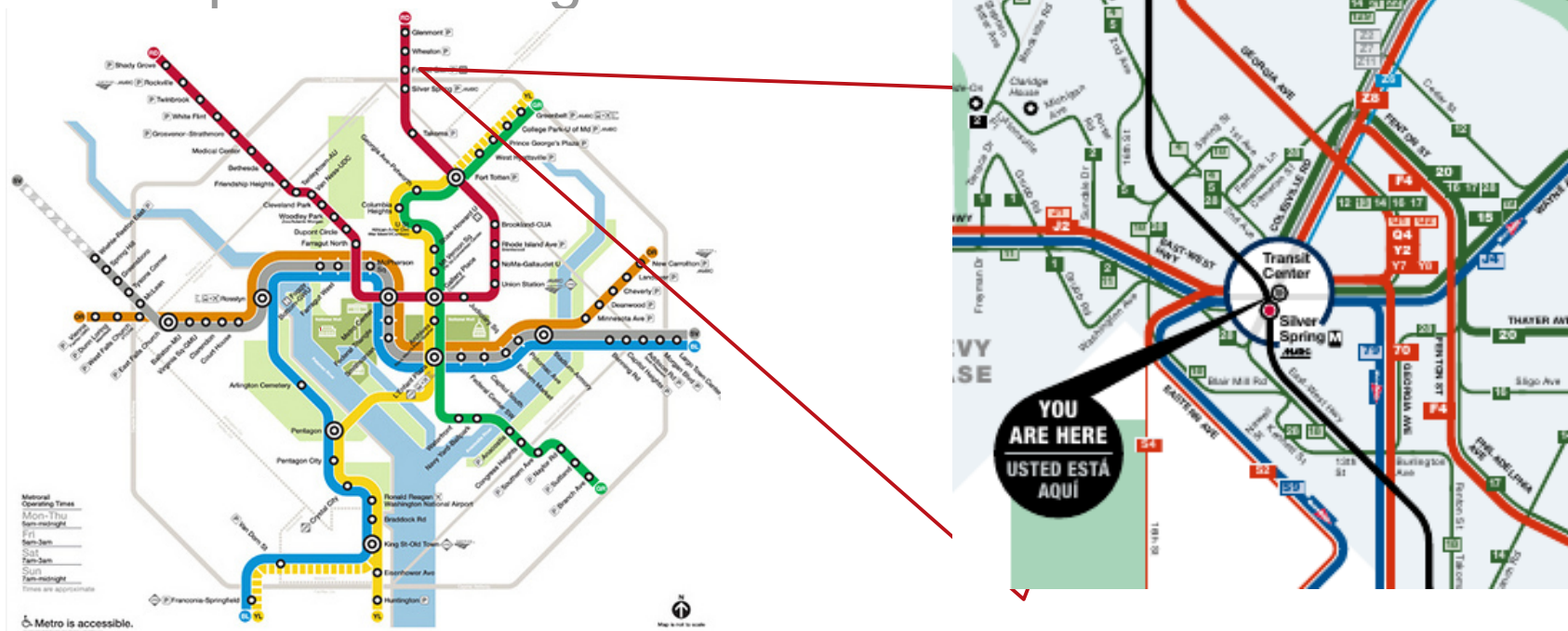
R_1

R_2

(a)   (b)

Figure 2.2 Contact (a) between two elastic spheres; and (b) between truck tire and pavement under heavy load

USDOT Region V Regional University Transportation Center

Claim 2: Electric trains do the job best

- Electric urban rail **systems** are the most effective, efficient, and ecologically sustainable way to provide the transportation large cities need

