

Geo-Innovations, Past, Present, and Future: Where Are We Going?

Geo-Omaha 2023



► Kord Wissmann, PhD, PE, D.GE . | Geopier Foundation Company

► Omaha, NE | Feb 2023

Geo-Innovations 2022

1. Our Shared History

2. The Golden Age

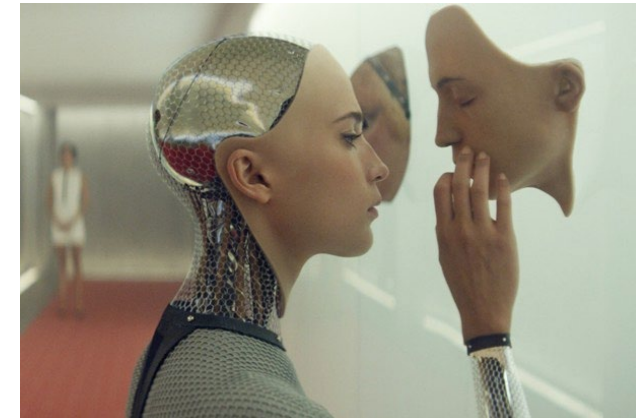
3. What Dreams May Come

Disclaimer:

“This presentation does not necessarily reflect the views of ASCE, the GI, our conference organizers, or this television station.”

*[and many of the supporting images are straight from the **interweb** anyways so....]*

Remember how we felt at the beginning?

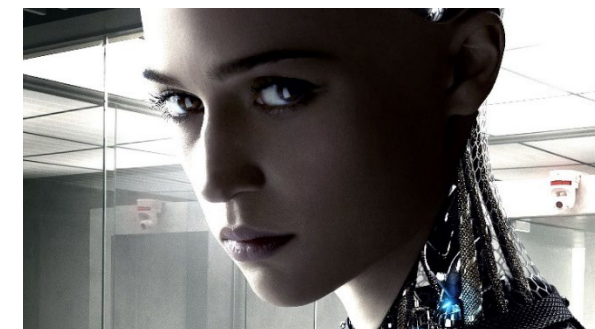
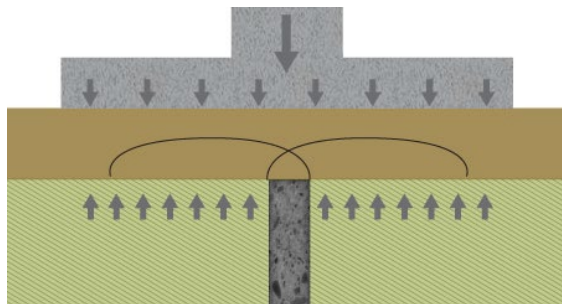
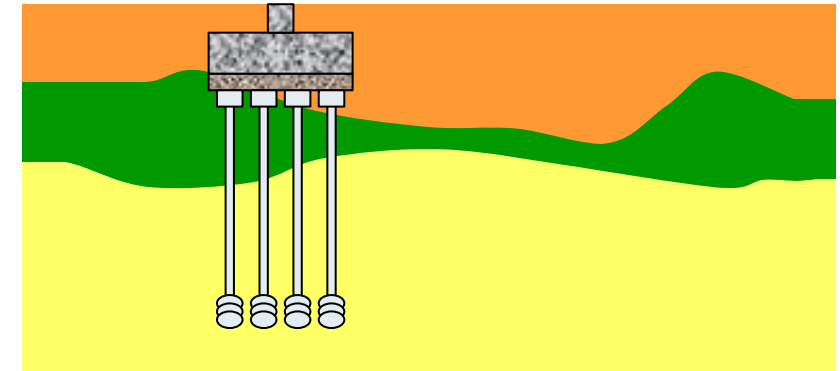
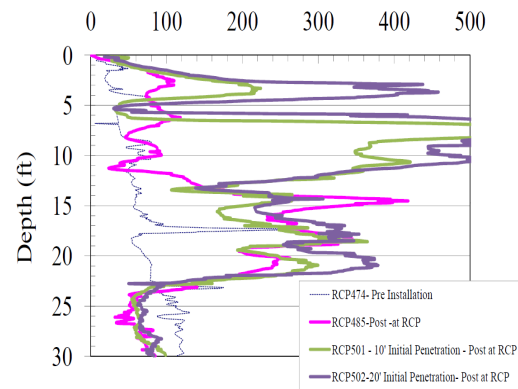
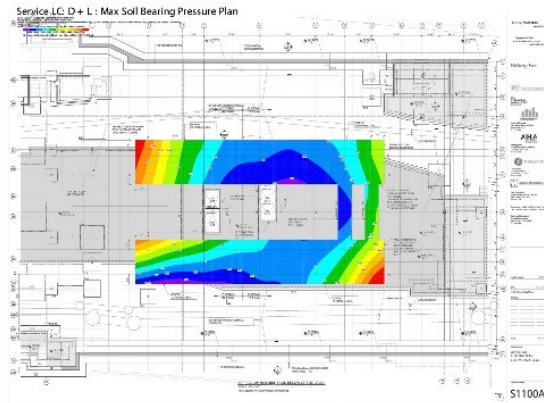


Remember our first date at the U?

For me it was just a few (37!) *years ago*...

Where we first fell for.....

Geo-engineering...



My first love?

Remember the Honeymoon?



My love was called..."Harding Lawson"

Remember those early rocky times?

After 3-4 years in the field, I felt like I needed some marriage counseling

- I got my “romance” back after switching jobs....anybody else like me?



We then retook our vows..... with another lover.

(for me, her name was Shannon / Wilson ❤️❤️)

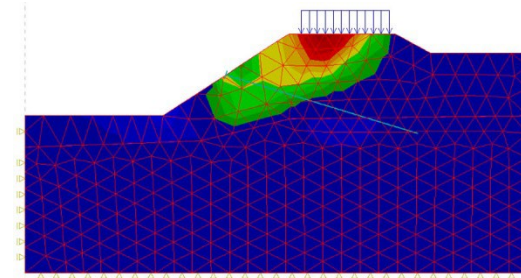
[Our relationship lasted 4 years]

The Strained Relationship

With time, the second marriage strained again....because of the *gap in expectations*:

The Promise:

- Exciting engineering..... solve hard problems.
- Do a great job.....work on neat projects.



The Reality:

- Timesheets / billability.....small budgets.
- “Bid” to win we can’t quite do what we’d like to do.



And we face some tough questions when we write our proposals...

But it wasn't always this way....

Where we have been – Our profession at its start?



Our ancestors built some great things – how?

Pre-historic “observational method” – a mixture of experimentation, art, and geometric rules.

The ancients at “ground improvement”



Egyptians > 2000 years ago: Over-excavation below pyramids.

Babylonians > 1500 years ago: Earth reinforcement with reeds.

Chinese > 1500 years ago: Tamping with stones / earth reinforcement.



The Great Cathedrals



St. Paul's
Settlement



Malmesbury Abbey
Collapse

Venice & Mexico City
Consolidation



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Everything Changed with Industrial Revolution

Prior to the mid 1800's Western economies driven by agriculture, crafts, and trading:

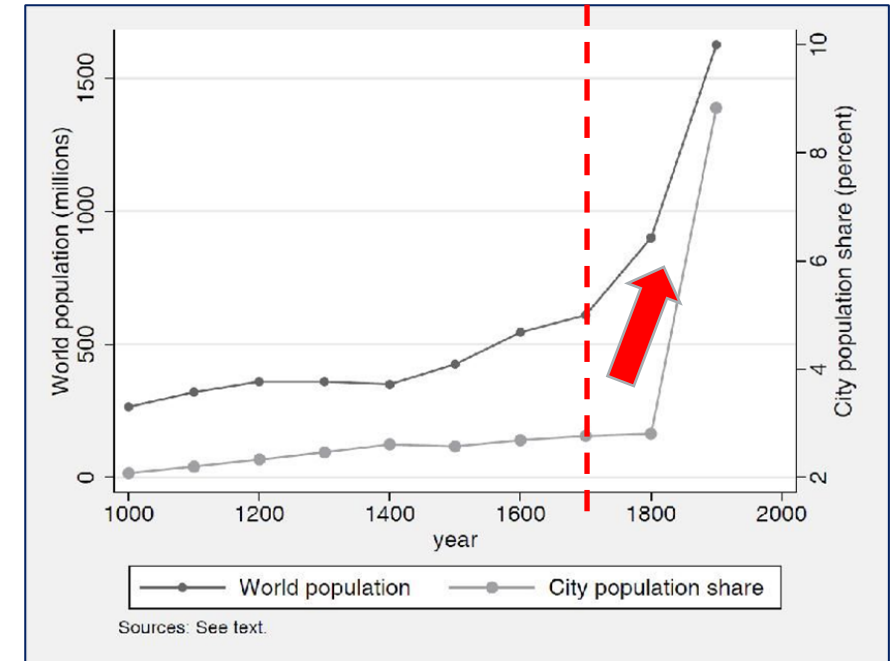
- **Land** = ability to put “bread on the table”
- **Wealth concentrated** to those with ability to leverage land use.
- Importance of **Craftsman Guilds**: “Middle Class”



Everything Changed with Industrial Revolution

Revolution harnessed **math/science** to create *enormous value*

- **Automation:** so many things all at once
- Disappearance of Craftsman
- **Population BOOM:** natural resources and transportation
- **Urbanization**
- Food still important....when industrialized



Population & Urbanization BOOM ~ late 1700s

Corresponding GDP / Capita BOOM



The Industrial Revolution Facilitated by Engineering

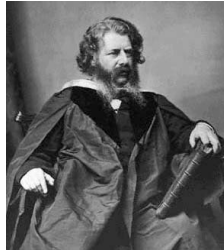
Our “modern” Geo engineering roots were French

1700s

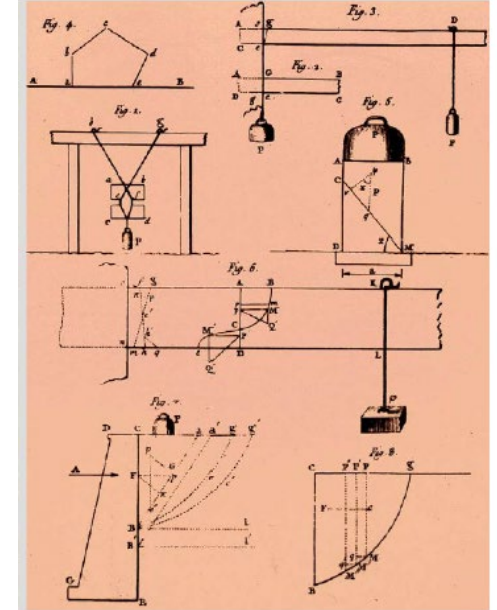
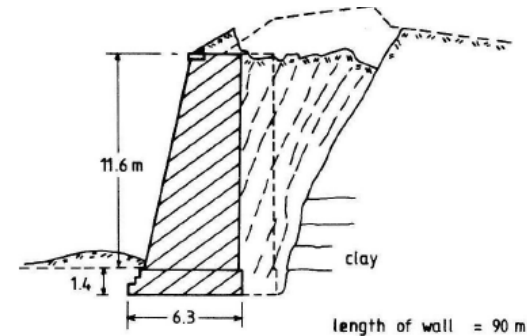


Coulomb applied mathematics to define *shear strength*.
Determined sliding surfaces in slopes and walls.

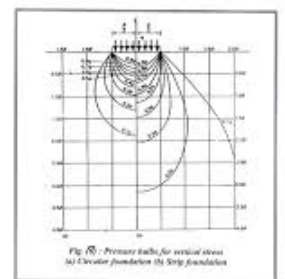
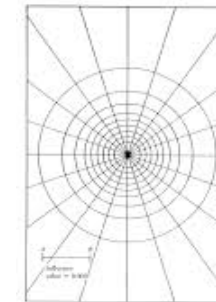
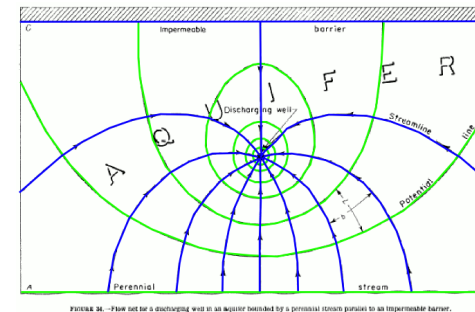
1800s



Wm. J.M. Rankine:
Passive & active earth pressures



Henry D'arcy:
Permeability



Boussinesq:
Elasticity theory

In the 1900's, the Germans (Austrians) took charge

1900s



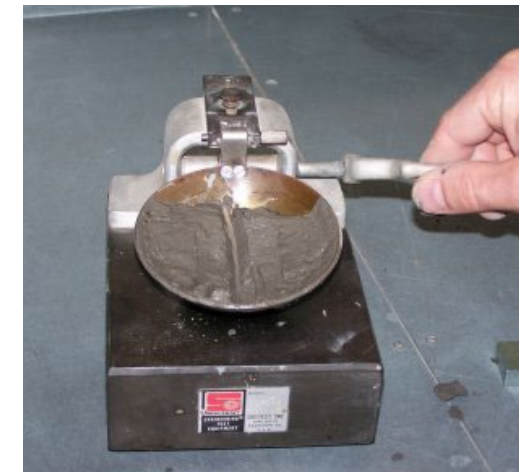
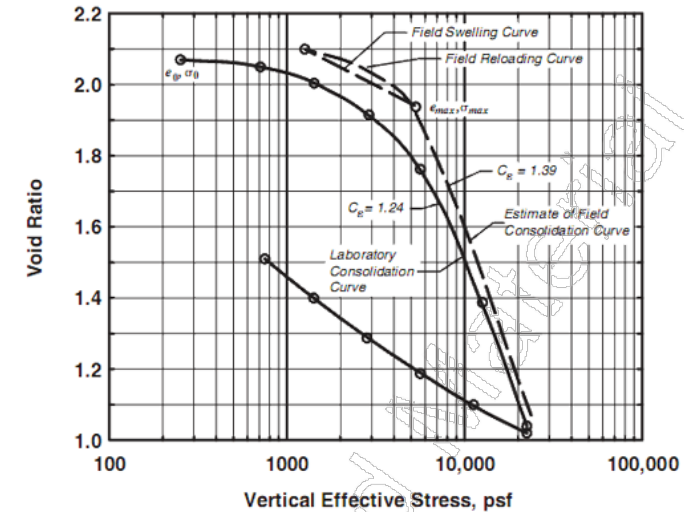
Karl Terzaghi: Effective stress and consolidation



Arthur Casagrande: Plasticity

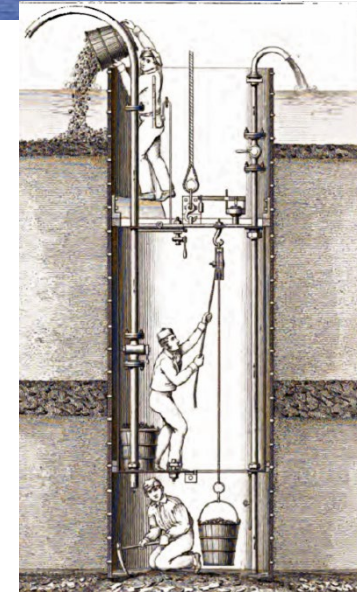


Kurt Atterberg: Self-named "limits"



Our ability to create strong materials and use engineering to predict response drove applications in the Civil World

- ▶ John & Washington Roebling conceived of, designed, and constructed the Brooklyn Bridge, 1870 - 1883



Urban population growth needed water supply



Los Angeles Aqueduct:
1908-1913

Bringing the Great Dams of the West



Hoover Dam

Grand Coulee Dam

Early forms of “modern” ground improvement commenced in the 1930’s

- **Vibroflotation** developed by J. Keller in Germany in the 1930’s for compacting sand.
- **Prefabricated Vertical Drains** (PVDs) “wick drains” invented by W. Kjellman at SGI in the 1940’s.
- **Soil Mixing** developed by U.S. firm Intrusion Prepakt in 1950’s with most of subsequent development in Sweden and Japan.

