http://bit.ly/IOT-MIT

Smart Cities ?

Euphoric about Utopia ?

Dr Shoumen Palit Austin Datta

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Senior Scientist, MD PnP Lab, Medical Device Interoperability, Massachusetts General Hospital, Harvard Medical School ● www.mdpnp.org

What is a smart city?

We don’t have to agree.

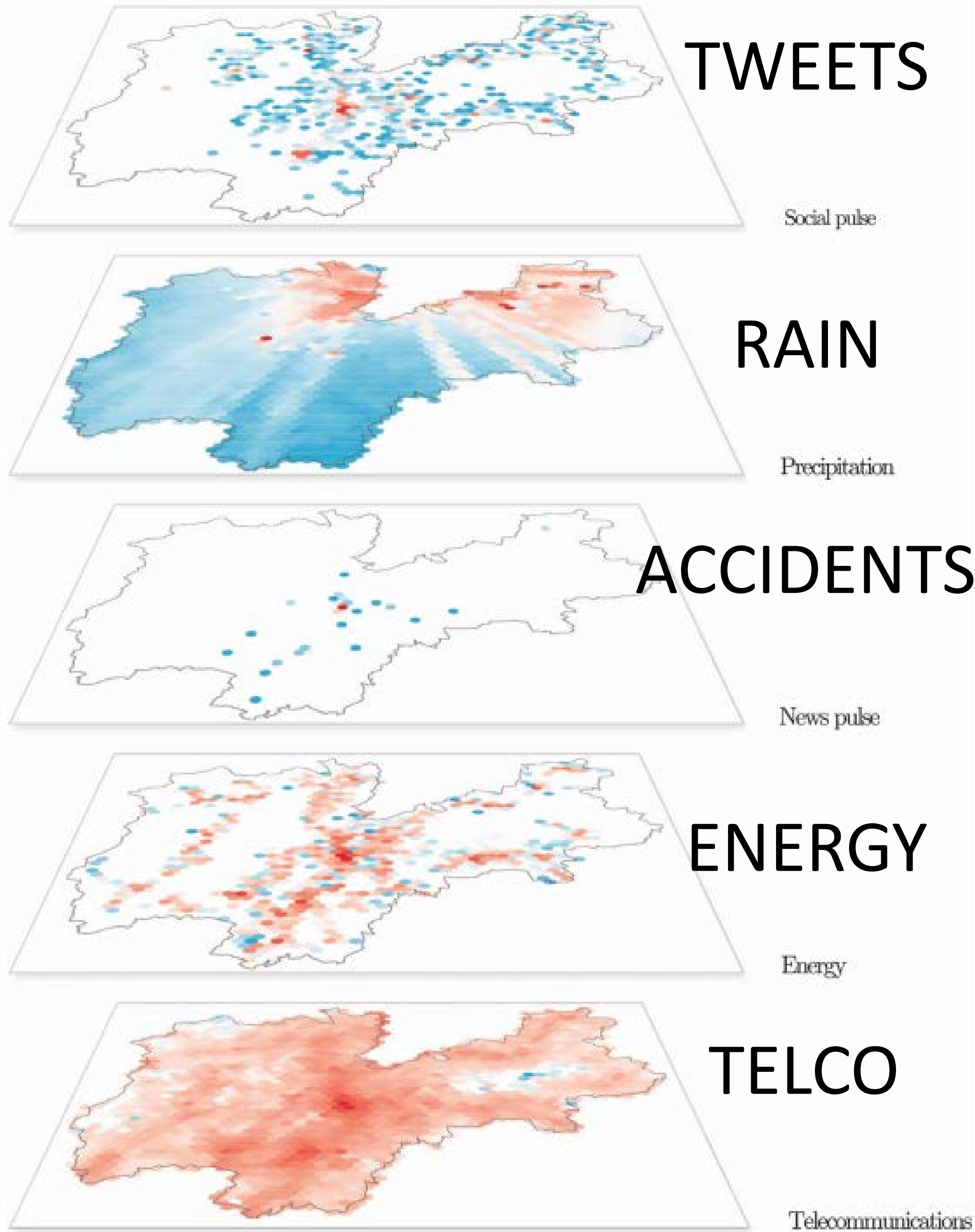
- GCTC (US), CEA (EU), JP, SK, IN, CN – awareness & PR
- Is the bus on time? Yes ☑ since 1991
- Organisms are networks by design
- Habitats are complex systems by design
- Smart Cities “Smart Parking”
- Connected solutions to reduce mortality and morbidity

Hexbin map with logarithmic color scale of the Province of Trentino, Italy. Each layer represents a specific dataset. Energy - red color represents the sum of consumed electricity. Precipitation - blue (minimum mean intensity of precipitations) to red (max). Blue - minimum number of events.

Trentino is a "Smart City" because you have data sets about events?

"Our wealth of information induces a poverty of attention" (Herbert Simon)

www.nature.com/articles/sdata201555



Energy “Intelligence”

Connecting local to national and may be even global

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No “Intelligence” in AI

See pdf EYE-in-AI

https://arxiv.org/abs/1610.07862

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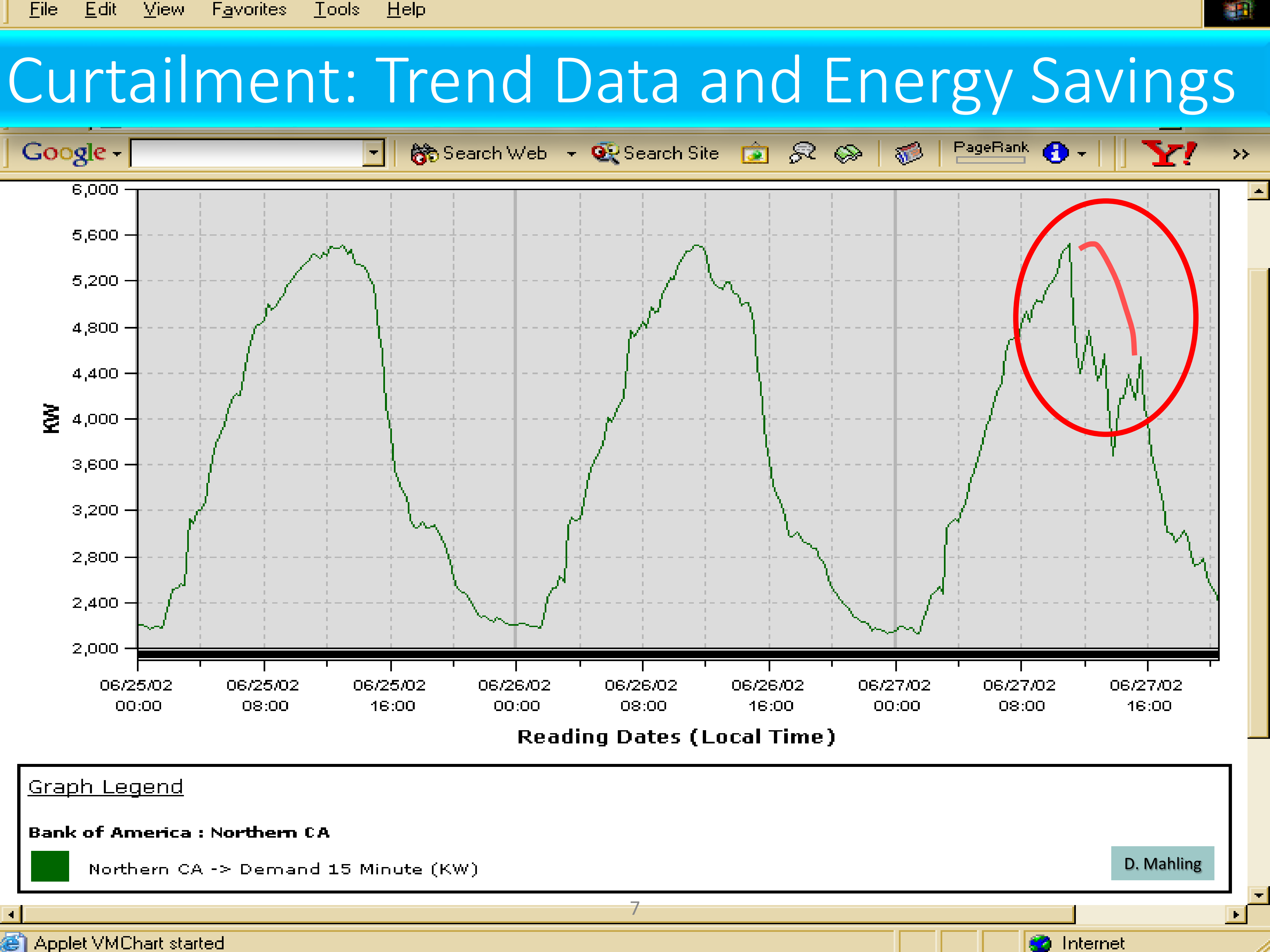
2002 ● MIT Demonstration ● Energy Auto-Load Balancing

- Electronic signal was sent from CA-ISO to building system
    - Curtail 2 MW for 4 hours across 78 retail sites
- Base load for 78 properties approximately 10 MW
- Signal received at 1:45 PM [15 minutes ahead of the start time of 2PM]
- Curtailment commenced at 2PM and completed at 6PM PDST

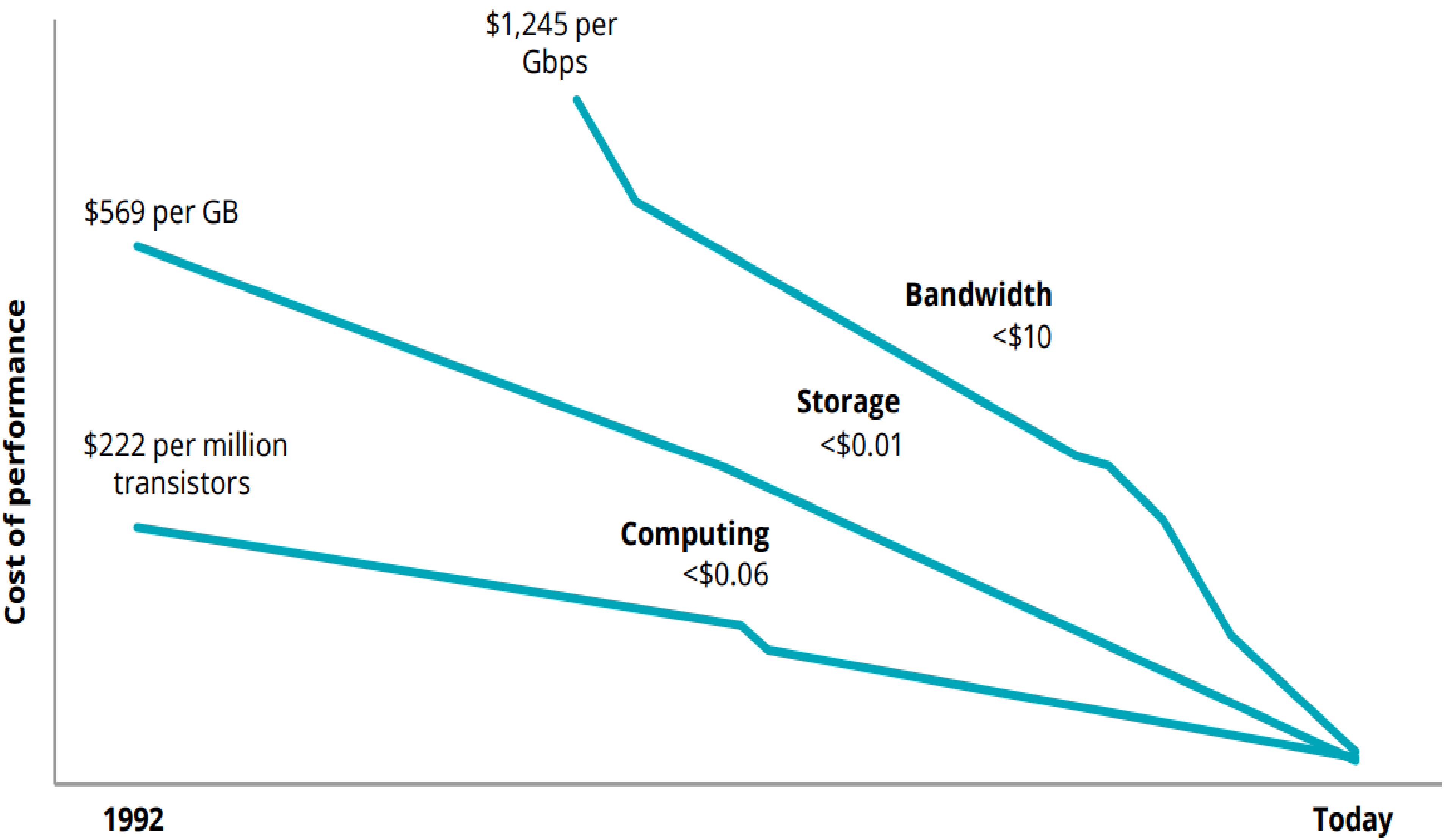
- 1:45 – DR signal received
- 1:46 – Agents shift from BAU mode to curtailment mode
- 1:47 – Energy Operator dials in 2 MW curtailment goal
- 2:00 – L/R agent deploys speed reduction on largest fans in North and South
- 2:10 – 1MW reduction
- 2:15 – Agent releases first L/R; Agent assembles second L/R set; deploys
- 2:20 – 2MW reduction
- Repeats until 3pm
- 3:00 – SAT agent raises SAT at select buildings
- 3:15 – SAT shifts buildings
- 3:05 – 1.2 MW reduction
- 3:20 – L/R rotates groups
- Etc

Curtailment: Trend Data and Energy Savings



Why the resurgence?

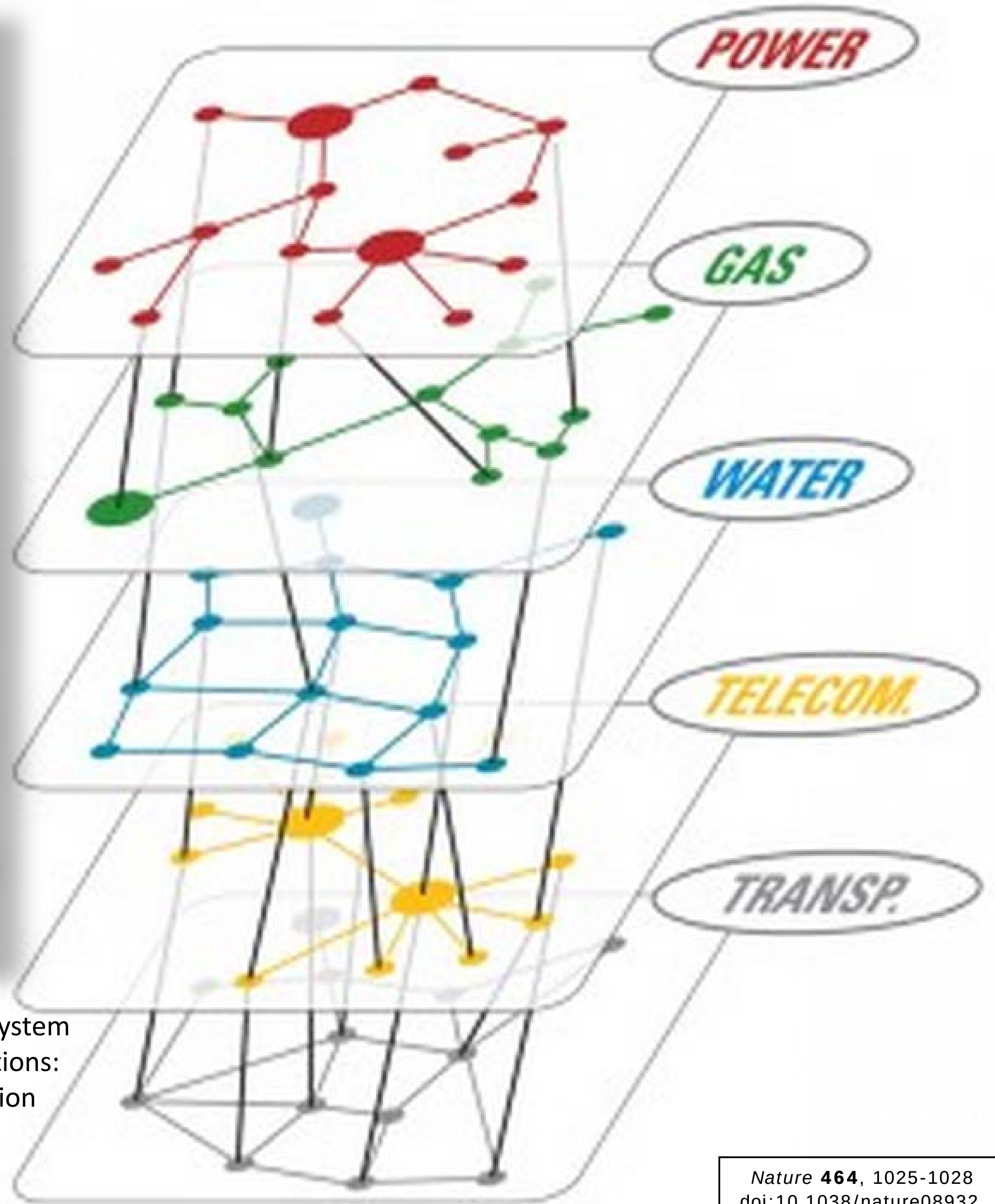
Low cost needs more volume - Smart Cities



Think Different

Cities

- Network of Systems
- Network Optimization
- Agent Driven Analytics
- Emergency / Resiliency



Smart City Emergency Management and Response System
Contingency/Resiliency planning and logistics operations:
Address failure/fault tolerance/redundancy/restoration
each key node in every layer
- data visualization portal
- citizen connectivity app

Nature **464**, 1025-1028
doi:10.1038/nature08932

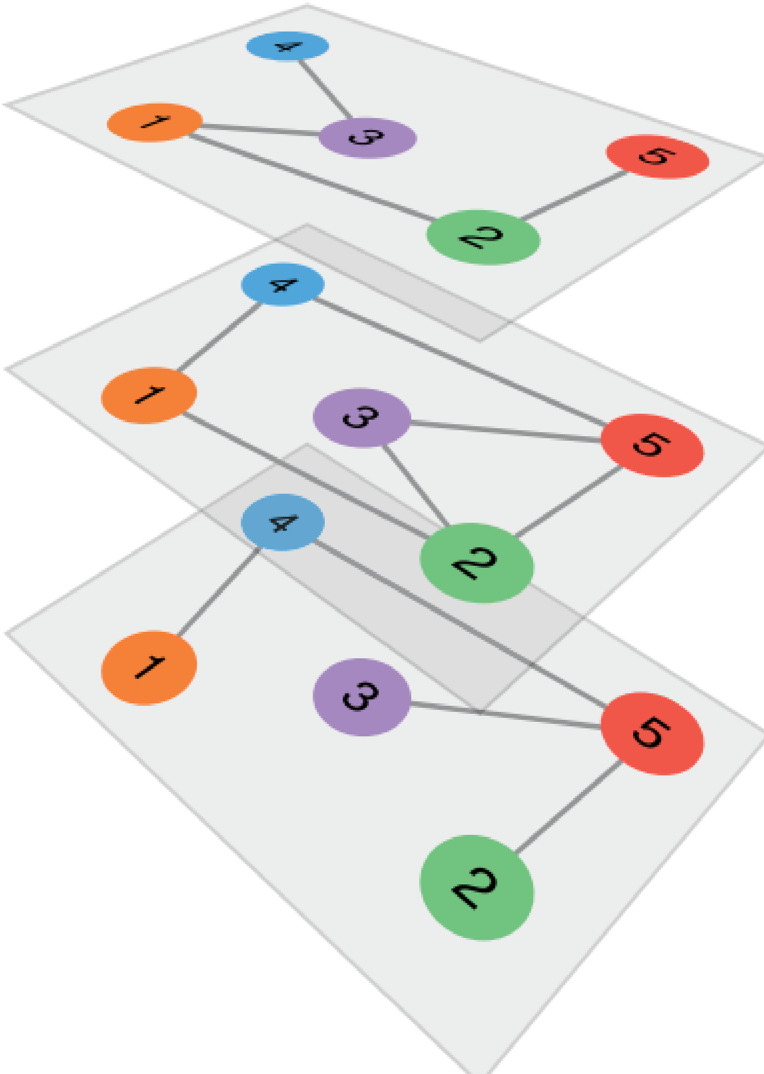
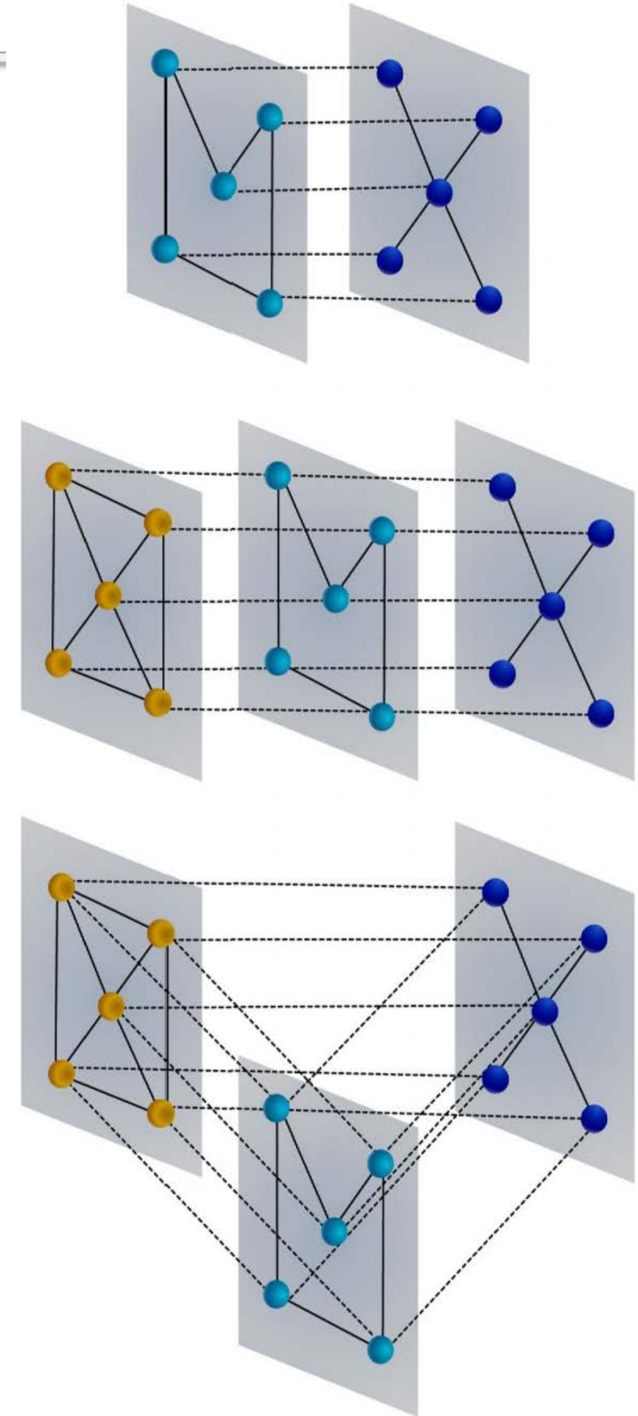
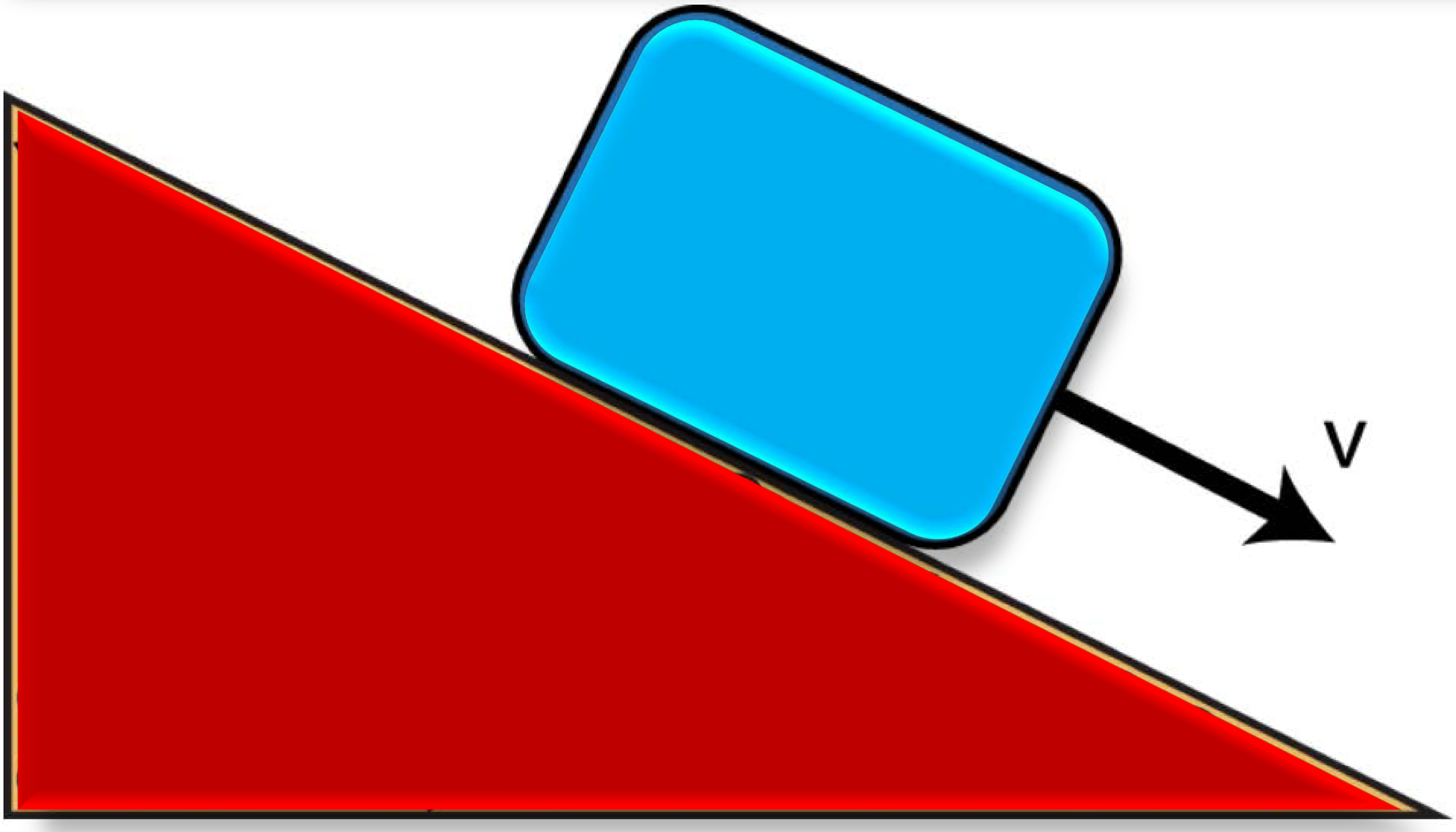


FIG. 1. A multiplex network with $M = 3$ layers and $N = 5$ nodes is shown. Every node i has $M = 3$ interdependent replica nodes (i, α) with $\alpha = 1, 2, 3$. In this figure, triplets of replica nodes are also identified by their color.