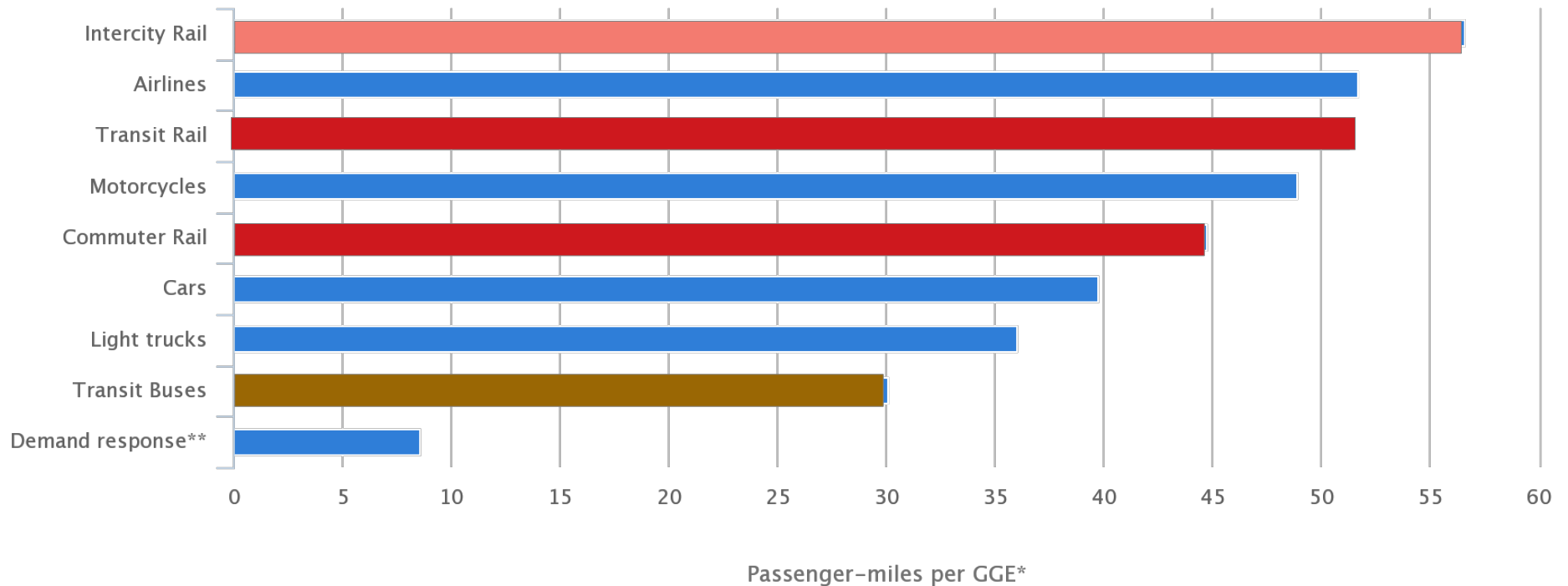# Claim 2: Electric trains do the job best

- Electric urban rail systems are the most **effective,** efficient, and ecologically sustainable way to provide the transportation large cities need

- Effective: "producing a decided, decisive, or desired effect" (Merriam-Webster online)

- What is the desired effect? **To move people quickly, inexpensively, in large numbers, from their residence to their workplace.** (This isn't the only desired effect, but it's the most consistently challenging.)

- Two ways to look at effectiveness of trains:

  1) Do they produce the desired effect?

  2) Do other forms of transportation perform better?

Claim 2: Electric trains do the job best

- Electric urban rail systems are the most effective, **efficient,** and ecologically sustainable way to provide the transportation large cities need

- Efficiency of land use was discussed already

- Energy efficiency and operational cost efficiency coming right up!

Claim 2: Electric trains do the job best

Average Per-Passenger Fuel Economy of Various Travel Modes

Passenger-miles per GGE*

Source: Oak Ridge National Laboratory Table 2.14 of the Transportation Energy Data Book 36B. 2018.