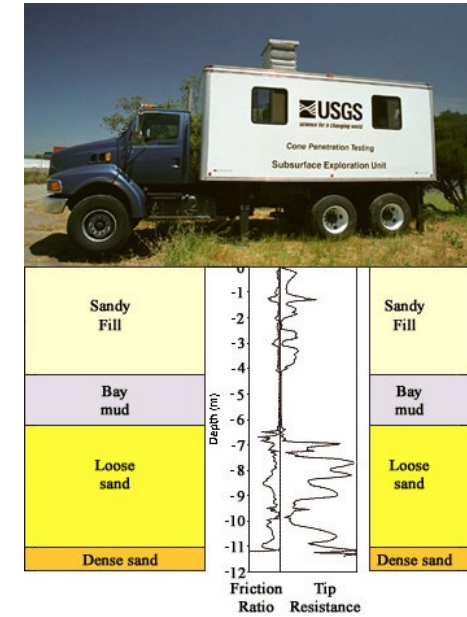
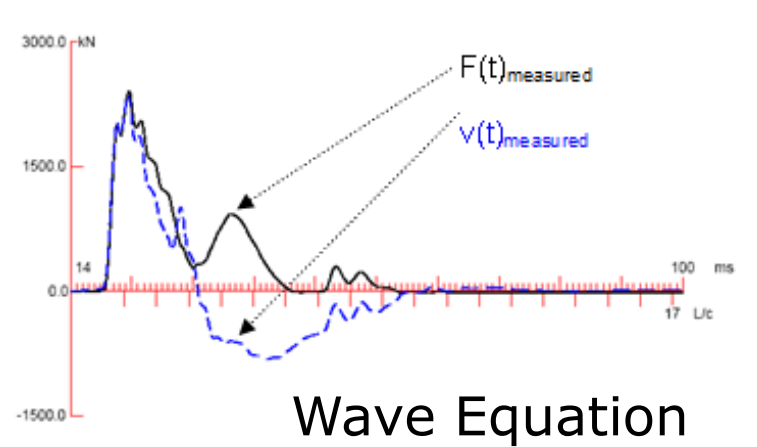


Things Heated up in the 40's and 50's

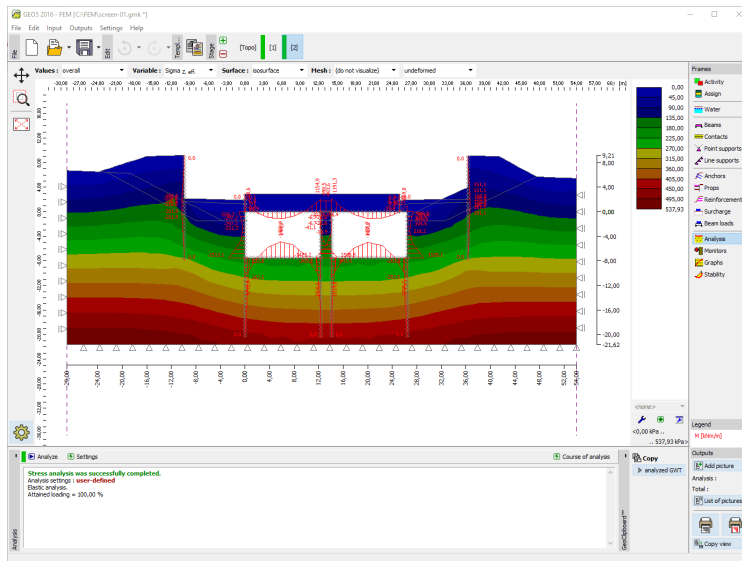
- *Terzaghi hosted the first International Conference*
- *Controlled Modulus Columns & Vibro Concrete Columns*
- *Rapid Impact & Deep Dynamic Compaction*



1950's, 1960's, 1970's



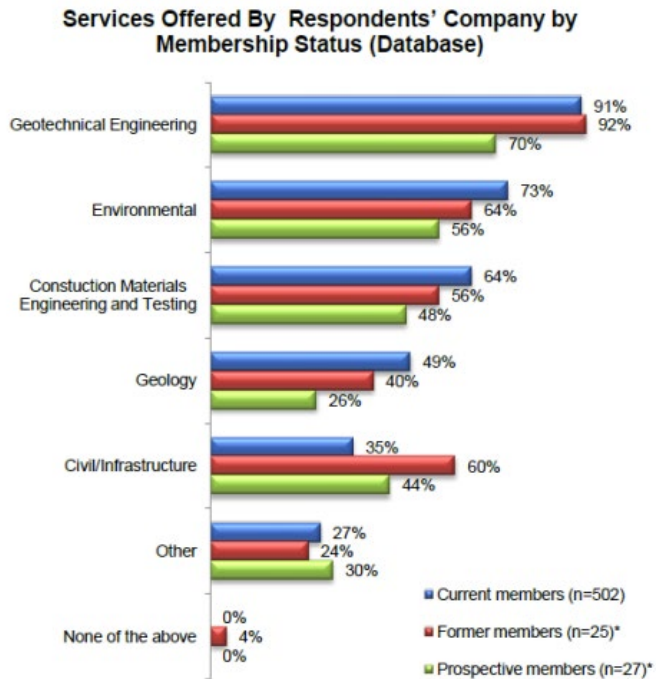
In-situ testing



FEA applied toanything!

Our profession in the 1980's and 1990's

Diversification in the 80's



Top business challenges (GBA firms, 2018)

Technical challenges =	7%
General business =	15%
Legal / risk / litigation =	19%
Staffing / leadership =	28%
Commoditization =	31%

Commoditization = where our love is *lost*
How do we get our love back?



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“May You Live in Interesting Times”



It Turns Out that We... DO!

Three Fundamental (exciting?) forces in play that will change our world

Force 1: the Information Age *Revolution*

Force 1: the Information Age: Adds Info to Objects

The **Information Age Revolution** is transforming **EVERYTHING**

- The **Information Age Revolution (IAR)** Enhances **Objects with Information**
 - Giving **you** *enormous leverage in decision making.*
 - Rapidly and creatively destroying entire businesses / Changing the wealth equation

“ This revolution, the information revolution, is a revolution of free energy as well, but of another kind: free intellectual energy ”

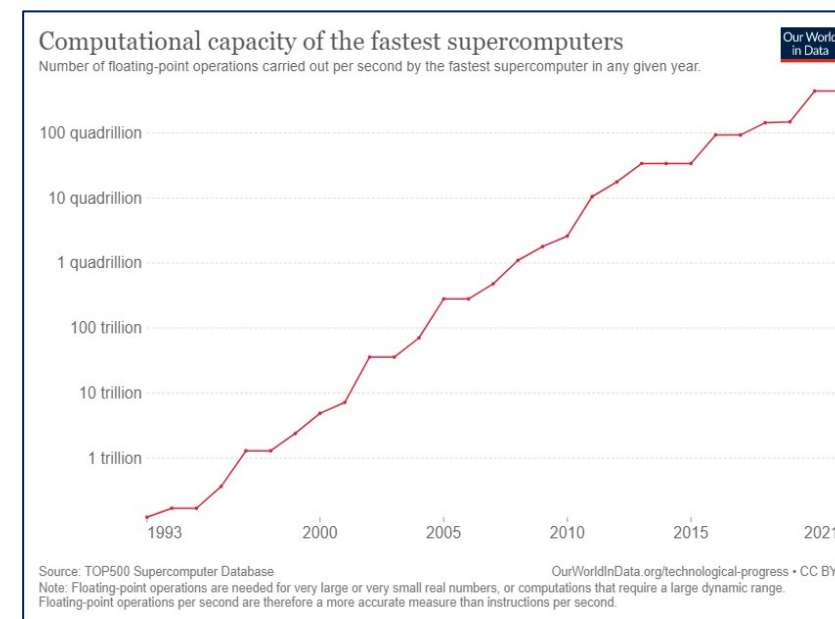
- Steve Jobs

The Information Age Revolution is MORE transformative than the Industrial revolution

Force 1: the Information Age Revolution: Language & Knowledge

Human “progress” is proportional to *our ability to learn lessons from others*

- **Language** allowed us to learn of dangers & opportunities
- Roman empire driven by **infrastructure = movement & information**
- **Renaissance** started with the arts then science
- **IR** driven by **language of science / engineering**
- The **IAR** starts with access to data = **knowledge amplifier**



Exponential expansion of computational ability

The Information Age Revolution provides unfettered access to experiences captured by others

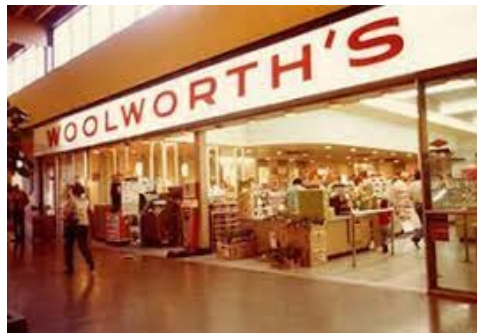
Force 1: the Information Age Revolution – Supercharges Objects with *Information*



Yellow cab



A cab of a different color?



Efficient Retail



Retail on steroids



My recent sock purchase

Force 1: Information Age Revolution – Eats People

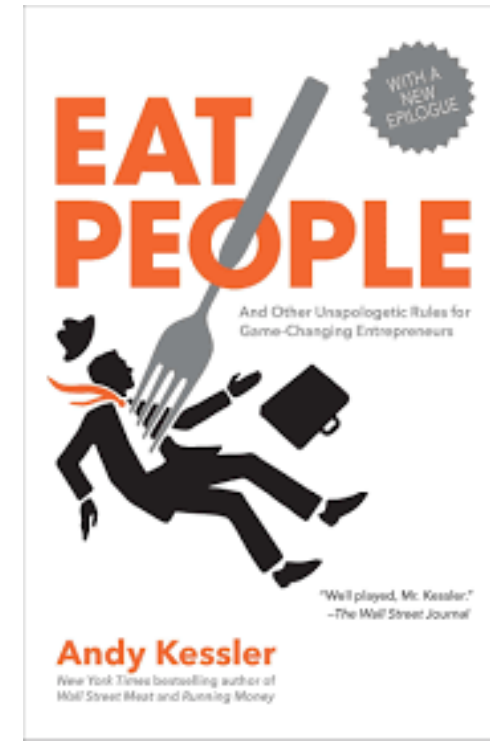


Exiting the Parking Deck – Last Year



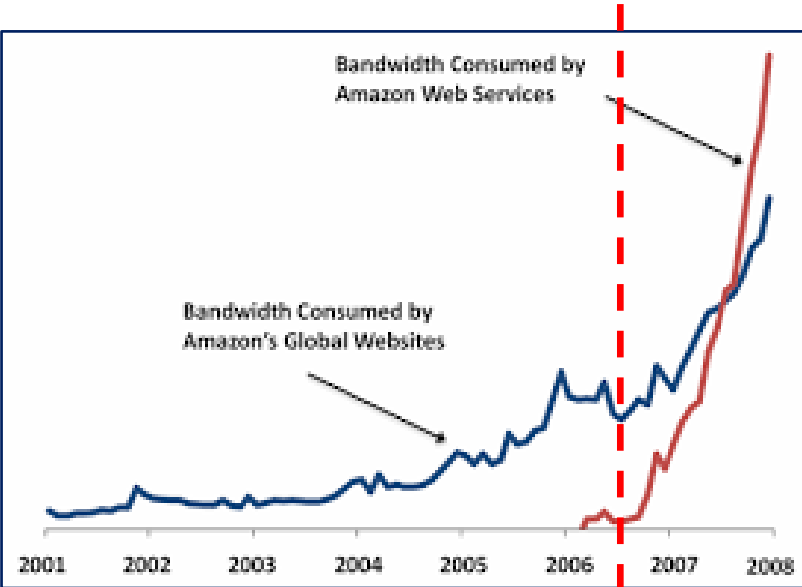
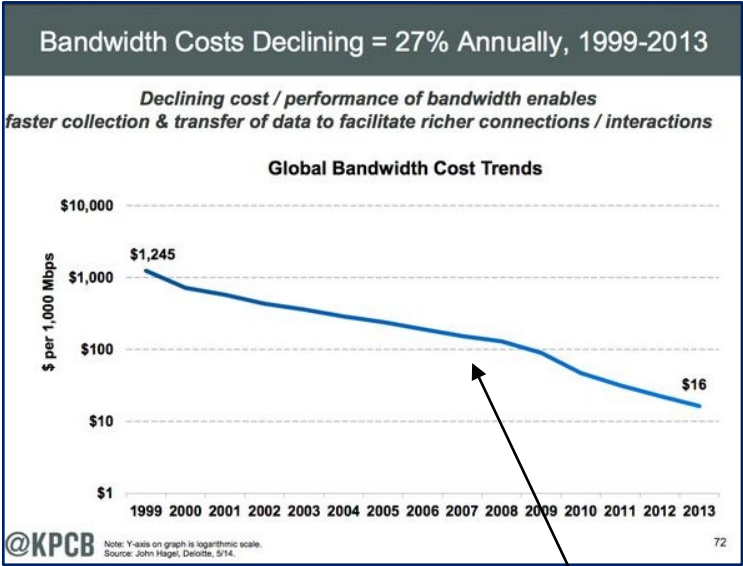
Exiting the Parking Deck - Today

Like the Industrial Revolution Before it, the IAR **Eats People**
(maybe now we know where they all went!)



Force 1: the Information Age Revolution – Now the Cloud

Low-cost **Cloud Computing** is now allowing for unprecedented data storage.....



20% annual growth in storage capacity 2020-2025



What we are all building today...

