arpa.e digital transportation workshop

jason rugolo — program director

team:

justin manzo	technical contractor
geoff short	technical contractor
paul d'angio	technical contractor
mike kane	fellow

our theme for the day:

bits not atoms.

(or we will be miserable and doomed.)

171 flights

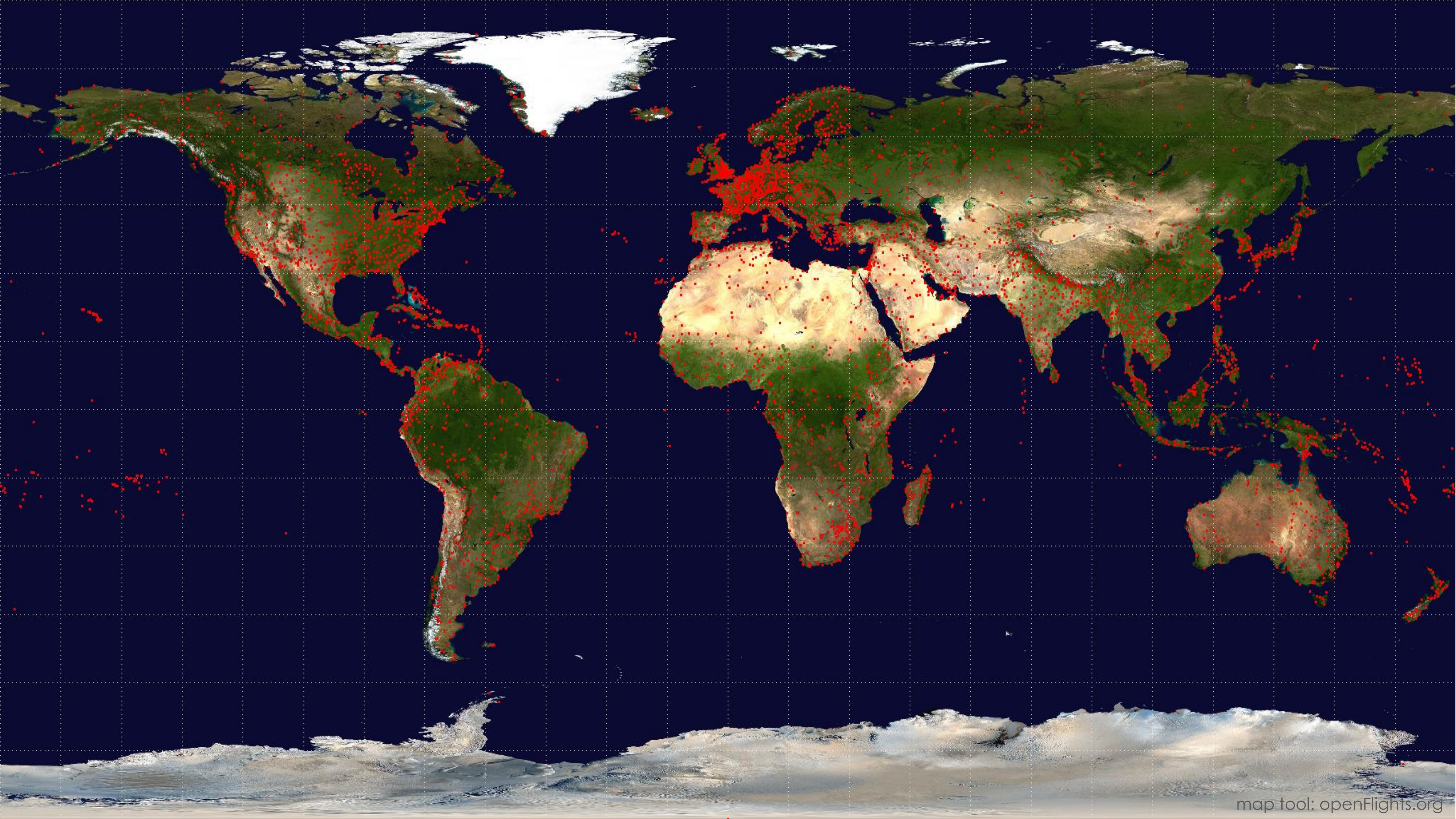
38 airports
10 carriers

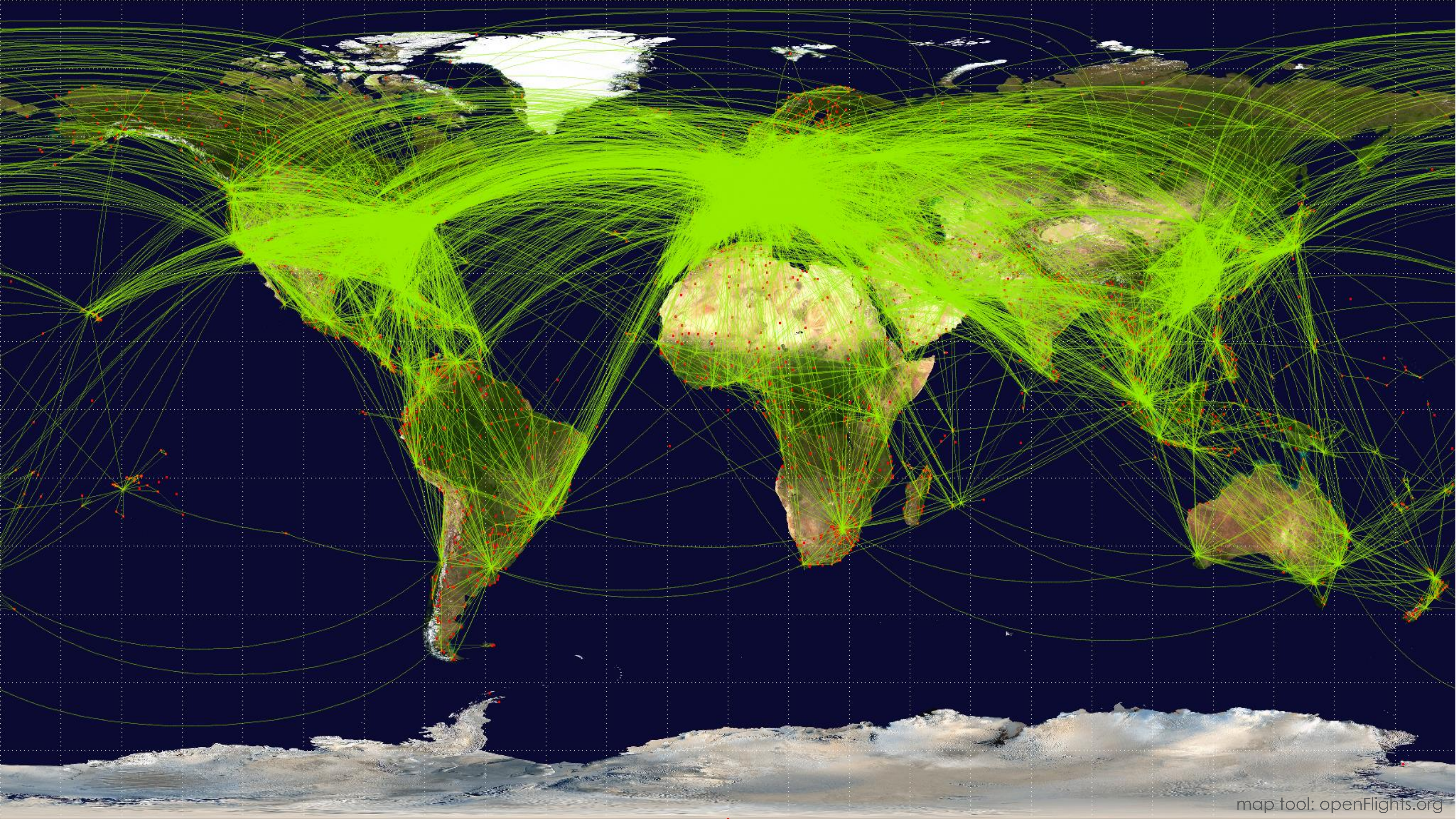
180,000 mi

18d 10h 41m

100% misery

map tool: openFlights.org


map tool: openFlights.org

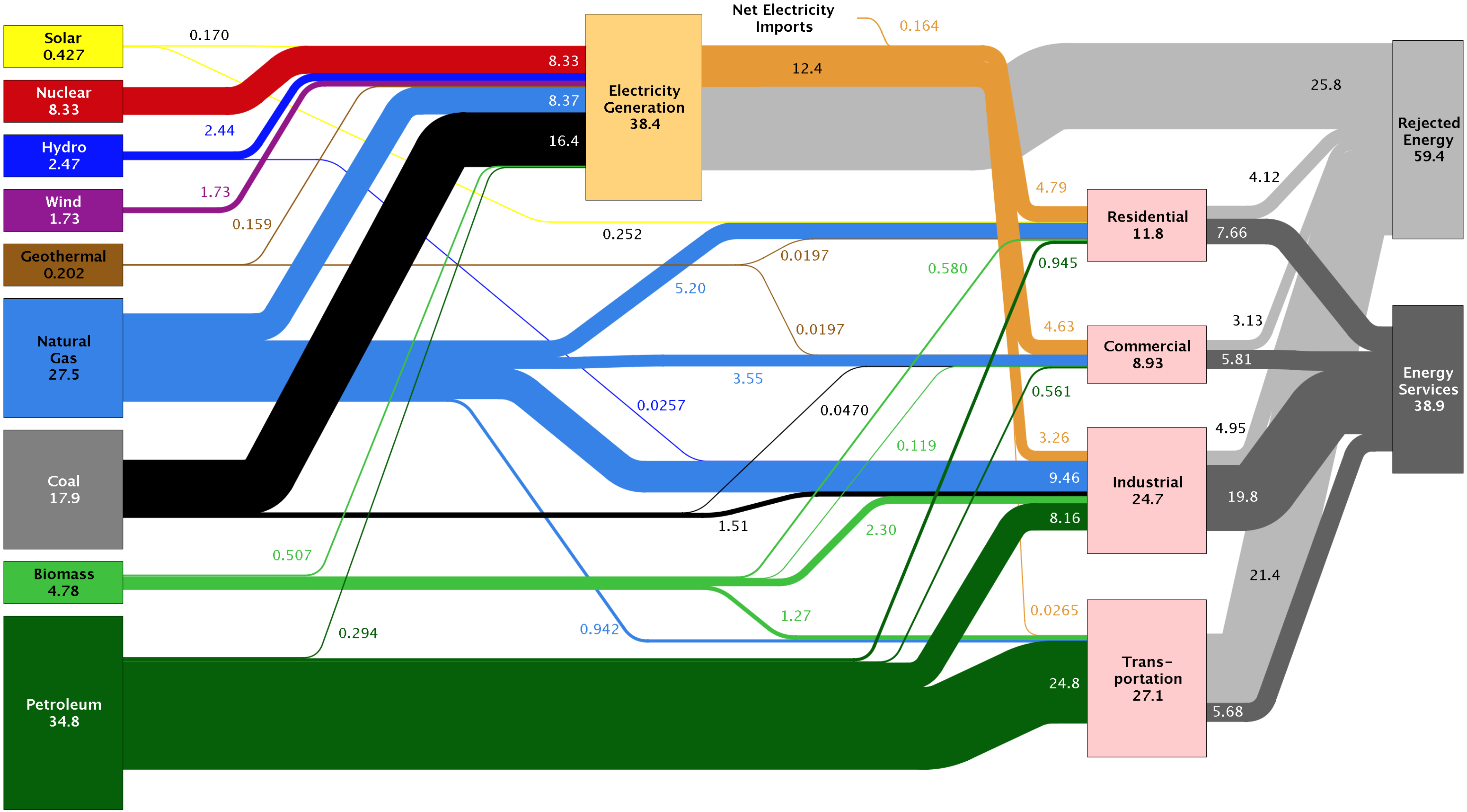

map tool: openFlights.org

air travel = 2 Q