Claim 2: Electric trains do the job best

- Which is cheaper to operate...bus or train?
    - Depends on how many people ride
    - To normalize stats, cost per passenger mile (PPM) is used
      = full cost of taking 1 passenger 1 mile
- This is my calculation (Krieg's) based on…
    - Full operating+overhead cost average of 12 U.S. commuter rail lines (captured 2005, updated for inflation to 2015)
    - Proposal by Greyhound Inc. to Mich. Dept. of Transportation for subsidy to run 24-passenger buses between Detroit-Ann Arbor-Flint and Detroit-Port Huron, submitted 2014
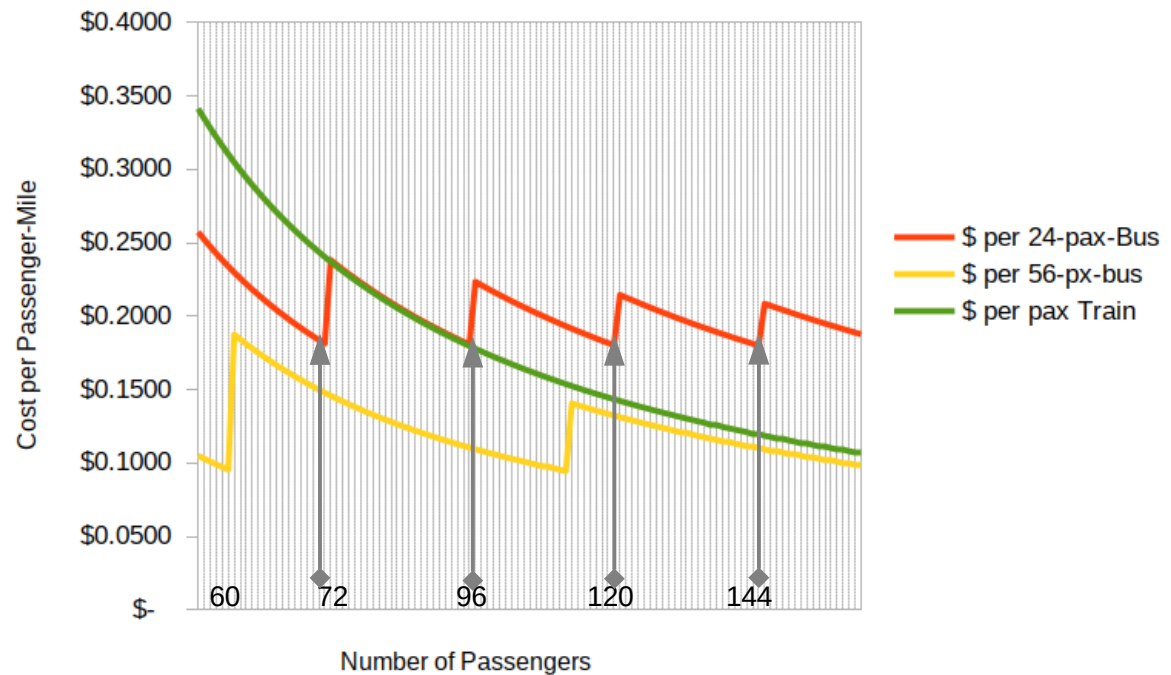
Cost Per Passenger Mile

24-Pax Bus - 56-pax Bus - Train

Cheaper to operate train for more than 168 passengers per trip
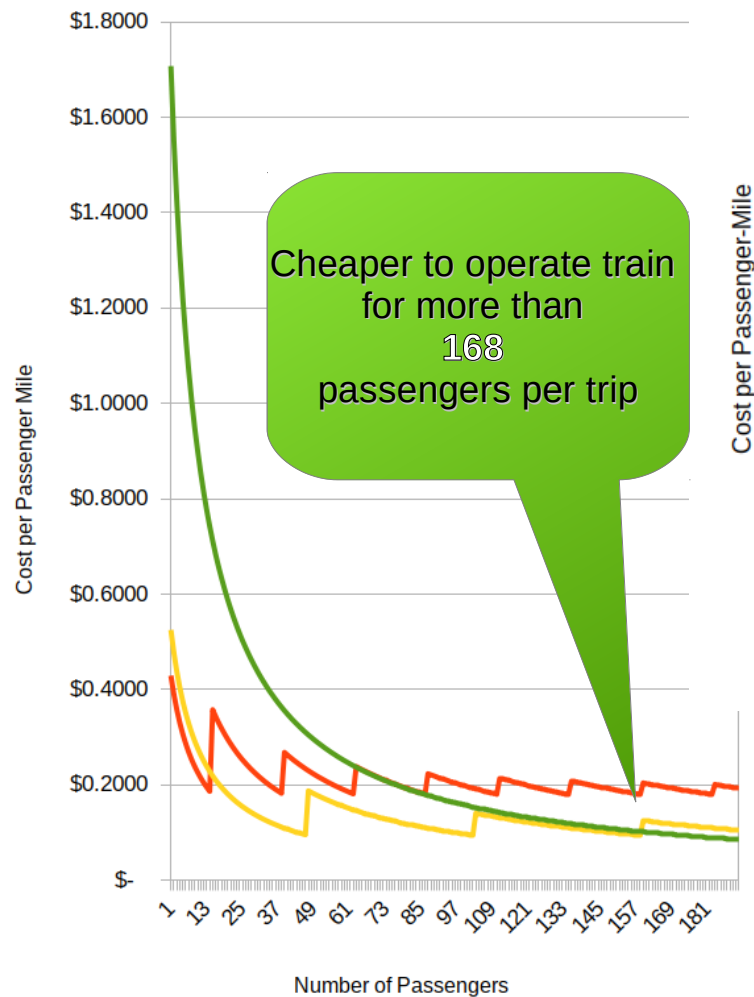
Mode Comparison: Cost per Passenger Mile