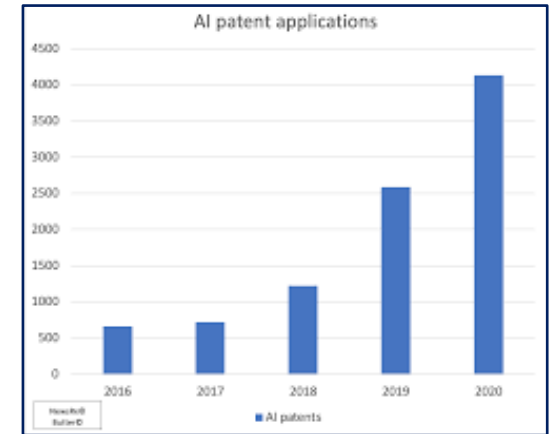
The *lower cost* of cloud computing drives **e-commerce = explosion**

Force 1: the Information Age Revolution – The Cloud Feeds AI (Machine Learning) which feeds the providers

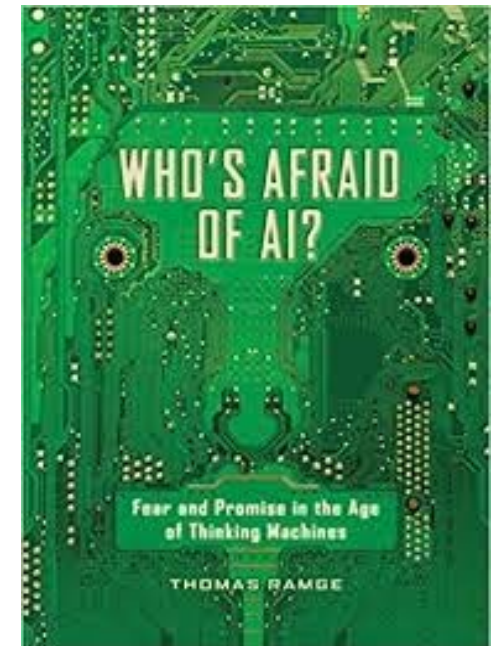
Artificial Intelligence (AI) is already here.

What is it?

- A conventional neural network that
 1. **When given data** and algorithms
 2. **Provides trends and predictions** that is
 3. Used by the operator to
 4. Update the instructions to get
 5. **Improved results**



(Doesn't sound so scary....or does it?)

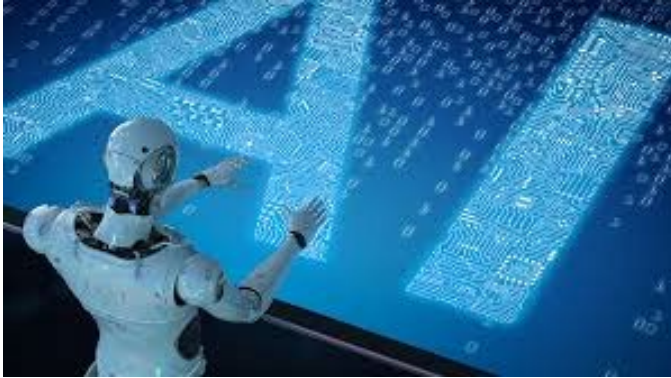


Force 1: the Information Age Revolution – Example – OpenAI.com

“impressionist painting of five cyclists with red jerseys climbing the blue ridge parkway”



Force 1: the Information Age Revolution – AI (machine learning) is the force multiplier



- AI is being used to influence customer experience & keep customers engaged and retained.
- Industry growing to **\$50B** by 2025
- AI = new **monopoly creator**



2 billion active users averaging > 2hours / day



92% of search engine market



180 countries, 2 **billion** users



Using Big Data, Netflix saves \$1B / year on user retention

Force 1: the Information Age Revolution - AI

**Who will be the best at eating people,
how will they do it, and **what does that
mean to the rest of us?****



RESOURCEFUL**SELLING**.COM

"OUR AI TEAM MEMBERS ARE BETTER PROSPECTORS THAN THE 'REAL' INTELLIGENCE TEAM
- AND THEY EAT LESS, TOO!"



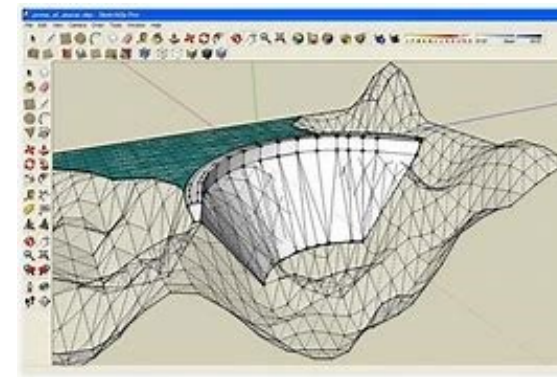
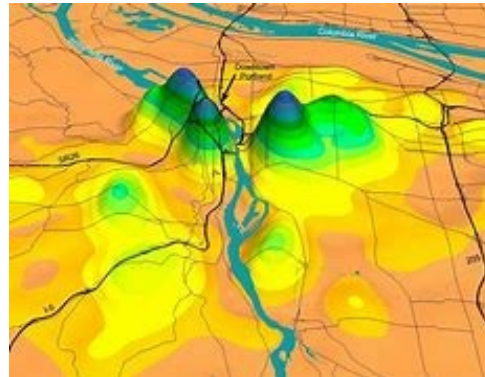
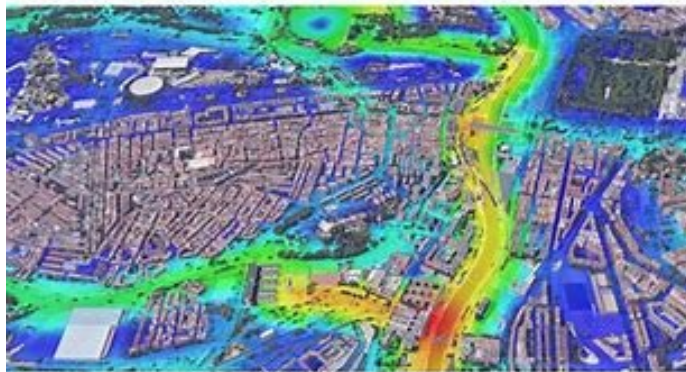
Ingios “eating people” with Intelligent Compaction

Force 1: the Information Age Revolution

What does it mean to us Geos? **What is the world getting ready to do to us?**

Approximately **70%** of our geo-effort related to **data / mapping**

- ✓ *Information explosion*
- ✓ *Value++ when data added to objects*
- ✓ *Engineering = language of construction*
- ✓ *Visualization*

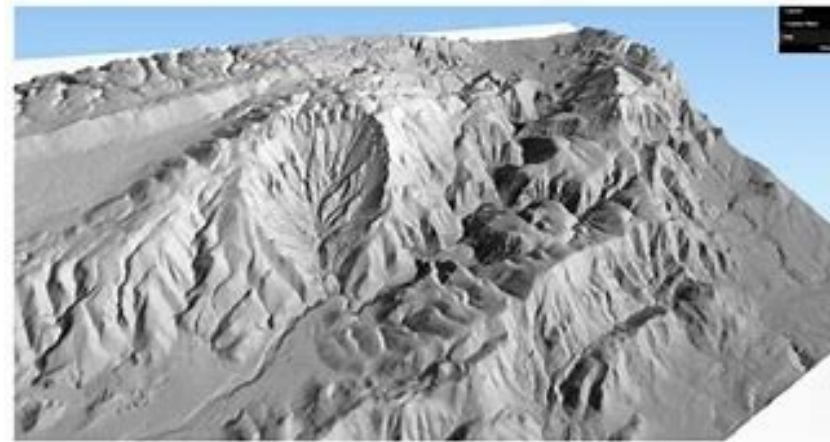
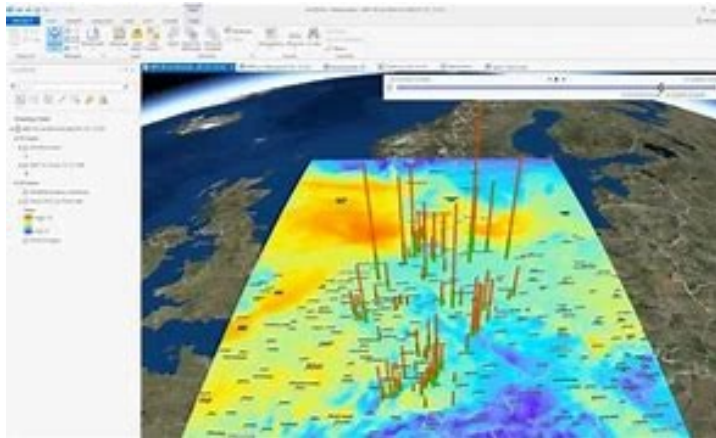


Those of us that can create great maps efficiently will disrupt the industry

Force 1: the Information Age Revolution

What does it mean to us Geos? **What is the world getting ready to do to us?**

Data. Data. Data. **AI (machine learning) is the multiplier**



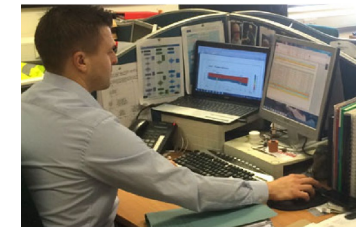
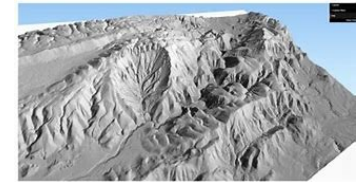
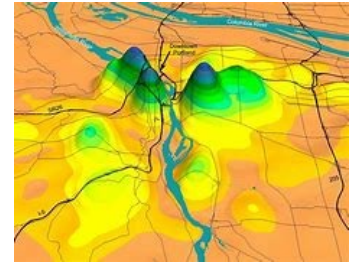
Of the Geo-winners, those of us that can apply AI effectively to a maximum amount of data ***will create monopolies***

Force 1: the Information Age Revolution

What does it mean to us Geos? **What is the world getting ready to do to us?**

Data miners will win.

- a. *If you create data capture it.*
- b. Switch everything to digital. **Forget SPTs, Pressuremeters...**
- c. **CPTs and Geophysics** will trump all cards.
- d. *Hire a data manager.*
- e. **Get more data.** Collaborate to get more. **Forget who “owns” it.**
- f. **Machine learning** will separate the rest.
- g. *Think of business as “maps” vs “expertise”.*
- h. *The best mappers will have the opportunity to provide the most expertise.*



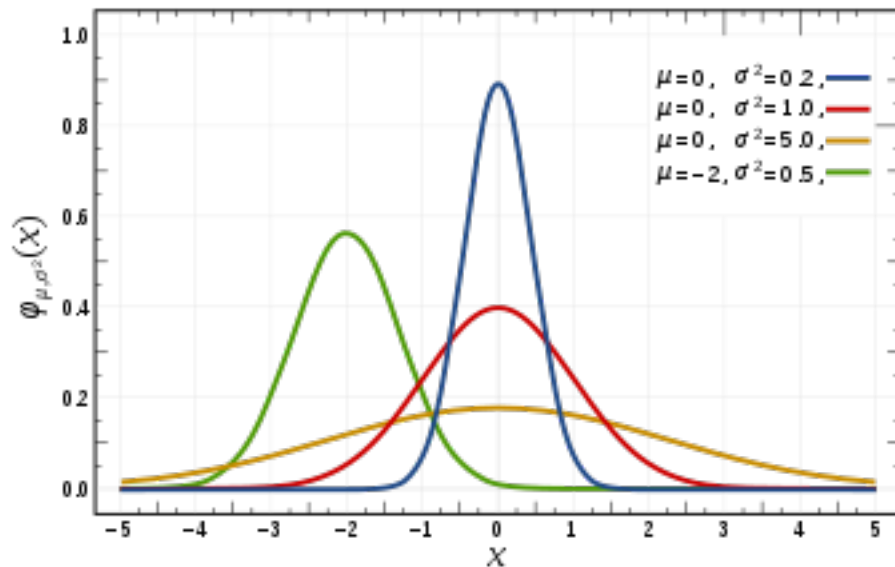
It Turns Out that We... DO! (Live in Interesting Times)

FIVE Fundamental (exciting?) forces in play that will change our world

Force 2: the Changing Probabilities

Force 2: Changing Probabilities

- **The good news:** Most of our designs are for static loads & gravity **Gravity is still 32.2 ft/sec²** 😊
- **Not so much** — the frequency / intensities (probability) of extreme events is changing.



Risk = probability x consequence

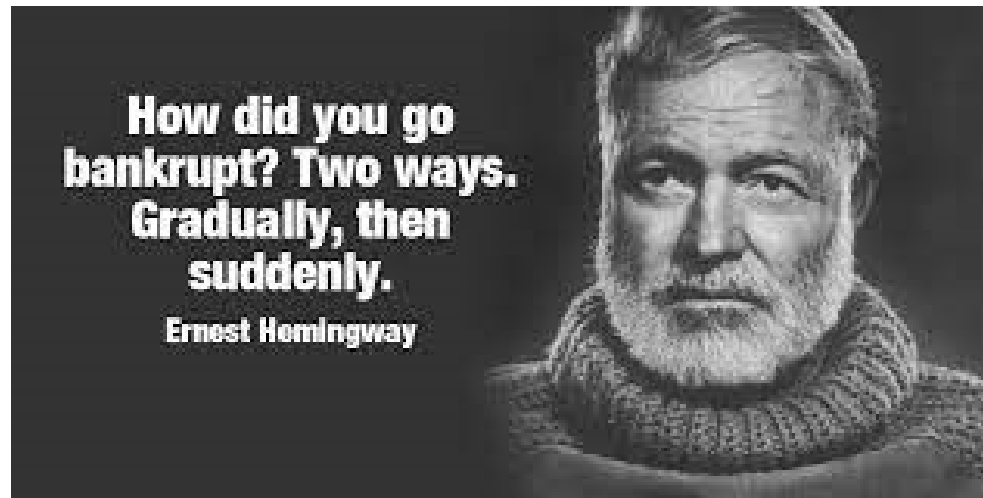


“Do you feel lucky?”