passenger = 18 Q

Estimated U.S. Energy Use in 2014: ~98.3 Quads

Lawrence Livermore National Laboratory



Source: LLNL 2015. Data is based on DOE/EIA-0035(2015-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

arpa.e has invested in advanced transportation since the beginning

.natural gas vehicles
.electric vehicles
.lightweighting
.optimal route planning and incentives
.powertrain efficiency for autonomous vehicles
.etc

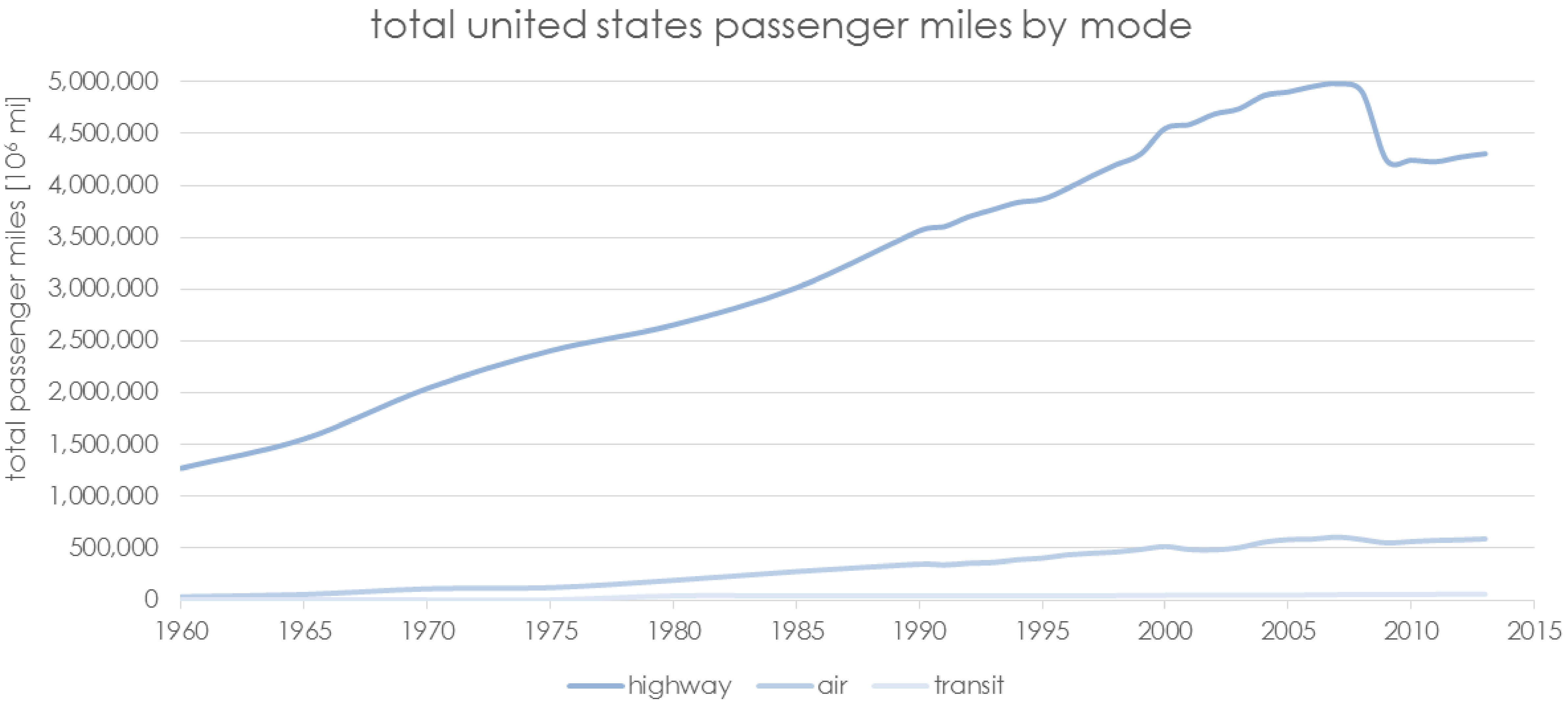
unifying theme:
the new technologies we develop must have market pull
(or else they won't matter)