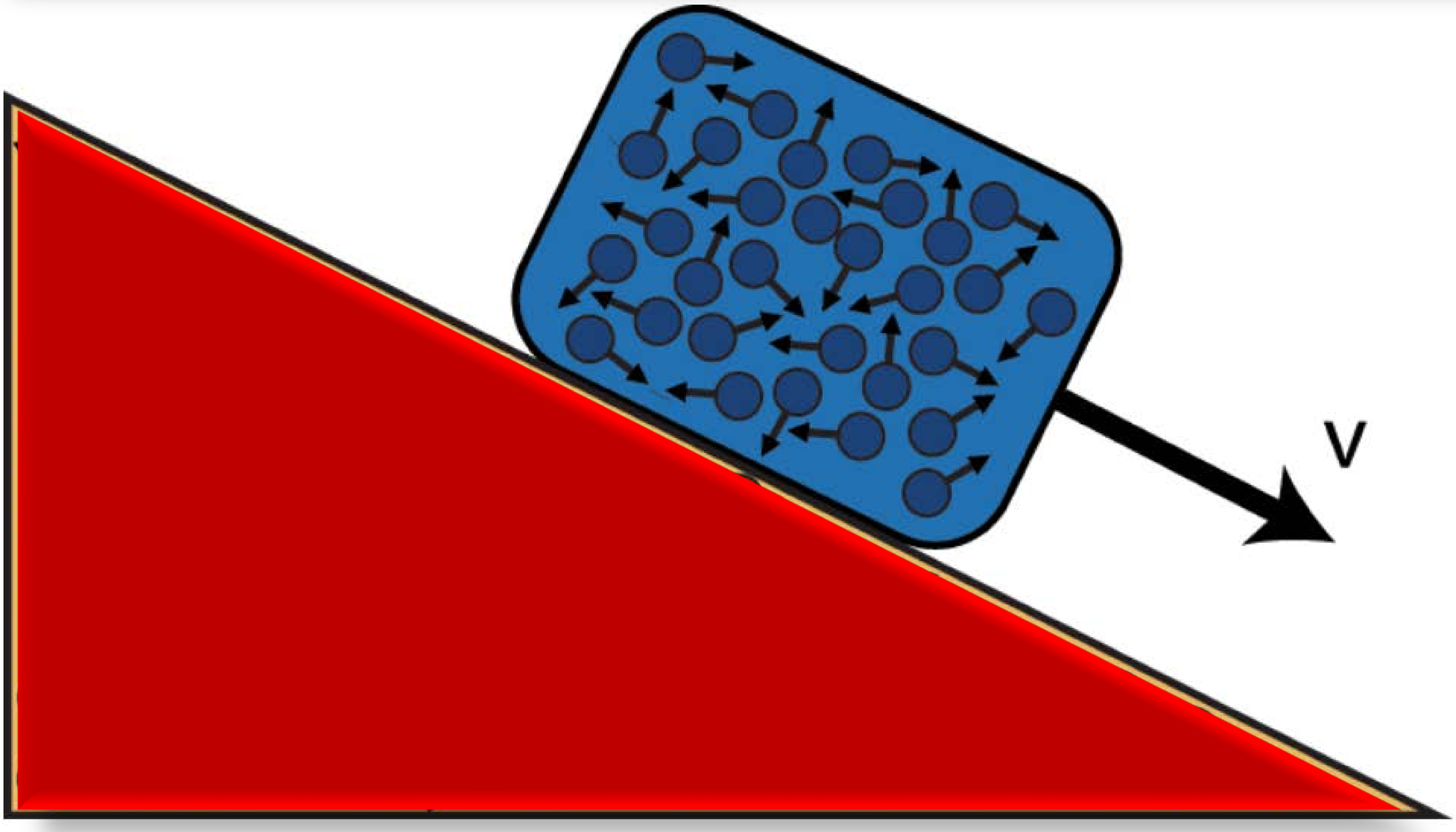
Simplicity v Complexity

Block Sliding Down an Inclined Plane (velocity at a certain point = v)



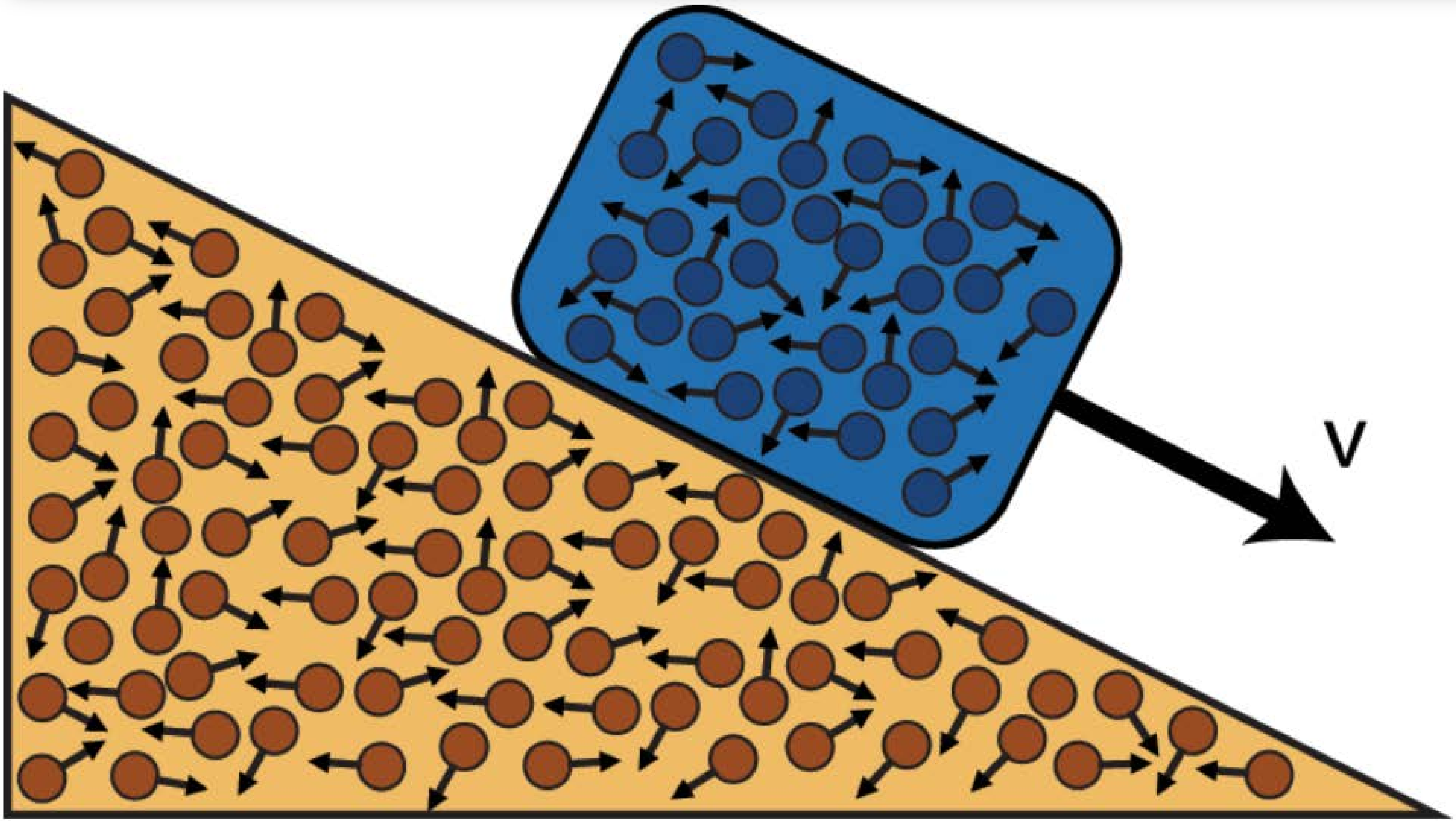
Macroscopic motion subject to gravity and friction (Newton’s Laws of Motion)

Block Sliding Down an Inclined Plane (velocity at a certain point = v)



Microscopic behavior – local oscillations of groups of atoms – random and independent

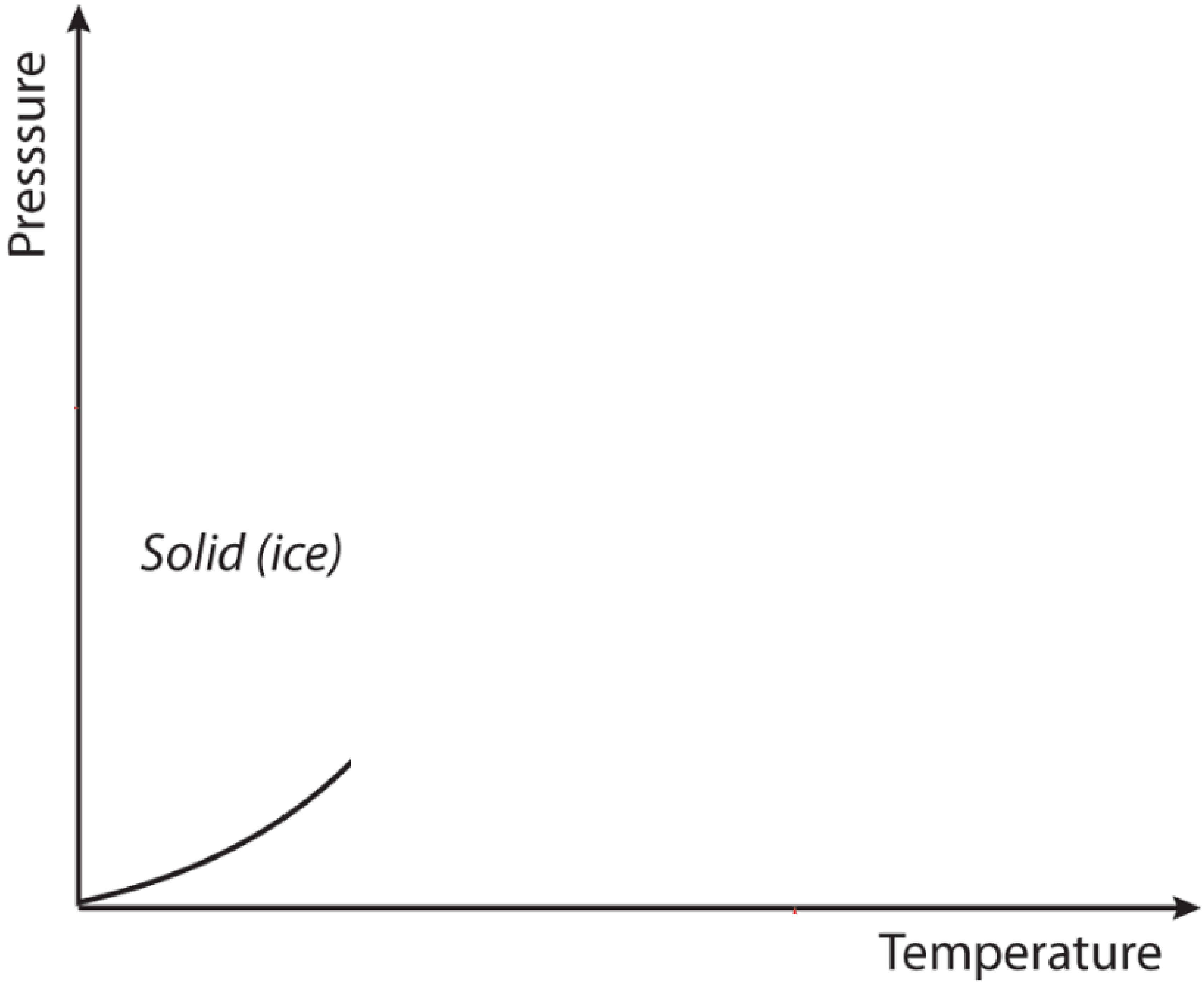
Block Sliding Down an Inclined Plane (velocity at a certain point = v)



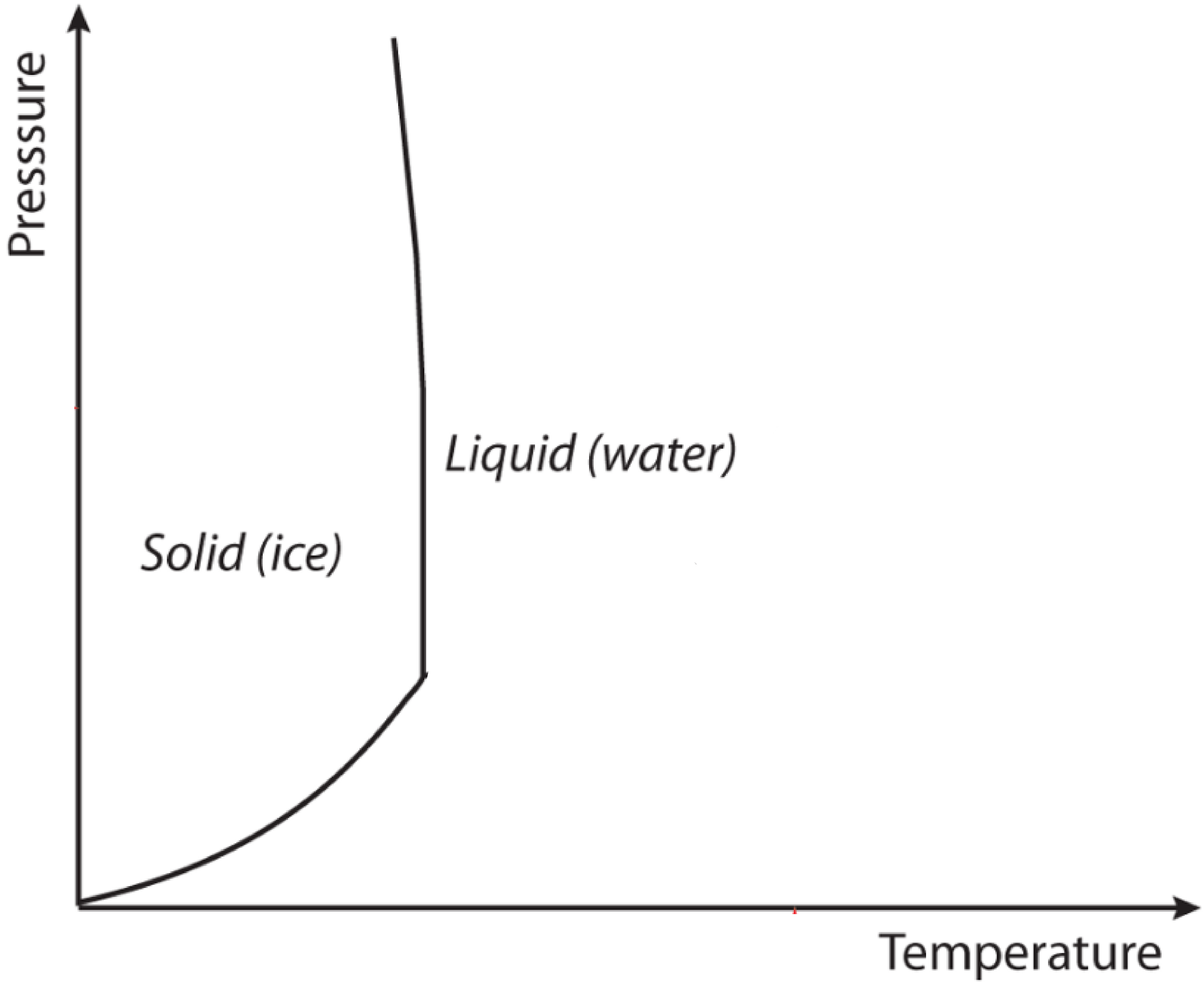
Microscopic behavior of atoms in accordance with laws of thermodynamics

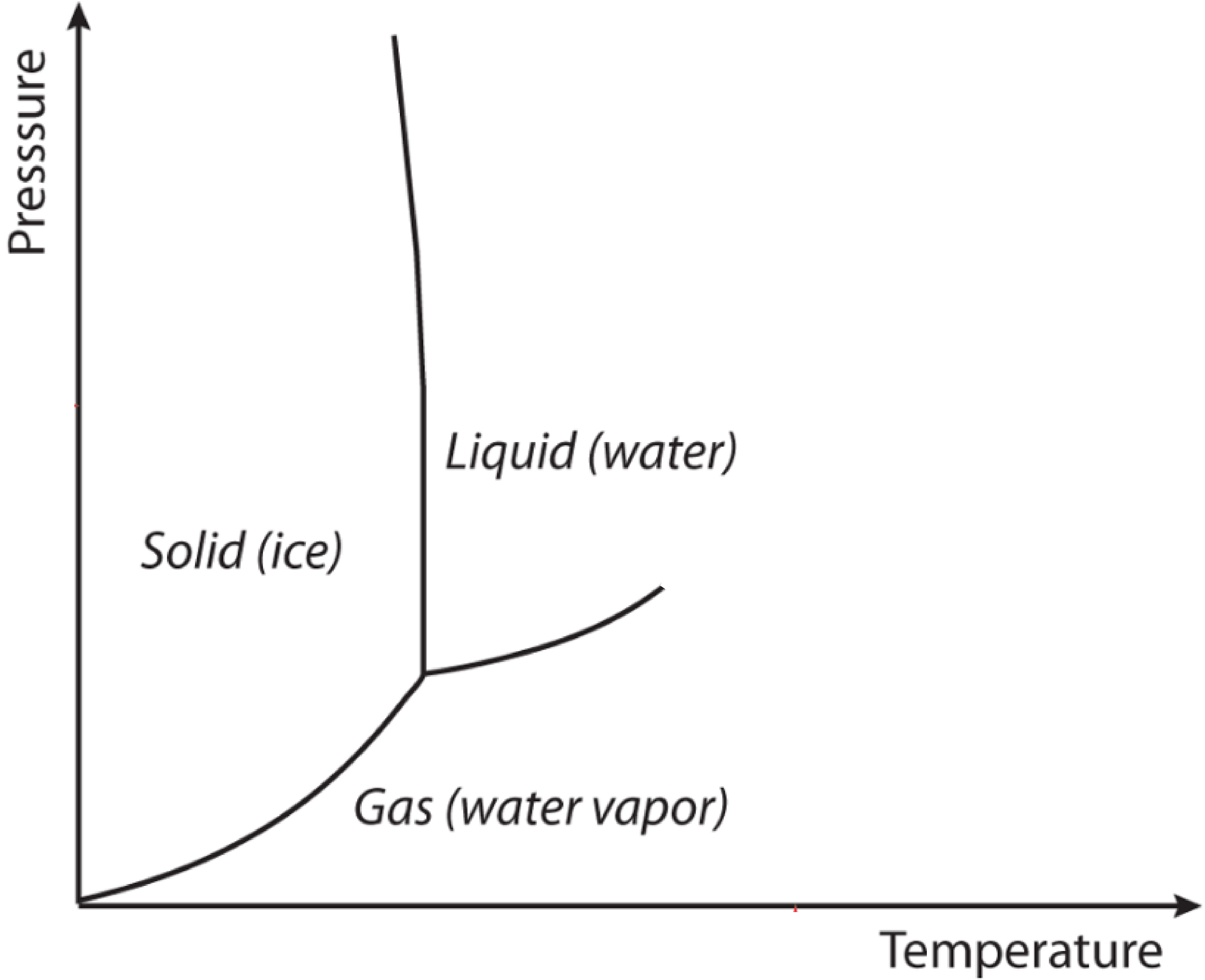
States of Matter

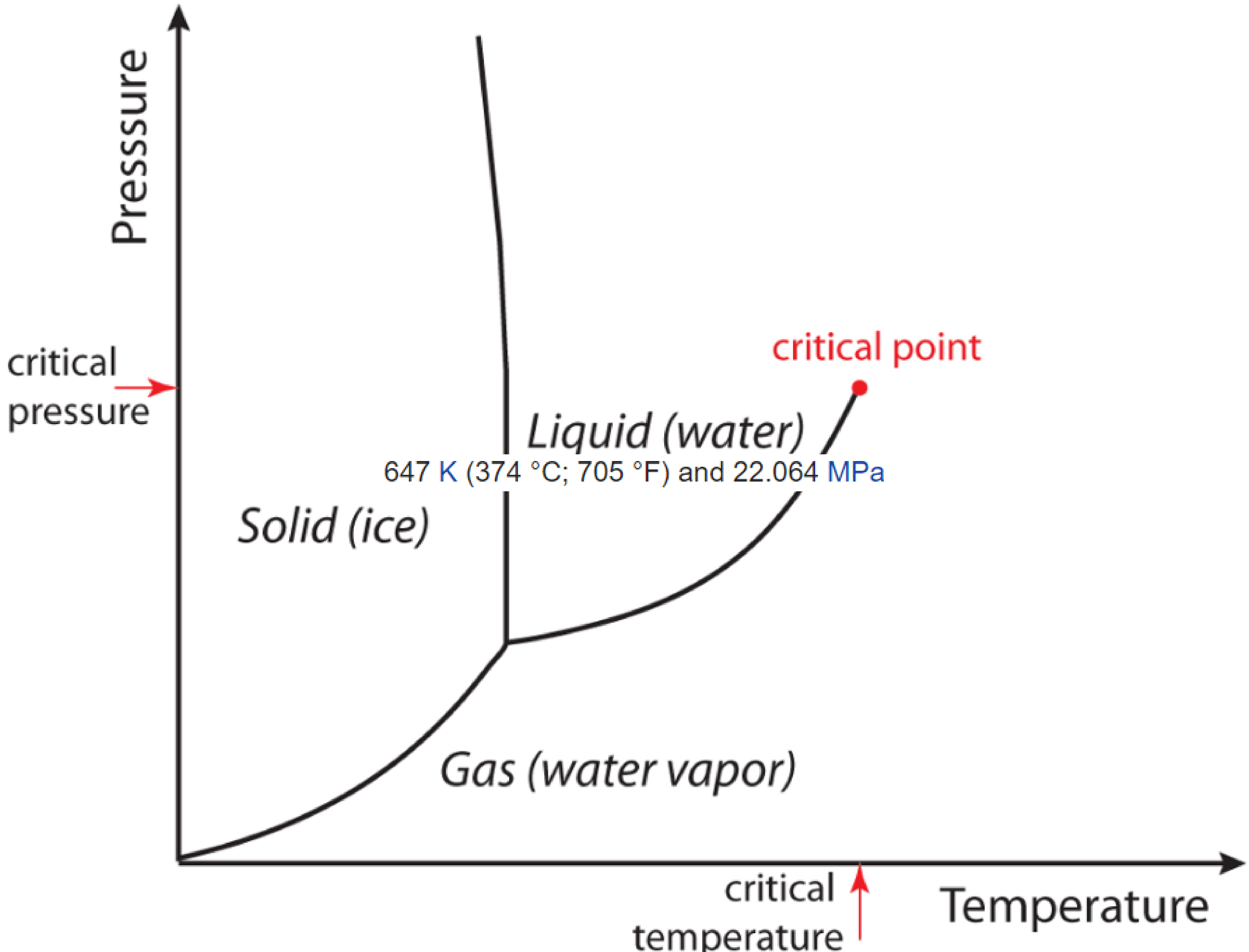
WATER



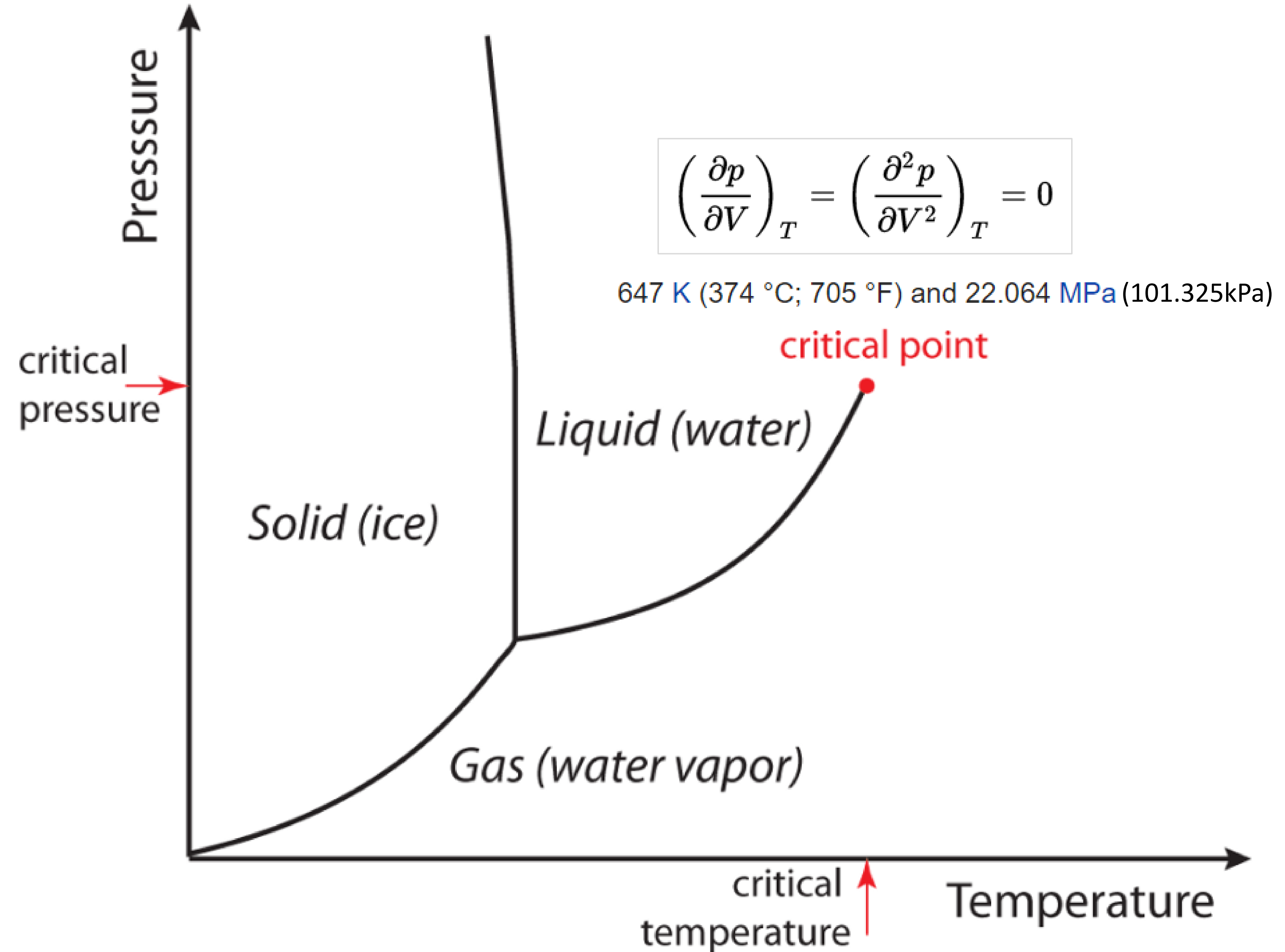
Presssure
Solid (ice)
Temperature


Pressure
Liquid (water)
Solid (ice)
Temperature

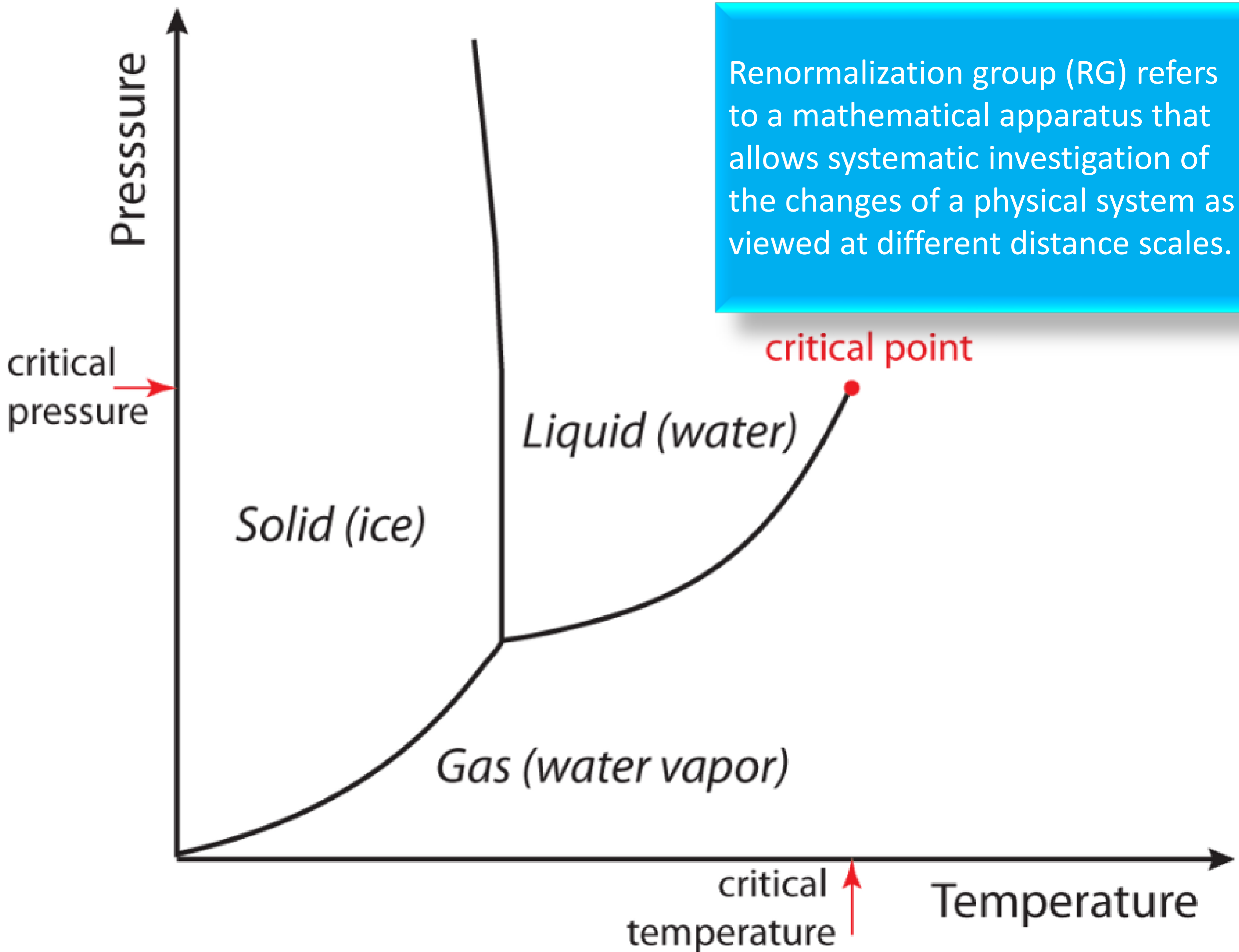

Presssure
Liquid (water)
Solid (ice)
Gas (water vapor)
Temperature



Presssure
critical pressure
critical point
Liquid (water)
647 K (374 °C; 705 °F) and 22.064 MPa
Solid (ice)
Gas (water vapor)
critical temperature
Temperature



Presssure
$$\left(\frac{\partial p}{\partial V}\right)_T = \left(\frac{\partial^2 p}{\partial V^2}\right)_T = 0$$
647 K (374 °C; 705 °F) and 22.064 MPa (101.325kPa)
critical point
critical pressure
Liquid (water)
Solid (ice)
Gas (water vapor)
critical temperature
Temperature



Renormalization group (RG) refers to a mathematical apparatus that allows systematic investigation of the changes of a physical system as viewed at different distance scales.

What does it signify?

You may not solve tomorrow's problems using yesterdays tools, current thinking and conventional wisdom.

New ideas, new design, new engineering, new context, new worlds, new computation, new directions.