Force 2: Changing Probabilities

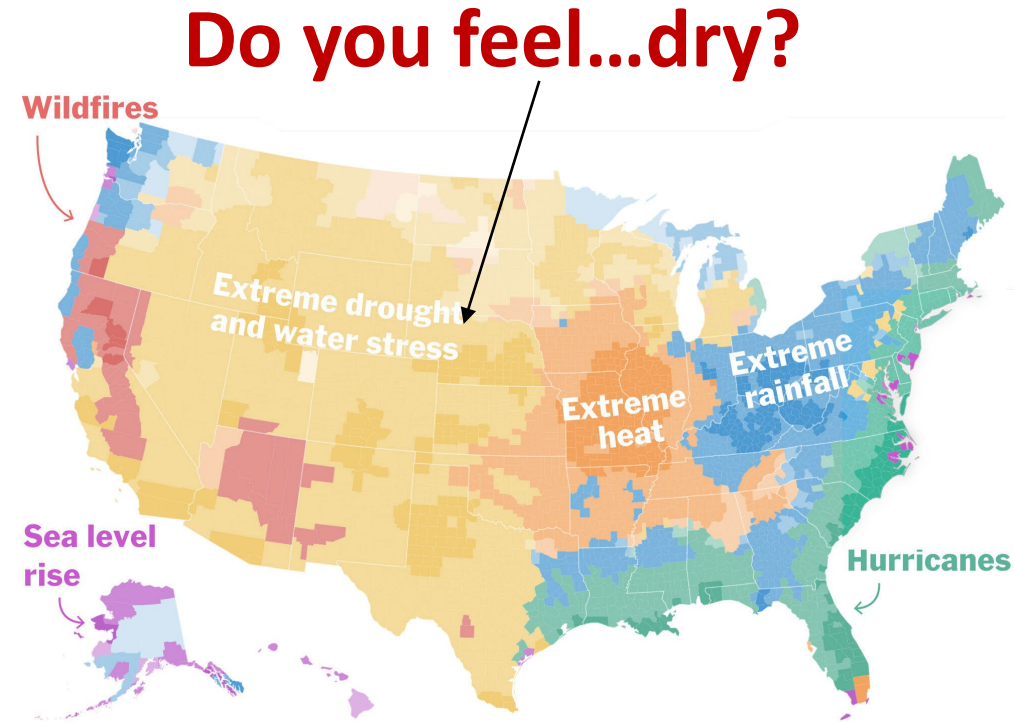
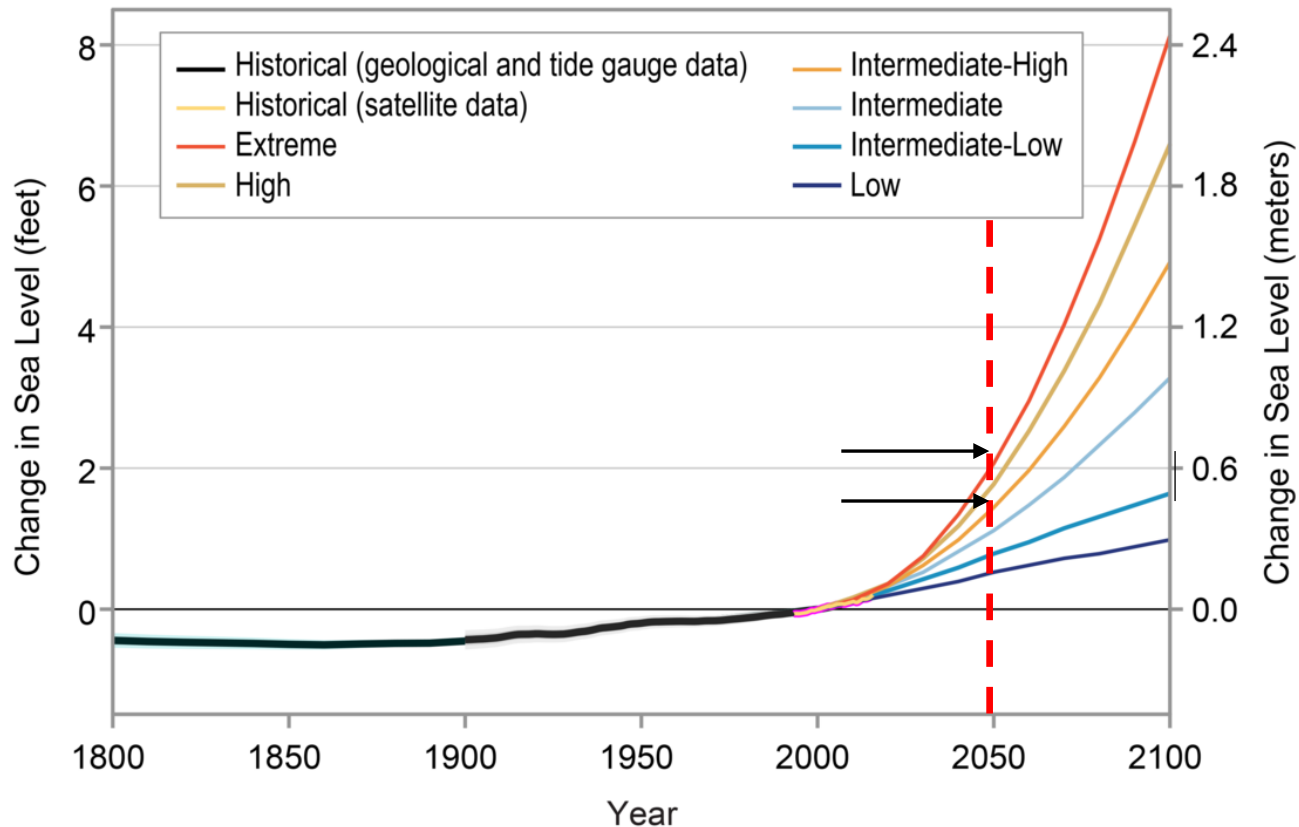
Climate change is a bit like bankruptcy....



Force 2: Probabilities - Water

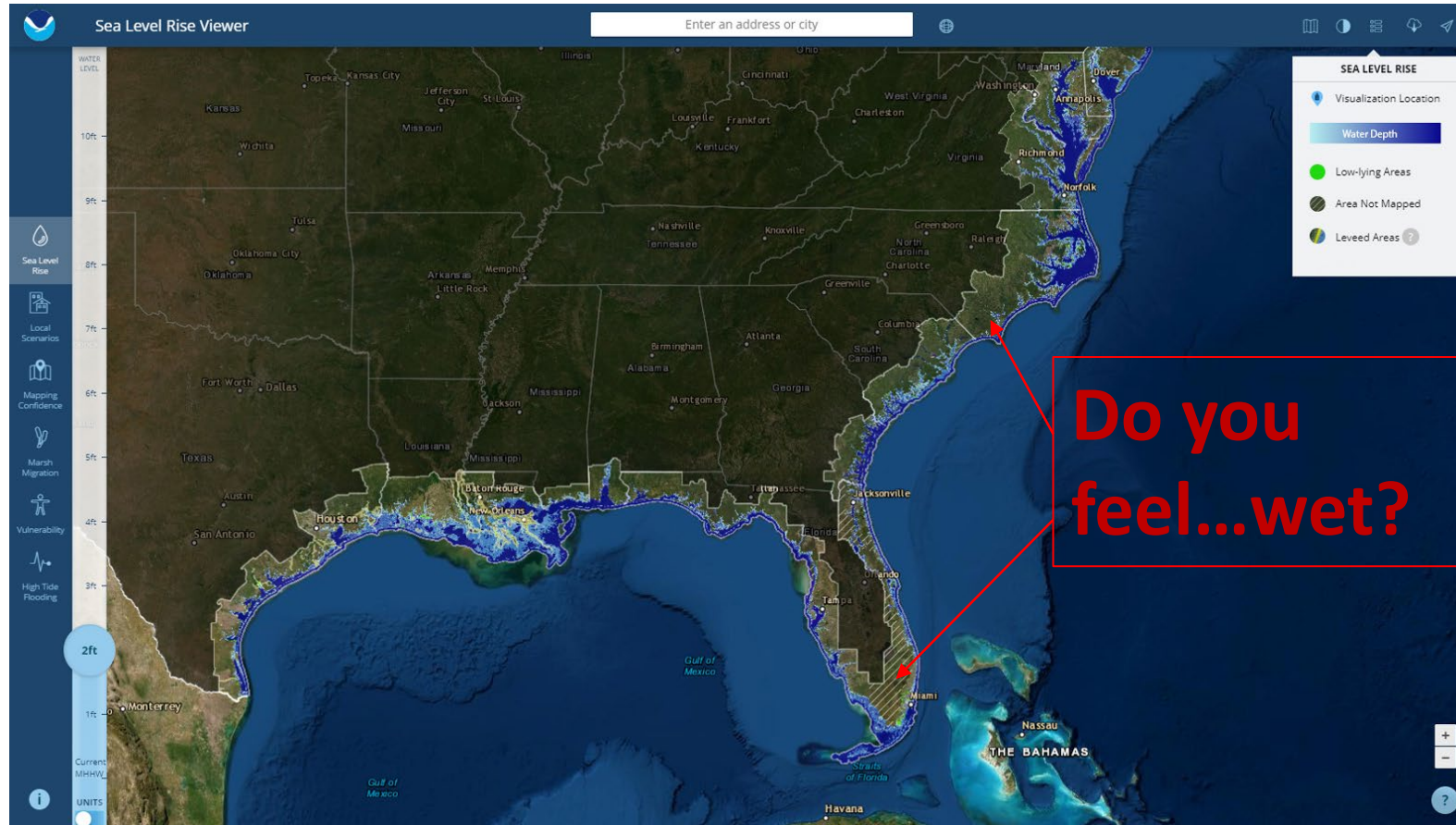
Climate change is really all about water

- Our predictive models show a wide spectrum of results; most models show **1' to 3' (about 2')** of sea level rise in the next 50 years.



Force 2: Changing Probabilities - Water

Most models predict coastline setbacks from Miami to the Carolinas



NOAA

Where will all of these people go?
(Ans. How about Omaha?)

Force 2: Changing Probabilities - Water

Climate change all comes down to water



Nelson, NZ flooding August **2022**)



Bay City TX, Hurricane Harvey, **2017**



Coastline erosion, Hurr. Hermine, MA **2016**.



Inland recession from sea level rise, NC, **2016**

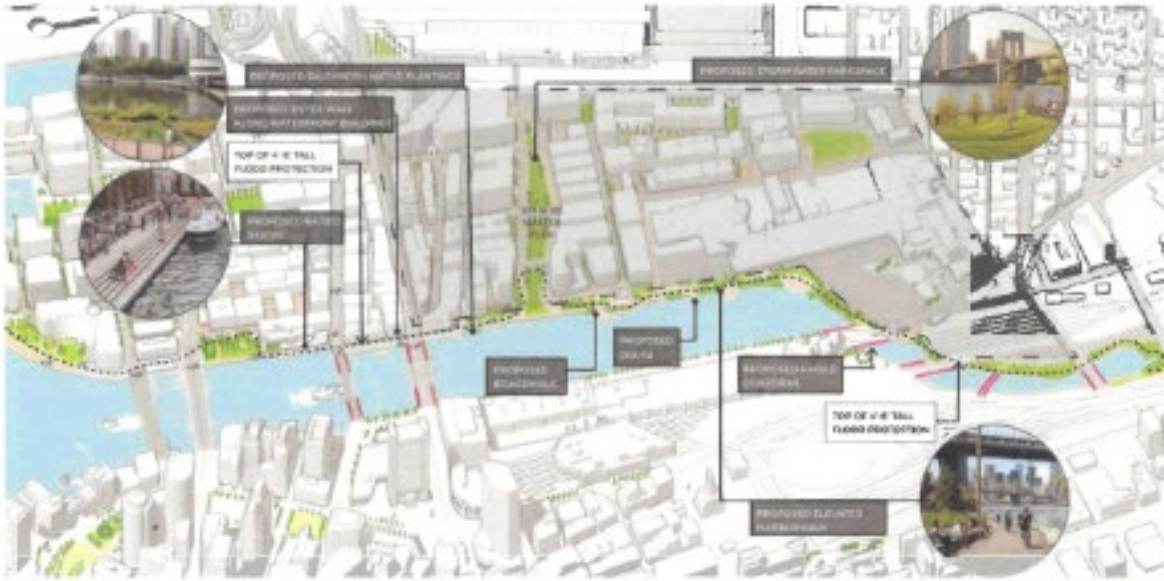


Beach erosion, Solana Beach, CA, **2017**



Puerto Rico....2022

Force 2: Changing Probabilities – Adaptation = CE Work!



Boston:

Fort Point Channel – Proposed Flood **Resilience** = Elevating structures, greenspace.

Manhattan:

- **\$20 billion** project to build raised parks, esplanades and barriers.
- Massive **sea gates** to close off New York Harbor during big storms.

\$400B needed for construction of sea walls to protect coastal communities

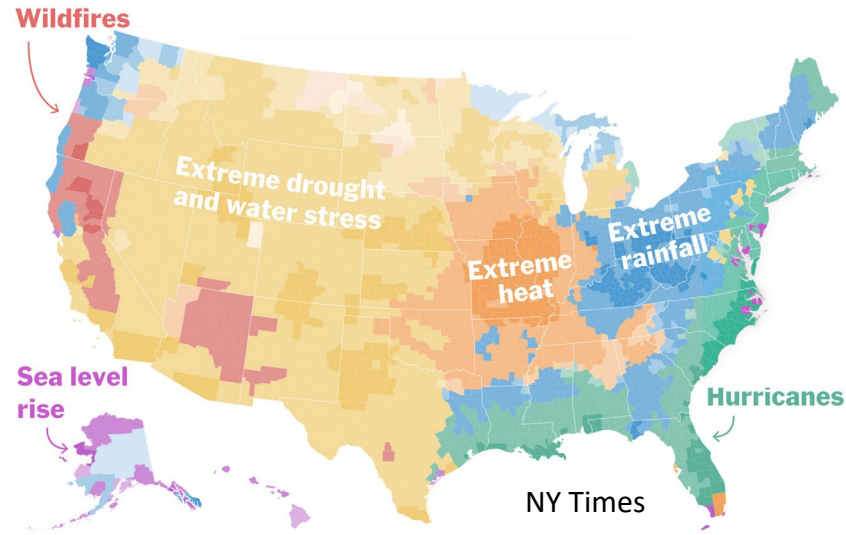


We are now well beyond the blame game.
We are now in adaptation mode.

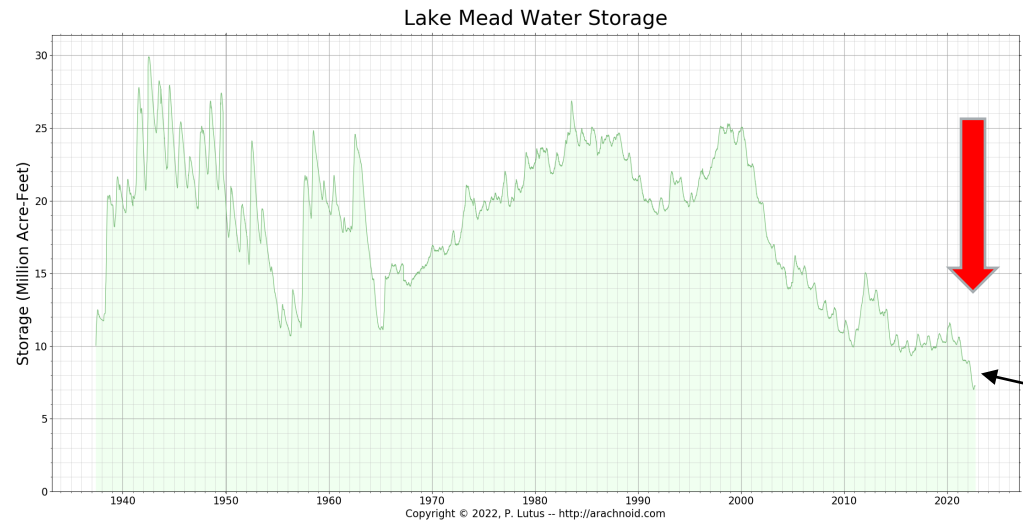
Geotechnical expertise will be needed for breakwaters, groins, flood walls, dikes, levees, bulkheads, sea walls.... Keep going!