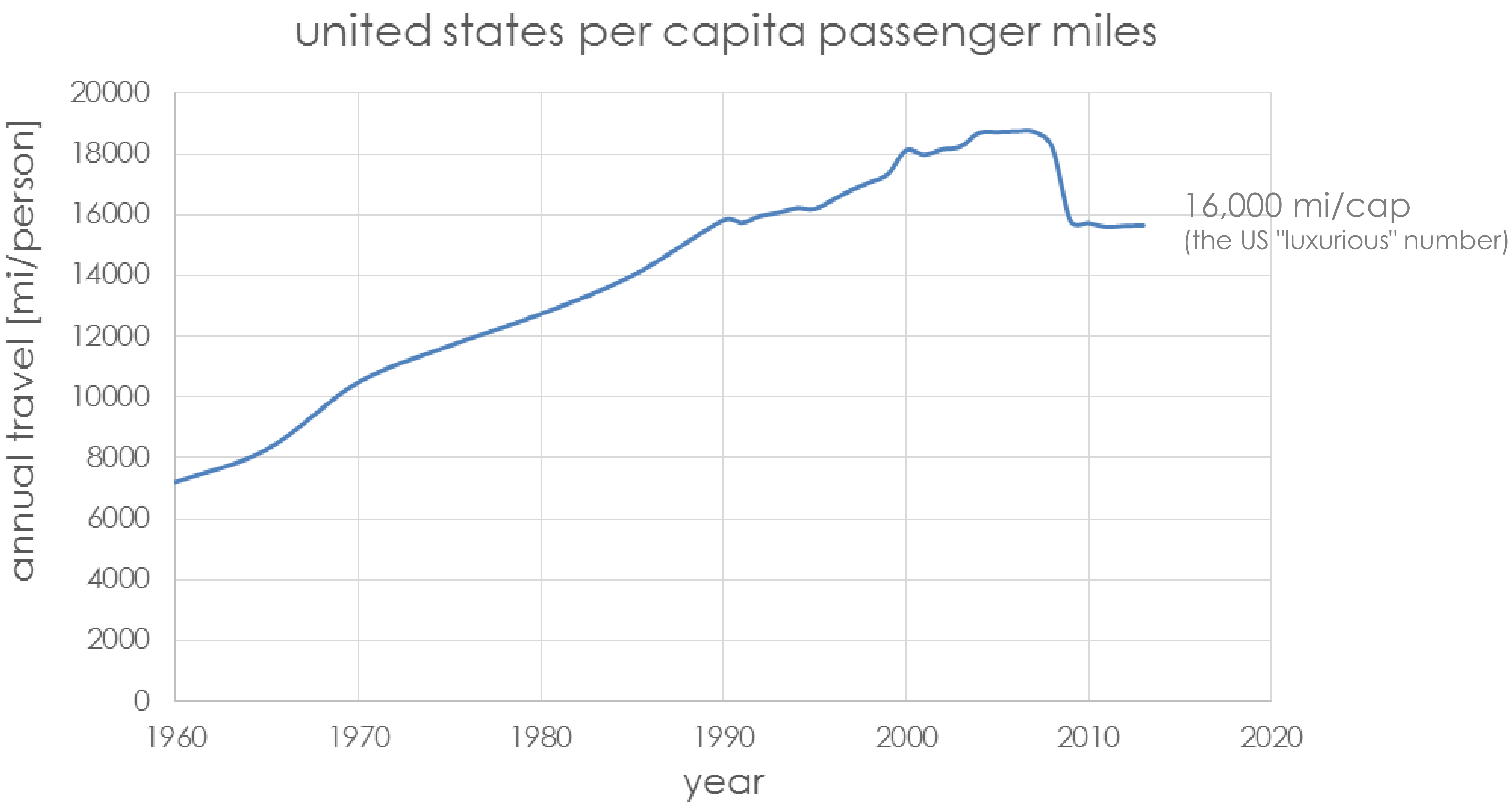
market pull => make transportation better => cheaper, faster, convenient