Intelligent Autonomy ● Resiliency and Emergency Response
Systemic foundational compass essential for smart anything

Think – People

[1] Rehydration App [2] Reflected radiowaves

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See PDF “Smart ? Cities”

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Name	Size	Format	Description
Digital Twins.pdf	717.3Kb	PDF	DIGITAL TWINS
Intelligence-in-AI.pdf	641.4Kb	PDF	EYE-in-AI
DIGITAL DIFFUSION.pdf	426.4Kb	PDF	Digital Diffusion
Primum non nocere ...	223.8Kb	PDF	Primum non nocere
Digital Ledger.pdf	12.45Mb	PDF	Digital Ledger - preBLOCKCHAIN
DSED_DATTA.pdf	228.4Kb	PDF	DSED-IoT
Commencement.pdf	259.1Kb	PDF	Commencement
CONNECTIVITY _ ...	45.75Mb	PDF	Digital-by-Design
CSCF-TXL.pdf	17.13Mb	PDF	CSCF-TXL
Cyber-Security.pdf	2.417Mb	PDF	Cybersecurity
Healthcare.pdf	1.382Mb	PDF	Healthcare
03 _ Healthcare.pdf	26.08Mb	PDF	Medical IoT
MDPnP _ www.mdpnp.org ...	6.944Mb	PDF	Medical IoT MDPnP
MDPNP DOCS.zip	82.80Mb	application/zip	MDPnP
TRANS ENG.pdf	13.23Mb	PDF	Trans Eng
IoT Markets.pdf	13.51Mb	PDF	MARKETS
Purpose _ v1.0.pdf	5.560Mb	PDF	PURPOSE
Digital Twins -MIT, ...	47.07Mb	MPEG video	DT 2000
Smart Cities.docx	12.17Kb	Unknown	Smart ? Cities

http://bit.ly/IOT-MIT

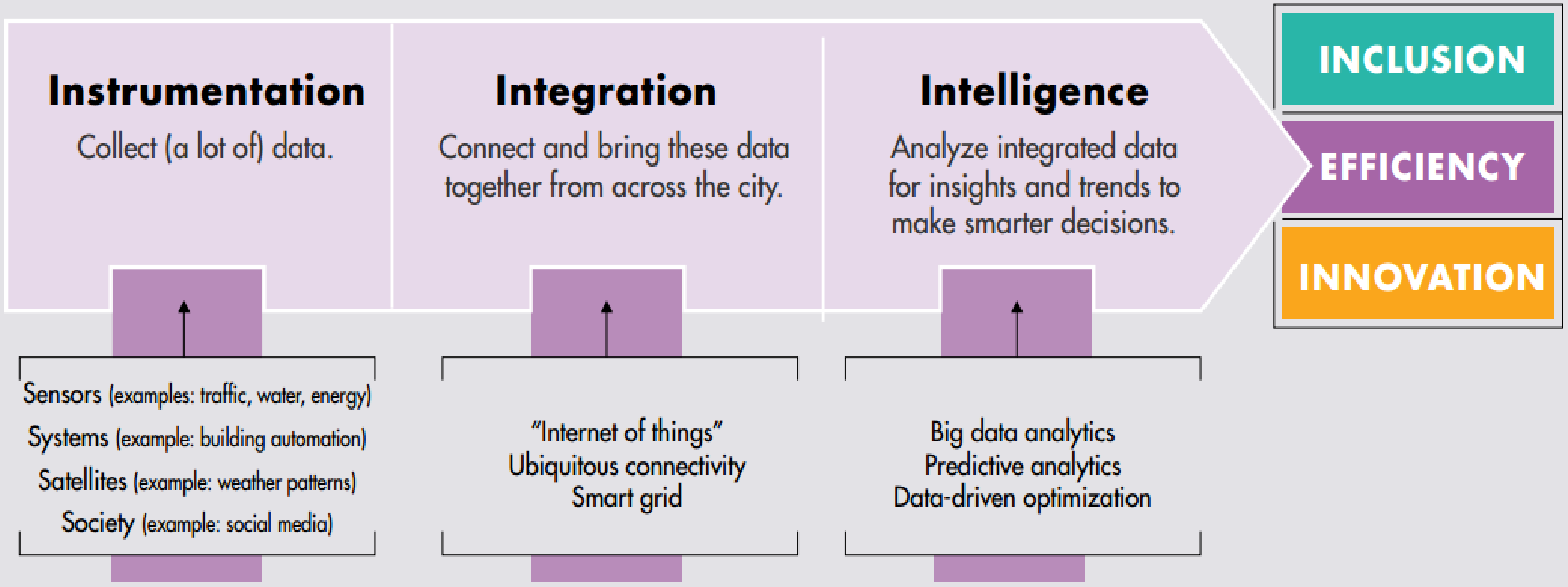
http://bit.ly/MIT-SD

http://bit.ly/MIT-IOT

Smart City concepts, tools and technologies have been around for more than two decades

Here is one example

Here is an illustration from 2008



Source: Adapted from Palmisano 2008.

Platforms as triggers …

Triggers for economic momentum

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WiFi

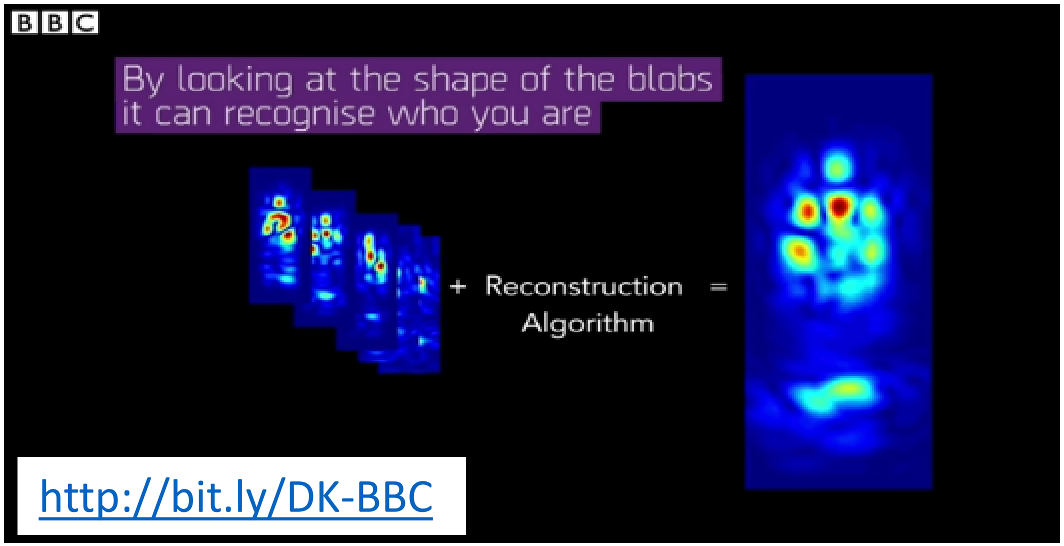
WiVi

Wireless Vision

BBC | Sign in | News | Sport | Weather

NEWS

Home | Video | World | UK | Business | Tech | Science | Magazine



How wi-fi can identify and track people through walls

4 November 2015 Last updated at 00:22 GMT

Researchers at the Massachusetts Institute of Technology's (MIT) Computer Science and Artificial Intelligence Laboratory have created a system that can identify people through walls using just wi-fi signals.

The technology works by detecting "reflections" created by the signals when they touch other objects, such as human bodies.

Professor Dina Katabi, MIT

SIGCOMM'13. August 12–16. 2013. Hong Kong. China.

http://bit.ly/DK-WiVi

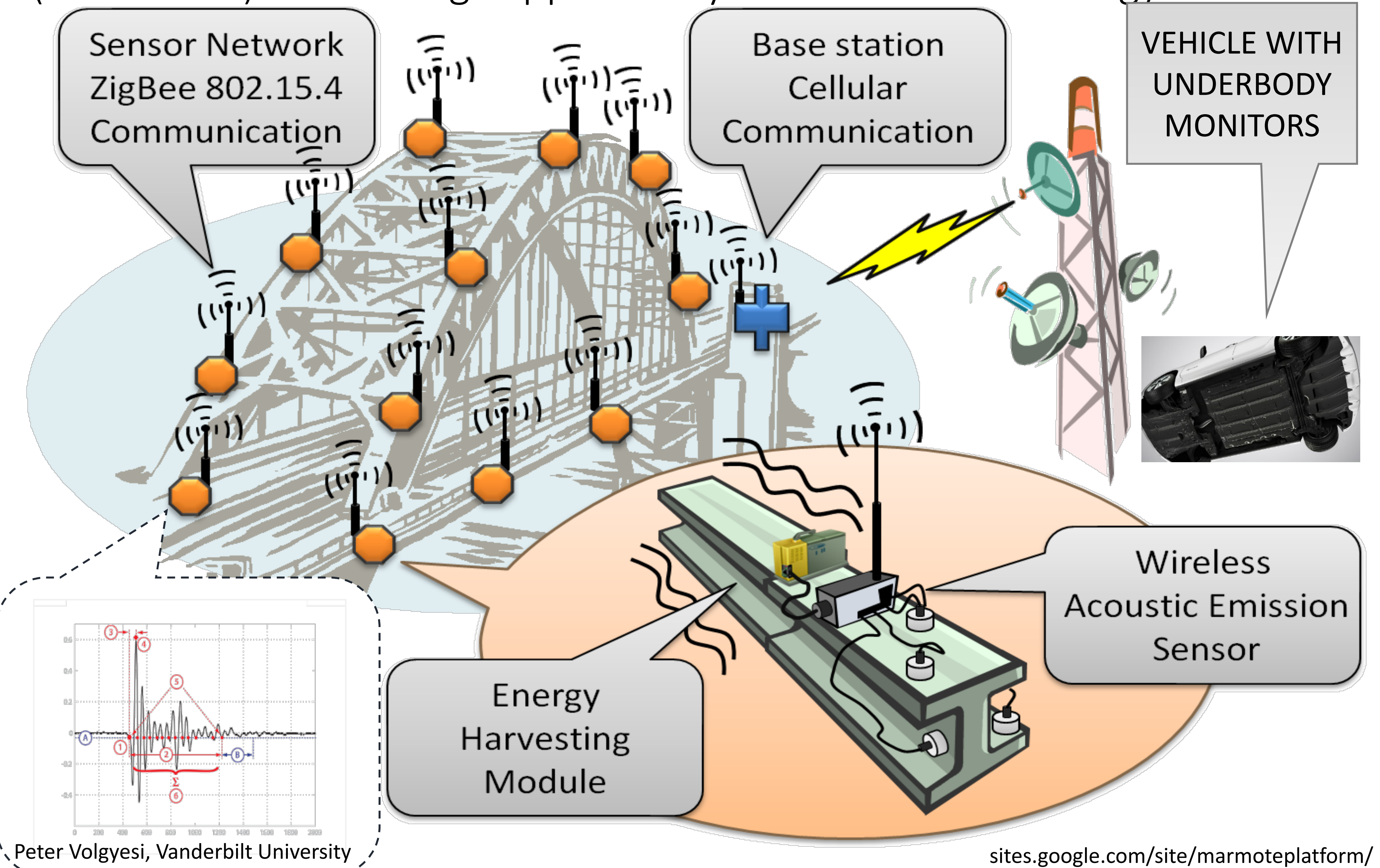
Why it may be important for Smart Cities?

WiVi

- Non-invasive critical infrastructure monitoring
- Silent Seismic Impact on Essential Services

DATA COLLECTION FROM INFRASTRUCTURE – BRIDGES & OTHER MAJOR CRITICAL STRUCTURES

Autonomous vibration (accel-erometers), stress (strain gauges) & cracks (AE sensors) monitoring supported by vibration-based energy harvester



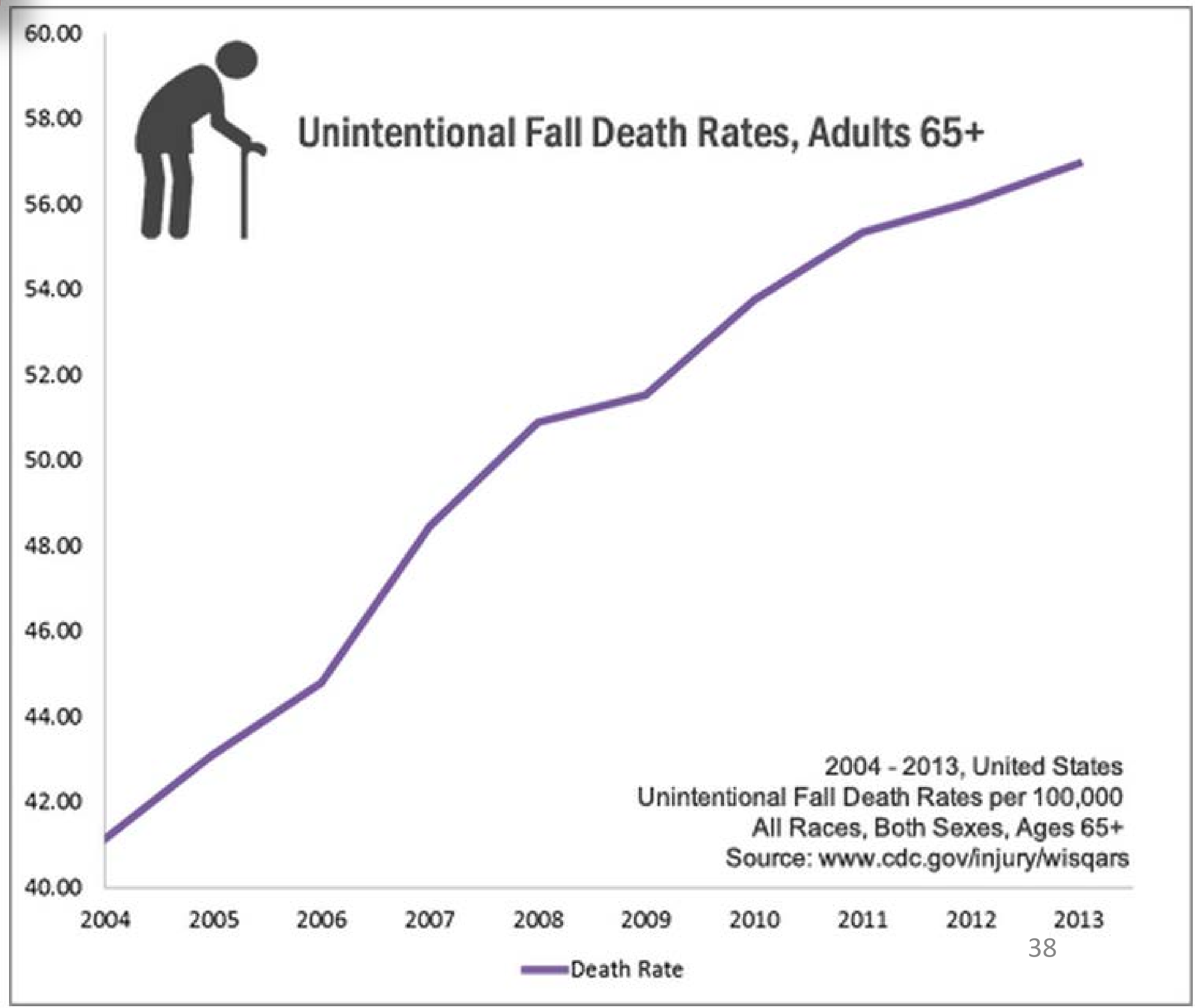
sites.google.com/site/marmoteplatform/

Why it may be important for Smart Cities?

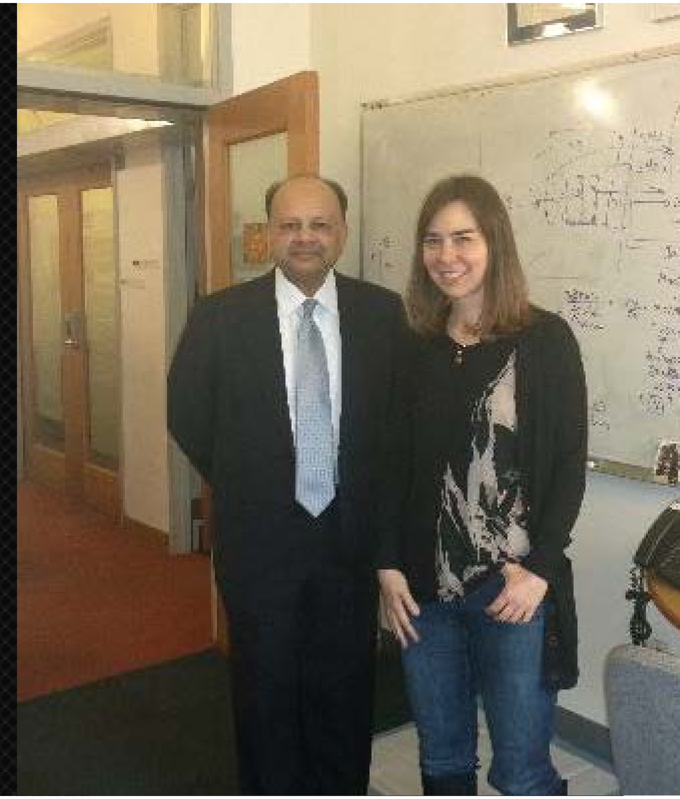
WiVi

- Non-invasive critical infrastructure monitoring
- Silent Seismic Impact on Essential Services
- Physical Security
- Cyber-security
- Healthcare

2.5 million falls 2013
734,000 hospitalized
25,500 died from fall
$34 billion direct cost



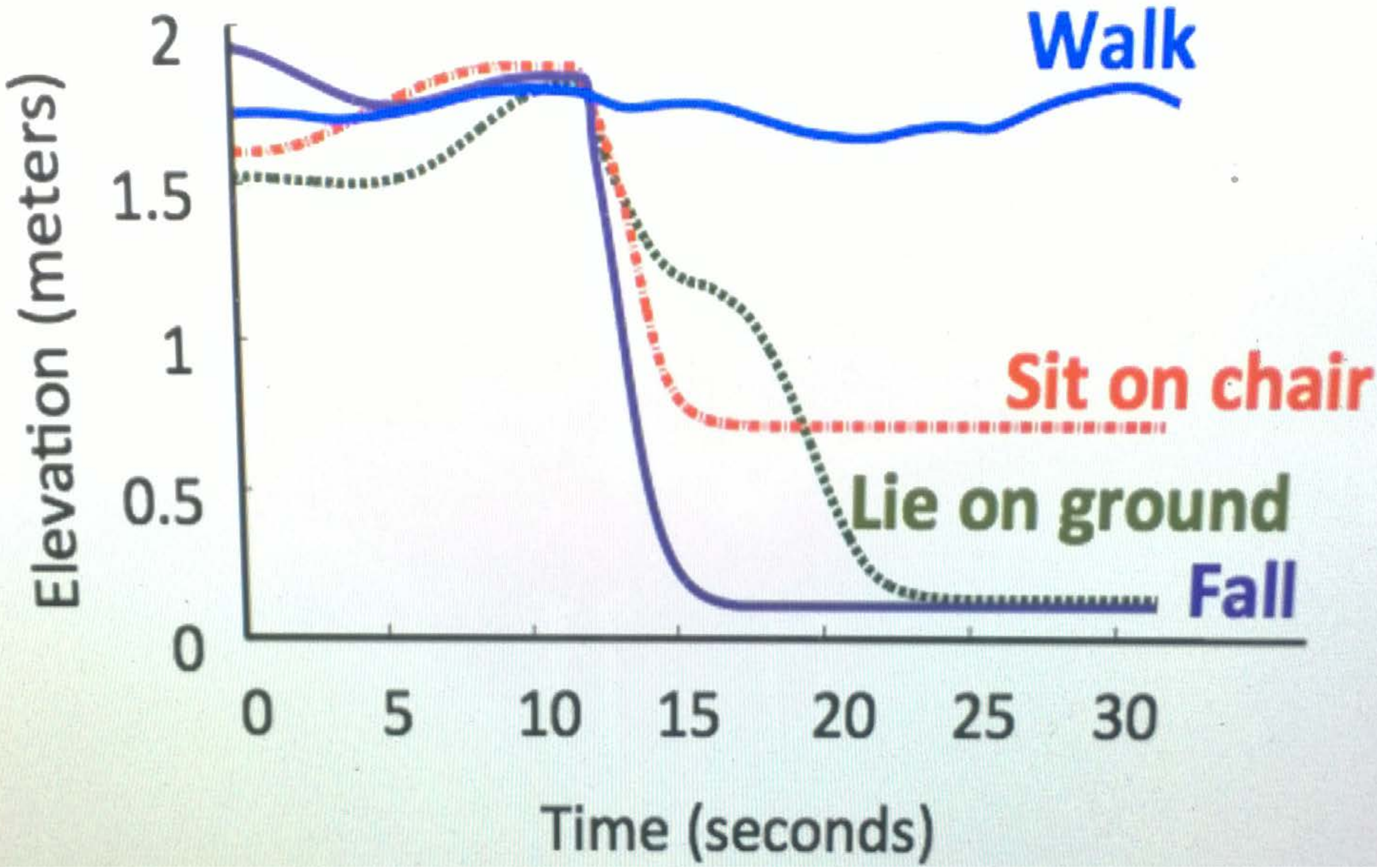
Professor Dina Katabi (MIT) presenting RF Reflection to President Obama (White House Demo, 4 August 2015)



President Obama invites MIT entrepreneurs to give demo at the White House http://bit.ly/President-Obama-with-Dina-Katabi

http://newsoffice.mit.edu/2015/president-obama-meets-mit-entrepreneurs-white-house-demo-day-0806

Fall Detection – Wire less, Sensor less, Without Wearables



RF Reflection Data - Professor Dina Katabi, Wireless Center, CSAIL, MIT ● IIC Member

Detect fall, then what ….

Respond and/or connect to appropriate network of services

Think …

Networks

Network Optimization

Business of Smart Cities

Repeating the mistakes of electrification and RFID

- connecting things -

SCIENTIFIC DATA

Smart Cities are complex systems of socio-technical networks which must integrate and analyze wide range of problems for which there must be adequate digital records for each data element.

OPEN

SUBJECT CATEGORIES

» Complex networks

» Sociology

» Geography

» Computational science

A multi-source dataset of urban life in the city of Milan and the Province of Trentino

Gianni Barlacchi[1,2,*], Marco De Nadai[2,*], Roberto Larcher[1], Antonio Casella[1], Cristiana Chitic[1], Giovanni Torrisi[1], Fabrizio Antonelli[1], Alessandro Vespignani[3], Alex Pentland[4] & Bruno Lepri[2]

MIT Media Lab

Received: 27 May 2015

Accepted: 18 September 2015

Published: 27 October 2015

The study of socio-technical systems has been revolutionized by the unprecedented amount of digital records that are constantly being produced by human activities such as accessing Internet services, using mobile devices, and consuming energy and knowledge. In this paper, we describe the richest open multi-source dataset ever released on two geographical areas. The dataset is composed of telecommunications, weather, news, social networks and electricity data from the city of Milan and the Province of Trentino. The unique multi-source composition of the dataset makes it an ideal testbed for methodologies and approaches aimed at tackling a wide range of problems including energy consumption, mobility planning, tourist and migrant flows, urban structures and interactions, event detection, urban well-being and many others.

www.nature.com/articles/sdata201555

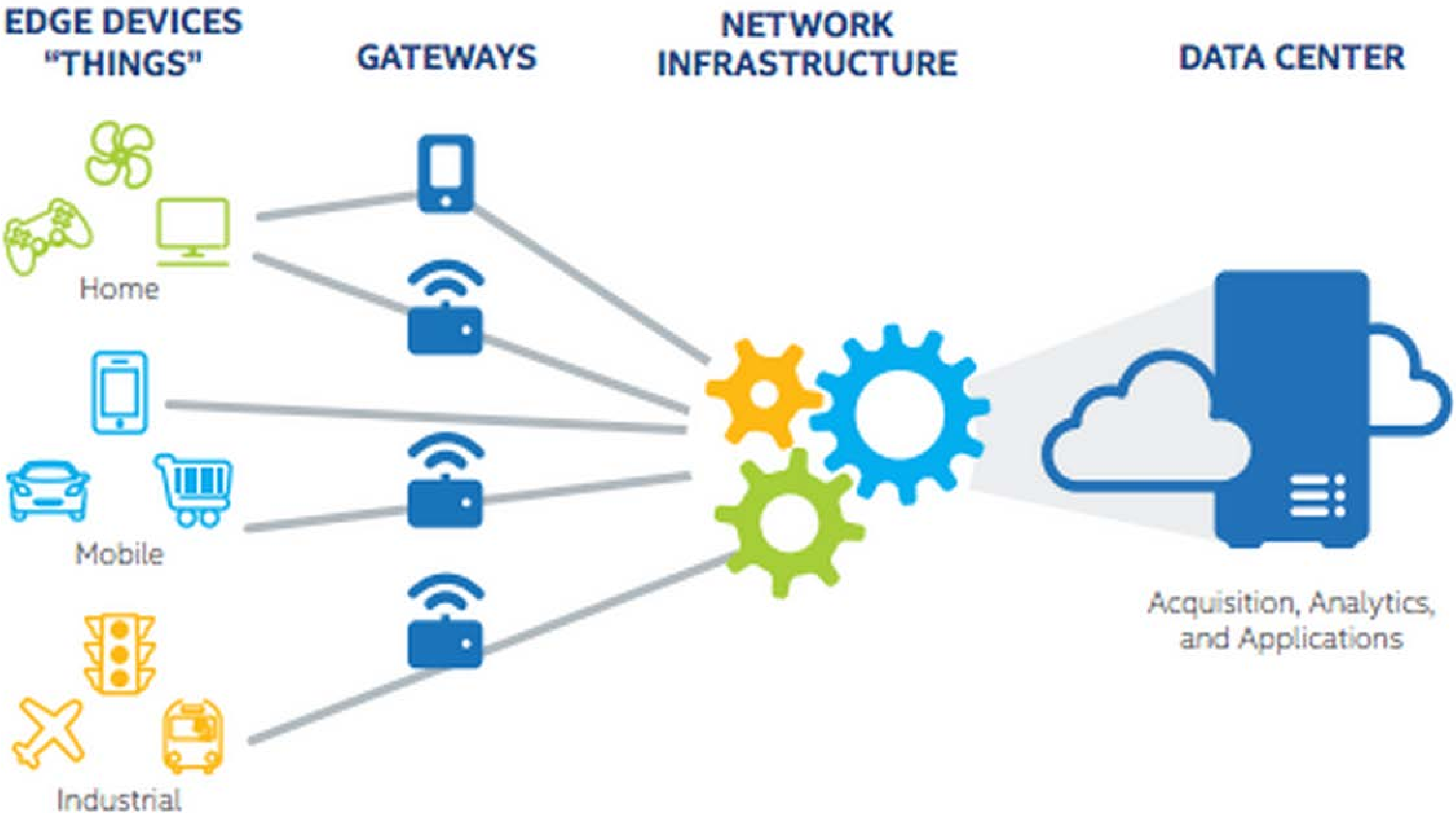
Smart City Business Needs to Integrate

- Systems Science
- Network Optimization
- Food, Water, Health, Energy, Air
- Autonomy, Resilience, Communication
- Supply Chain, Logistics, Freight Transport
- Tools for the Evolution – The Smart City Vision
- What is important or differentiates your community?