Force 2: Changing Probabilities - Water

How about the Dry Spots?



Lake Mead, NV



- We are here now at **25% capacity**
- *What happens when the pool goes lower?*

Force 2: Changing Probabilities - Water

How will California get water?

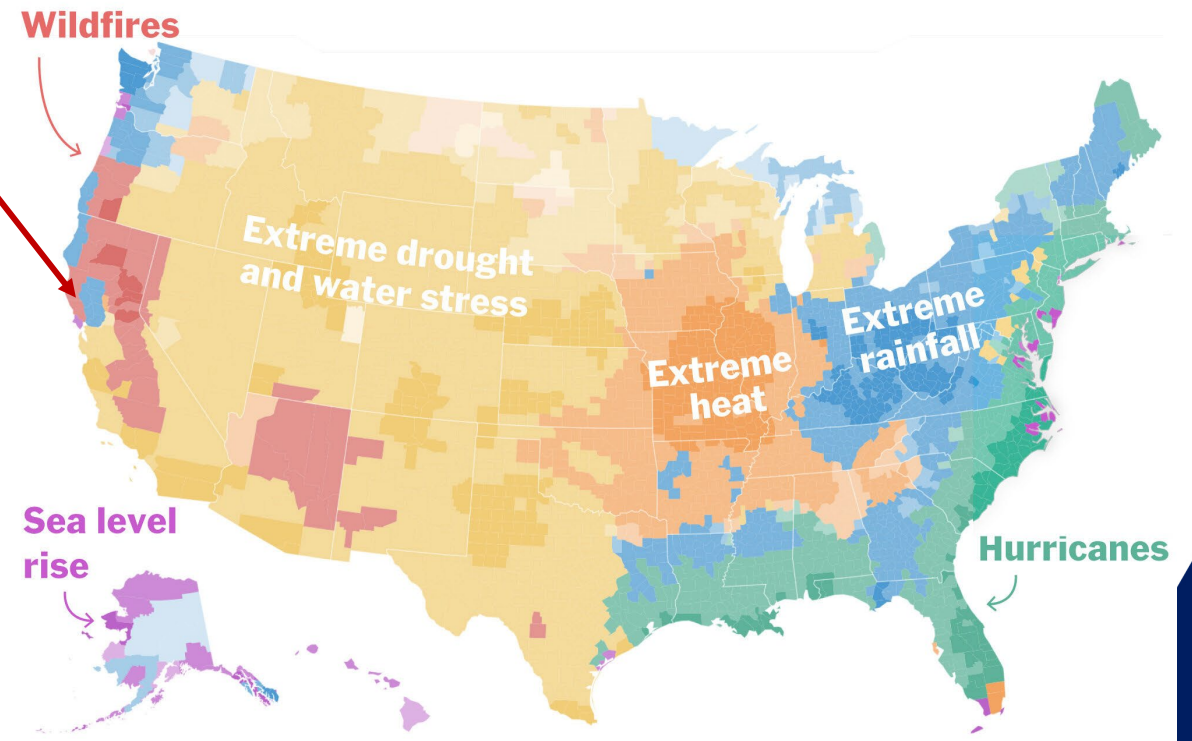


Offshore wind



Large scale solar

Conservation and **desalination**,
which requires massive amounts of.....



Force 2: Changing Probabilities – **Water = Power**

Power is already everything.



Desalination



Transportation



Wind (on and offshore)



Pocket Nuclear?



Clean hydrogen



Solar



Battery Plants

Geotechnical expertise will be needed for water transmission (canals / tunnels) water storage, water retention, desalination plant construction, and **POWER**

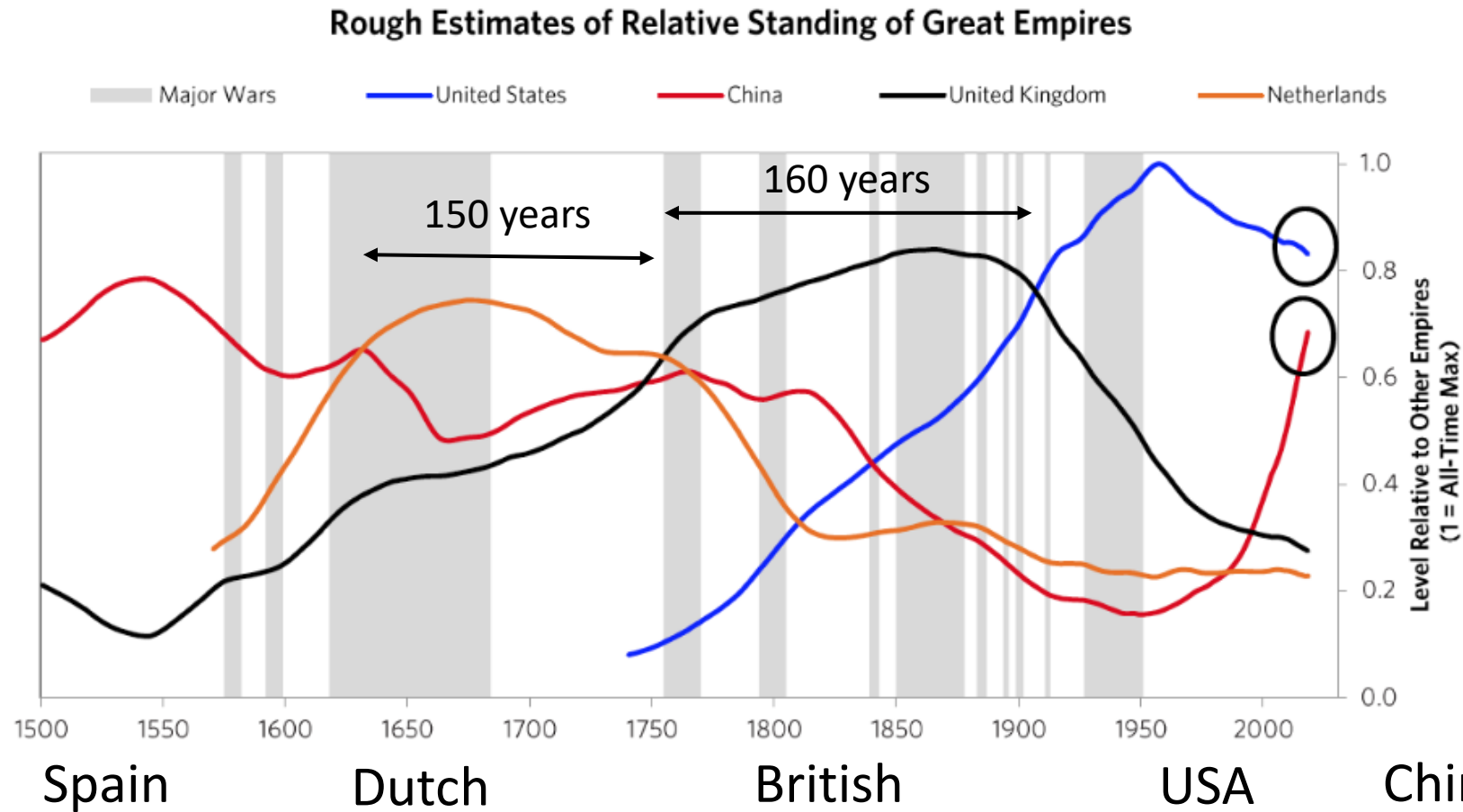
It Turns Out that We... DO! (Live in Interesting Times)

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Force 3: the Monetary Debt Cycle

Force 3: The Monetary / Debt Cycle: Changing World Order?

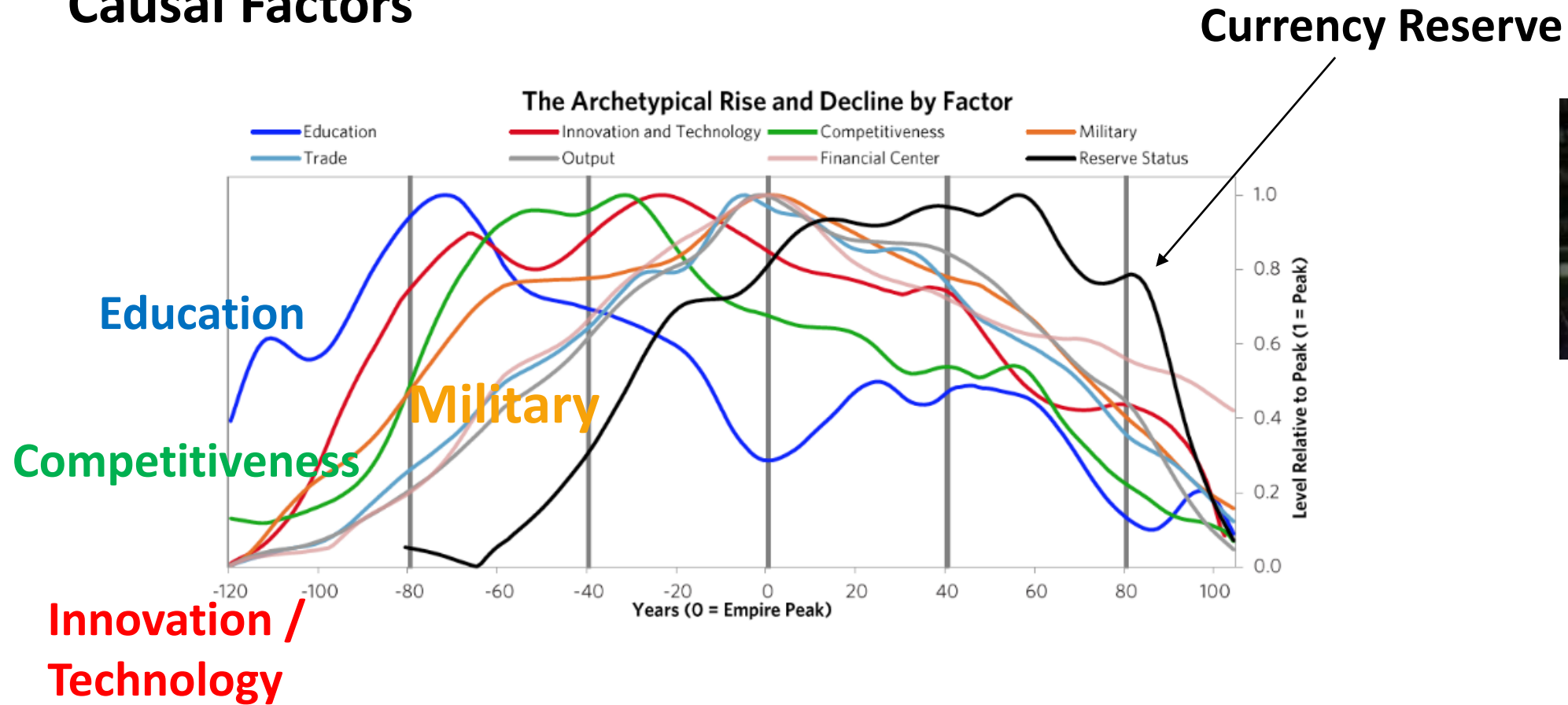
Ray Dalio's studies of the rise and fall of Empires / holders of reserve currency



(Ref: The Changing World Order, Ray Dalio)

Force 3: The Monetary / Debt Cycle: Changing World Order?

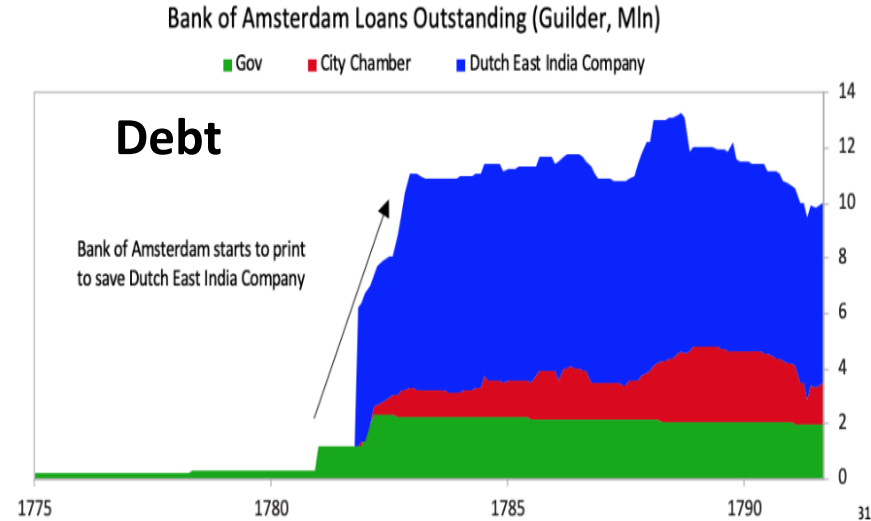
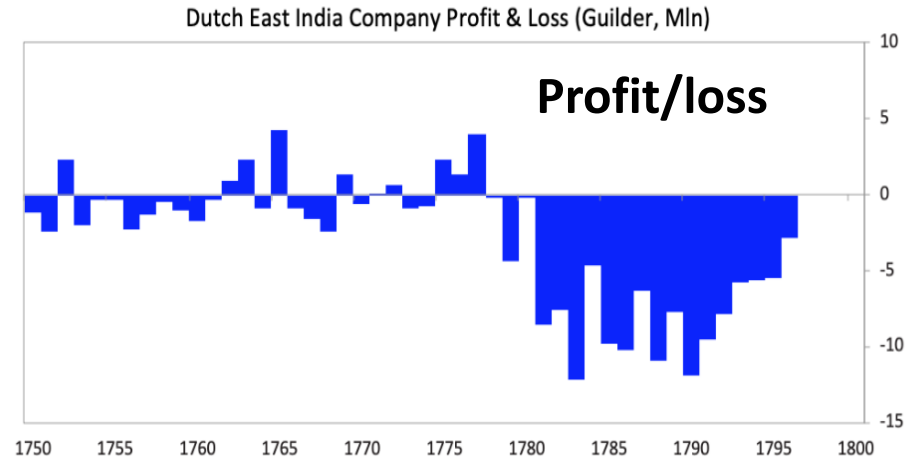
Causal Factors