JEVON'S PARADOX

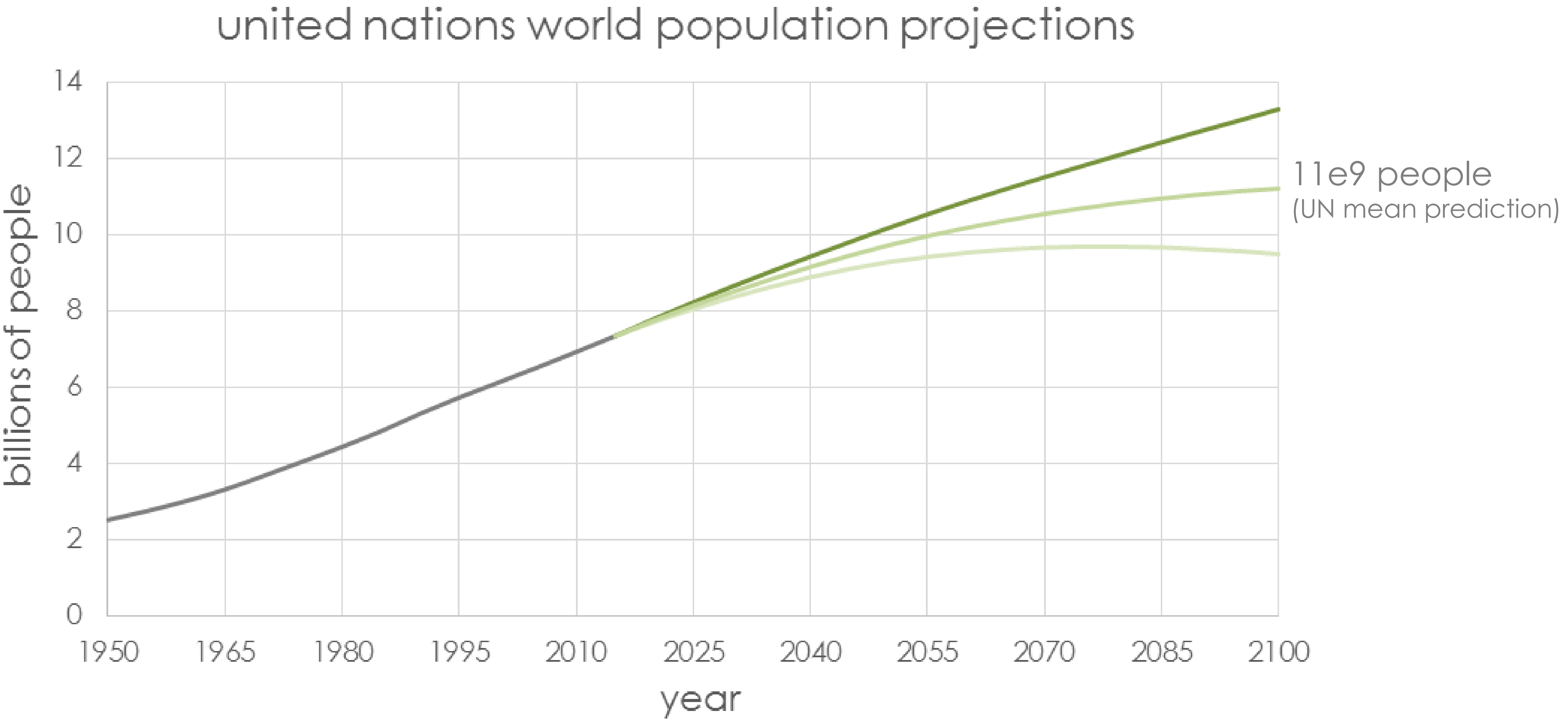
In economics, the **Jevons paradox** (/ˈdʒɛvənz/; sometimes **Jevons effect**) occurs when technological progress increases the efficiency with which a resource is used (reducing the amount necessary for any one use), but the rate of consumption of that resource rises because of increasing demand.[1] The Jevons paradox is perhaps the most widely known paradox in environmental economics.[2] However, governments and environmentalists generally assume that efficiency gains will lower resource consumption, ignoring the possibility of the paradox arising.[3]

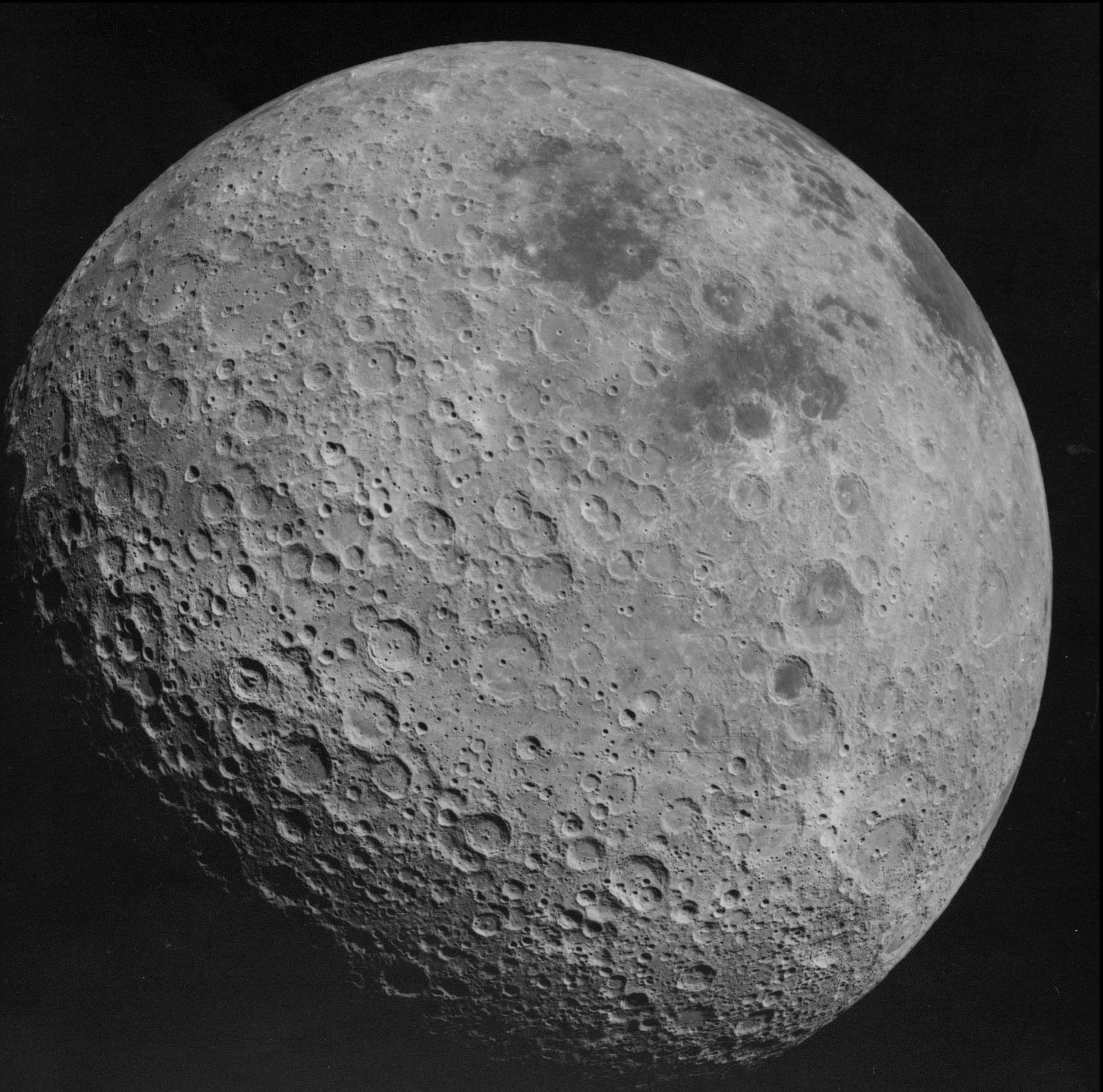
-Wikipedia.


total united states passenger miles by mode
total passenger miles [10^6 mi]
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
highway
air
transit



united states per capita passenger miles
annual travel [mi/person]
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1960
1970
1980
1990
2000
2010
2020
year
16,000 mi/cap
(the US "luxurious" number)