Zoom on 60-160 Passenger Range

- $ per 24-pax-Bus
- $ per 56-px-bus
- $ per pax Train

- Buses are less expensive to operate when less that 4 buses are needed (whether 24- or 56-passenger size).
- Every time another bus+operator is added, per-passenger-mile cost of the operation jumps.
- Costs of operating a train are much higher, but a train holds far more people, so costs don't go up as fast.

Outrageous Claim 3

Detroit metropolitan area (Southeast Michigan) has reached its limit of productive growth without urban rail; its stagnating population and productivity is a result

Claim 3: Detroit is choked by lack of rail

- Compared to other cities similar in size and economy to Detroit, we are lagging
  - I present circumstantial evidence here, not "proof"
- I've chosen 8 example cities in the same general size-range as Detroit

Each of these cities *except Detroit* has significant **miles of passenger rail** (next slide)

Metro	Population 2018 estimated
San Francisco--Oakland--San Jose, CA	8,841,475
Atlanta, GA	6,630,231
Toronto	5,928,040
Detroit--Ann Arbor--Flint, MI	5,353,002
Sydney	5,230,330
Melbourne	4,936,349
Seattle--Tacoma--Bremerton, WA	4,853,364
Singapore	3,994,300
Minneapolis--St. Paul, MN--WI	3,977,790

Claim 3: Detroit is choked by lack of rail

- Detroit metropolitan area (Southeast Michigan) has reached the limit of productive growth without urban rail; its **stagnating population** and productivity is a result

You probably knew this already

Population Growth 1990-2018

Detroit-Size Cities
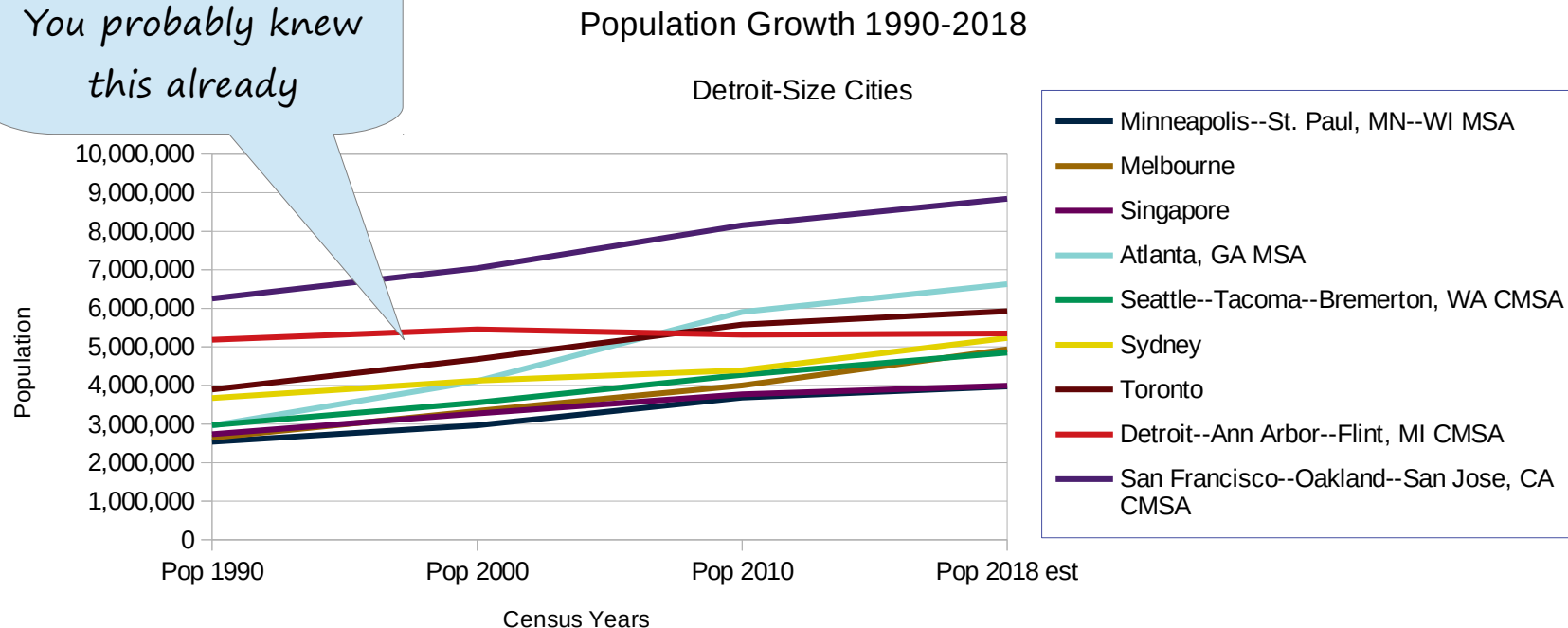
Claim 3: Detroit is choked by lack of rail