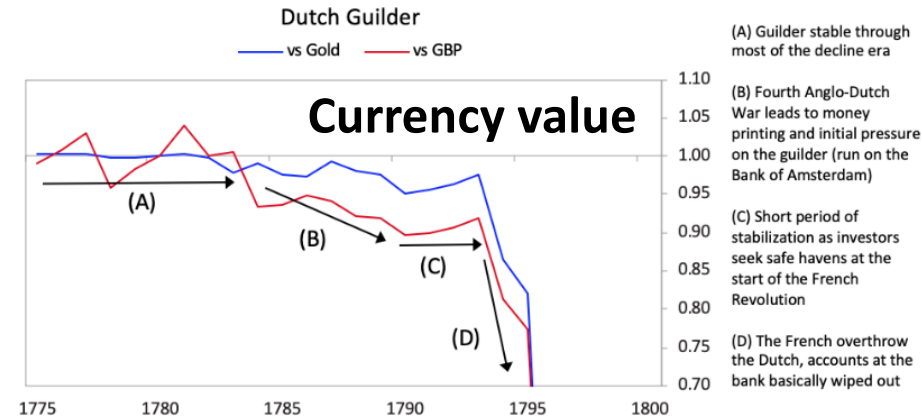
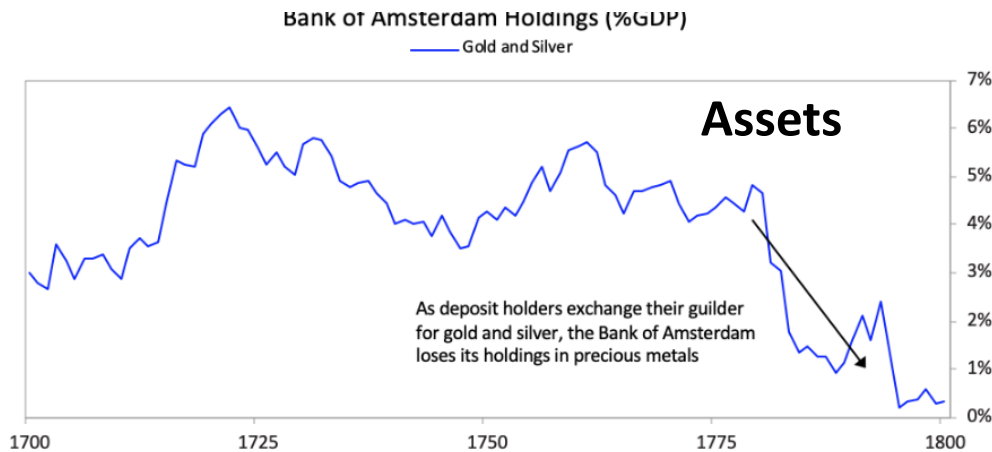
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Force 3: The Monetary / Debt Cycle: Changing World Order?

Example: Dutch Empire

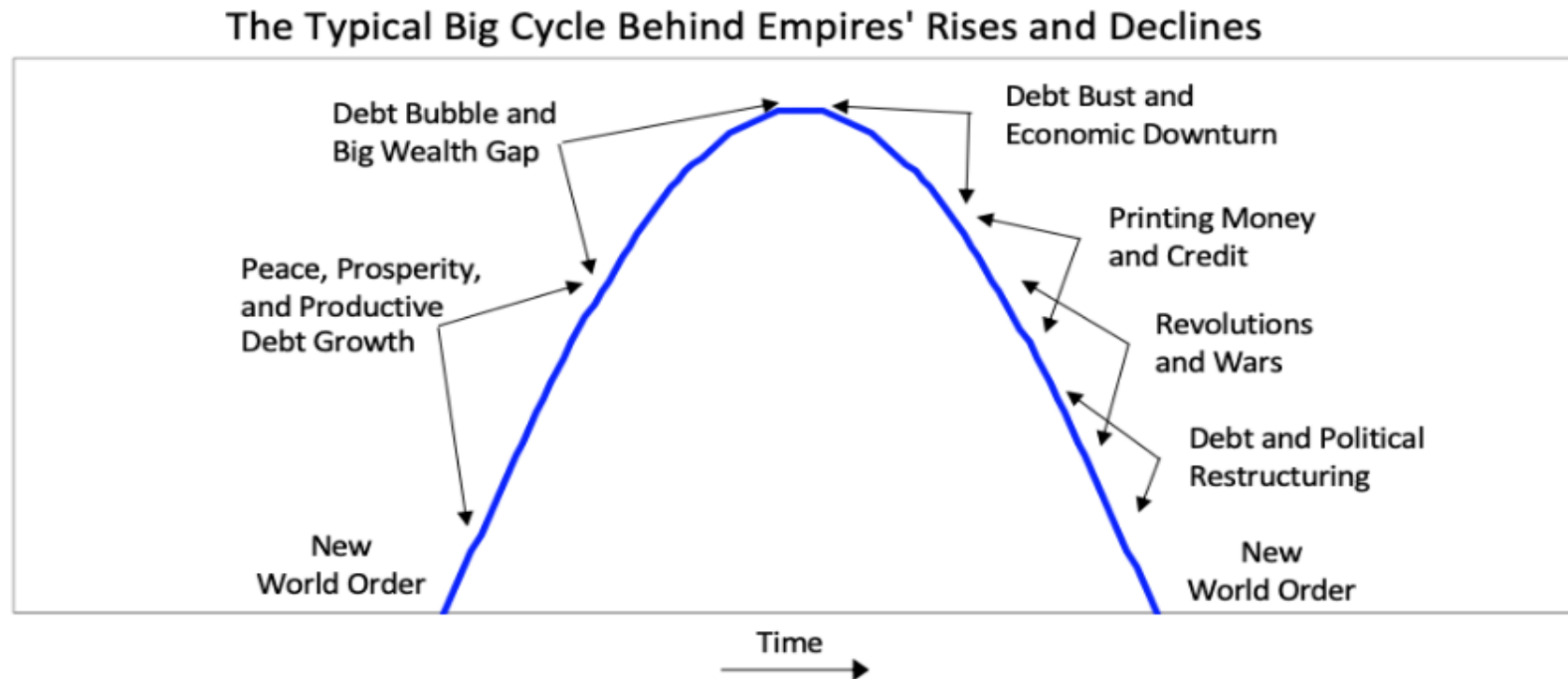


(Ref: The Changing World Order, Ray Dalio)



Force 3: The Monetary / Debt Cycle: Changing World Order?

Causal Factors



(Ref: The Changing World Order, Ray Dalio)

Growth → Debt bubble(s) → Recession → Printing money → Debt / political restructuring

Where are we on this curve?

Force 3: The Monetary / Debt Cycle: Population Hedge

Capitalism is fed by growth: tomorrow's value > today's value.

- Economic **growth** has *only 2 ingredients*: (1) people; (2) productivity
 - If we have more customers tomorrow, we can sell more (engineering) to them and grow.
 - If we make more (engineering) for the same cost, we can sell more of it and grow.



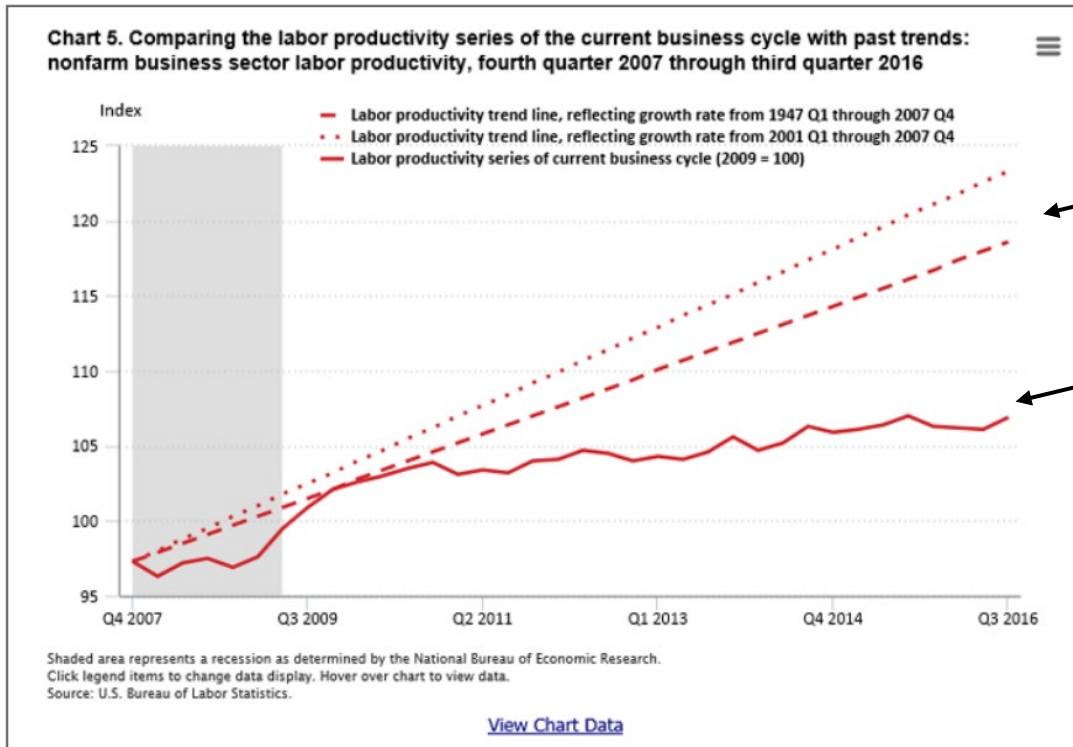
People



Productivity

Force 3: The Monetary / Debt Cycle: Productivity Hedge

Productivity gains since 2009? (it's been roughly flat since 2001)



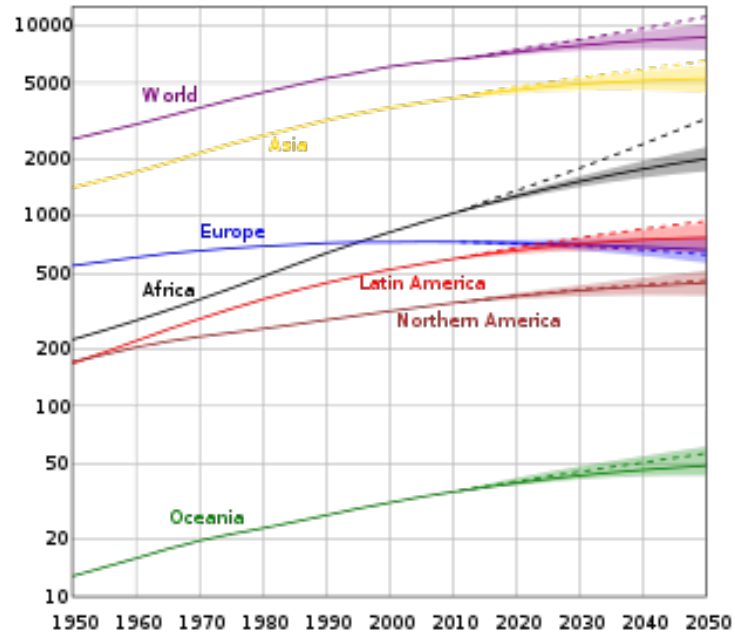
Historical growth rate ~ **2 to 2.5%** / year

Modern growth rate ~ **0 to 1%** / year

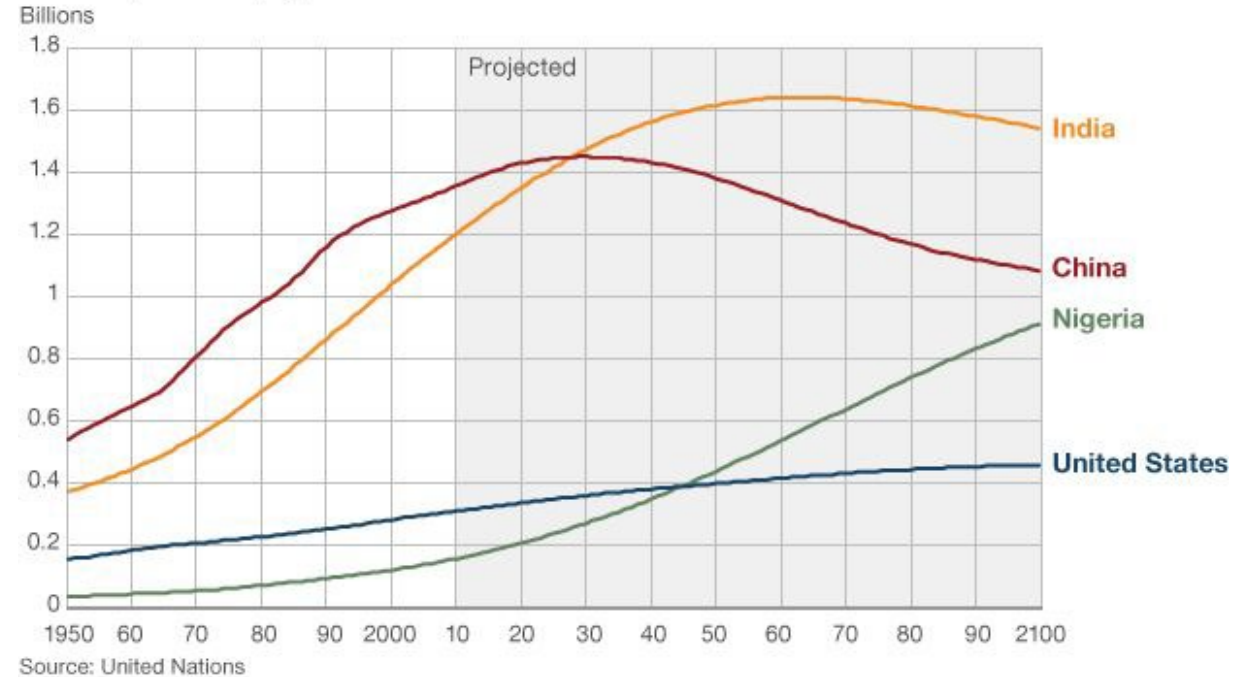
**Where has all of our
productivity gone??**

Force 3: The Monetary / Debt Cycle: Population Hedge

How about population?