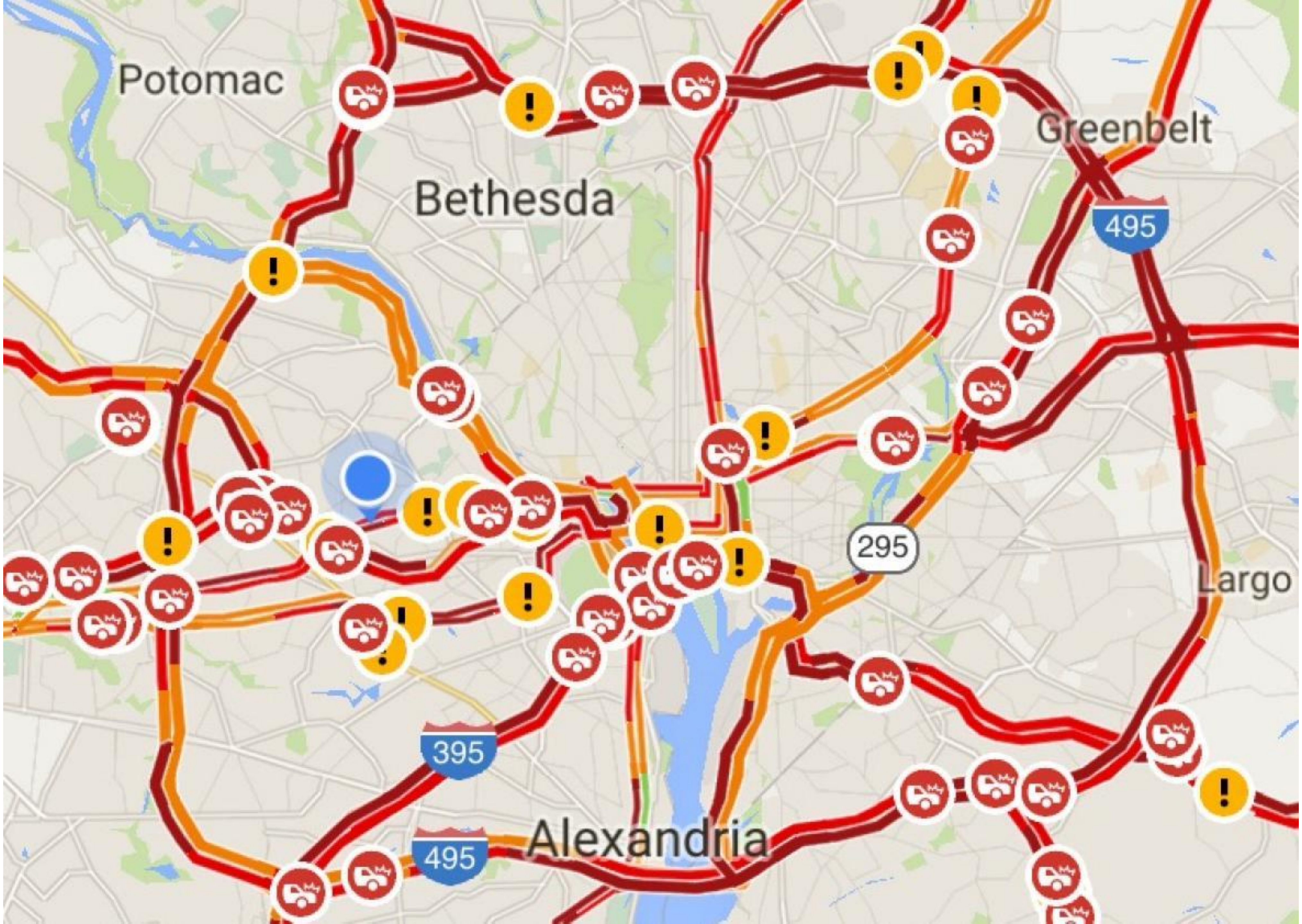

united nations world population projections
billions of people
14
12
10
8
6
4
2
0
1950
1965
1980
1995
2010
2025
2040
2055
2070
2085
2100
year
11e9 people
(UN mean prediction)



1 moon round trip

= 460,200 mi

= 36% of lifetime miles


Potomac
Bethesda
Greenbelt
495
295
Largo
395
495
Alexandria

China National Highway 110 traffic jam

From Wikipedia, the free encyclopedia

The **China National Highway 110 traffic jam** was a recurring[1] massive traffic jam that began to form on August 14, 2010, mostly on China National Highway 110 (G110) and Beijing–Tibet expressway (G6), in Hebei and Inner Mongolia.[2][3] The traffic jam slowed down thousands of vehicles for more than 100 kilometres (60 mi) and lasted for more than ten days.[3][4][5] Many drivers were able to move their vehicles only 1 km (0.6 mi) per day, and some drivers reported being stuck in the traffic jam for five days.[5] It is considered to be one of the longest traffic jams by some media.[6][7][8]

Contents [hide]

1 Cause
2 Effect and end
3 References
4 External links

Cause [edit]

Traffic on the China National Highway 110 had grown 40 percent every year in the previous several years, making the highway chronically congested.[5] The traffic volume at the time of the incident was 60% more than the design capacity.[9]

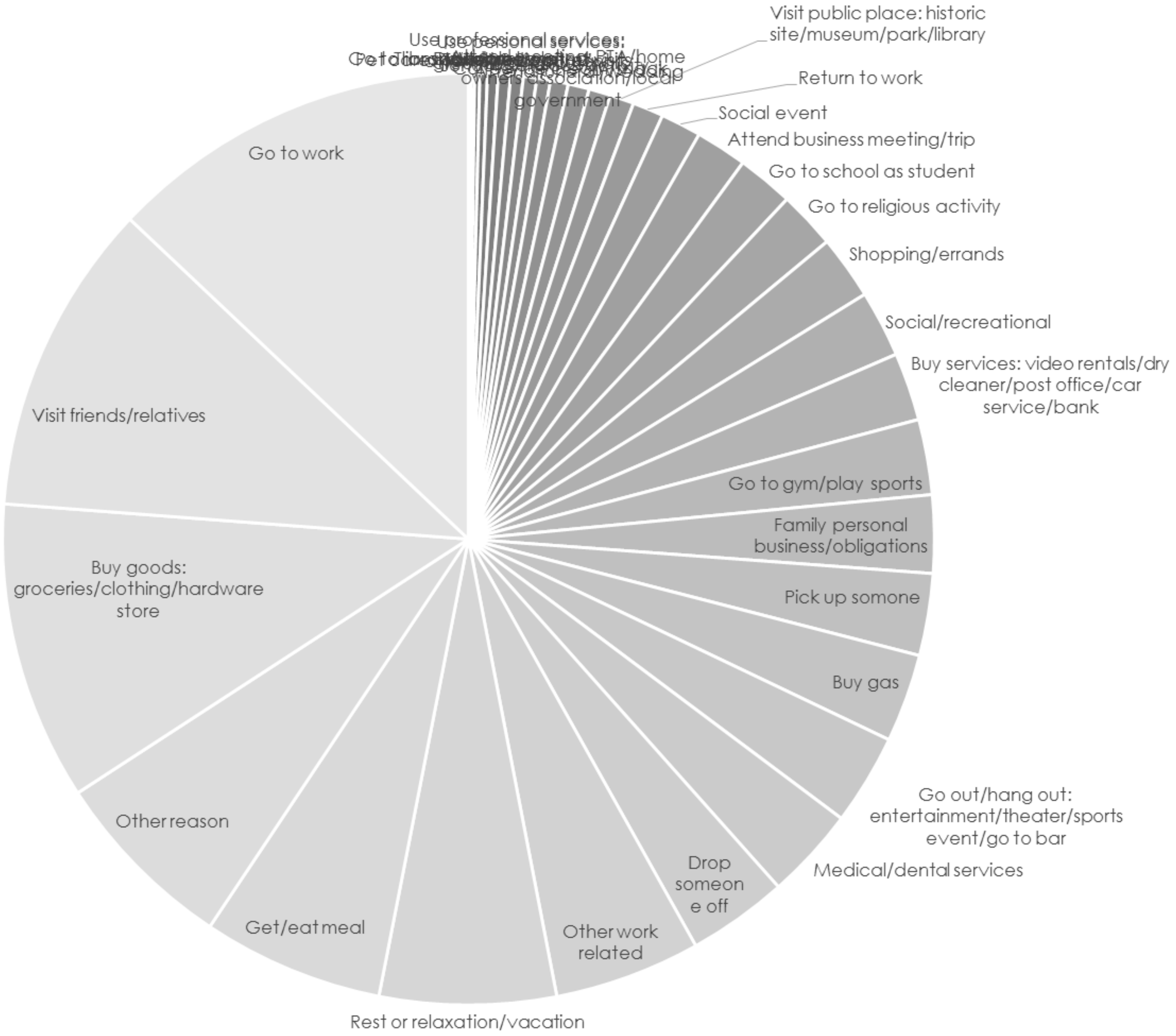
The cause of the traffic jam was reported to be a spike in traffic by heavy trucks heading to Beijing, along with