Architectural Guidance

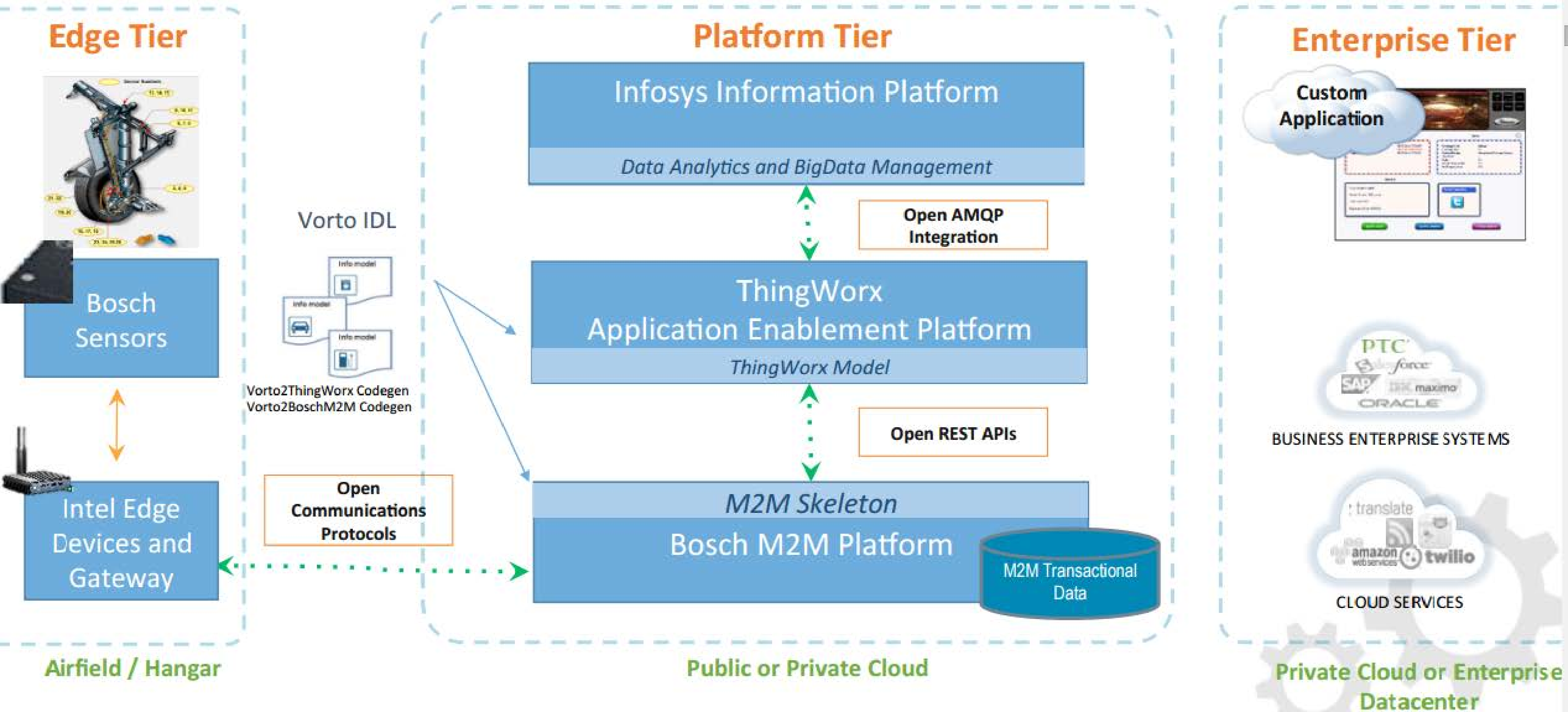
Dynamic Composition? Composable Infrastructure Units?

http://smartcities.ieee.org/articles-publications/trento-white-papers.html

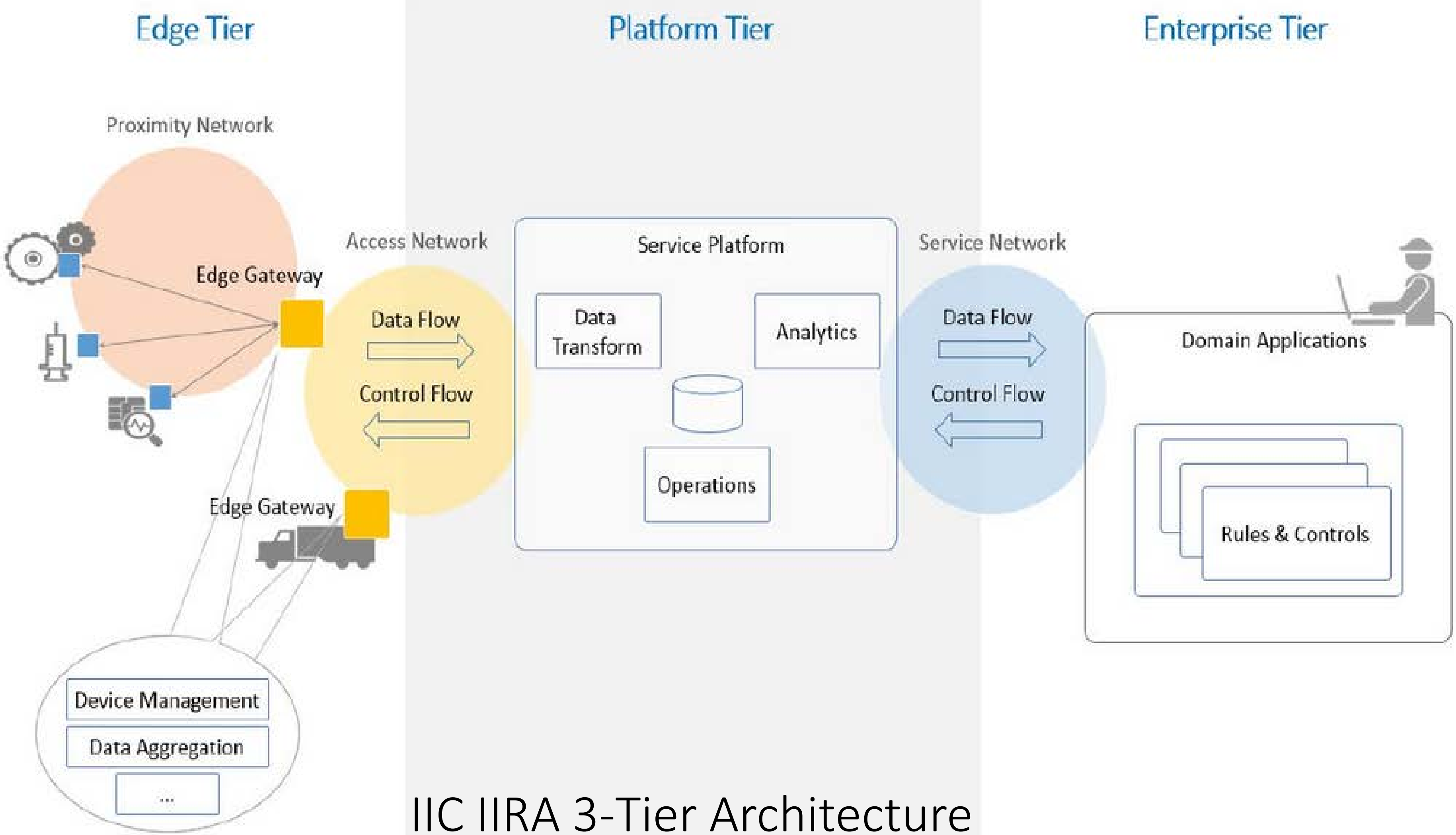


EDGE DEVICES "THINGS"
GATEWAYS
NETWORK INFRASTRUCTURE
DATA CENTER
Home
Mobile
Industrial
Acquisition, Analytics, and Applications

Formula In Use – Example from Industrial Internet Consortium



Source: Industrial Internet Consortium



IIC IIRA 3-Tier Architecture

Business viewpoint - identification of stakeholders and their business vision, values and objectives in establishing an IIS and its regulatory context. These concerns are key business drivers of interest to business decision-makers, product managers and system engineers in order to deploy IIS.

Usage viewpoint - human in the loop sequence of activities necessary to deliver IIS functionality and achieving system capabilities.

Functional viewpoint - interrelationships and structure, interfaces and interactions between them and with external elements in the environment.

Implementation viewpoint - tools needed to implement functional components, their communication schemes and their lifecycle procedures.

http://industrial-iot.com/2015/06/the-industrial-internet-reference-architecture-first-impressions/


industrial internet CONSORTIUM

www.iiconsortium.org

Industrial Internet Reference Architecture

tech-arch.tr.001 2015-06-04 Version 1.7

Industrial Internet Reference Architecture

http://bit.ly/IIRA-IIC

National Institute of Standards and Technology
NIST, US Department of Commerce
CYBERPHYSICAL SYSTEMS (CPS) PUBLIC WORKING GROUP (PWG)

PRELIMINARY DISCUSSION DRAFT
Framework for Cyber-Physical Systems

Release 0.7

3/3/2015 5:27 PM

Cyber Physical Systems Public Working Group

EU - AIOTI REPORTS

EU - SINGLE DIGITAL MARKET

http://bit.ly/EU-AIOTI-REPORTS

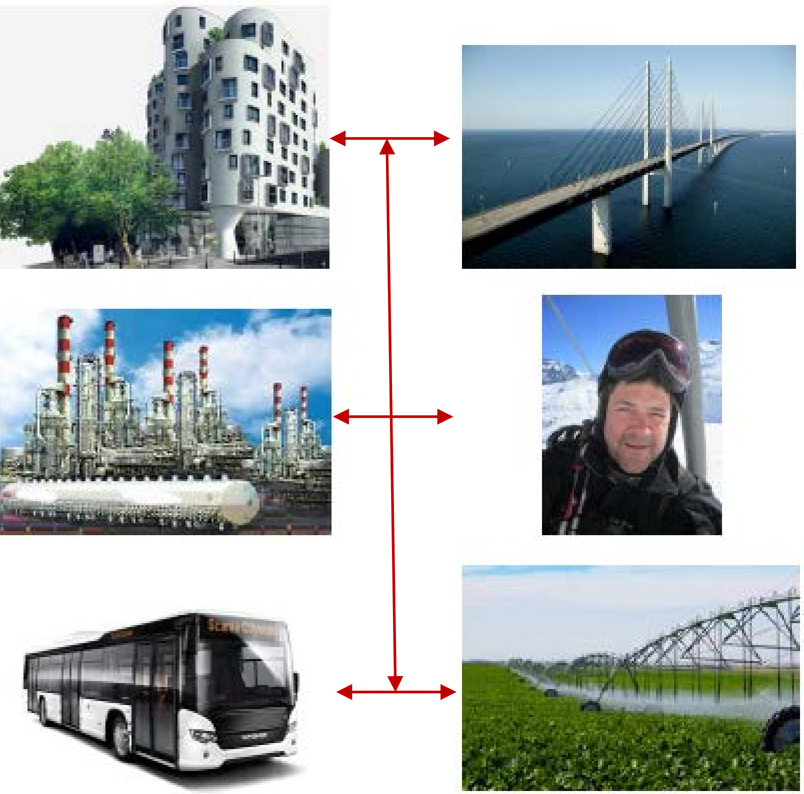
http://bit.ly/DIGITAL-DECLINE

Conventional Wisdom

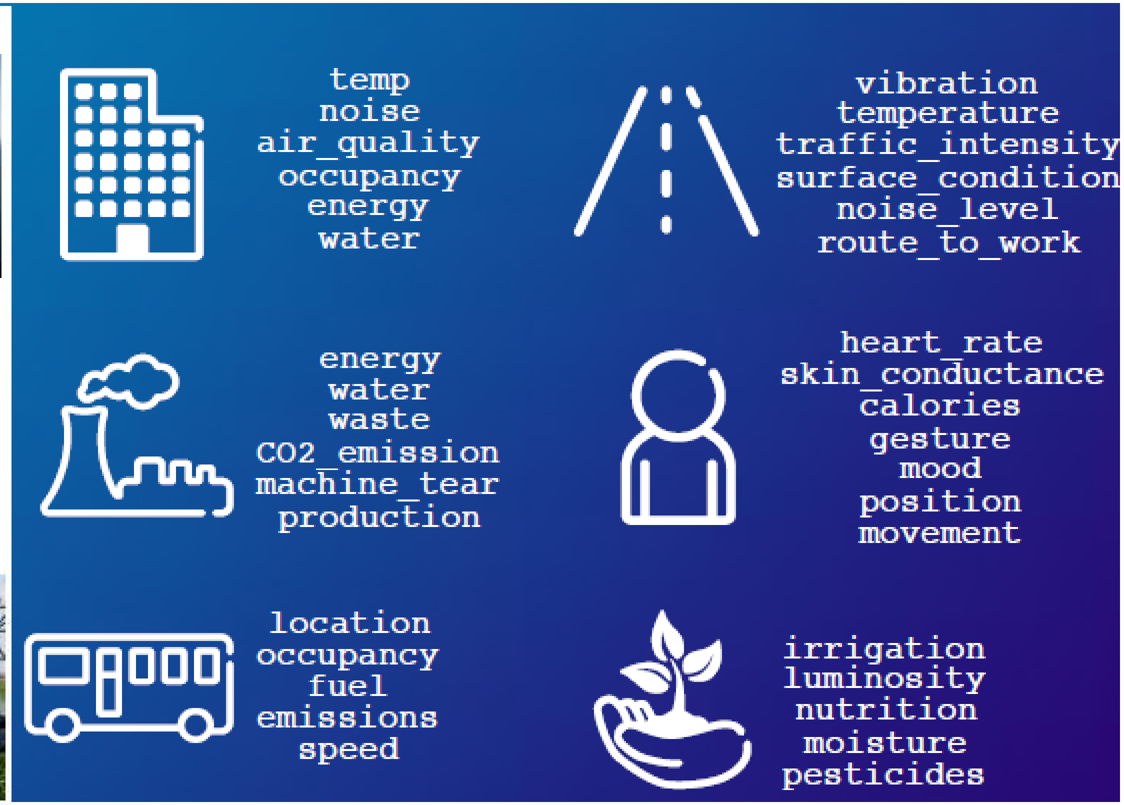
The generic Smart City

REPRESENT OBJECTS

DETECT,



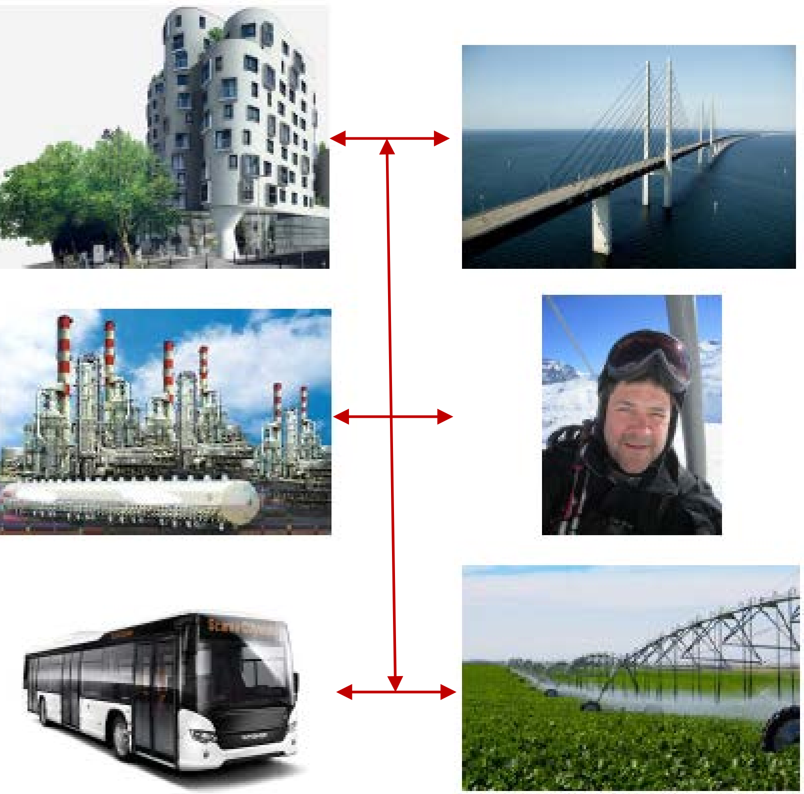
REPRESENT,

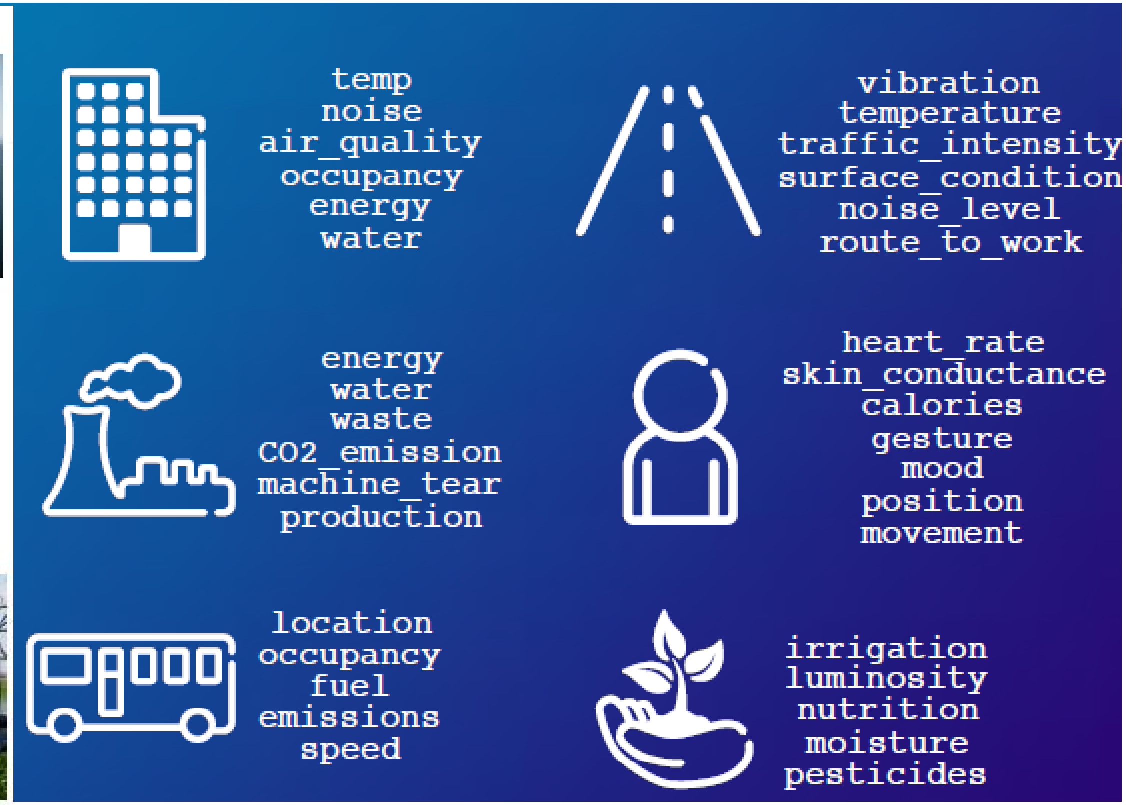


The generic Smart City

DATA ACQUISITION

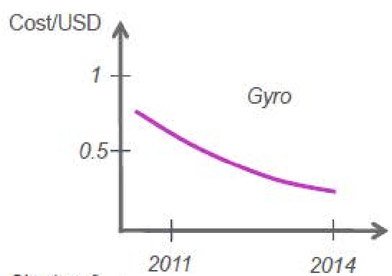
DETECT, CONNECT, REPRESENT, SENSE,

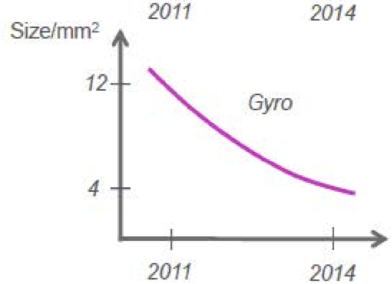




Sensors

- Barometric pressure
- Accelerometer
- Gyroscope
- Magnetometer
- CO_2, O_2, other
- Heart rate
- Galvanic Skin Response
- Luminosity
- Sound
- Temperature
- Ultrasonic
- Gas flow
- Radiation
- ...





BMP280
- Pressure sensor
- Current: 2.74 μA @ 1 Hz
- Accuracy: ±0.12 hPa (± 1 m)
- Size: 2.0*2.0*0.95 mm³
- Price: 1.55 € @ 1000

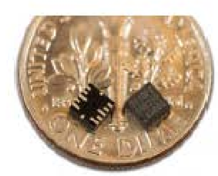

BMP280


(BMP180)

3-axis accelerometer sensor

mCube

MC3420
- 3-axis accelerometer
- Current: 30 μA @ 128 Hz
- Event detection. tap, shake, drop, tilt, orientation (P/L)
- Size: 2.0*2.0*0.92 mm³
- Price: 0.843 € @ 1000

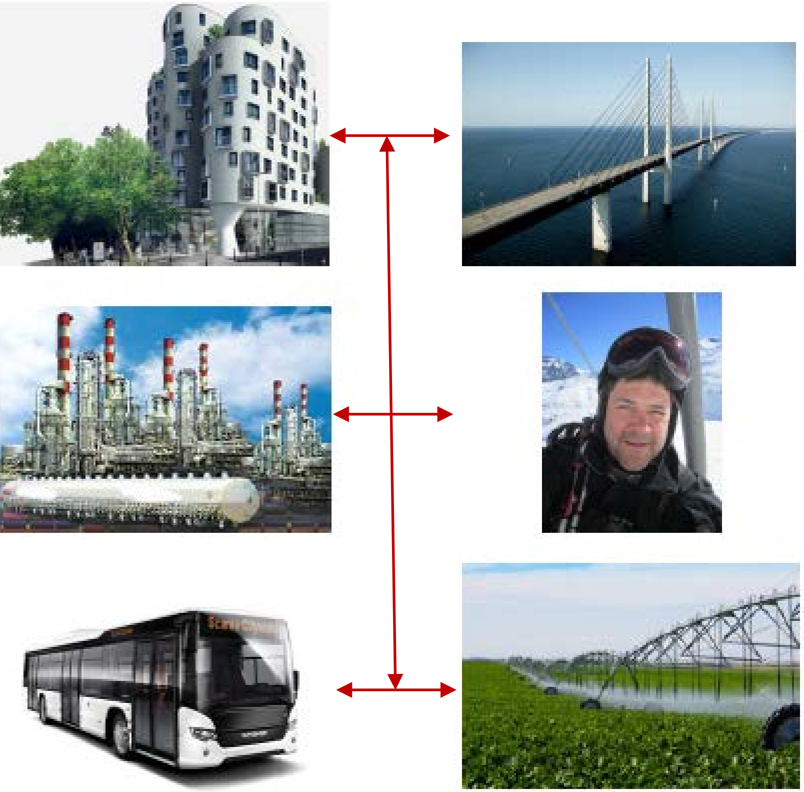


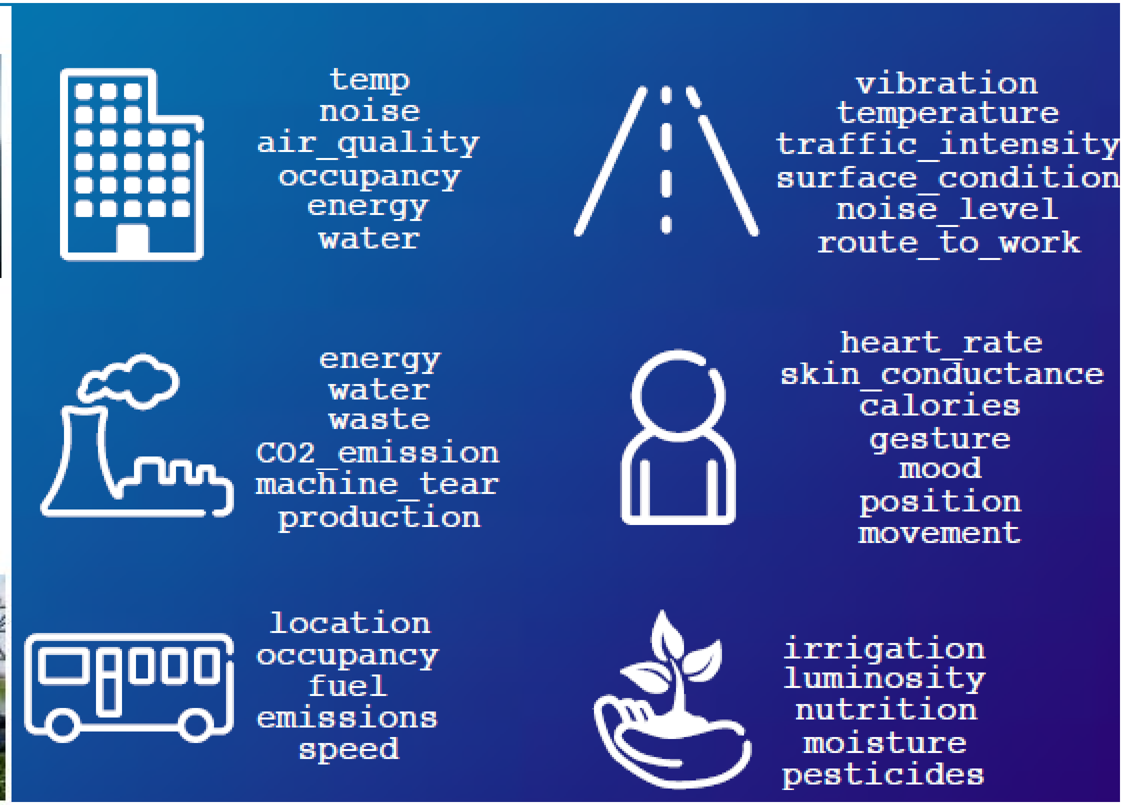
Jan Holler

The generic Smart City

CLOUD OF CONNECTED THINGS

DETECT, CONNECT, REPRESENT, SENSE,





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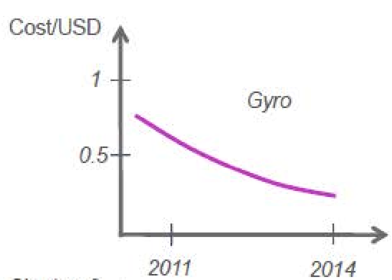

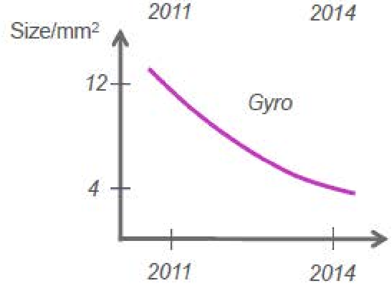

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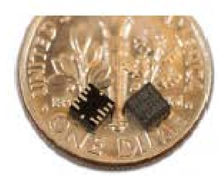


Jan Holler

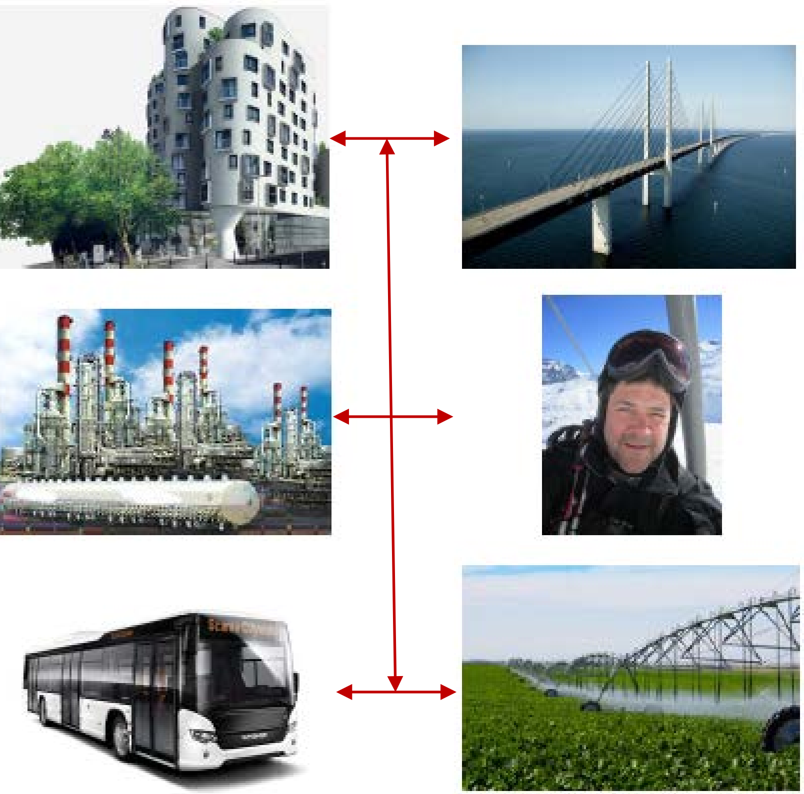
What stops the "generic" Smart City from being generic?

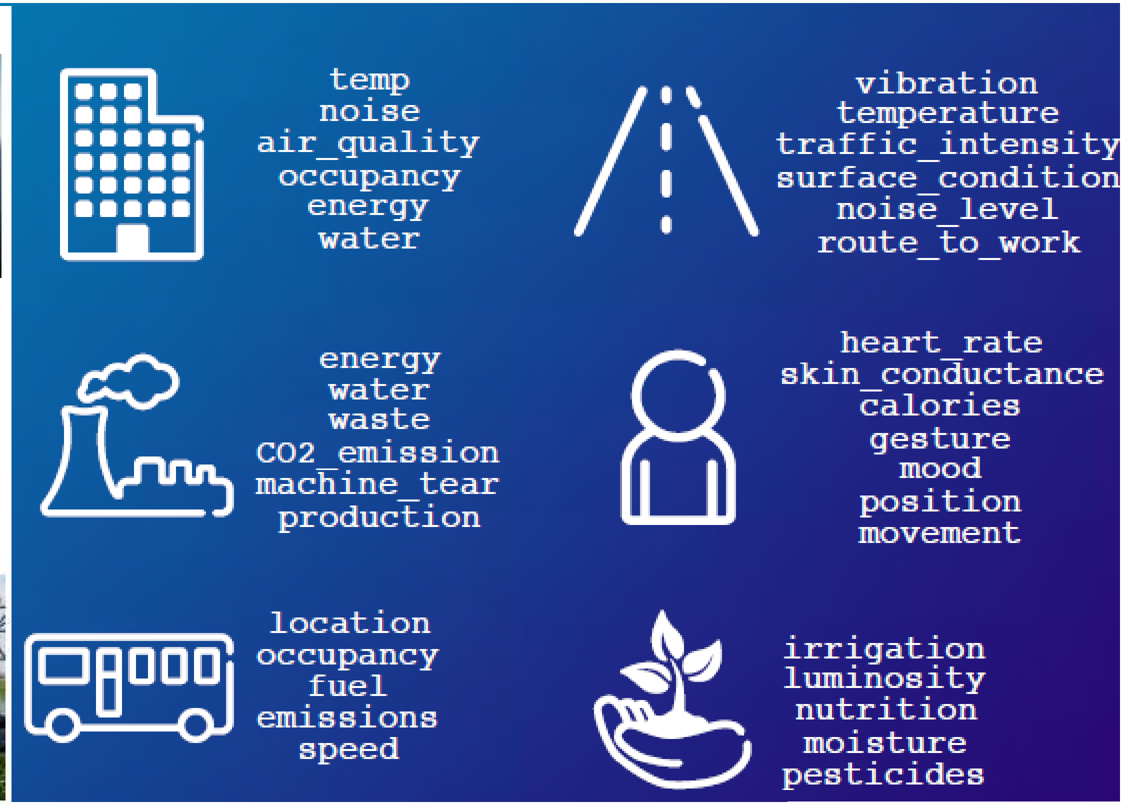
SEMANTICS →→ CONTEXT

but, we are not there, yet.

DETECT, CONNECT, CONTEXT, INTELLECT

REPRESENT, SENSE, SEMANTICS, RESPONSE





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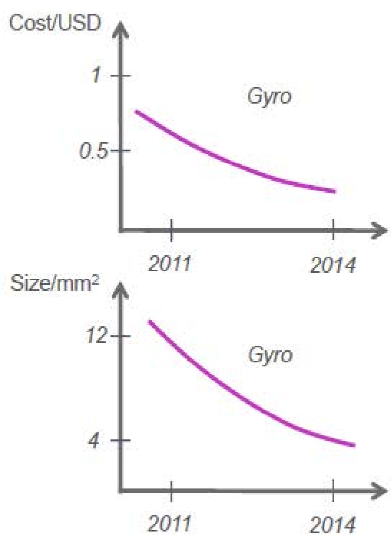
- Barometric pressure
- Accelerometer
- Gyroscope
- Magnetometer
- CO_2, O_2, other
- Heart rate
- Galvanic Skin Response
- Luminosity
- Sound
- Temperature
- Ultrasonic
- Gas flow
- Radiation
- ...