Population growth in China, India, Nigeria and USA
1950-2100, actual and projected

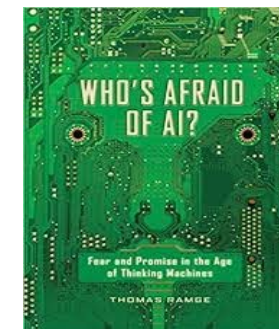
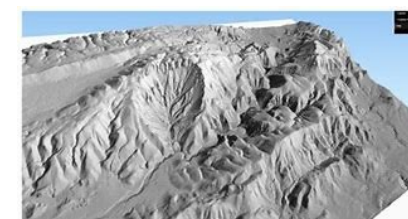
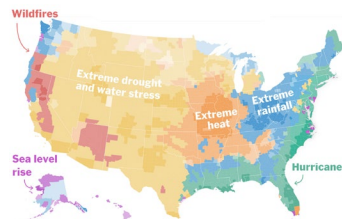
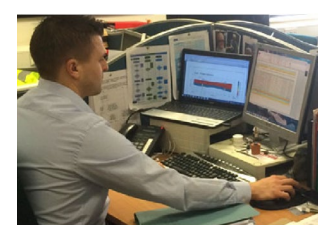
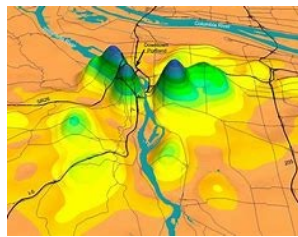


- Global population growth is flattening with **zero growth by 2050?**
- **China** expected to reach tipping point in 2030? **India** in 2060? **USA?**
- ***What will this mean for growth?***

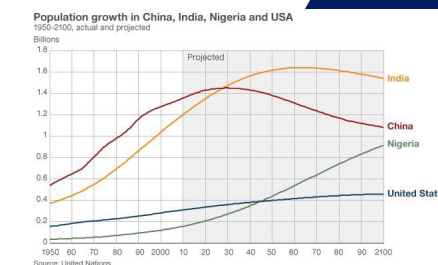
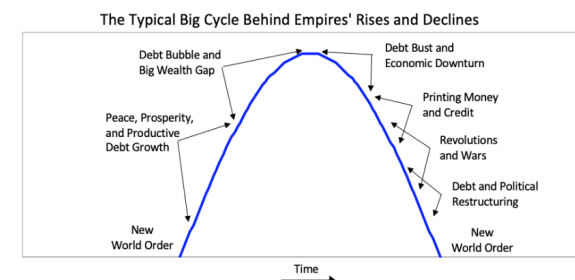
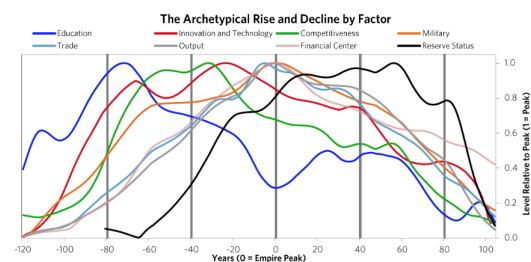
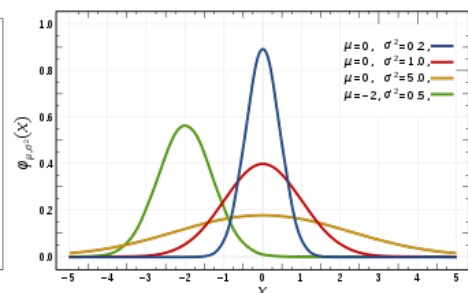
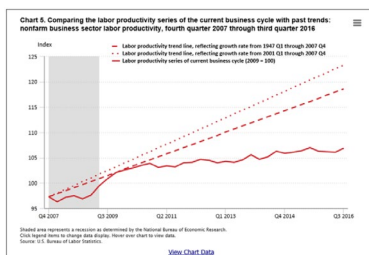
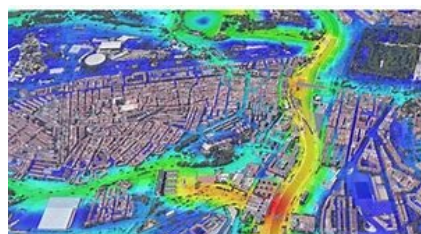
Force 4: Capitalism and Growth in a Zero Basis World

What does it mean for us Geos?

- ✓ Shareholders will *require growth*
- ✓ Over the **short term, US will continue to grow....**
- ✓ **China not so much**...jeopardizing their goal as reserve currency
- ✓ **US remains a good bet** / *cash will flow to emerging powers and populations*
- ✓ Emerging powers = India, Turkey, Poland



Putting it All Together



Putting it All Together (Where Does this Leave Us Geos?)

1. Data miners will win.

- If you create data capture it. Get more of it. Share it. Forget who owns it. Switch to digital.

2. We live in a global community with reduced resources (engineers)

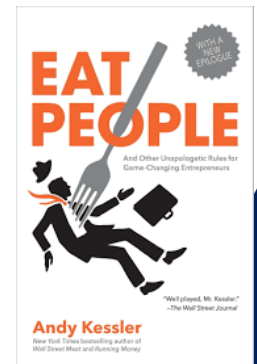
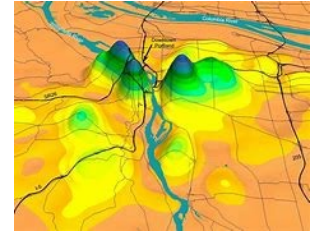
- The best firms will be agnostic about employee location; **Eat people**

3. We will see great demand for expertise in areas with changing probabilities

- Coastal revetments / levees / floodwalls / land use expertise / Resilient design
- Bias against steel and very strong bias against concrete (11% of global carbon production)
- Water will drive most infrastructure / **Water will drive power.**

4. Changing world order might compress our ability to raise debt / capitalize

5. Resiliency / cost efficiency (ground improvement!) will be the order of the day



Putting it All Together (Where Does this Leave Us Geos?)

“May you live in Interesting Times” (yes we do 😊)

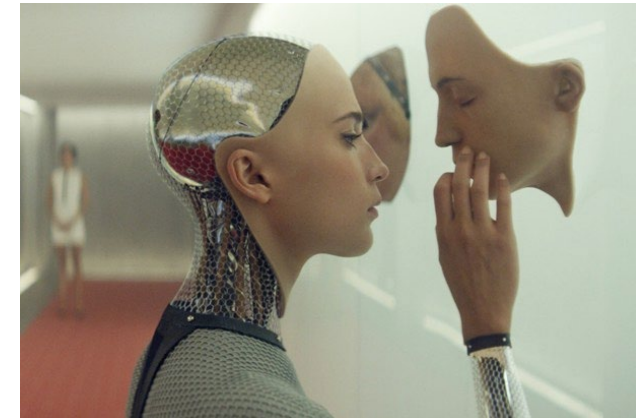
In my lifetime, we have never been unable to meet the challenges in front of us

Cayuga River (Cleveland) fire / Love Canal / PCBs / Smog / Acid Rain / Ozone Depletion / Air Quality

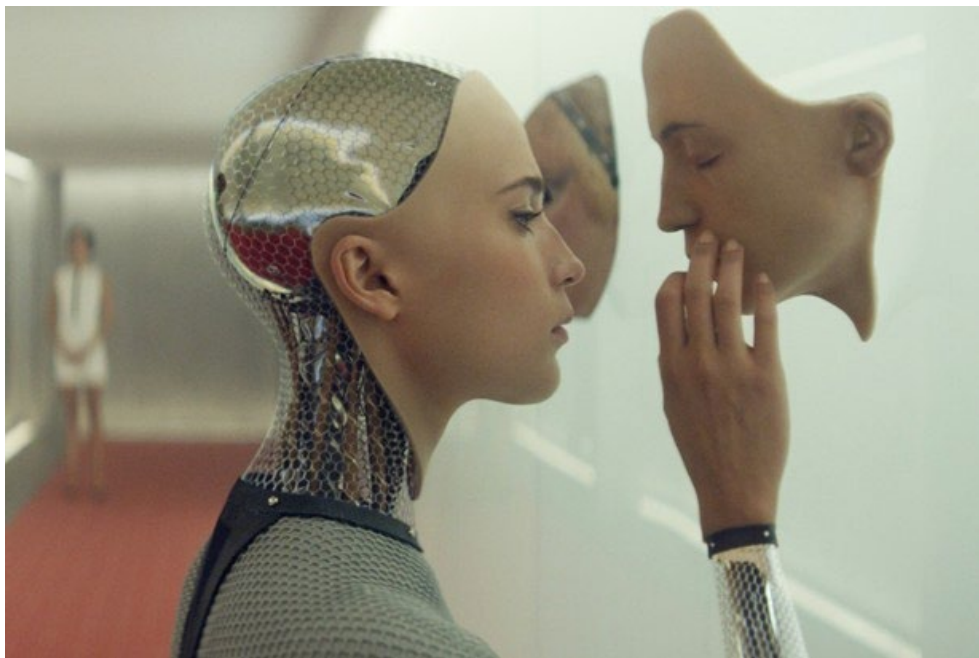
No matter what happens, our innovative spirit will rise to the challenge



I am feeling like I felt at the beginning...



I hope I left you in a good spot



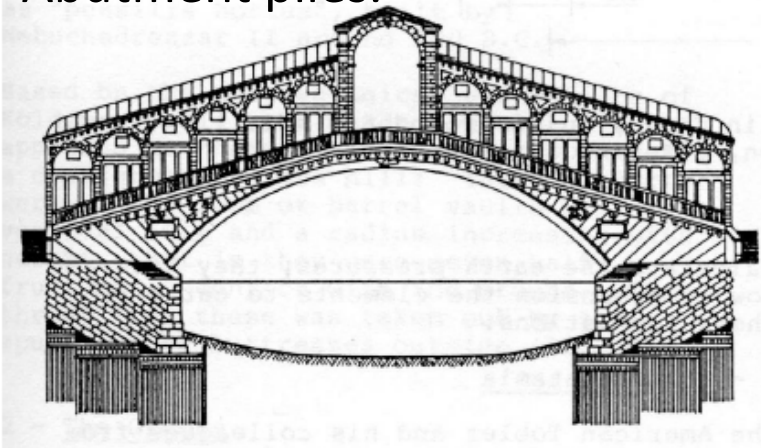
Thank you

The beginnings of pilings for stabilization



(Ref: www.tu-dresden.de)

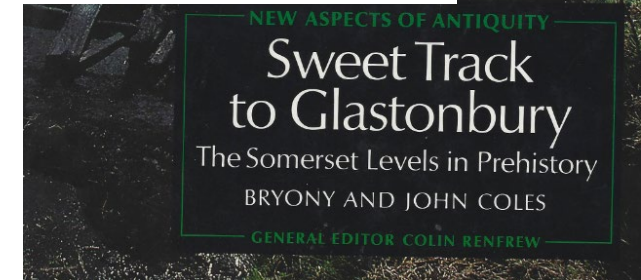
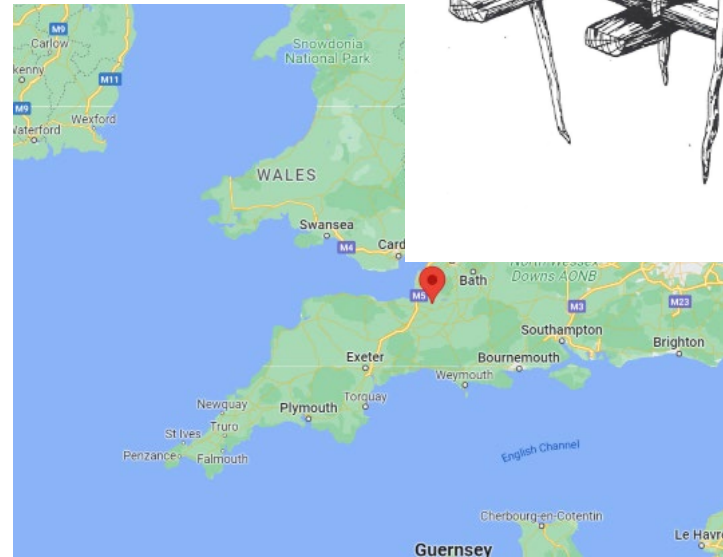
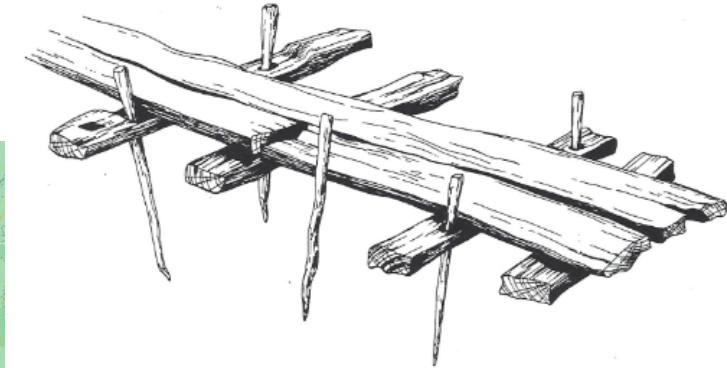
Rialto Bridge (Venice, 1500s).
Abutment piles.



Reconstruction of Roman piling hammer during empire's expansion a



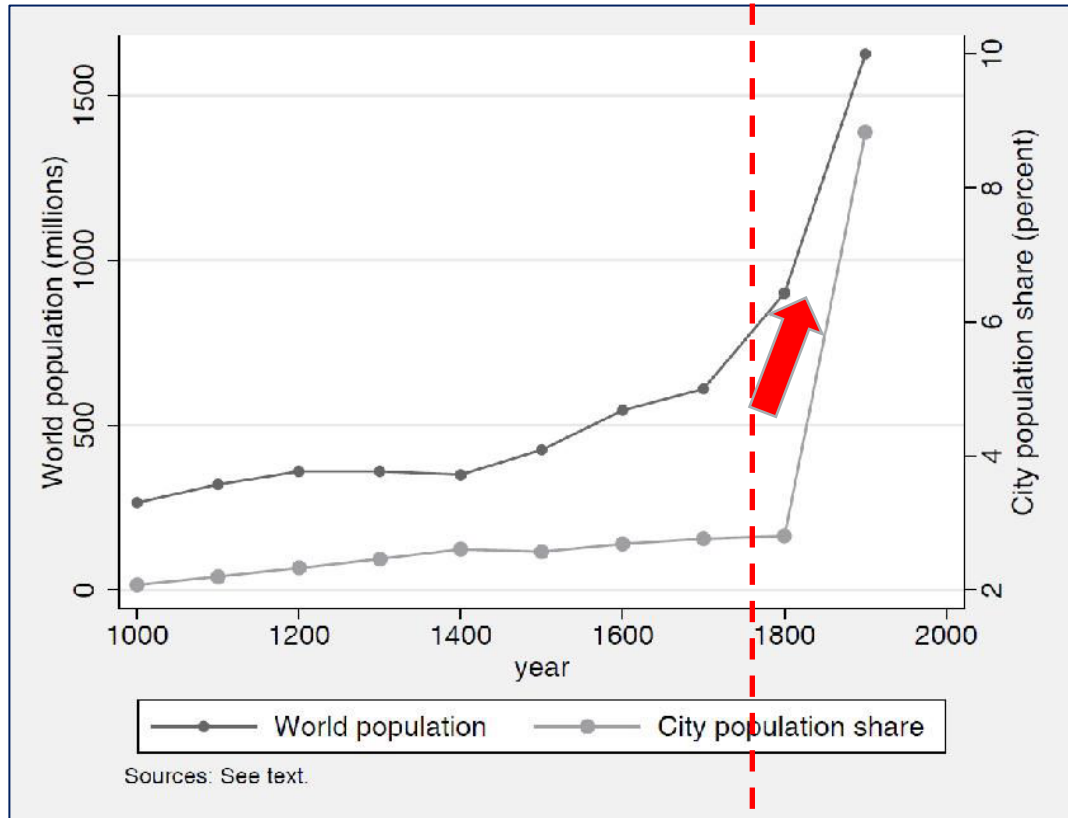
29 The Meare Heath track as reconstructed from recent excavations. Note the extensive use of heavy planks both as transverse bearers and for the longitudinal walking surfaces.