In 1894, the *Times of London* estimated that by 1950 every street in the city would be buried nine feet deep in horse manure.

One New York prognosticator of the 1890s concluded that by 1930 the horse droppings would rise to Manhattan's third-story windows.

150,000 horses at 15-30 lbs/day > 3,000,000 lbs/day

nhts travel purposes



passenger transportation trichotomy

we transport ourselves with the objective of:

communication

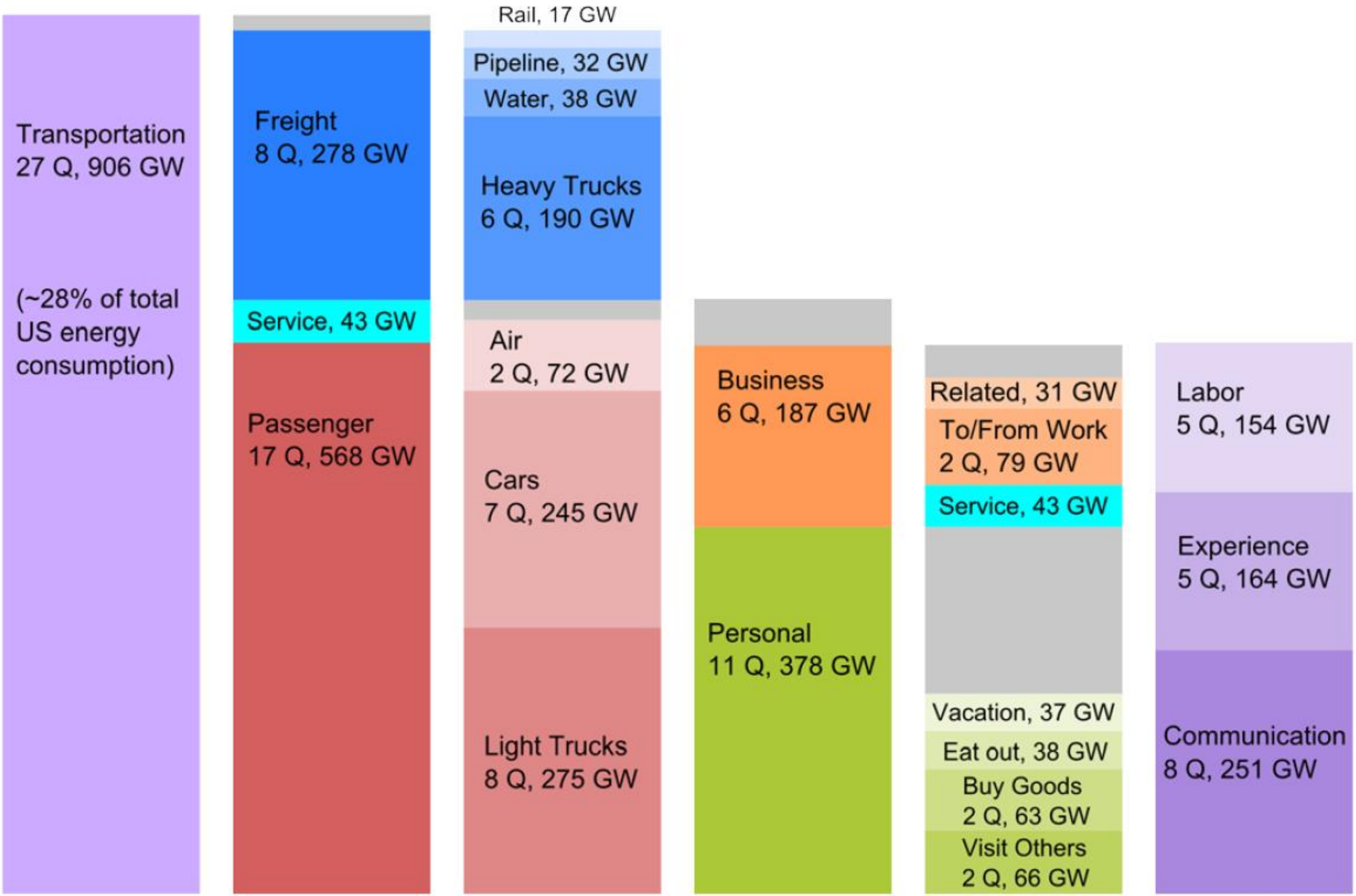
to convey or consume information

labor

to physically affect environment

experience

predominantly to "experience"



Transportation
27 Q, 906 GW
(~28% of total US energy consumption)
Freight
8 Q, 278 GW
Service, 43 GW
Passenger
17 Q, 568 GW
Rail, 17 GW
Pipeline, 32 GW
Water, 38 GW
Heavy Trucks
6 Q, 190 GW
Air
2 Q, 72 GW
Cars
7 Q, 245 GW
Light Trucks
8 Q, 275 GW
Business
6 Q, 187 GW
Personal
11 Q, 378 GW
Related, 31 GW
To/From Work
2 Q, 79 GW
Service, 43 GW
Vacation, 37 GW
Eat out, 38 GW
Buy Goods
2 Q, 63 GW
Visit Others
2 Q, 66 GW
Labor
5 Q, 154 GW
Experience
5 Q, 164 GW
Communication
8 Q, 251 GW

someday, we will only travel when we want to.