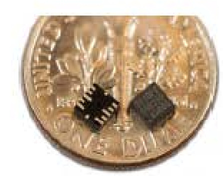
BMP280
- Pressure sensor
- Current: 2.74 µA @ 1 Hz
- Accuracy: ±0.12 hPa (± 1 m)
- Size: 2.0*2.0*0.95 mm³
- Price: 1.55 € @ 1000

BMP280 (BMP180)

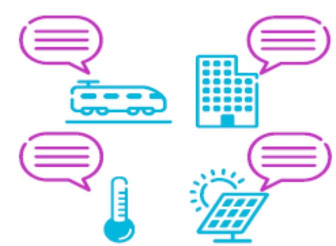
3-axis accelerometer sensor

mCube

MC3420
- 3-axis accelerometer
- Current: 30 µA @ 128 Hz
- Event detection. tap, shake, drop, tilt, orientation (P/L)
- Size: 2.0*2.0*0.92 mm³
- Price: 0.843 € @ 1000



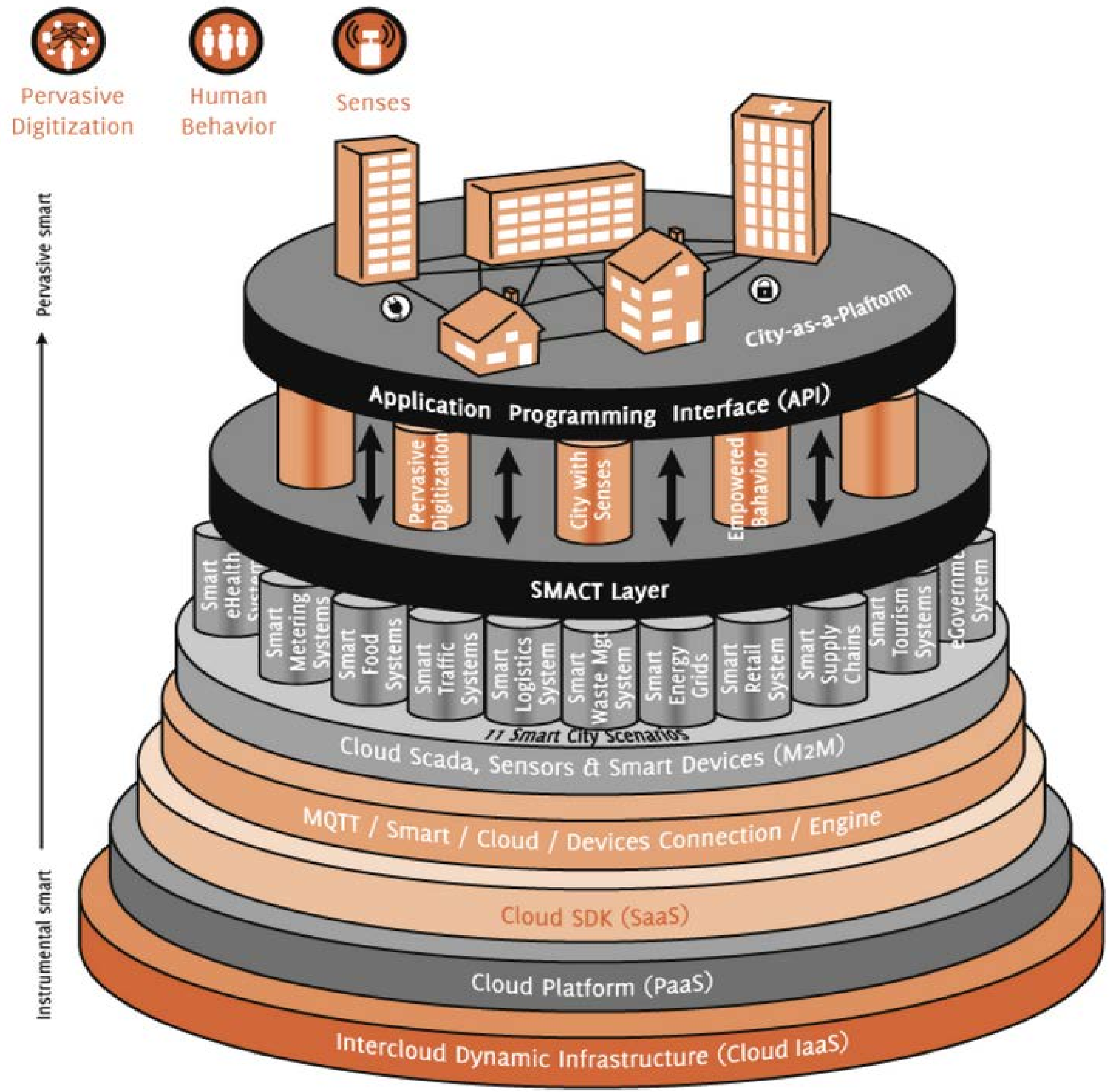
Semantics



Emerging View

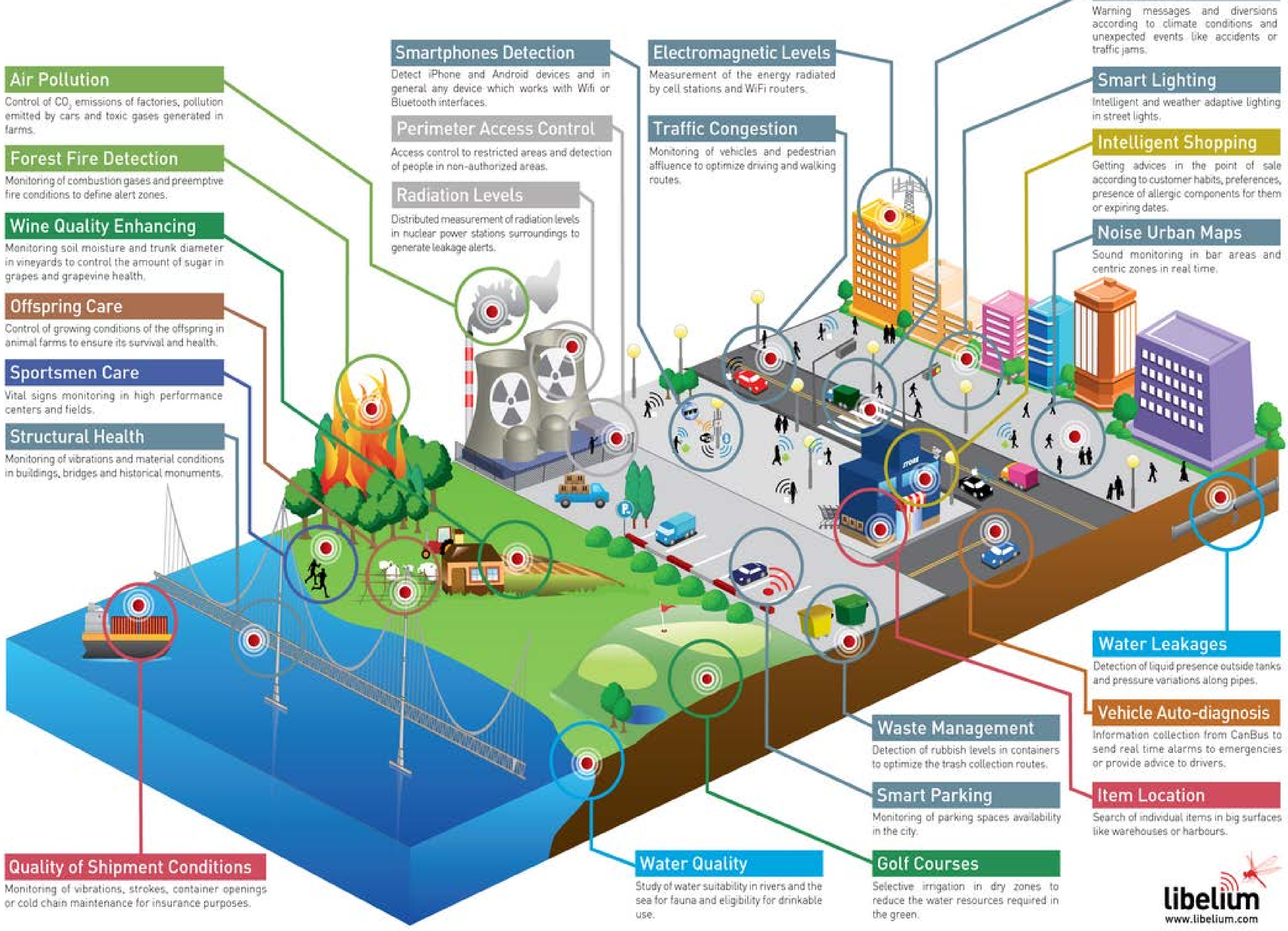
platforms & end-2-end connectivity

PLATFORMS



Pervasive Digitization
Human Behavior
Senses
Pervasive smart
Instrumental smart
City-as-a-Plaftorm
Application Programming Interface (API)
Pervasive Digitization
City with Senses
Empowered Bahavior
SMACT Layer
Smart eHealth
Smart Metering Systems
Smart Food Systems
Smart Traffic Systems
Smart Logistics System
Smart Waste Mgt System
Smart Energy Grids
Smart Retail System
Smart Supply Chains
Smart Tourism Systems
System
11 Smart City Scenarios
Cloud Scada, Sensors & Smart Devices (M2M)
MQTT / Smart / Cloud / Devices Connection / Engine
Cloud SDK (SaaS)
Cloud Platform (PaaS)
Intercloud Dynamic Infrastructure (Cloud IaaS)

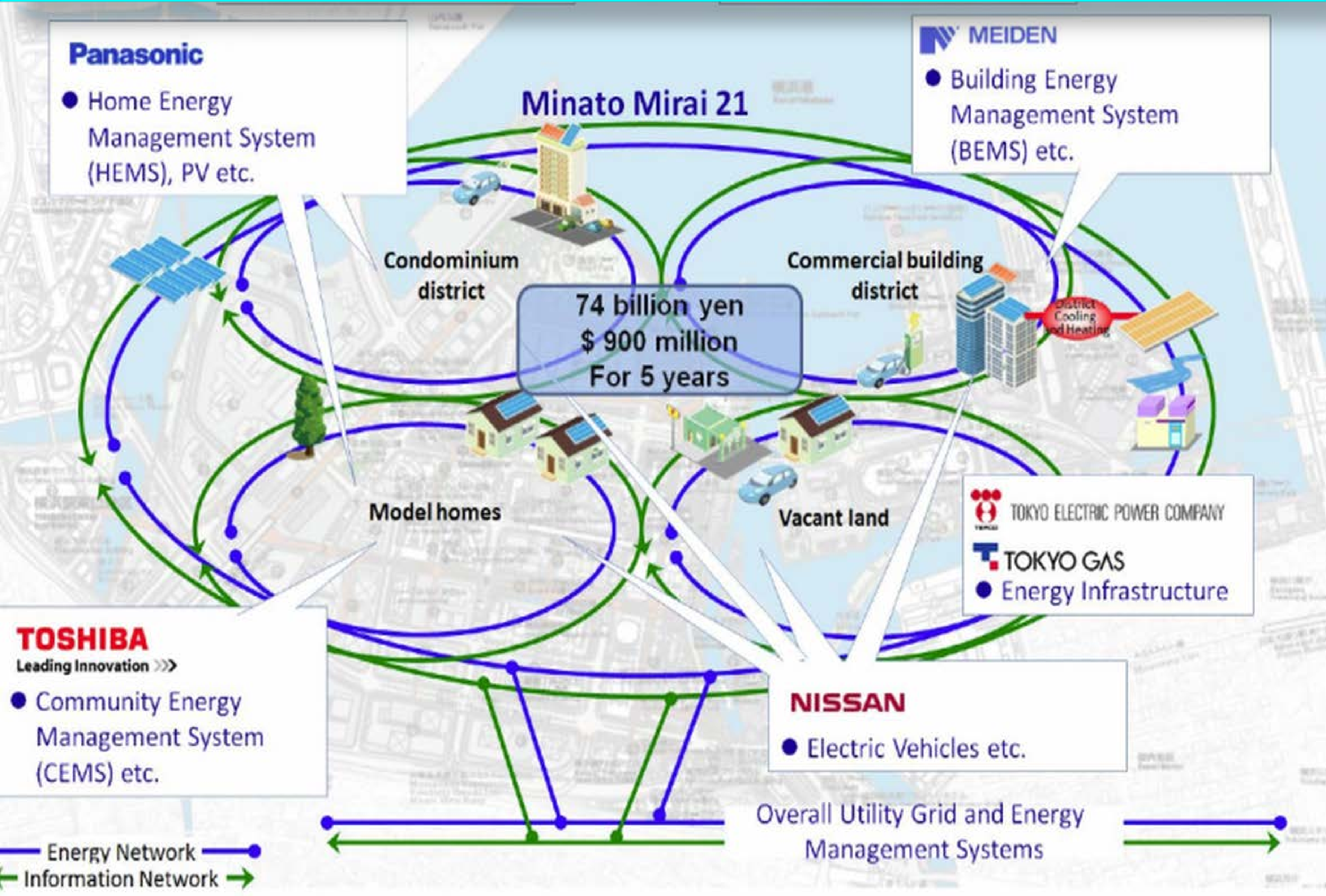
Smart Cities → Smart Nations → Smart World → Smarter Planet



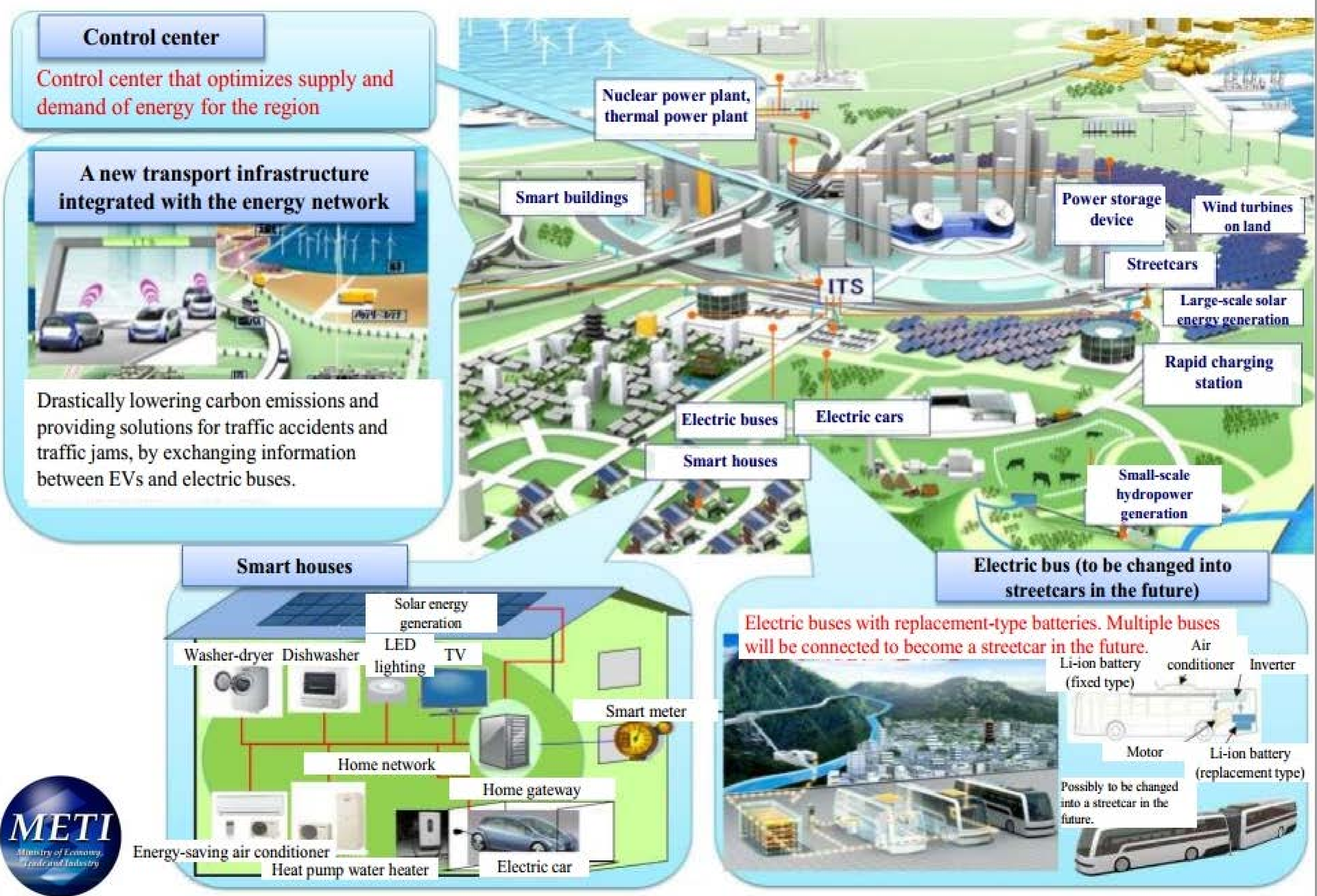
Patch-work Pilots

point-to-point connectivity of things

• Smart Cities • Yokohama • Santander • Nice



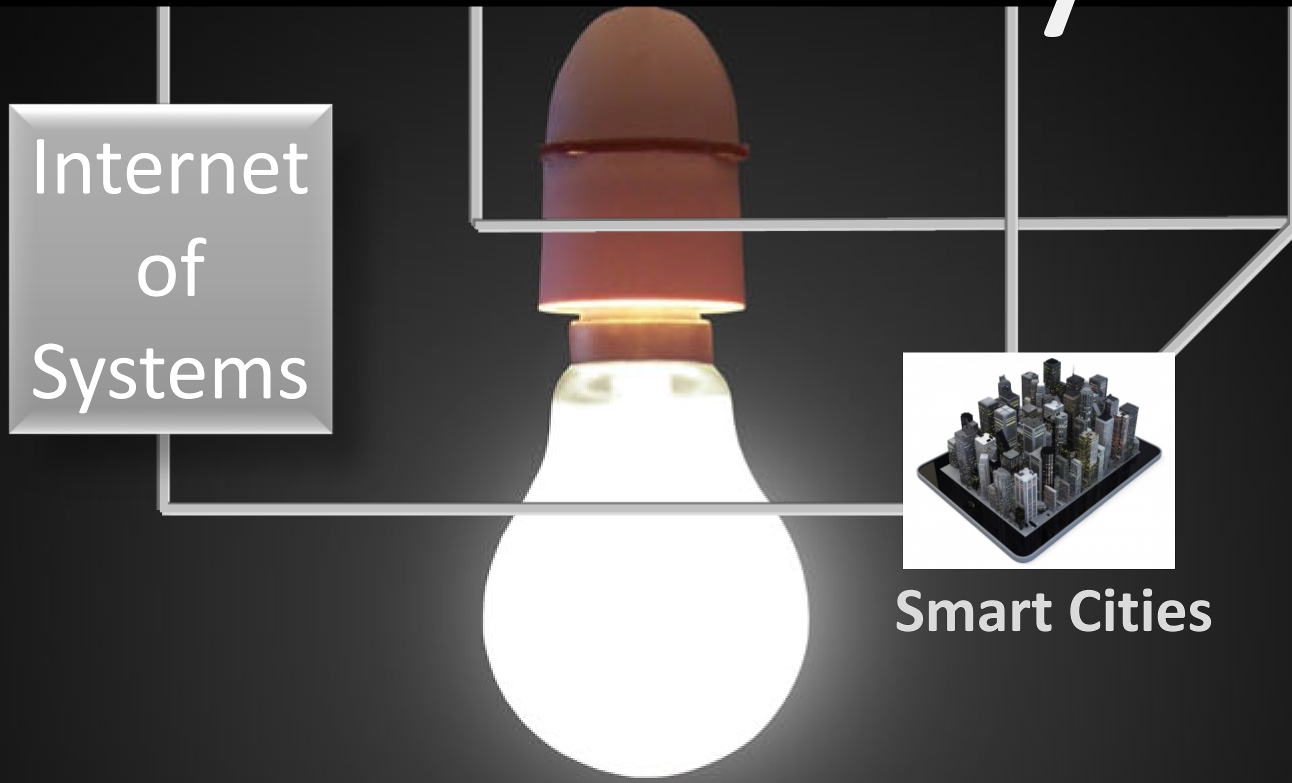
A SMARTER PLANET begins with SMART CITIES



Conventional Wisdom
- Deployment Plan -

SINGAPORE

Grand Unifying



Challenge?

GLOBAL SMART CITIES – GRAND UNIFYING IoS PLATFORMS?

Smart energy and electricity micro-grid network

Smart transportation and traffic management

Smart water and waste water treatment

Smart maintenance and infrastructure

Smart data and connectivity

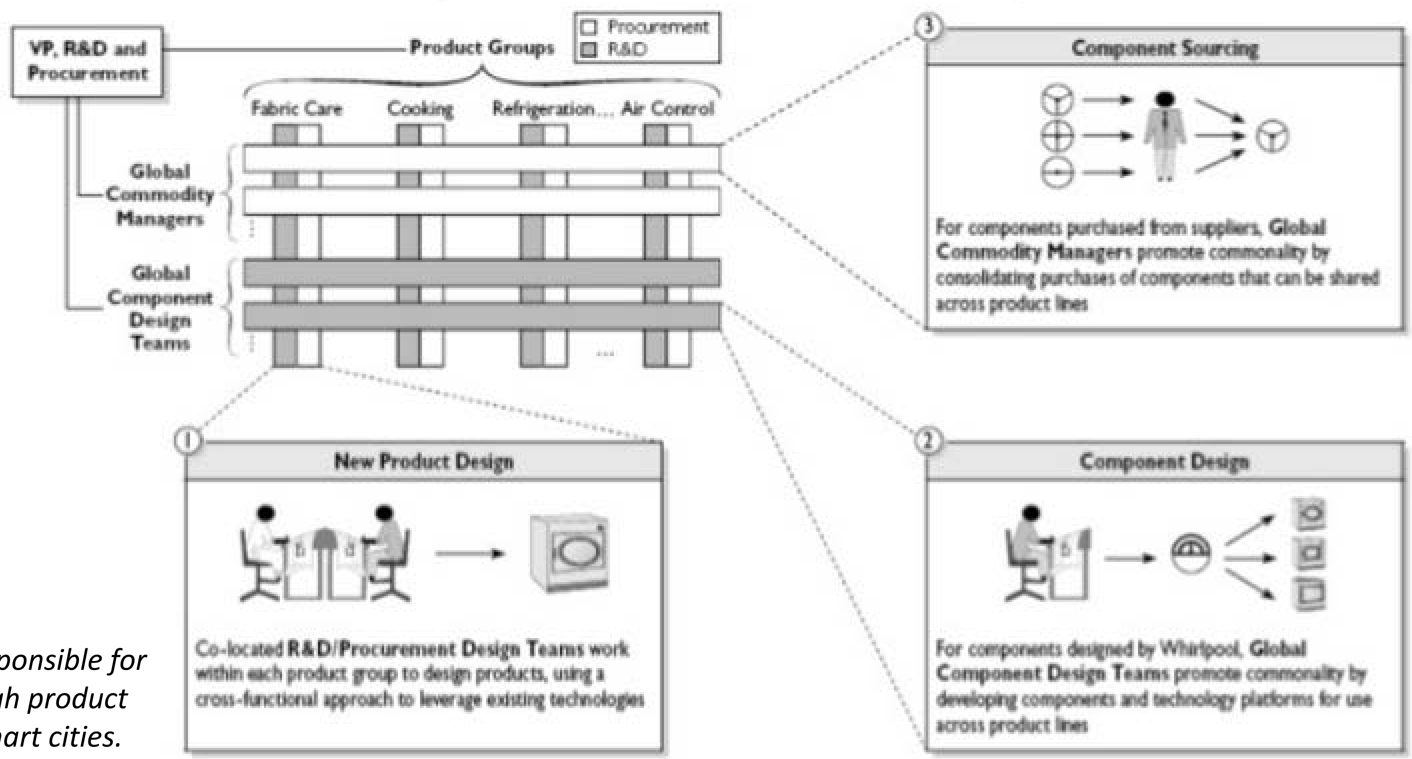
Smart waste management

Smart healthcare

Smart parking

Smart homes

[Smart drone]()



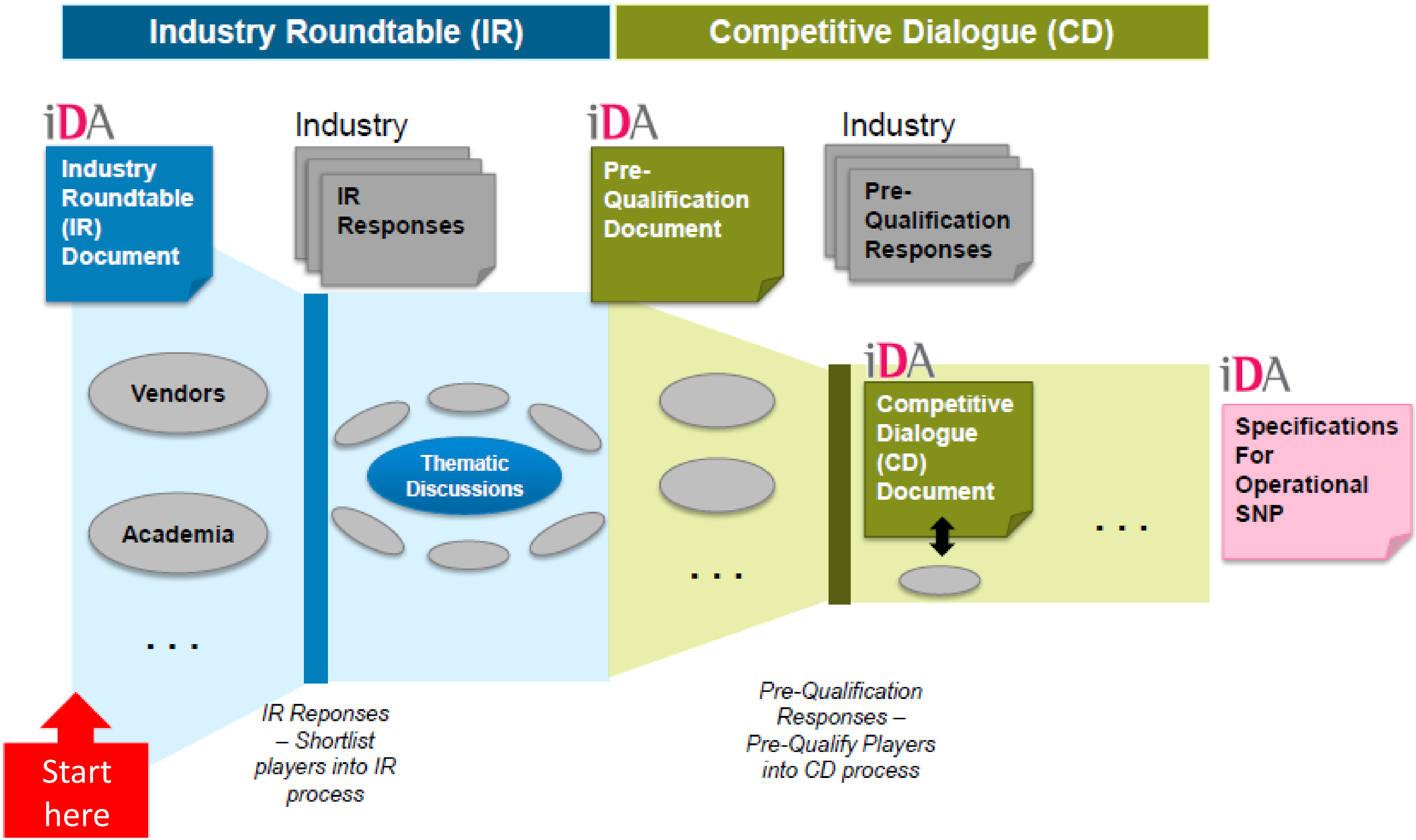
How groups within Whirlpool are responsible for optimizing commonality gains through product development stages – a lesson for smart cities.