Population and GDP per capita

| Key	Metro
1	San Francisco--Oakland--San Jose, CA
2	Atlanta, GA
3	Toronto
4	Detroit--Ann Arbor--Flint, MI
5	Sydney
6	Melbourne
7	Seattle--Tacoma--Bremerton, WA
8	Singapore
9	Minneapolis--St. Paul, MN—WI

GDP Per Capita 2015

Detroit-Size Cities

GDP is about on a par with our peers (except well behind Singapore and Seattle)
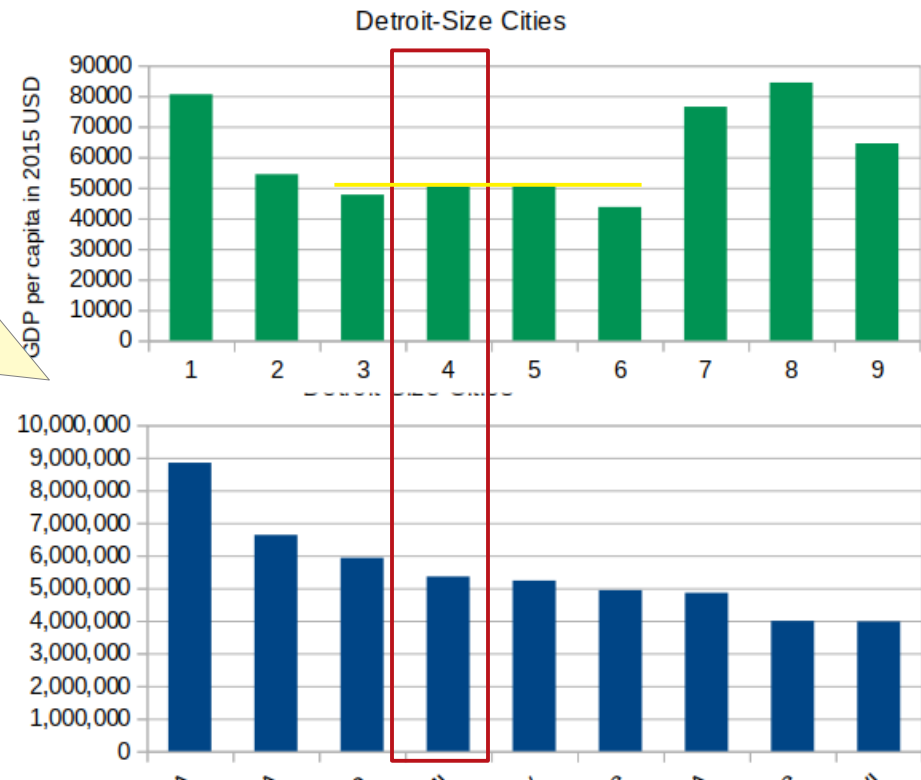
Claim 3: Detroit is choked by lack of rail