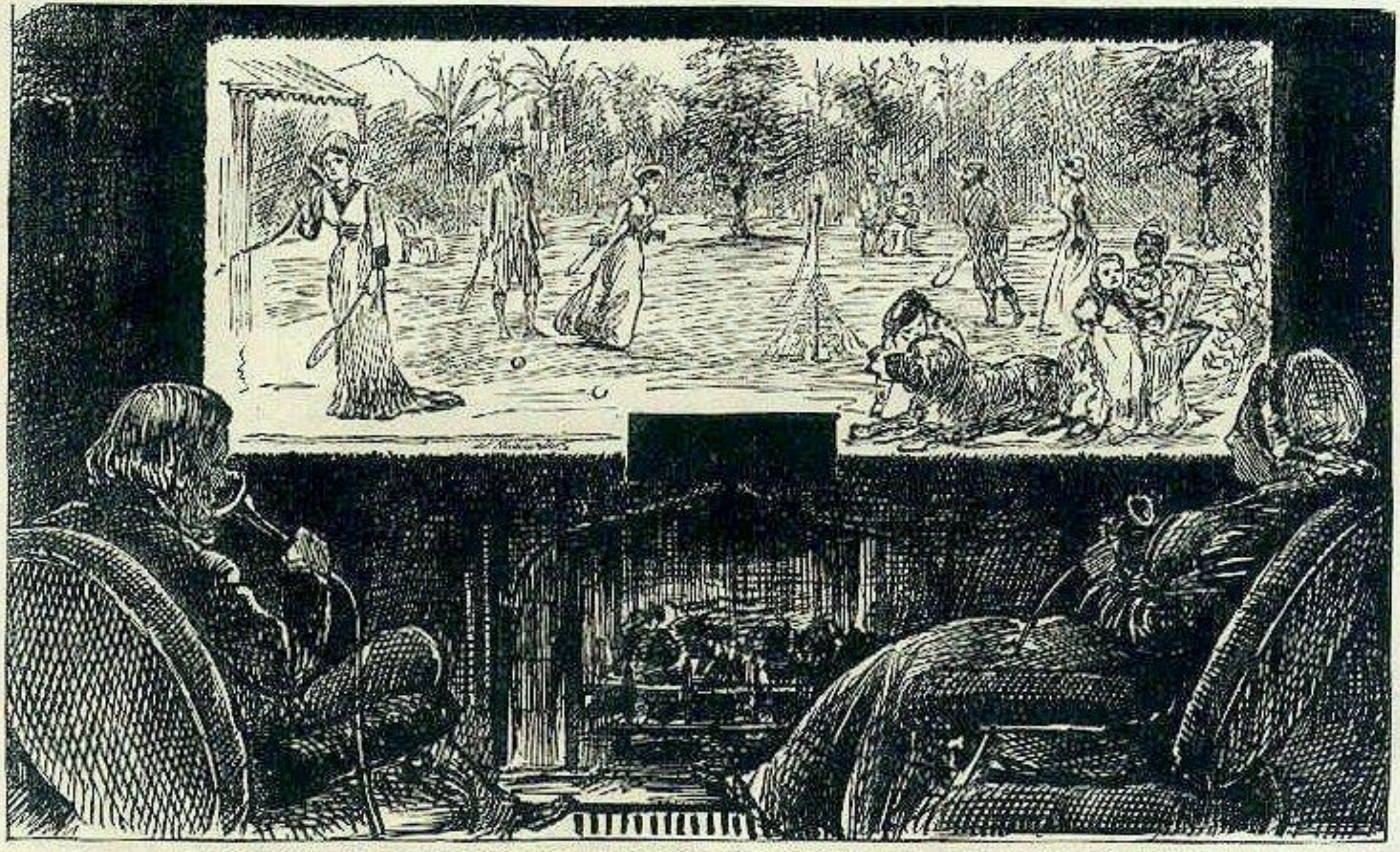
(and transportation energy will plummet) day 1: telecommunication

day 2: telelabor

opportunities in telecommunication

Jason Rugolo, Ph.D.	Program Director
Justin Manzo, Ph.D.	Tech SETA
Geoff Short, Ph.D.	Tech SETA
Paul D'Angio, Ph.D.	Tech SETA
Mike Kane, Ph.D.	Fellow

an ideal telecommunication technology would enable me to call home and feel similar to as if i were there, or to be introduced to a new business associate and form a trustful bond. it would generally convey all of the minutia of human interaction in pleasing fidelity with an unnoticeable decrease in simultaneity. it would be preferable to me over traveling even short distances.



EDISON'S TELEPHONOSCOPE (TRANSMITS LIGHT AS WELL AS SOUND).

(Every evening, before going to bed, Pater- and Materfamilias set up an electric camera-obscura over their bedroom mantel-piece, and gladden their eyes with the sight of their Children at the Antipodes, and converse gaily with them through the wire.)

Paterfamilias (in Wilton Place). "BEATRICE, COME CLOSER, I WANT TO WHISPER." *Beatrice (from Ceylon).* "YES, PAPA DEAR."

Paterfamilias. "WHO IS THAT CHARMING YOUNG LADY PLAYING ON CHARLIE'S SIDE?"

Beatrice. "SHE'S JUST COME OVER FROM ENGLAND, PAPA. I'LL INTRODUCE YOU TO HER AS SOON AS THE GAME'S OVER!"

what does this vision imply?

simultaneity

eye contact, gaze

3D sight
depth of field
changing focus
resolution

3D hearing
sound clarity
timbre of voice

agency

posture
hand expressions
body language
interpersonal distance

microexpressions
eye roll, etc
side glances

immersion (v. skype window)

flattering light, angles, etc

very imperfect history of communications innovations

c. 2.4 mya to 50kya	Human speech
c. 10,000 BC	Roads
c. 8200 BC	Man Powered Boats
c. 6000 BC	Writing
c. 5500 BC	Sailboats
c. 4000 BC	Paved Roads
c. 3500 BC	Wheel
c. 3500 BC	Wagon
c. 3000 BC	Money
c. 2400 BC	Mail
c. 2000 BC	Paper
c. 600 BC	Wagonways
131 BC	Newspaper
c. 0 AD	Pigeon post
c. 200 AD	Woodblock printing
1440 AD	Printing press
1792 AD	Optical telegraph
1783 AD	Steamboat
1804 AD	Steam Locomotive
1816 AD	Electronic telegraph
1876 AD	Telephone
1886 AD	Automobile
c. 1920s	Radio broadcasting
c. 1928	Television broadcasting
1927 AD	Videotelephony
1952 AD	Commercial Airliner
c. 1970 AD	Videoconference
1973 AD	Chatrooms
1973 AD	Email
1976 AD	Personal Computer
1982 AD	Internet
1983 AD	Mobile Telephone
1992 AD	Text Message
1996 AD	Smartphone

eye-related developments

camera sensors
high resolution screens
projector technolgoies
3D displays
HMDs, VR, AR

ear-related developments

microphones
speakers
noise cancellation
3D audio

touch-related developments

haptic feedback
physics engines

trends

massive computational power for cheap

high bandwidth internet everywhere

game and movie rendering, physics engines

consumer adoption of digital interaction

cisco IX5000

IX5000

simultaneity

eye contact, gaze

3D sight
depth of field
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interpersonal distance

microexpressions
eye roll, etc
side glances

immersion (v. skype window)
committment (showing up)

flattering light, angles, etc

second life

second life

simultaneity

eye contact, gaze

3D sight
depth of field
changing focus
resolution

3D hearing
sound clarity
timbre of voice

agency

posture
hand expressions
body language
interpersonal distance

microexpressions
eye roll, etc
side glances

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flattering light, angles, etc