Smart Nation (?) Singapore

The next 26 charts are copied from the briefing by Mr Steve Leonard, Executive Deputy Chairman, IDA delivered to the industry on 10 October 2014, Singapore

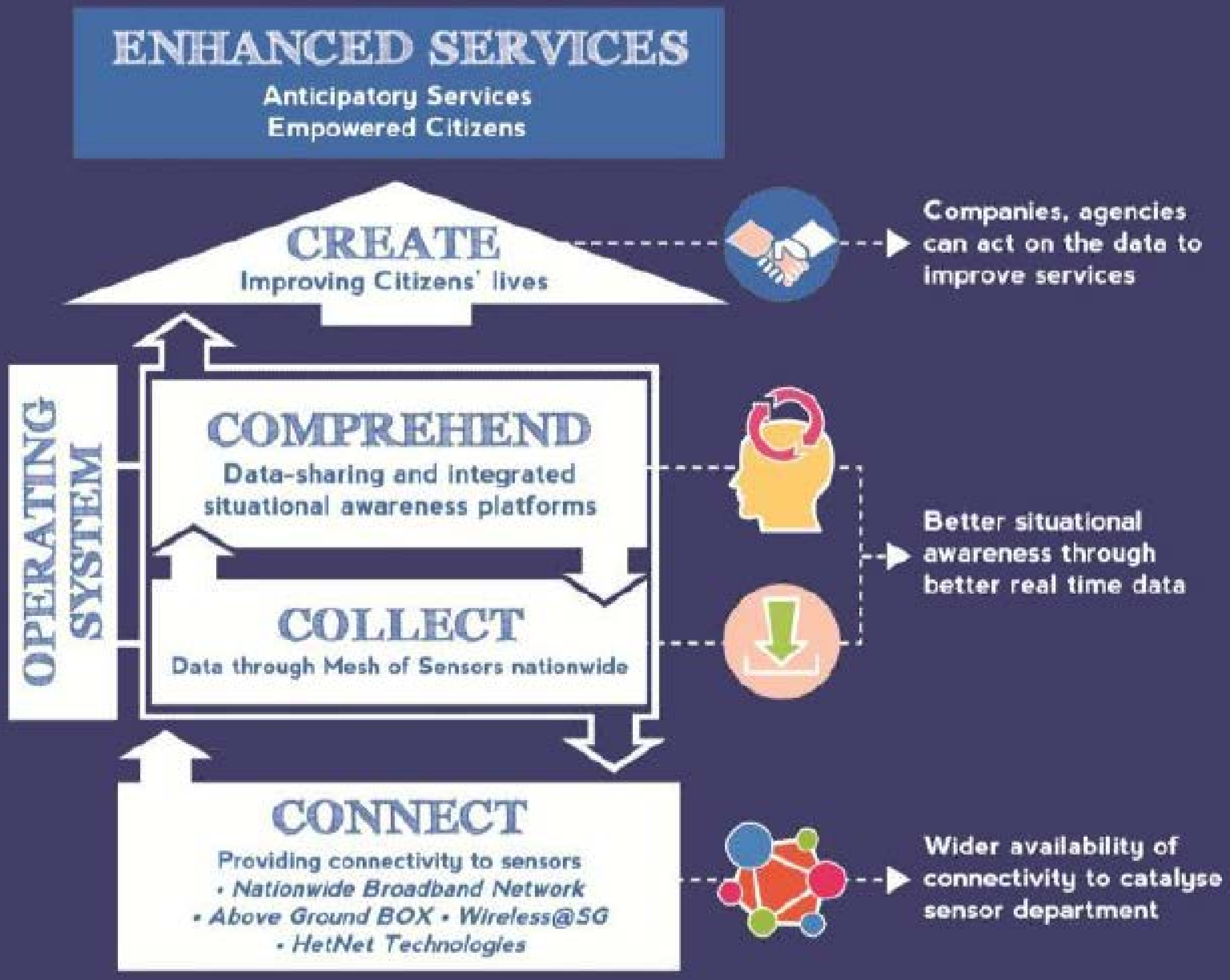
Smart Nation Platform

Overview of Process



http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

SMART NATION PLATFORM



http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

CITIZEN CENTRIC SERVICE DELIVERY

Enjoyable user experience

Make meaningful choices

Empowered to participate and co-create

One Public Service

IDA-logo.png

RESTRICTED

PLATFORM COMPONENTS

COMMUNICATIONS to establish resilient wired and wireless connectivity to sensors

---

SENSORS AND PROBES to sense, capture and register environmental information

---

SMART NATION OPERATING SYSTEM to process, fuse and share data with agencies

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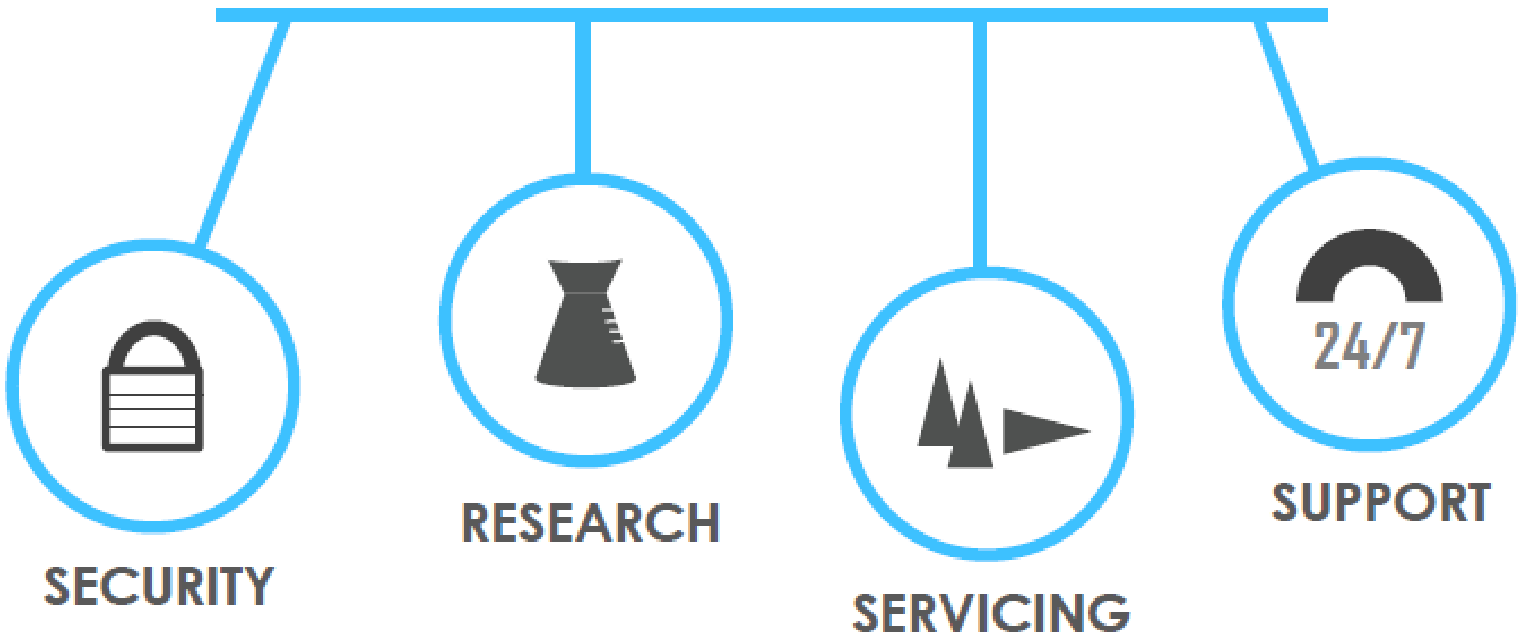
SUPPORTING INFRASTRUCTURE

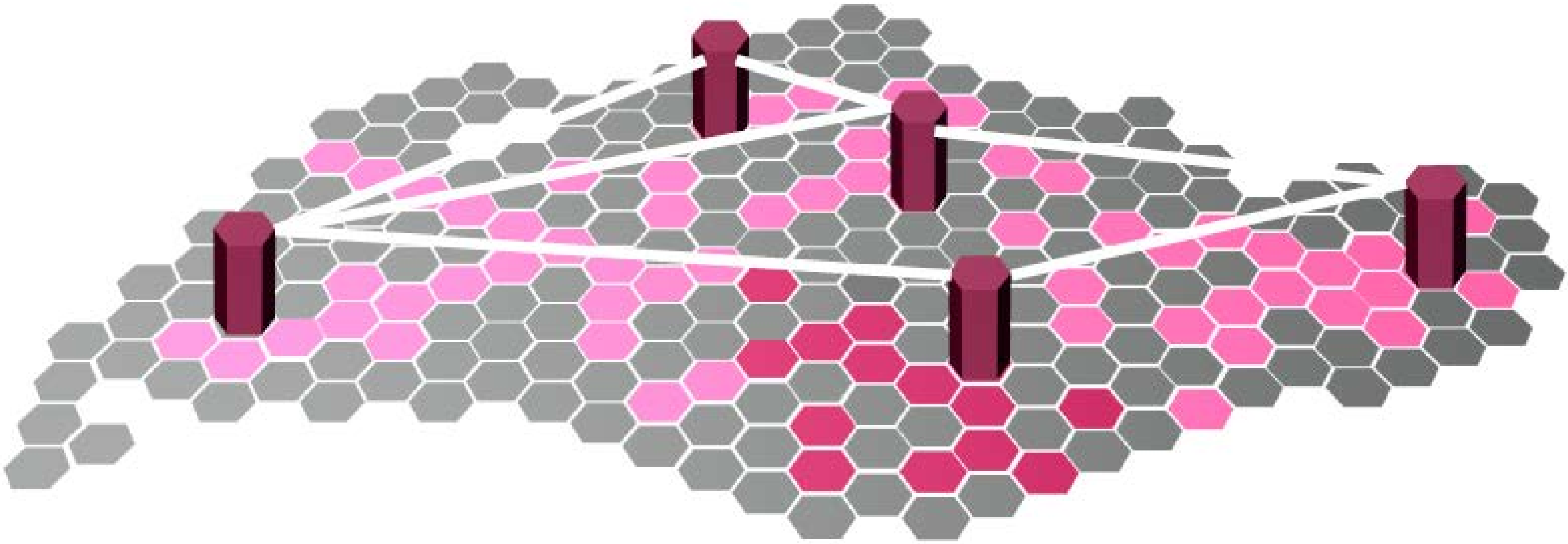
COMMUNICATIONS

SENSORS AND PROBES

SMART NATION OPERATING SYSTEM



NATIONWIDE DEPLOYMENT



Delivering **RESILIENT** and **TRUSTED** sensor connectivity nationwide to catalyse sensor rollouts and enable data-driven decision making and **ANTICIPATORY SERVICES**

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AN INTEGRATED SMART NATION

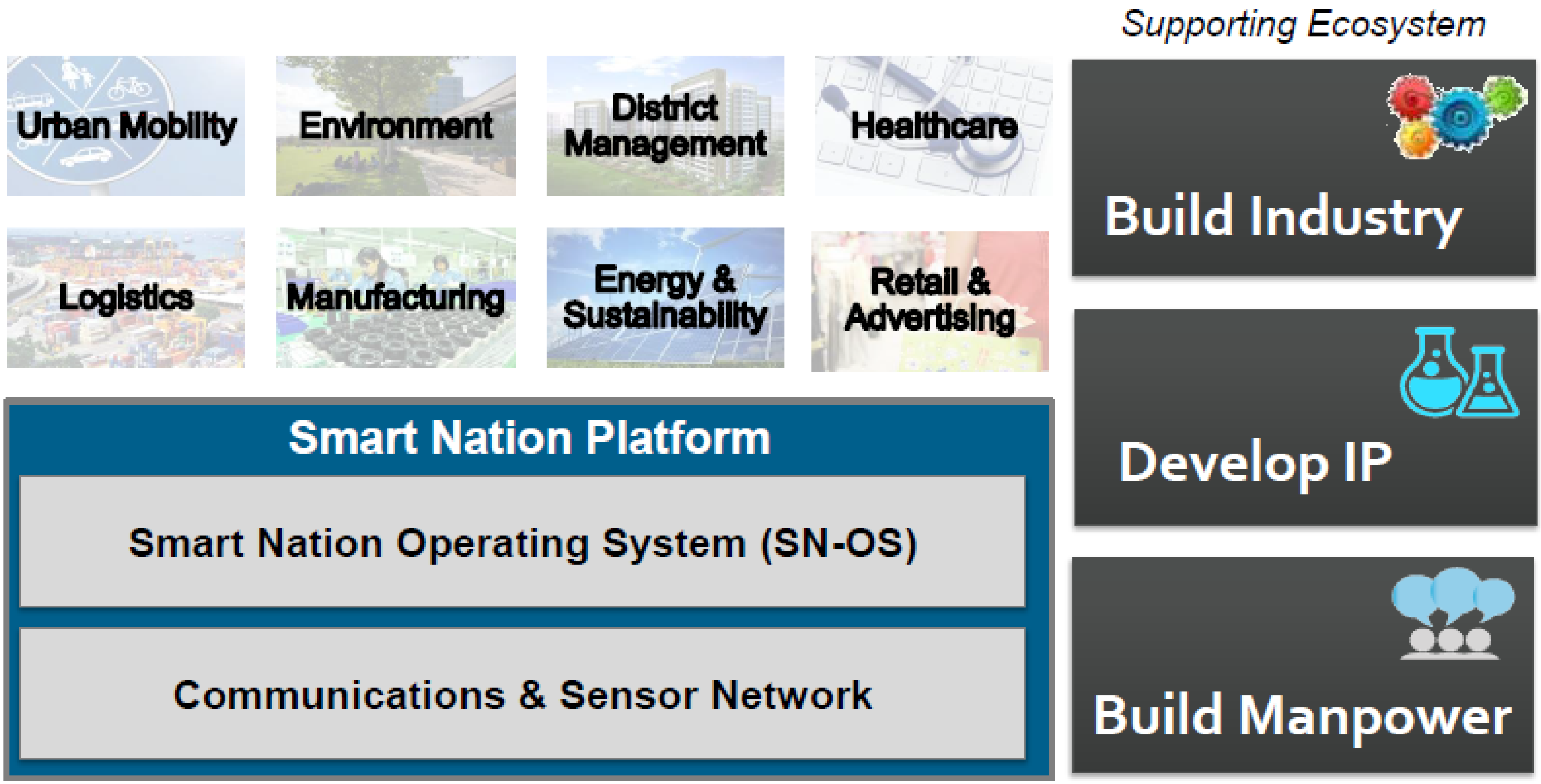
IMPROVED INFORMATION DISSEMINATION

OPTIMIZED TRANSPORT

ENHANCED RESOURCE MANAGEMENT

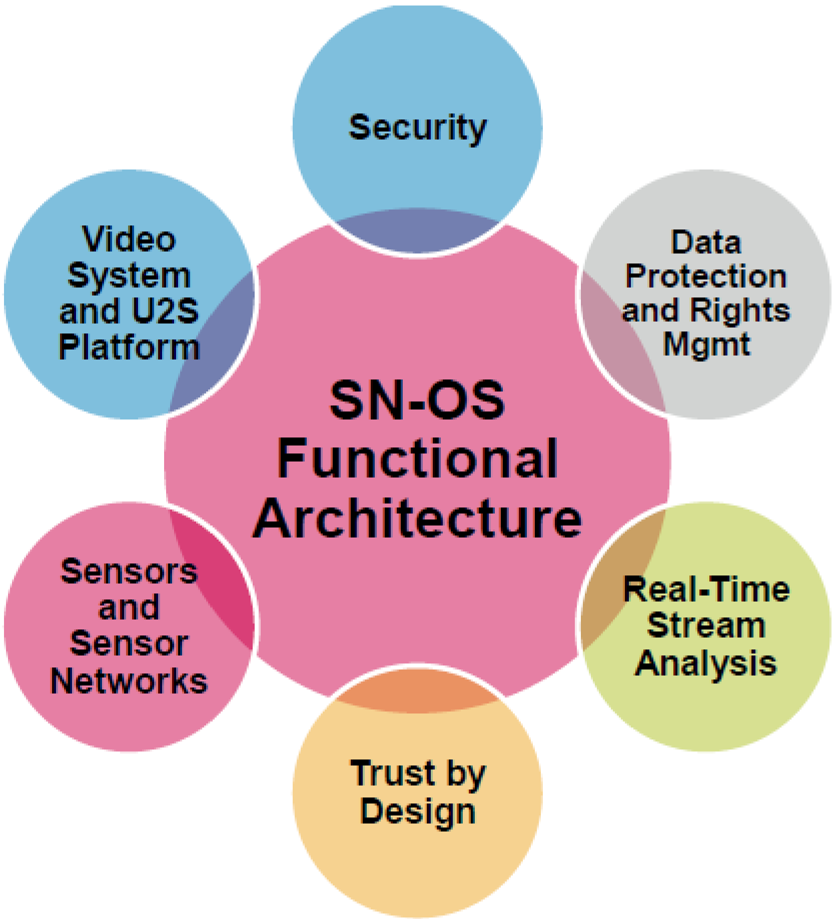
TIMELY MUNICIPAL SERVICE DELIVERY

Smart Nation Vision



iDA SINGAPORE

Smart Nation – Operating Systems



Internet of Systems

www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf a

Communications & Sensor Network

Smart Nation Platform

Smart Nation Operating System (SN-OS)

Communications & Sensor Network

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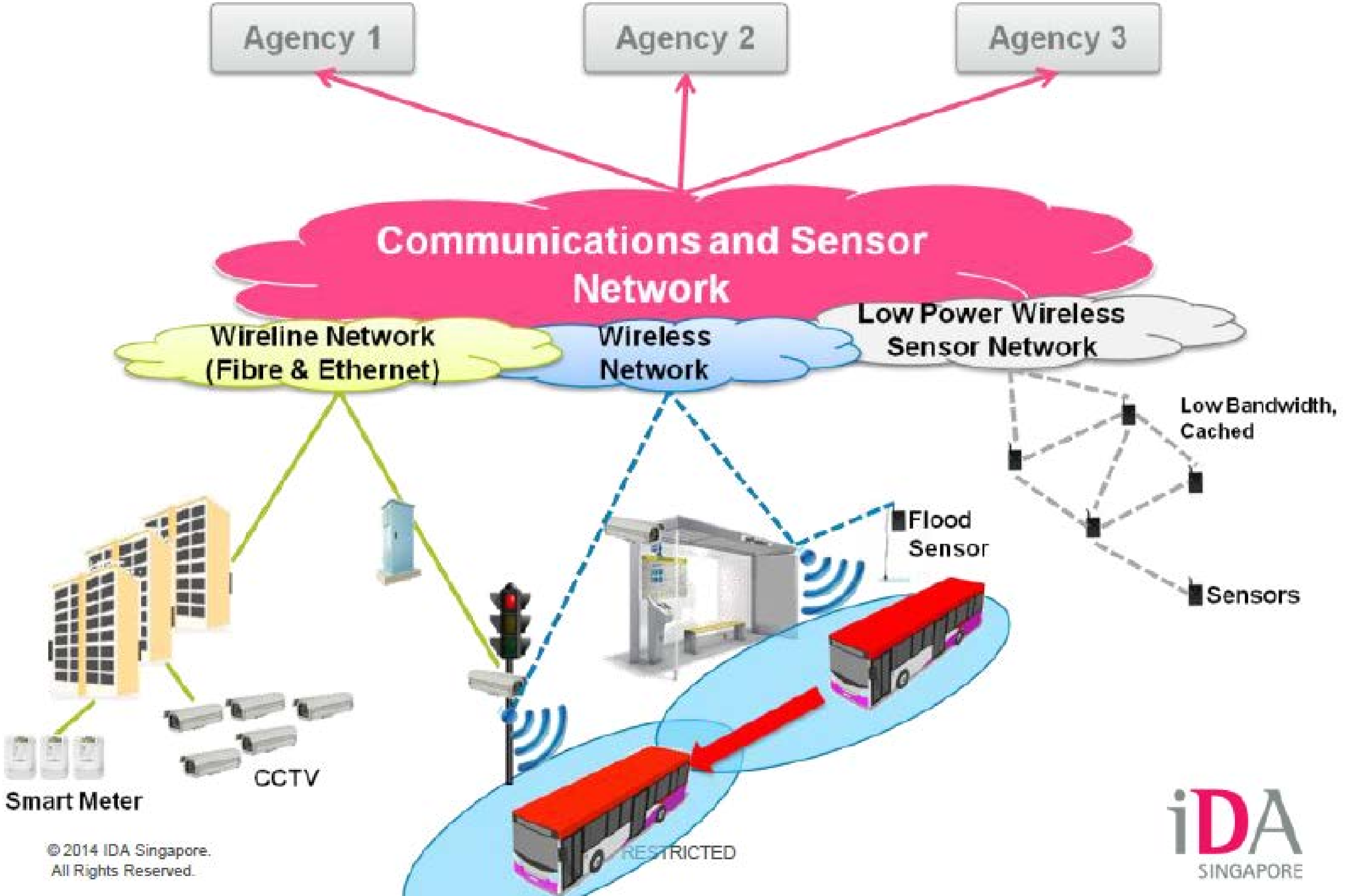
A "plug-n-play", trusted and resilient network infrastructure for deploying sensors



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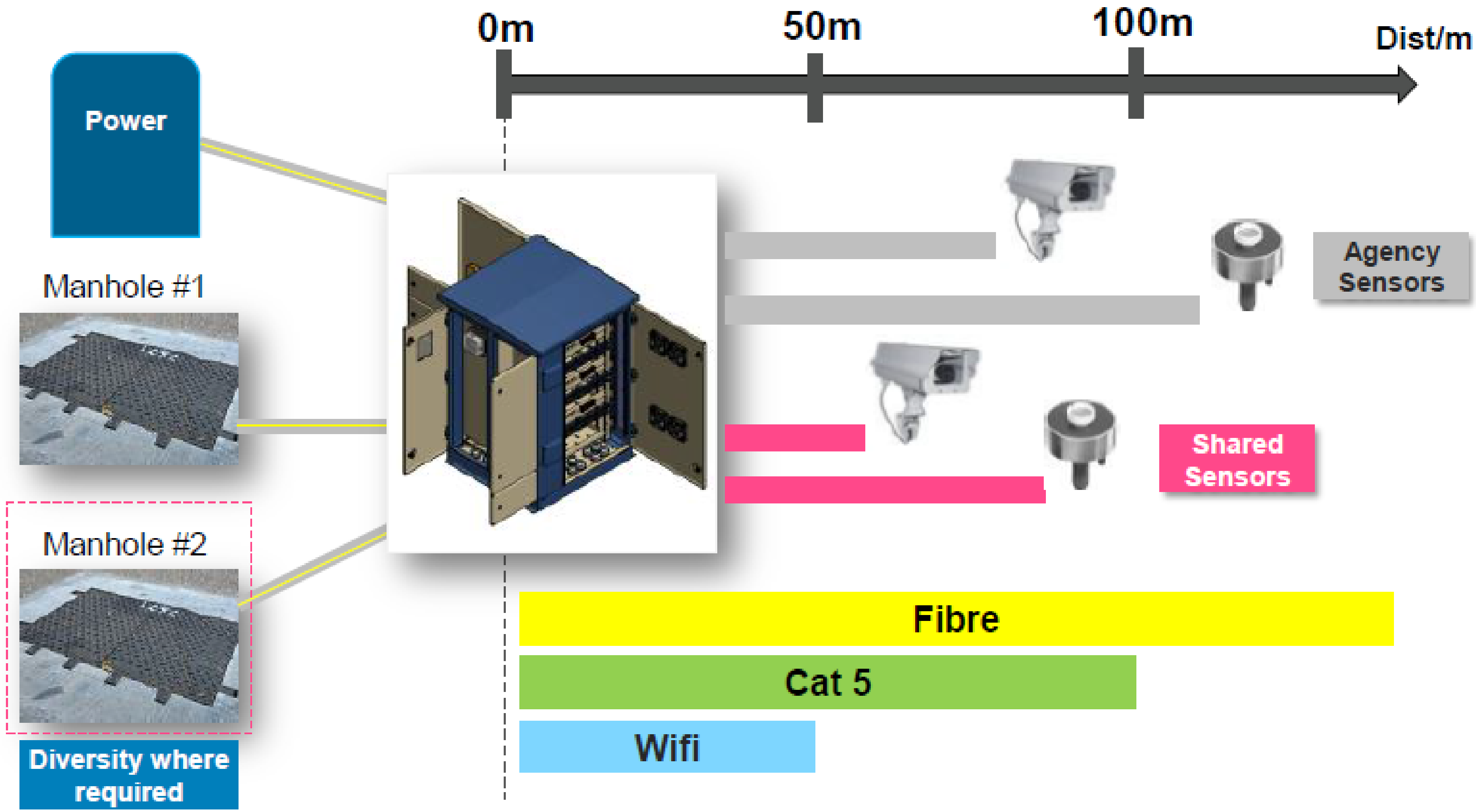
Aggregation Gateway (AG) Box provides connectivity and power



- Providing heterogeneous and resilient connectivity and power
- Ownership of trenches and physical infrastructure to support sensor rollout
- Set of shared sensors to support common needs

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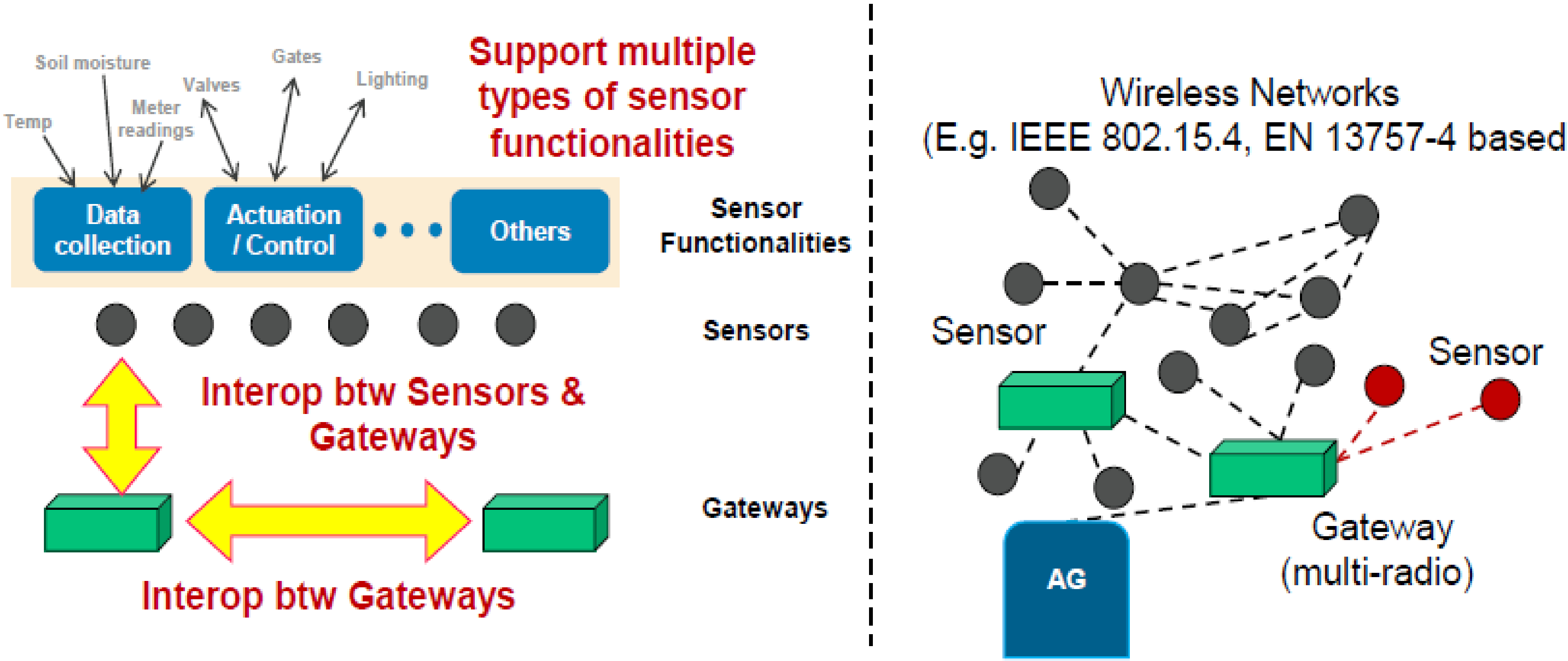
Wireless Sensor Network



- **Low power**
  - Support battery-powered sensors
- **Security**
  - Multi-tier security
  - End-to-end channel & data security
- **Dynamic topology**
  - Self-healing
  - Self-configuring
- **Scalable Management**
  - Device management
  - Network management