- But what about **growth** of GDP?
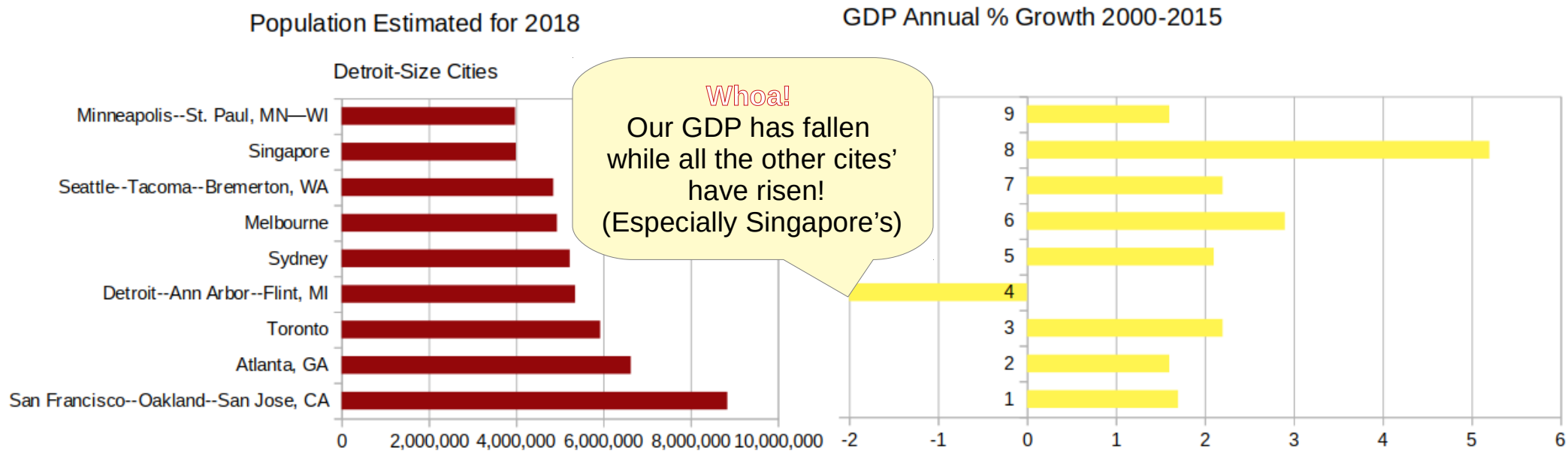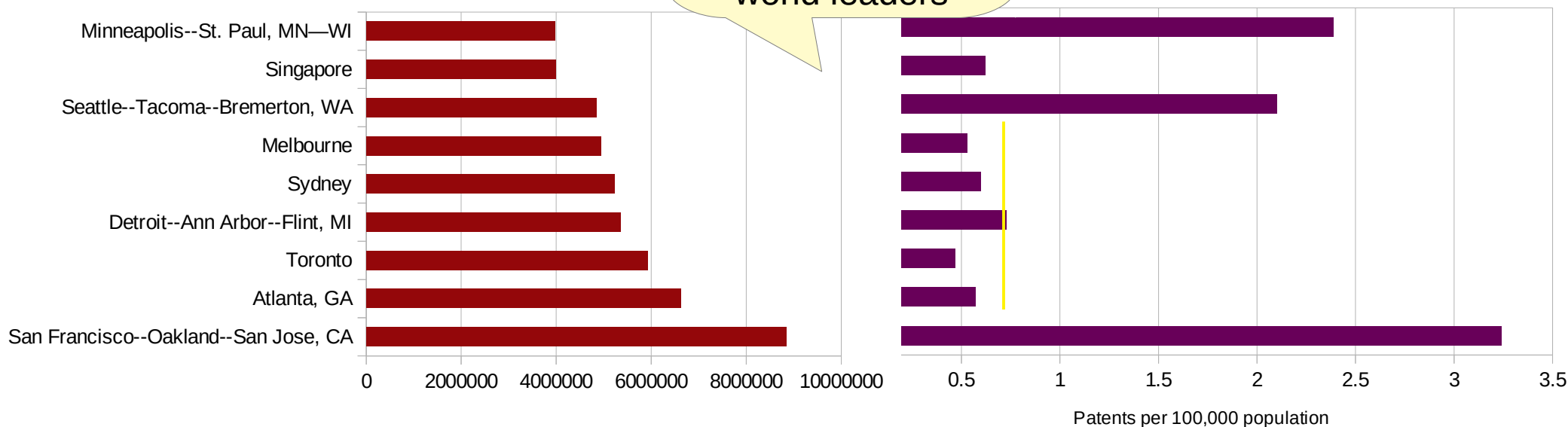
Claim 3: Detroit is choked by lack of rail

- **Patents per 100,000 people** – a measure of productivity for the information economy