Oculus
Oculus
Development Kit 2


Gear VR
Oculus


OSVR
OSVR


SONY


htc


FOVE

abbreviated technical space

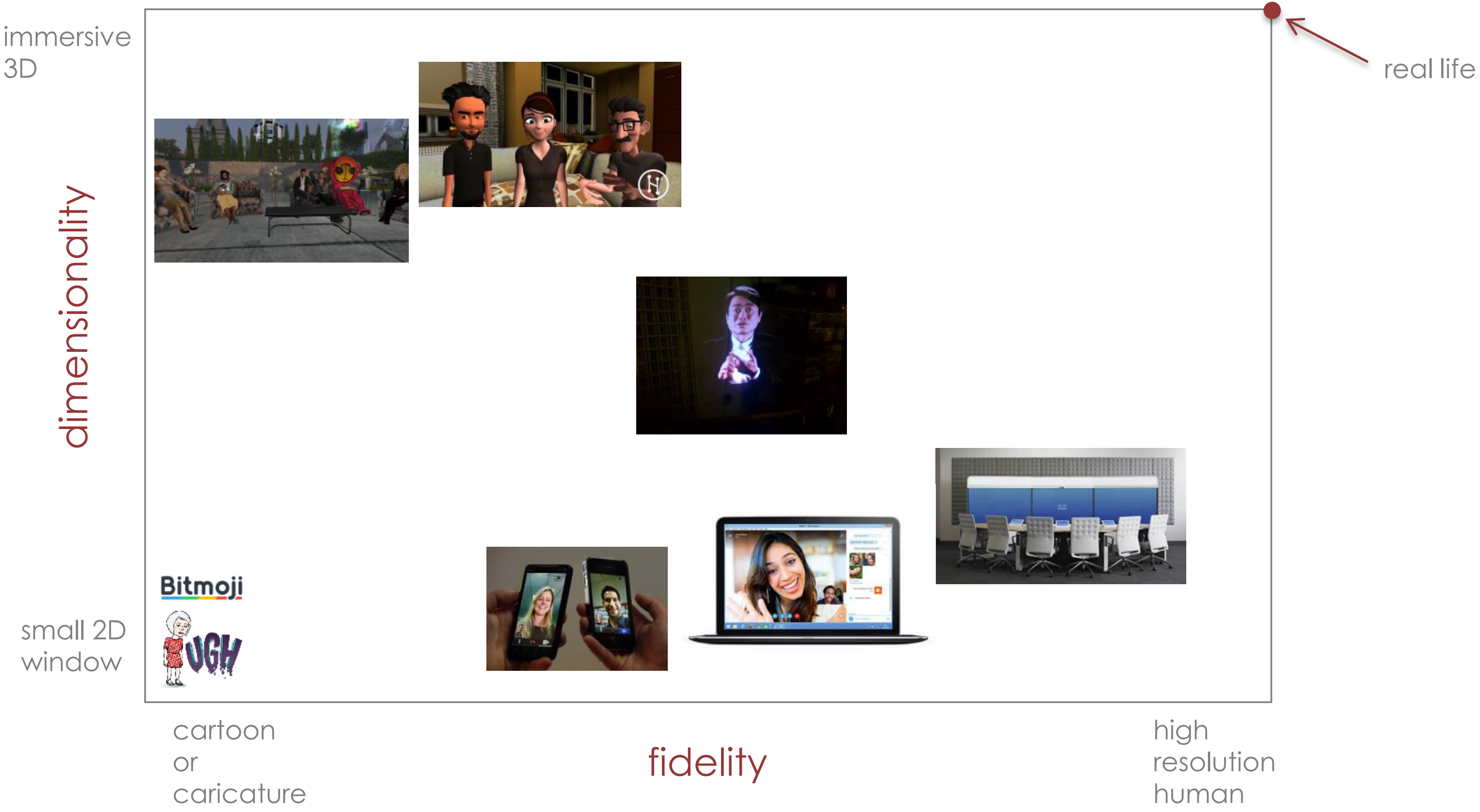
	hardware	*software*	*knowledge*
virtual reality	parallax headsets direct eye projection holodecks, caves brain computer interface limb/gesture tracking galvanic vestibular stimulation olfactory reproduction	rendering physics engines virtual space standards compression	acceptance uncanny valley attributes for "real"
3d telepresence	holography pepper's ghost glasses-free 3D displays	point cloud variable compression face physics	latency eye contact resolution
2d telepresnece	eye contact dedicated hardware	eye contact variable compression	latency eye contact
augmented reality	see through headsets direct eye projection lightfield projection limb/gesture tracking	rendering physics engines AR standards	acceptance value
physical telepresence	robotic arms high torque density actuation haptic feedback human interfaces	object physics models predictive motion	latency kinematics actuator cost curve

the digital human is a common need


USC Institute for
Creative Technologies
NVIDIA
GEFORCE
GTX

http://i.imgur.com/YYVPTR9.gif

digital presence technical space



N.B. presence = audiovisual

how can arpa.e make a difference?

quarterly R&D

msft	2.98B
goog	2.75B
fb	1.05B
csco	1.55B
hp	0.85B
arpa.e	0.003B

Rank 2011	Rank 2010	Company	R&D Spending: 2011, $US Billions	R&D Spending: Change from 2010	R&D Spending: As a % of Sales	Headquarters Location	Industry
1	6	Toyota	$9.9	16.5%	4.2%	Japan	Auto
2	3	Novartis	$9.6	5.5%	16.4%	Europe	Healthcare
3	1	Roche Holding	$9.4	-2.1%	19.6%	Europe	Healthcare
4	2	Pfizer	$9.1	-3.2%	13.5%	North America	Healthcare
5	4	Microsoft	$9.0	3.4%	12.9%	North America	Software and Internet
6	7	Samsung	$9.0	13.9%	6.0%	Asia	Computing and Electronics
7	5	Merck	$8.5	-1.2%	17.6%	North America	Healthcare
8	11	Intel	$8.4	27.3%	15.5%	North America	Computing and Electronics
9	9	General Motors	$8.1	15.7%	5.4%	North America	Auto
10	8	Nokia	$7.8	0%	14.5%	Europe	Computing and Electronics
11	14	Volkswagen	$7.7	26.2%	3.5%	Europe	Auto
12	10	Johnson & Johnson	$7.5	10.3%	11.6%	North America	Healthcare
13	16	Sanofi	$6.7	15.5%	14.4%	Europe	Healthcare
14	12	Panasonic	$6.6	6.5%	6.6%	Japan	Computing and Electronics
15	17	Honda	$6.6	15.8%	6.5%	Japan	Auto
16	13	GlaxoSmithKline	$6.3	3.3%	14.3%	Europe	Healthcare
17	15	IBM	$6.3	5.0%	5.9%	North America	Computing and Electronics
18	19	Cisco Systems	$5.8	9.4%	13.5%	North America	Computing and Electronics
19	26	Daimler	$5.8	26.1%	3.9%	Europe	Auto
20	18	AstraZeneca	$5.5	3.8%	16.4%	Europe	Healthcare
		TOP 20 TOTAL:	**$153.6**	**9.9% Avg.**	**8.3% Avg.**		

Source: Bloomberg data, Booz & Company we invest in high technology risk R&D