Deployment of Shared Sensors

Hotspot Cleanliness

Crowdedness and Flow of People Traffic

Water Level Detection

Earthquake Monitoring

Example: Possible data that can be derived from CCTV feeds

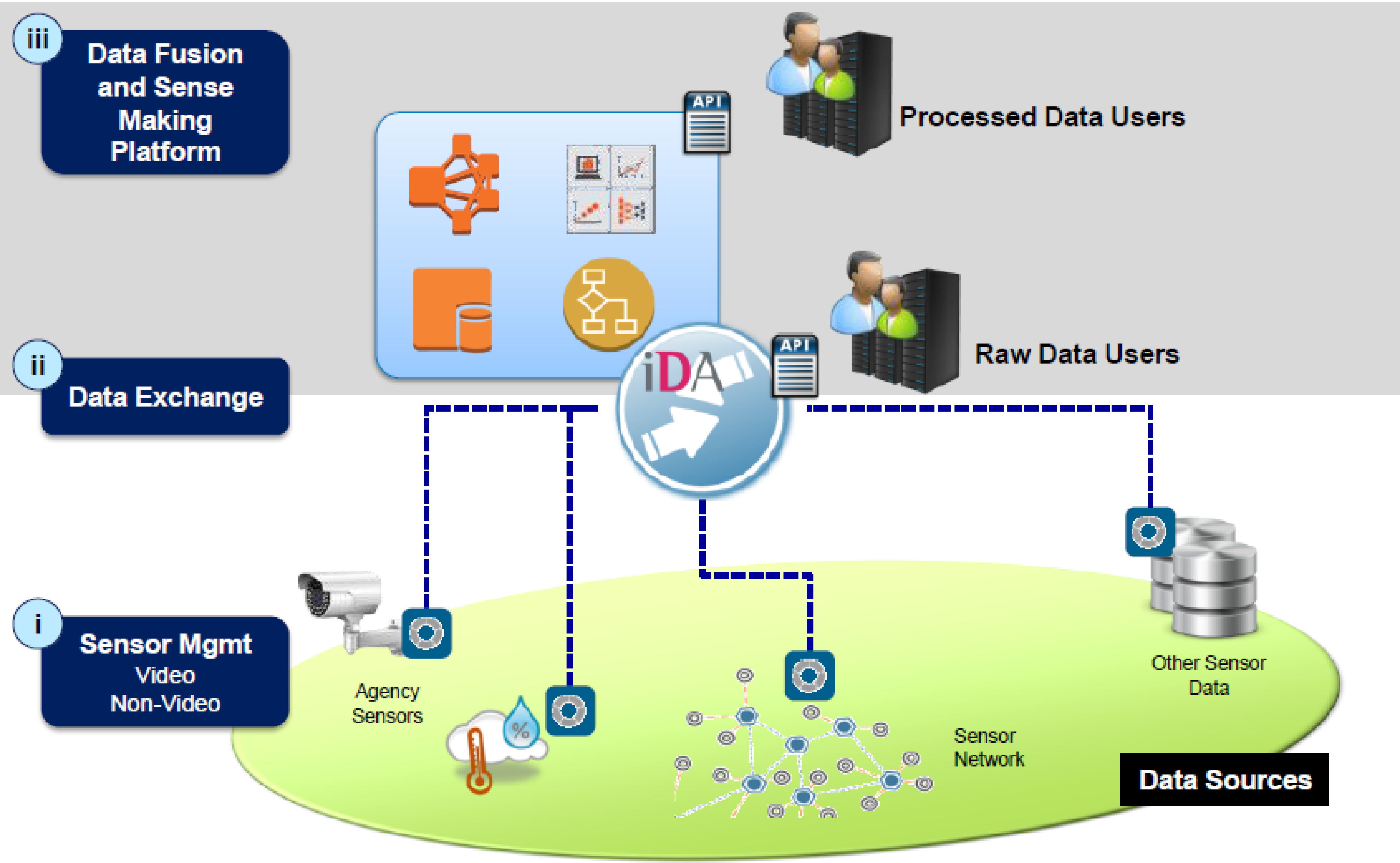
Indicative Initial Deployment of AG Boxes

http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

b

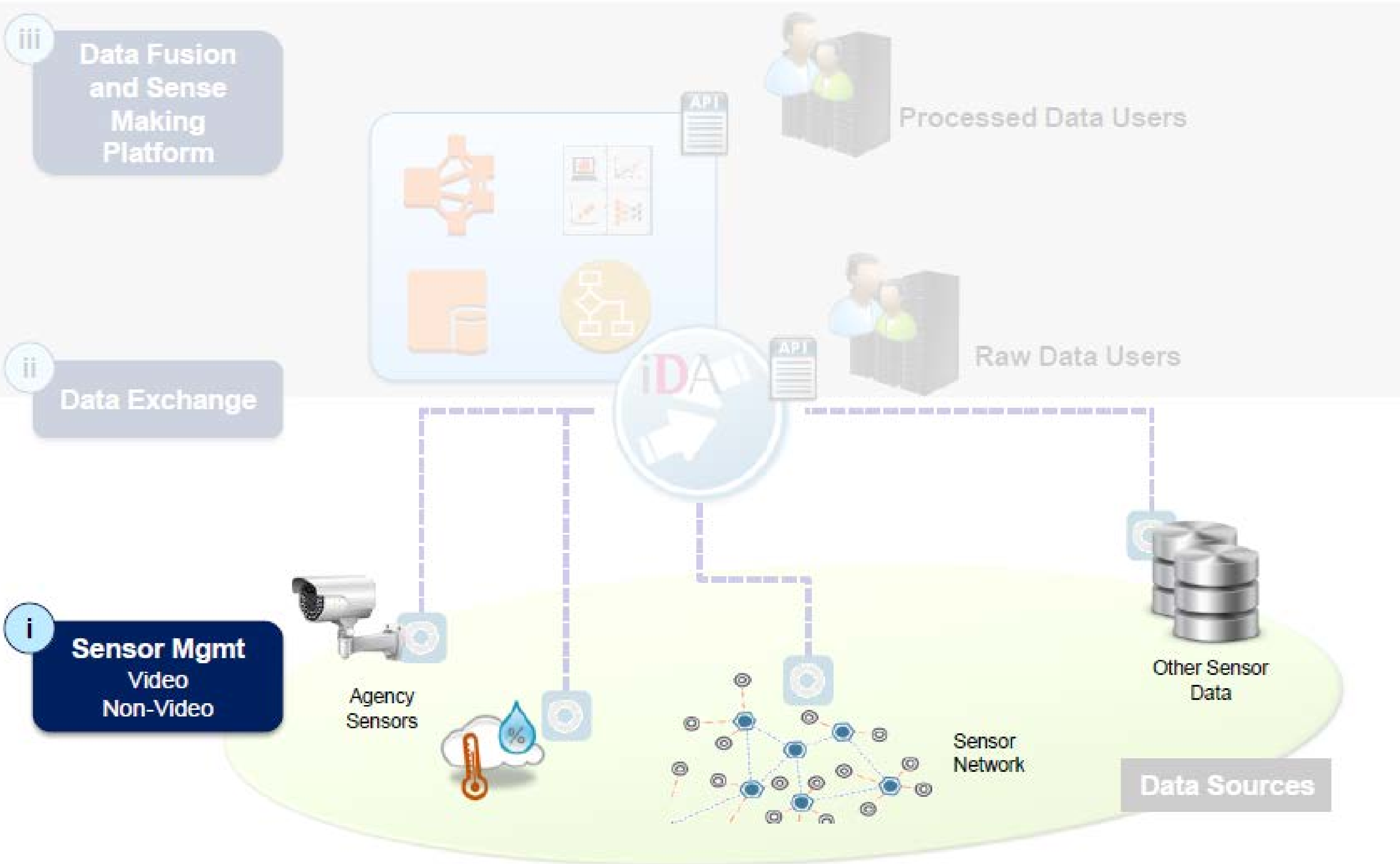
Smart Nation Operating System (SN-OS)

Smart Nation Operating System (SN-OS)



http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

(i) Sensor Management



http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

(i) Sensor Management Functionalities

Monitoring	Remote Configuration	Application Mgmt/Device Drivers
• Battery voltage and state of charge • Node/gateway status • Sensor network performance: load, latency	• Activation, de-activation of sensors • Sensing mode or period update rate • Sensor-specific configuration	• List of sensors to be implemented • OTA support of new sensors

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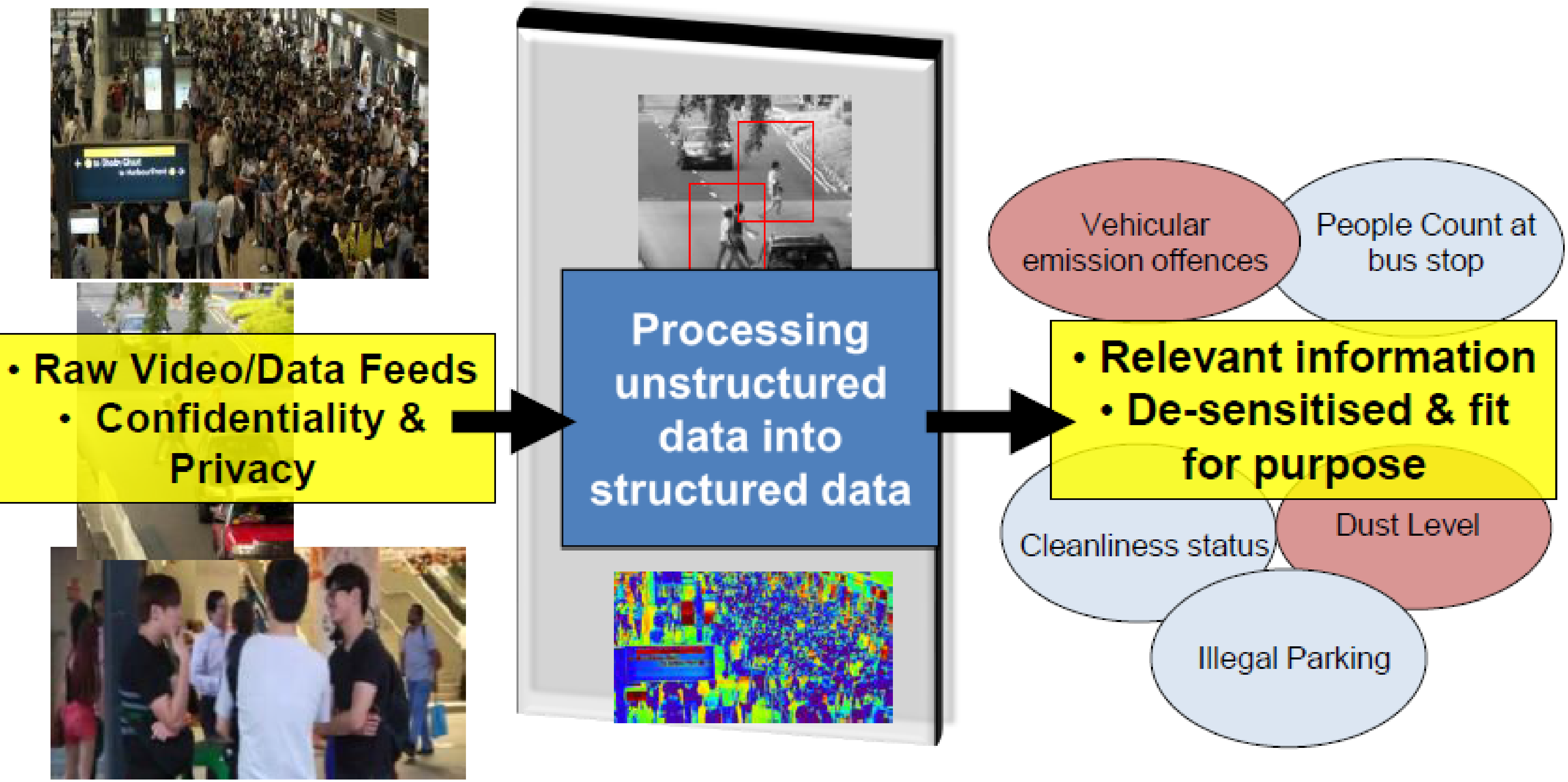
Unstructured to Structured (U2S) Platform

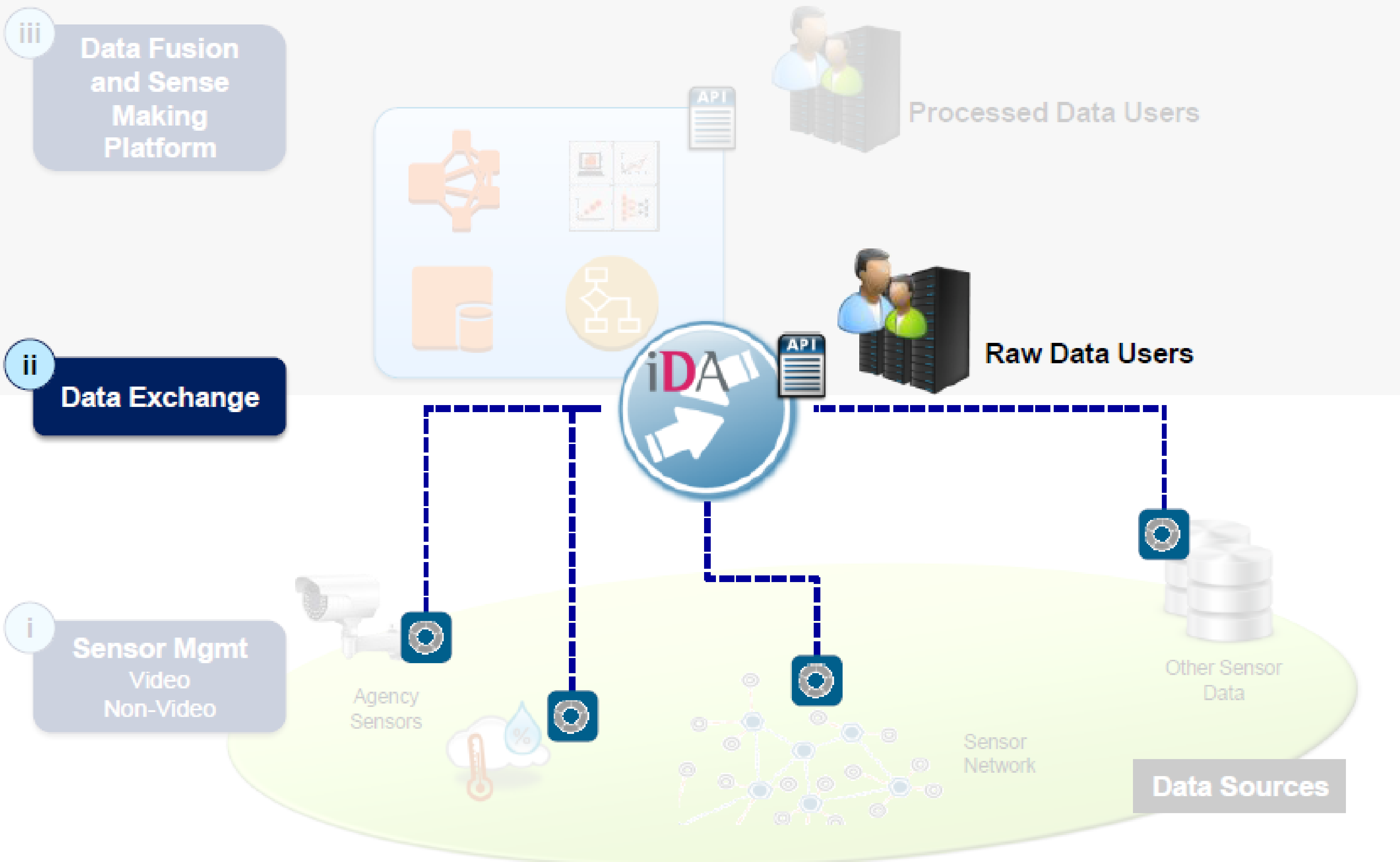
Conversion of Unstructured Streams into Data



(1) Obfuscate sensitive sensor data

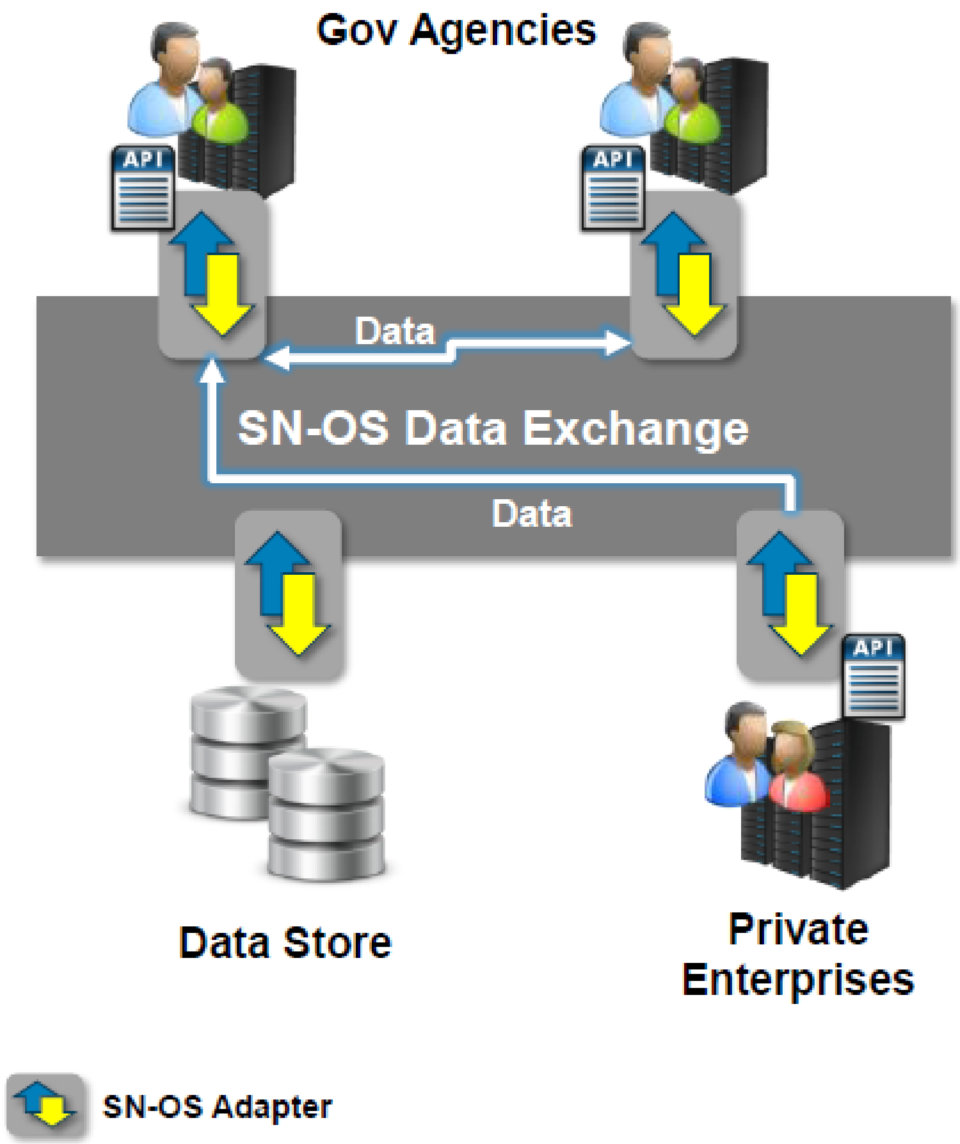
(2) Produce only relevant information for Agencies

(ii) Data Exchange



http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

(ii) Data Exchange to Facilitate Data Sharing



An **unified platform** to facilitate **reliable, secure, timely discovery & sharing** of human and machine-centric sensor data between government agencies (**WOG**) and between **Private Enterprises-WOG**

Open Standards & Protocols

Security & Trust

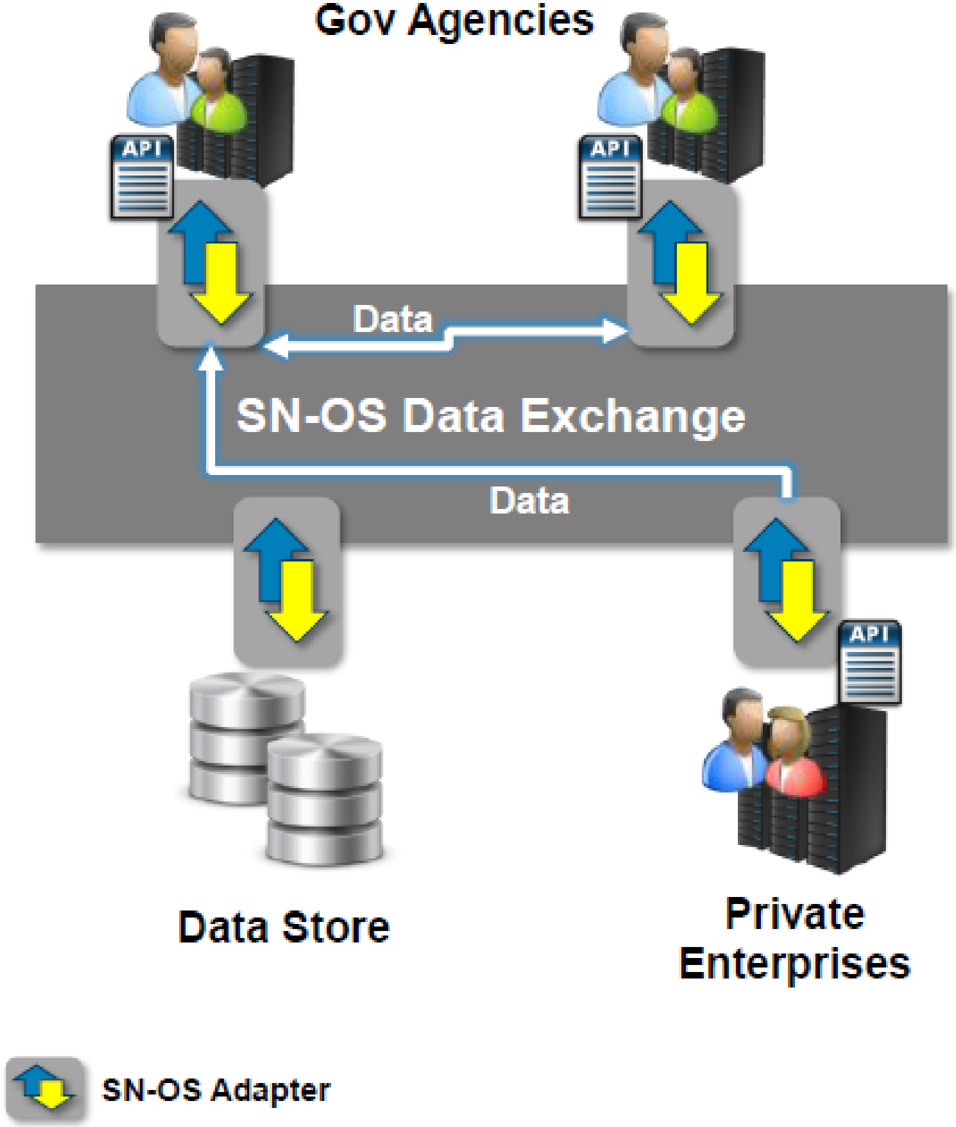
Modular

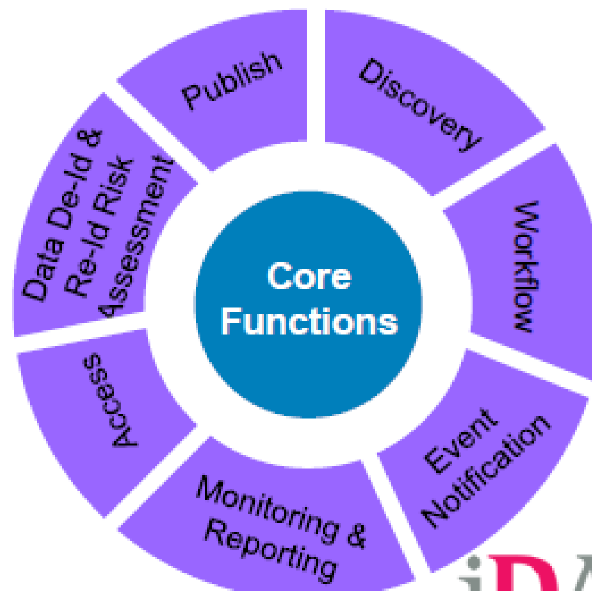
Data Security & Policies

Federated Design

iDA SINGAPORE

(ii) Data Exchange Functionalities





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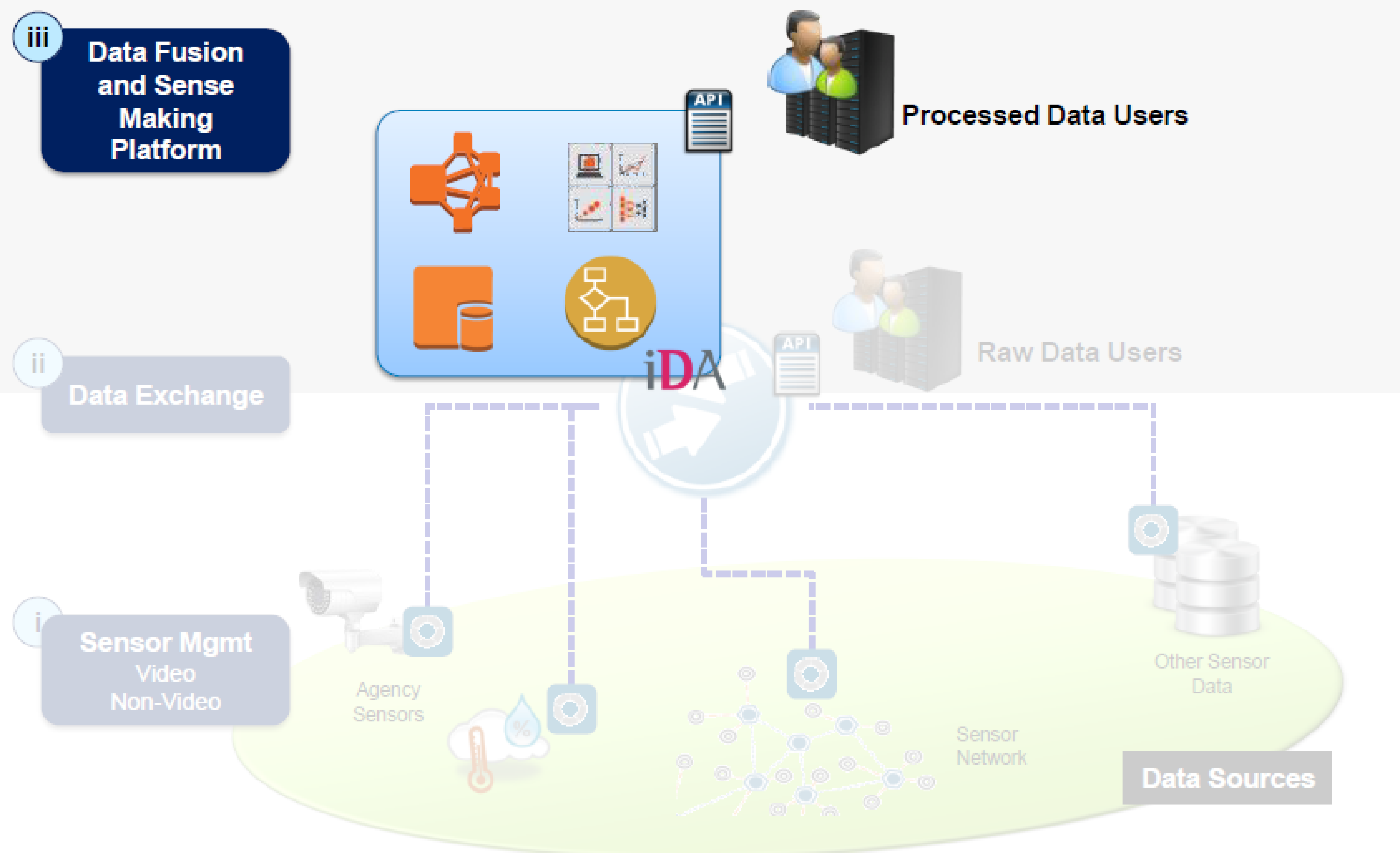
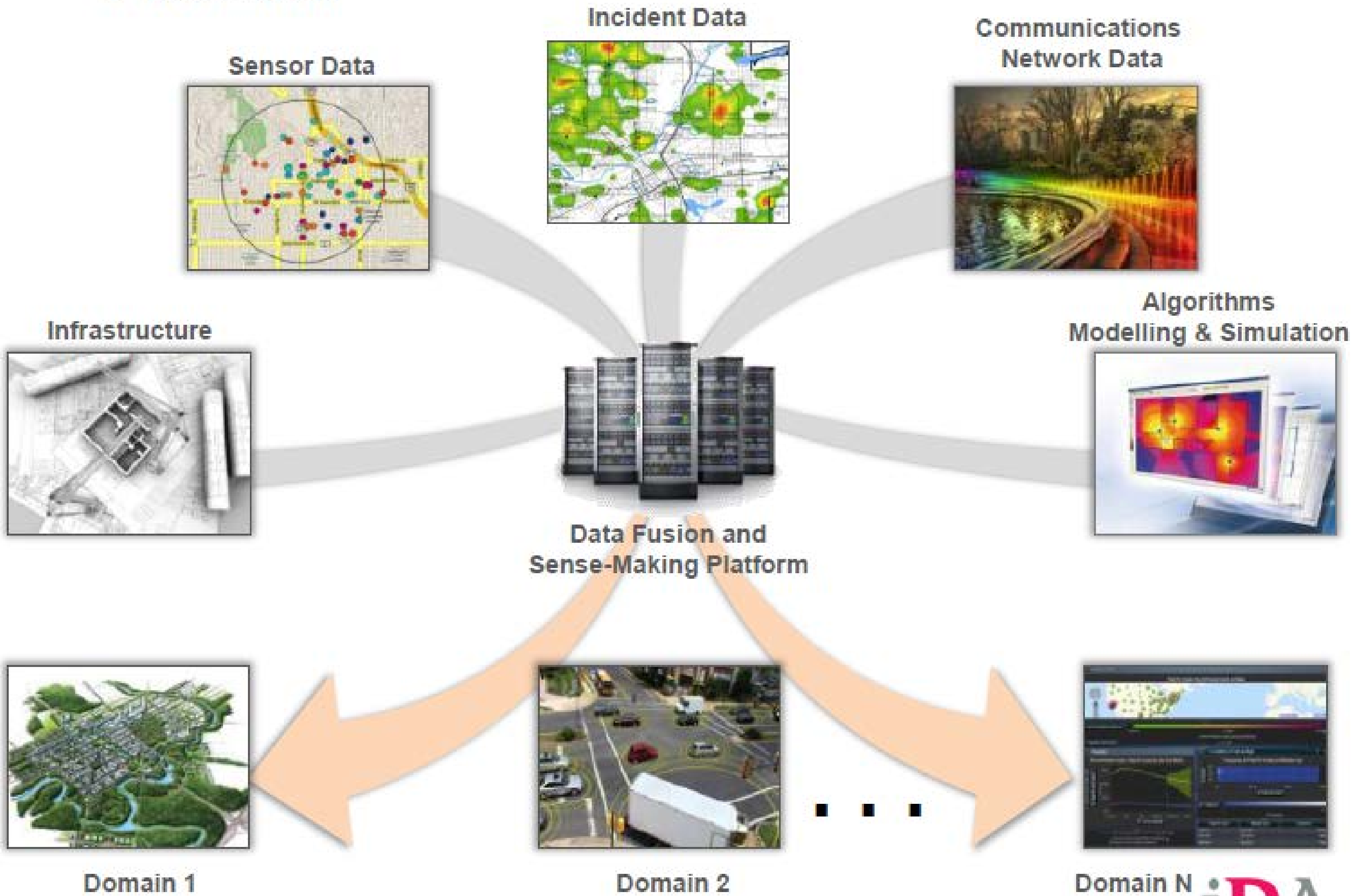
(iii) Integrated Data Fusion and Sense Making Platform