Population Estimated for 2018

Detroit-Size Cities

Patents per 100,000 People, 2008-2012

A little ahead of our closest peers, but well behind world leaders
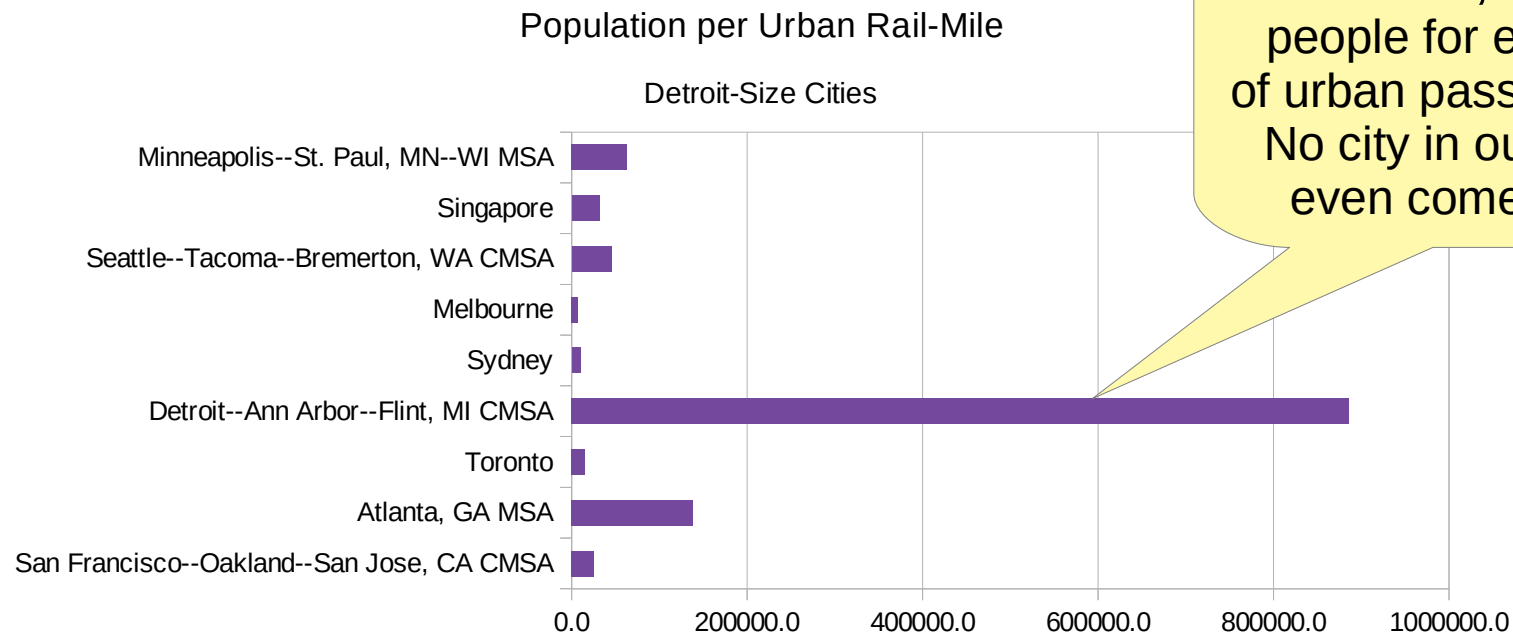

Patents per 100,000 population

Claim 3: Detroit is choked by lack of rail

Population per Passenger-Rail-Miles:
one measure of availability of rail transport

Population per Urban Rail-Mile

Detroit-Size Cities

886,259
people for each mile
of urban passenger rail:
No city in our league
even comes close!

Claim 3: Detroit is choked by lack of rail

Detroit metropolitan area (Southeast Michigan) has reached the limit of productive growth without urban rail; its stagnating population and productivity is a result

- Challenge for YOU: find out:
    - How has congestion grown in SEMCOG region in the last 20 years?
    - How much have traffic accidents (crashes) increased or decreased in that time span?

Outrageous Claim 4

Detroit needs many things, but effective urban rail is one which MUST be provided if the city is to grow and prosper.

- **Are you convinced? Why, or why not?**

Outrageous Claim 5

- As planning students and (future) planning professionals, you need to be aware of this.

- And if you care about Detroit, you need to work to build an effective urban passenger rail system here.

Claim 5: YOU need to work toward this goal

Advocacy Organizations you can work with:

- Michigan Association of Railroad Passengers
- Transportation Riders United
- Motor City Freedom Riders
- Rail Passengers Association (national)

Like-minded Organizations:

- Rail~Volution
- EcoCities
- UITP
- APTA