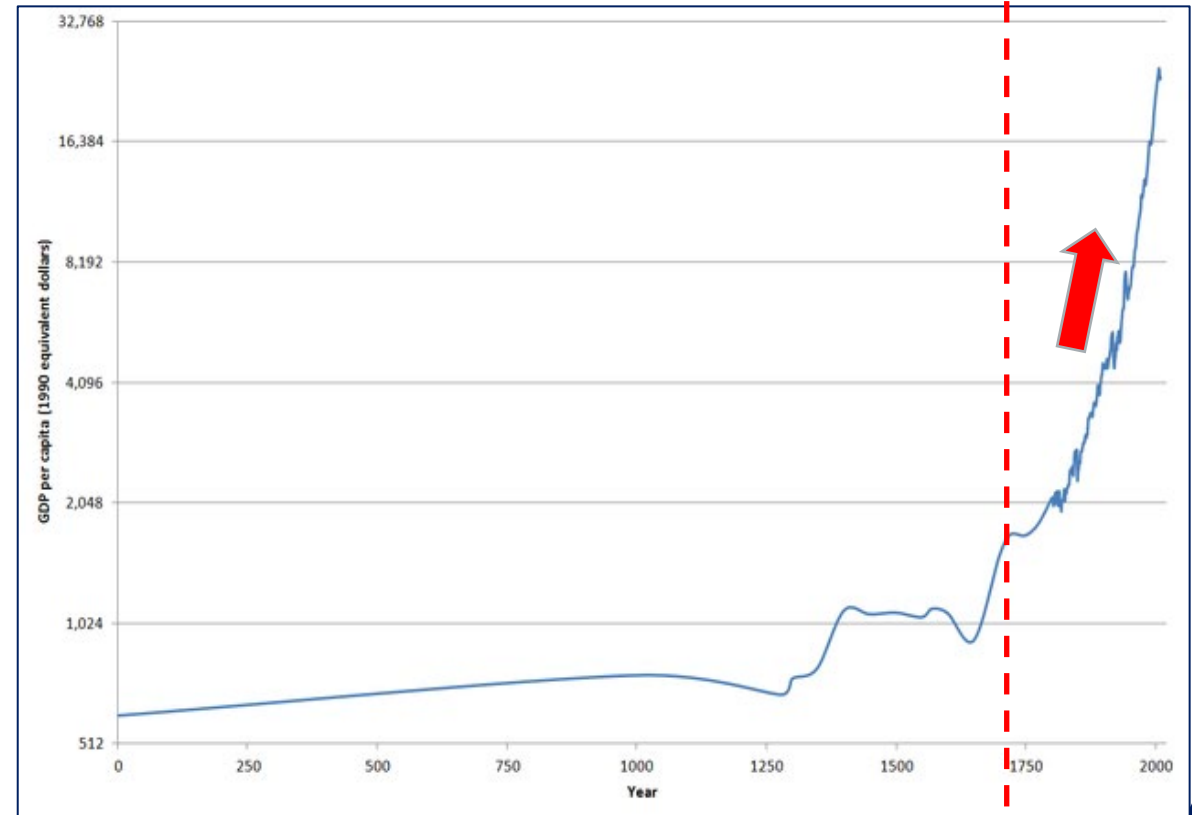
The "Sweet Track" is located about 25 miles southwest of Bath England. It was built around 3500 BC based on radiocarbon calibration.

"Amazing what can be accomplished without FEM." Larry Johnsen

Everything Changed with Industrial Revolution



Population & Urbanization BOOM ~ late 1700s



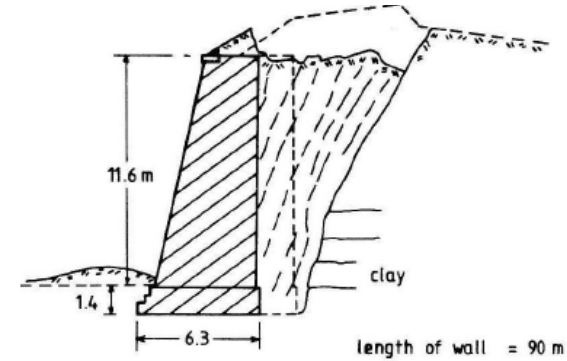
Corresponding GDP / Capita BOOM

And more French

1800s



Wm. J.M. Rankine:
Passive & active earth pressures



Henry D'arcy: Permeability

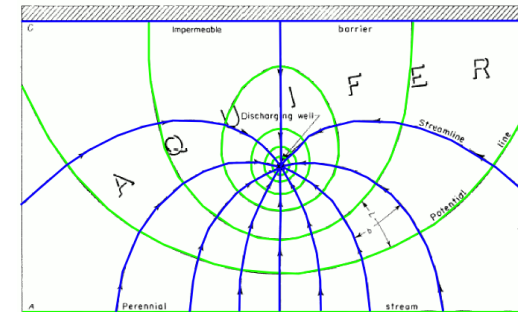


FIGURE 34.—Flow net for a discharging well in an aquifer bounded by a perennial stream parallel to an impermeable barrier.



Boussinesq: Elasticity theory

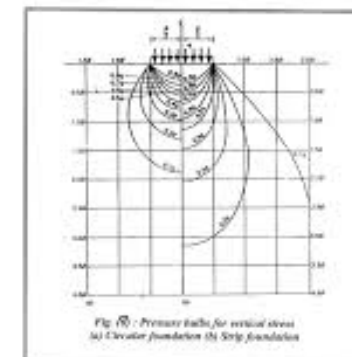
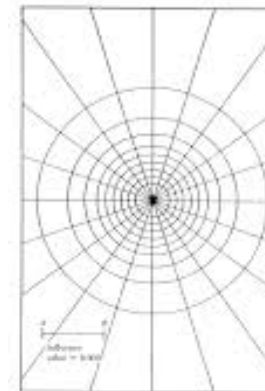
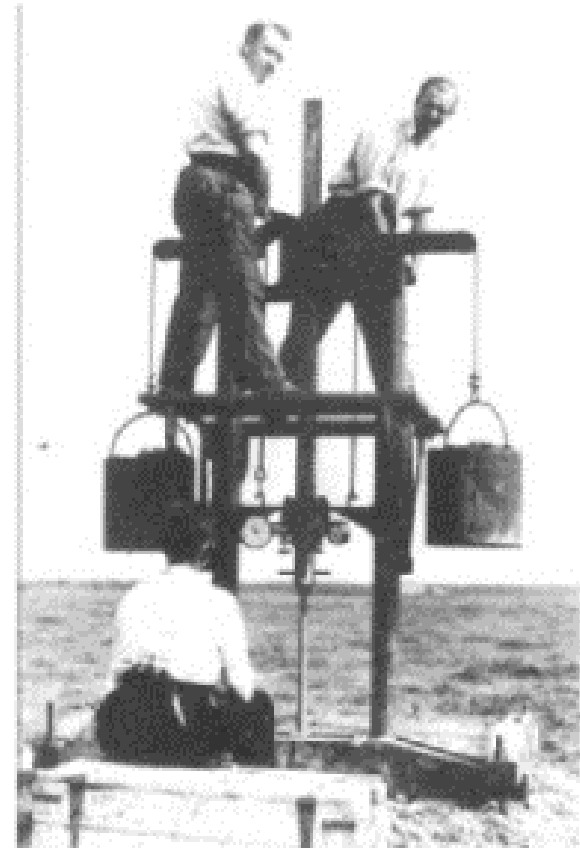


Fig. 10: Pressure built up for vertical stress
(a) Circular foundation (b) Strip foundation

Soil exploration methods advanced

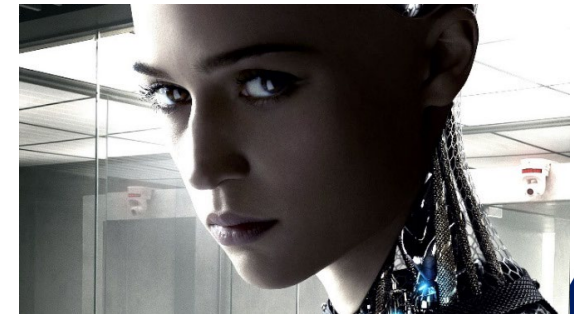


The Slowing Rates of Change / Innovation

Top business challenges (GBA firms, 2018)

Technical challenges =	7%
General business =	15%
Legal / risk / litigation =	19%
Staffing / leadership =	28%
Commoditization =	31%

Commoditization = where our love is *lost*
How do we get our love back?



2018 GBA survey told us what we don't want to know

Many of our current services are undifferentiated from others = commoditization and the broken promise.

Our Choices:

- We can accept it
- We can seek to change it

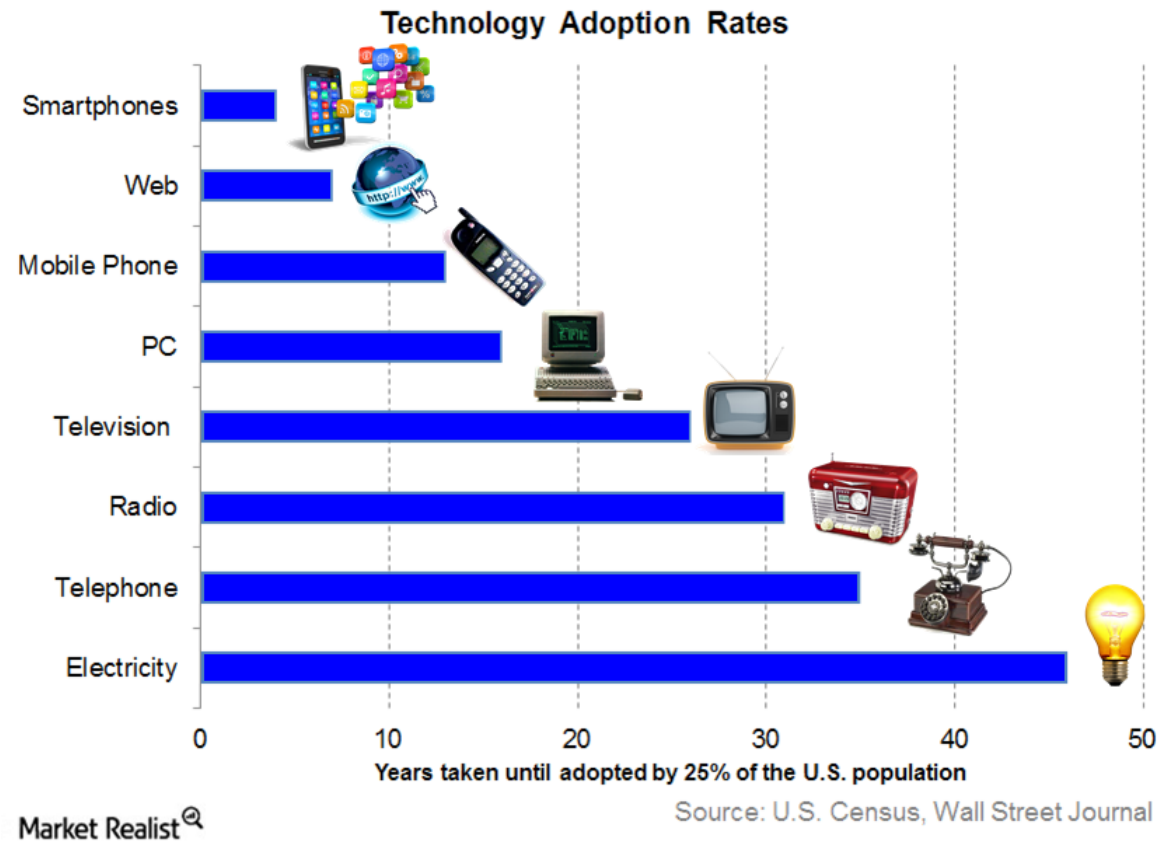


It Turns Out that We... DO! (Live in Interesting Times)

Three Fundamental (exciting?) forces in play that will change our world

Force 1: the Information Age *Revolution*

Force 1: the Information Age Revolution: Speed of adoption



The **IAR** knowledge amplifier = **10x faster technology adoption** = “IR on steroids”

Force 1: the Information Age Revolution – AI (machine learning) is the force multiplier



AI = new monopoly creator



2 billion active users averaging > 2hours / day



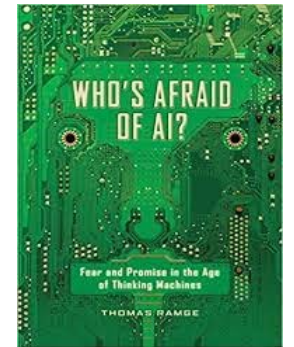
92% of search engine market



180 countries, 2 **billion** users



Using Big Data, Netflix saves \$1B / year on user retention



Force 1: the Information Age Revolution

What does it mean to us Geos?

What is our fundamental purpose?

[Provide expert “geo” data and expert advice for Civil design and construction]

Data or Expert Advice?

- *Geotechnical explorations = provides a map of subsurface*
- *Geotechnical laboratory testing = provides material properties*
- Engineering calculations
- *Report preparation (using [mostly] standard language / paragraphs)*
- *Report delivery / “Please call if you have any questions”*
- Post-report project meetings

Approximately **70%** of our geo-effort related to **data / mapping**



Force 3: The Monetary / Debt Cycle: Changing World Order?

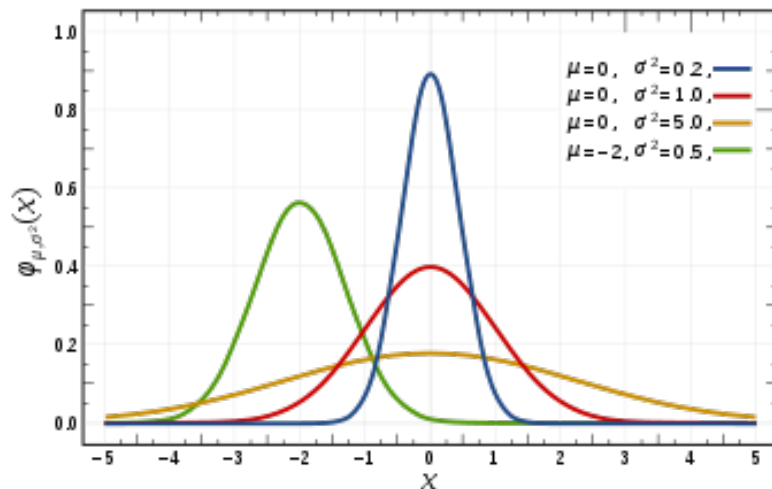
Why is Holding the Reserve Currency so Important?
What does this mean for us Geos?



(Ref: The Changing World Order, Ray Dalio)

If we lose the reserve currency, our ability to float debt will diminish making it **harder for us to fund infrastructure.**

What will be our opportunities?



Resiliency; Privatization; System Engineering