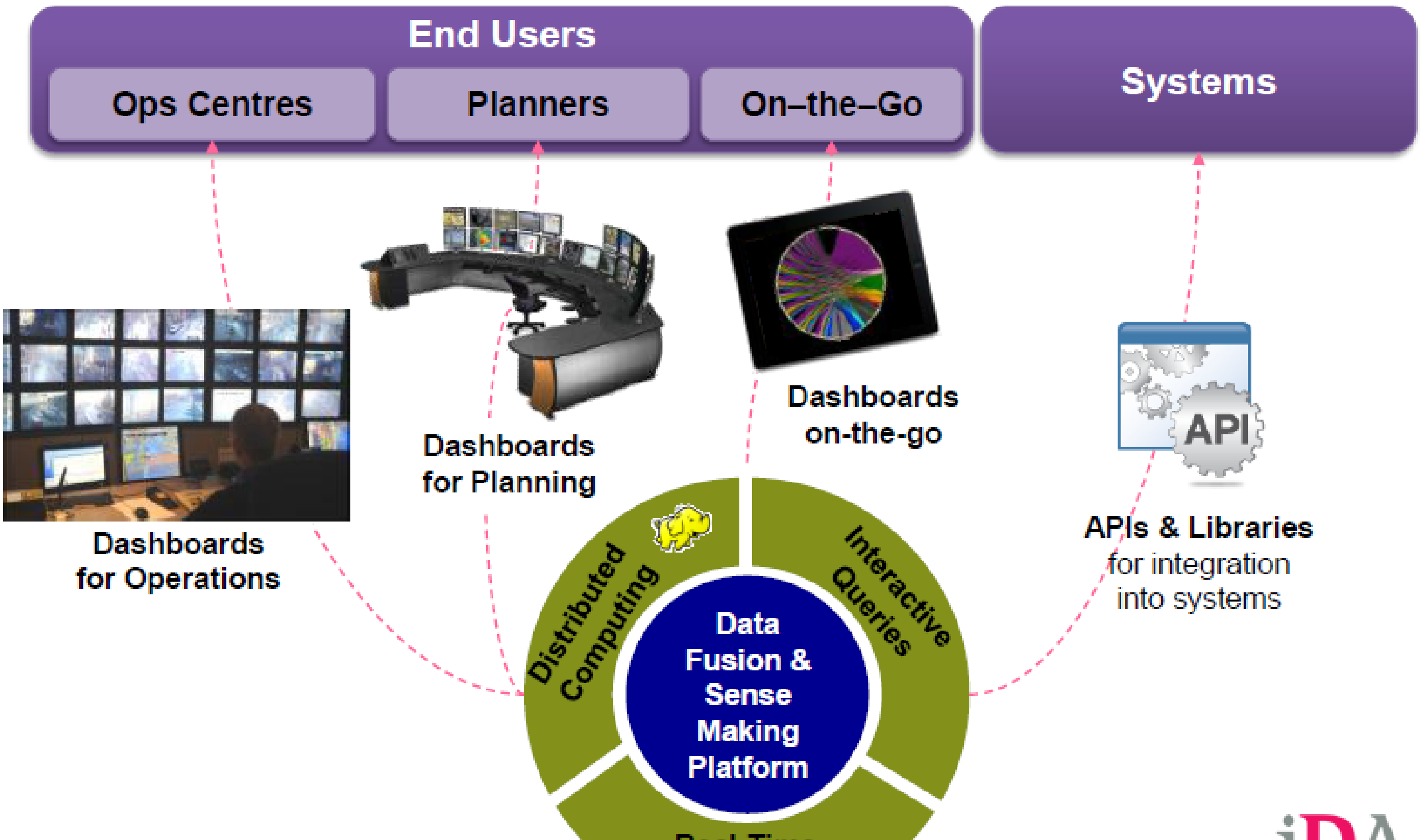
http://www.ida.gov.sg/~/media/Files/Collaboration%20Initiatives/Collaborations/2014/1010_SNP_IR/SNPBriefingSlides.pdf

(iii) Integrated Data Fusion and Sense Making Platform



(iii) Integrated Data Fusion and Sense Making Platform

Delivery of Data Products



Smart Nation Singapore

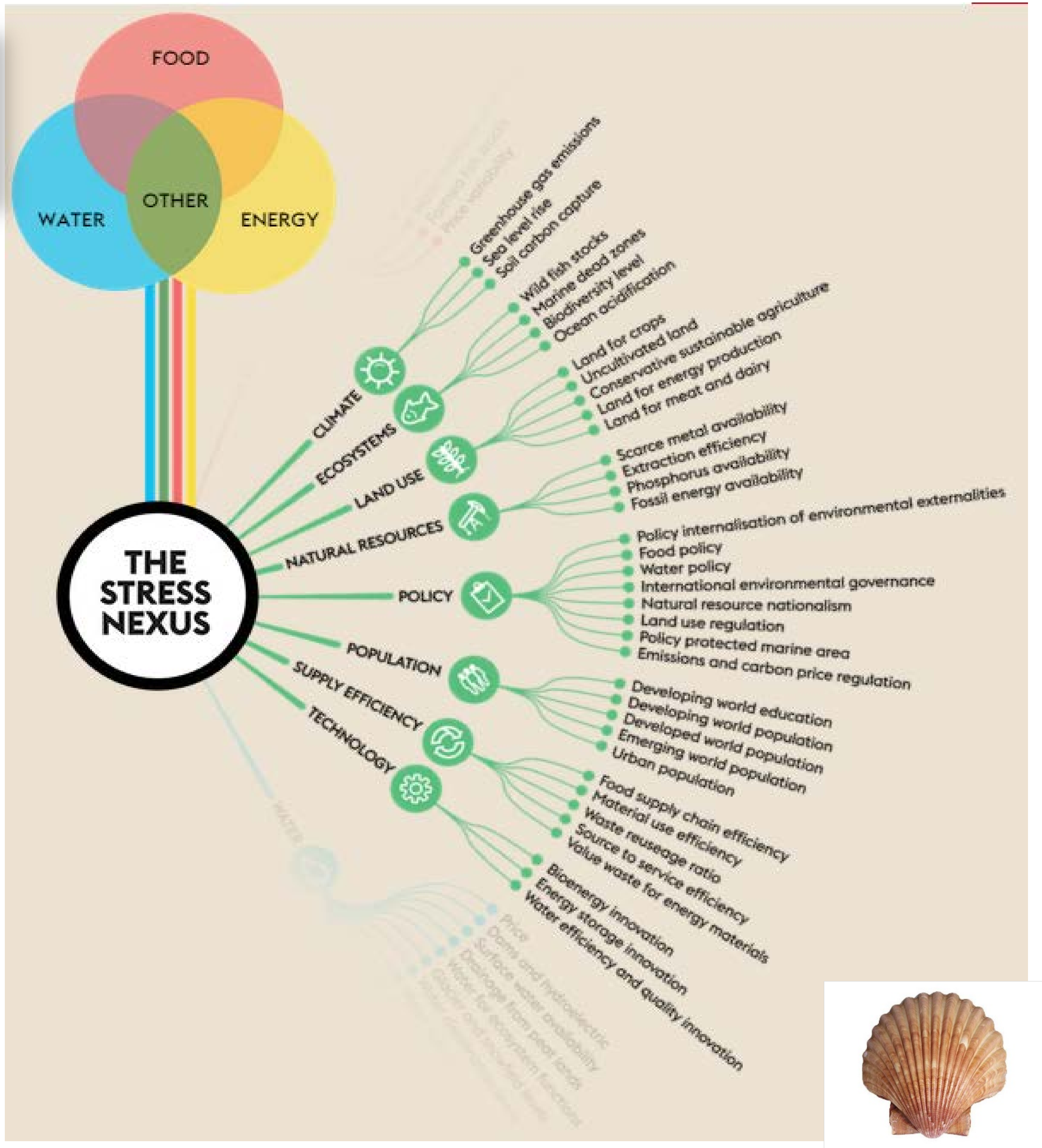
What did you notice?

apparent lack of hype about Big Data or IoT

But there is more to Smart Cities

much more

Smart City Stress Test



Can a Smart City reduce Food Waste?

Global Grand Challenge

By 2050, we will need to feed more than 10 billion people, requiring a 70% increase in global food production.

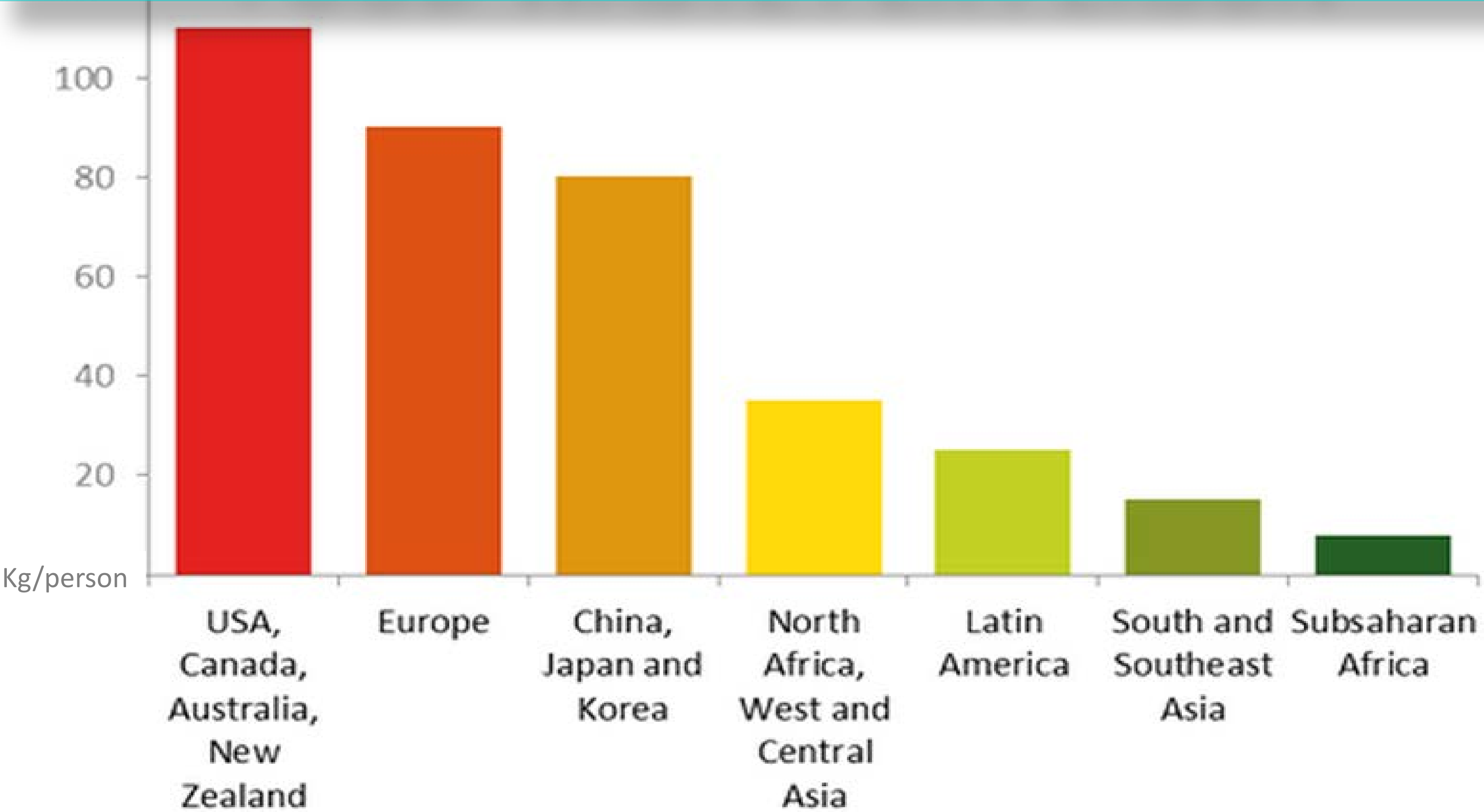
10bn

POPULATION BY 2050

70%

INCREASE IN FOOD PRODUCTION

FOOD WASTE PER PERSON

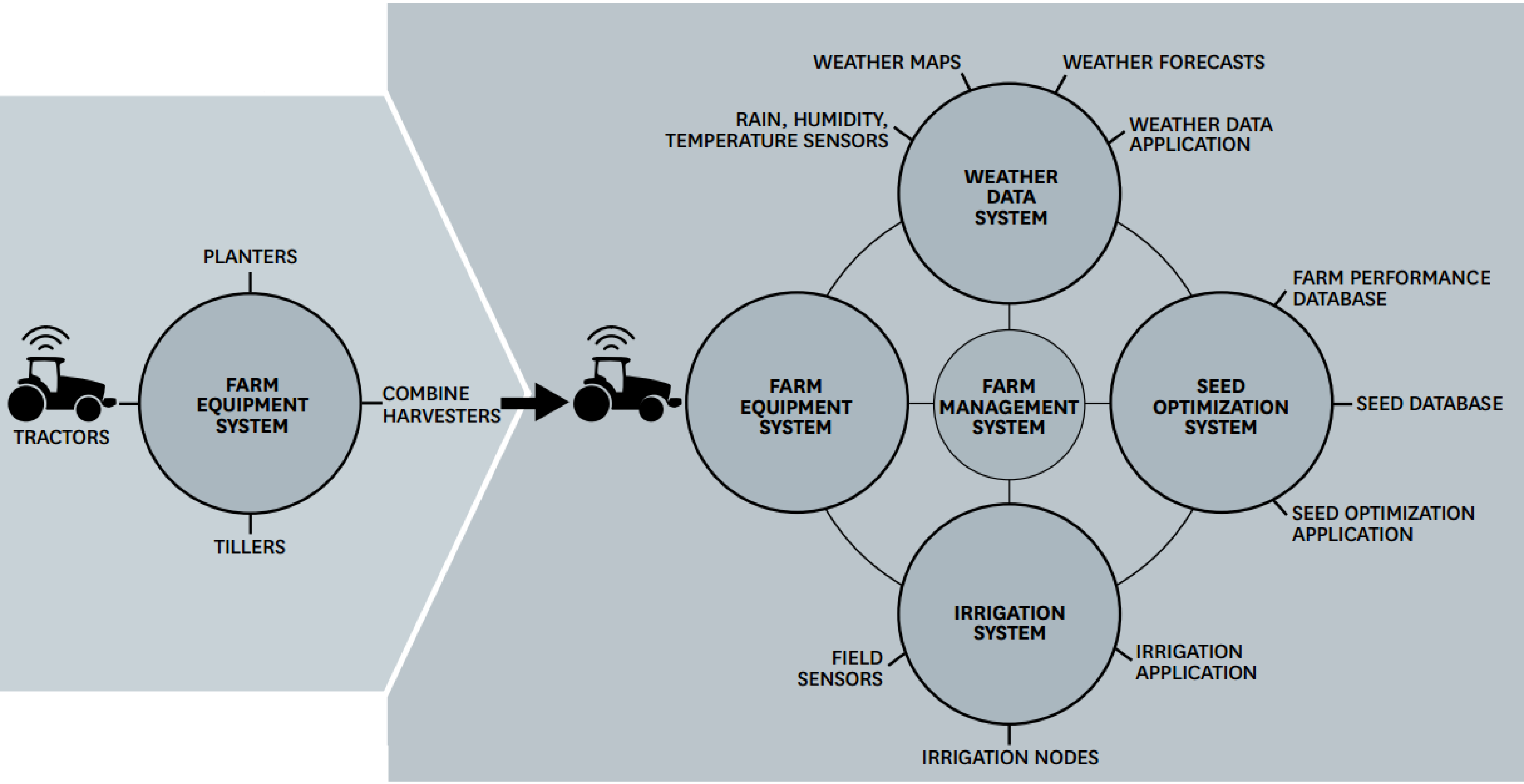


Note: Figures are consumer waste per capita based on data from 2007 in the FAO report 'Global Food Losses and Food Waste'. Globally consumer food waste amounts to roughly 350 Mt each year which equates to about 50 kg per person or 10% of total food supply.

Source: Gustavsson et al (2011), FAO

Shrink That Footprint

Food Waste Ecosystem - Smart Farming



http://bit.ly/HBR-IoT-PDF

Smart Farming Ecosystem - Food Supply Chain + Logistics of Farm2Fork

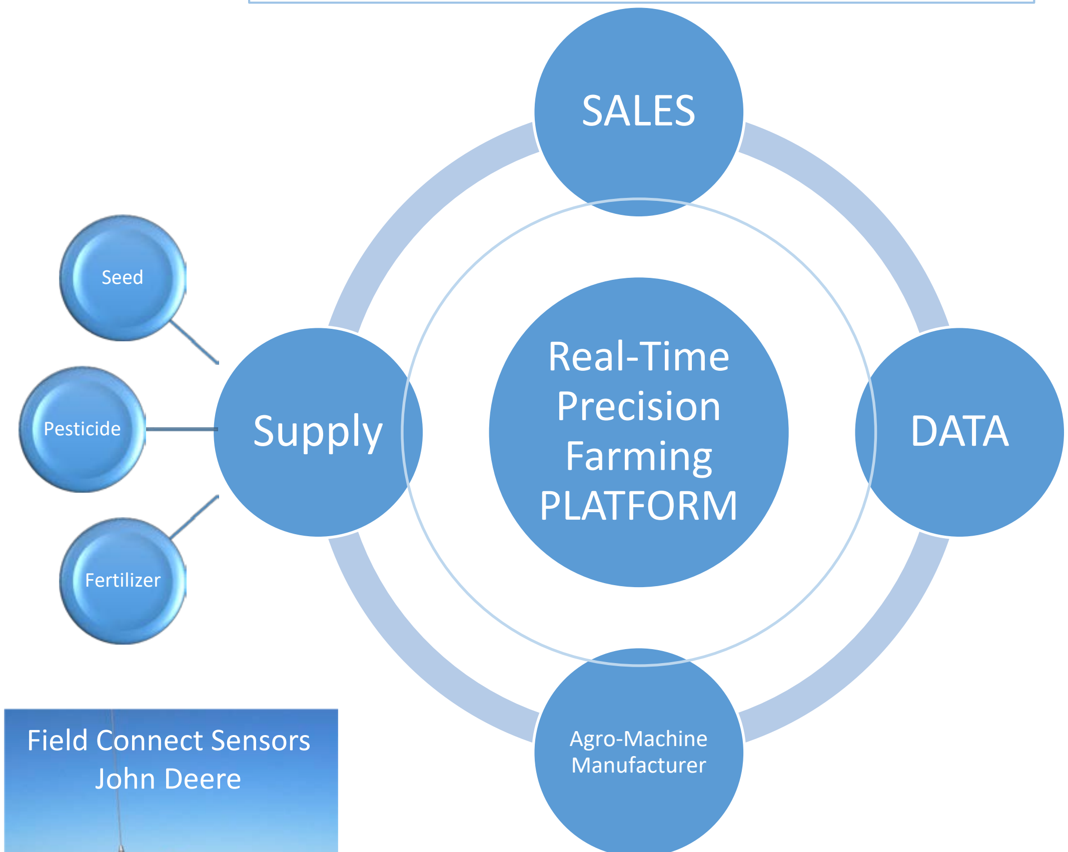
The potential convergence of Precision Farming ecosystem
- Seed to Mouth (S2M)
- Farm to Fork (F2F)

with other ecosystems, such as:
- Smart Cities
- Autonomous Transportation and operations management for trusted and secure supply chain network of partners.

Compliance with SOX-409 type regulations and DHS e-manifest are a part of this scenario. Additional links to energy and environmental systems are also obvious. Food safety, security, nutrition, availability and consumption are inextricably linked with global health, malnutrition, infant mortality and healthcare, in general.

Farming in California alone is a $50 billion industry

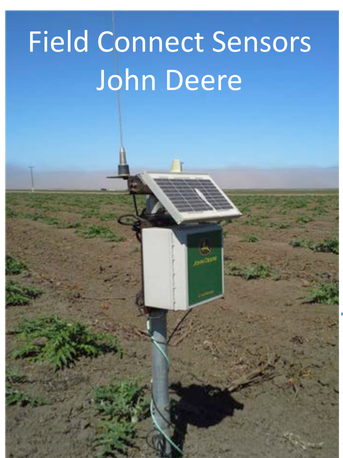
Retail Supply Chain – Sourcing / Distribution / Warehouse / Transportation
Track & Trace – Commodity Traders – Risk Management – Regulators (FDA)



-Measure, understand and apply
-Impact of data on quality & yield

-Weather data
-GPS micro-localization data
-Soil chemistry (GCMS) specifics
-Seed (sterile unless cultivated)
-Fertilizers (catalytic vs toxicity)
-Protection (pesticide, herbicide)
-Storage, shelf-life and waste
-Country of origin - goods supply

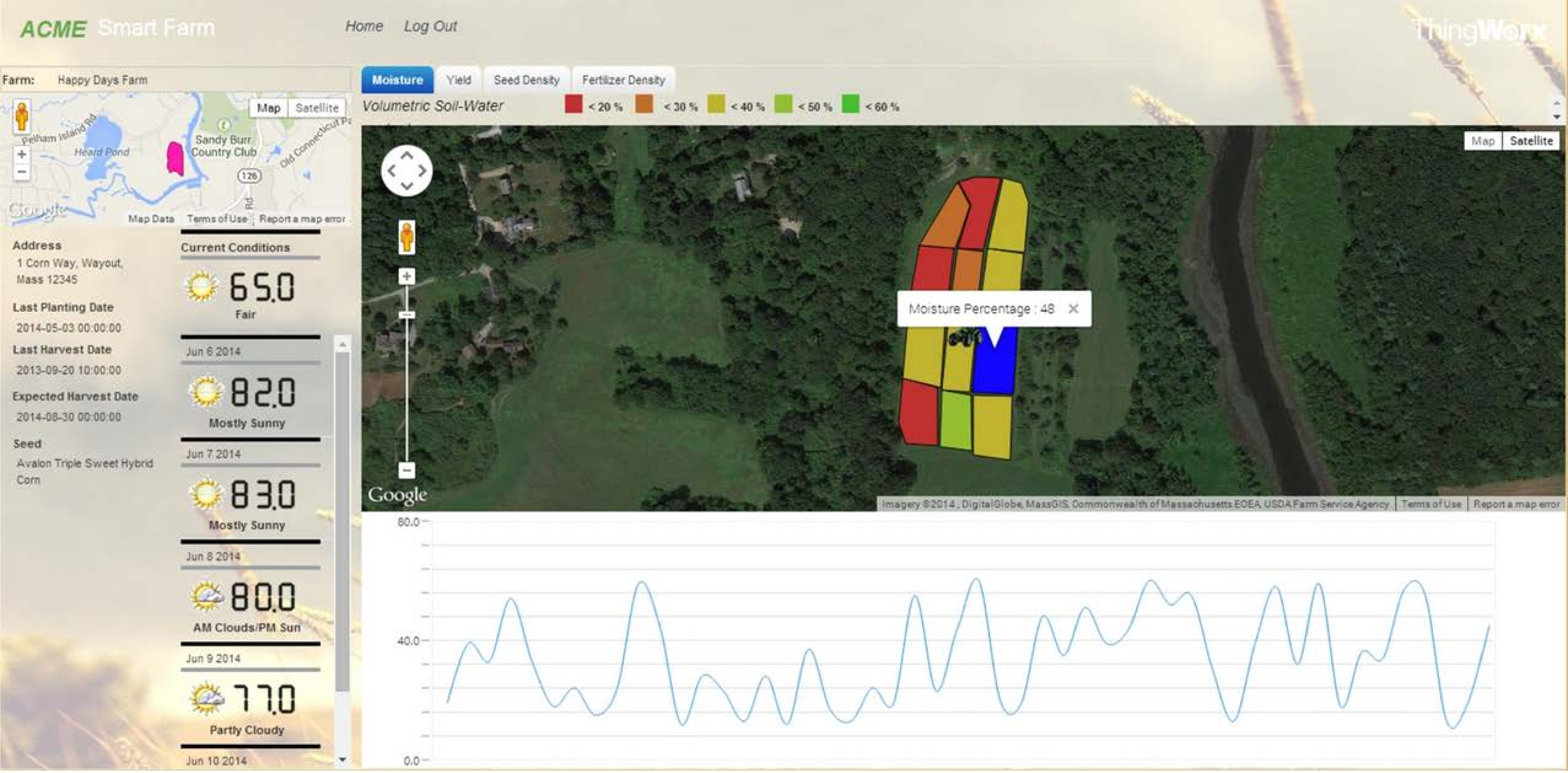
Leverage data to run long and short term simulations to plan for "what if" to optimize profit
- Weather patterns
- Demand uncertainty
- Export and import
- Tariff, cost, excise
- Regulatory policy

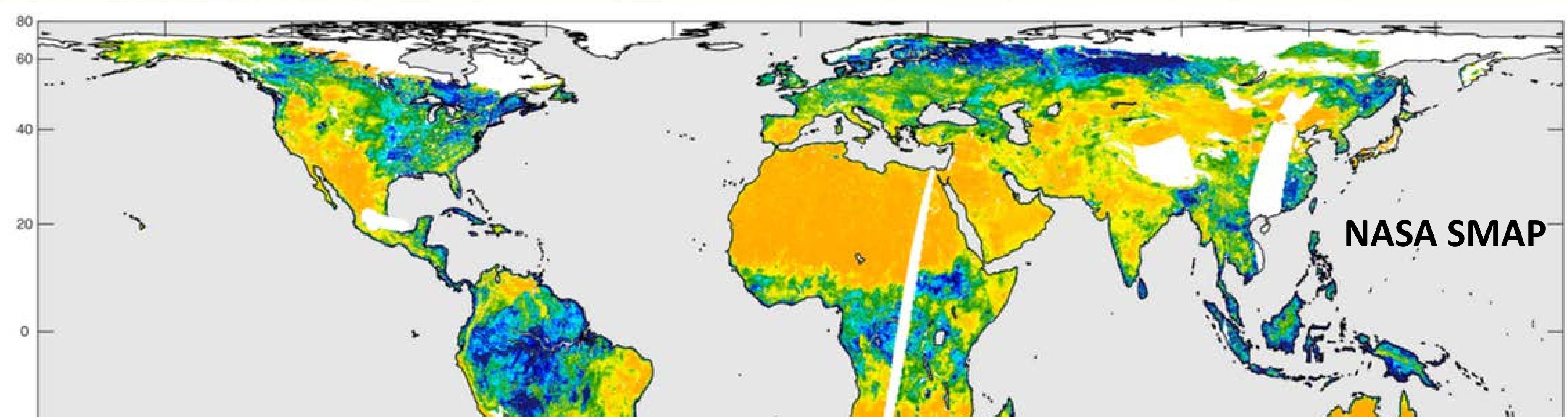


- Optimize MRO to improve asset uptime
- Mobile data collection and dissemination
  - soil sample / nutrient analysis (GCMS)
  - moisture monitors / field connect data
  - temperature / dielectric constant
  - color and chemistry of crops
  - growth rate / fertilizer distribution
  - weather micro-impact / acidity-alkalinity

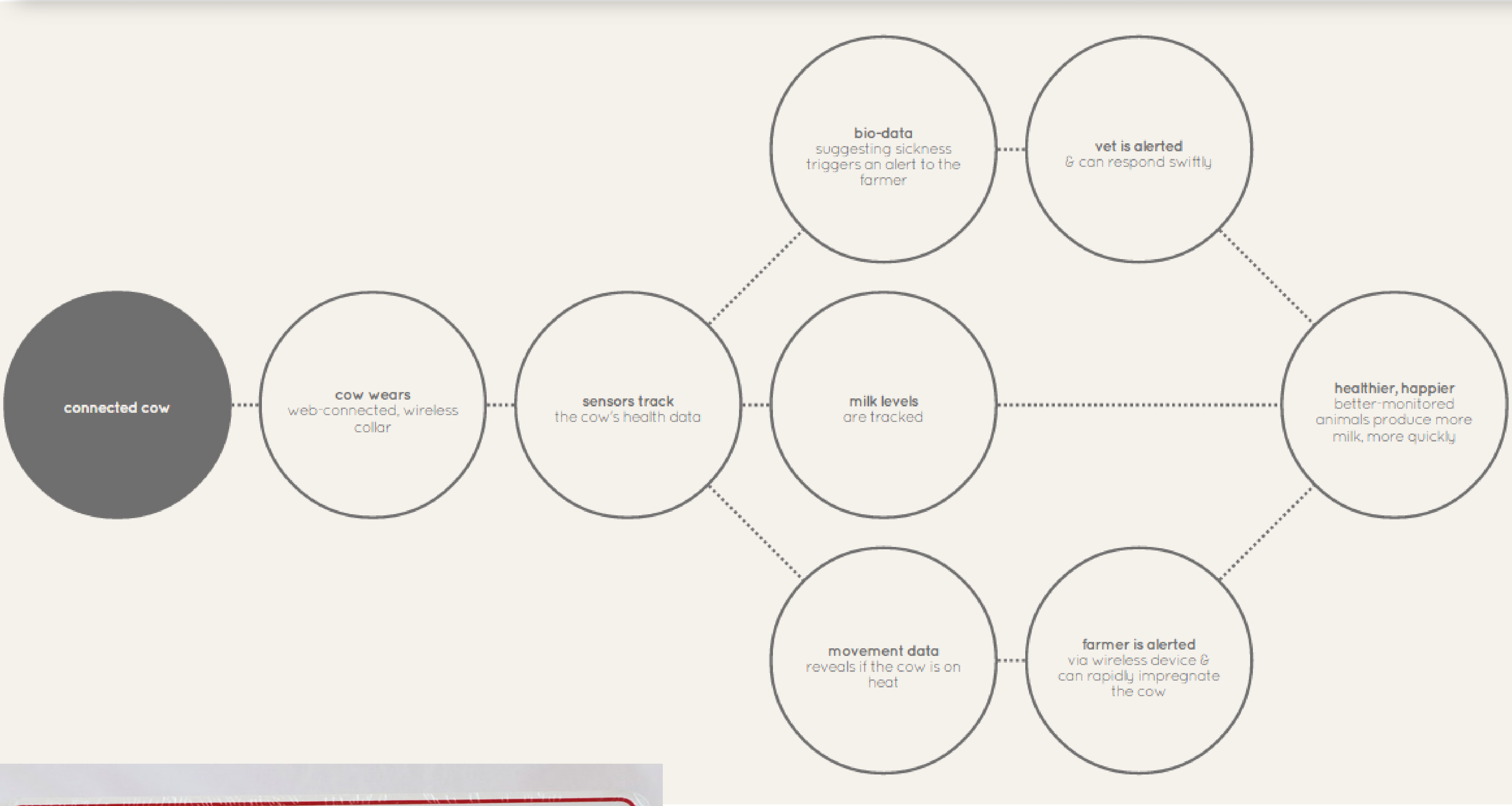
http://bit.ly/FARM-RECORDS

NASA Soil Moisture Active Passive (SMAP)

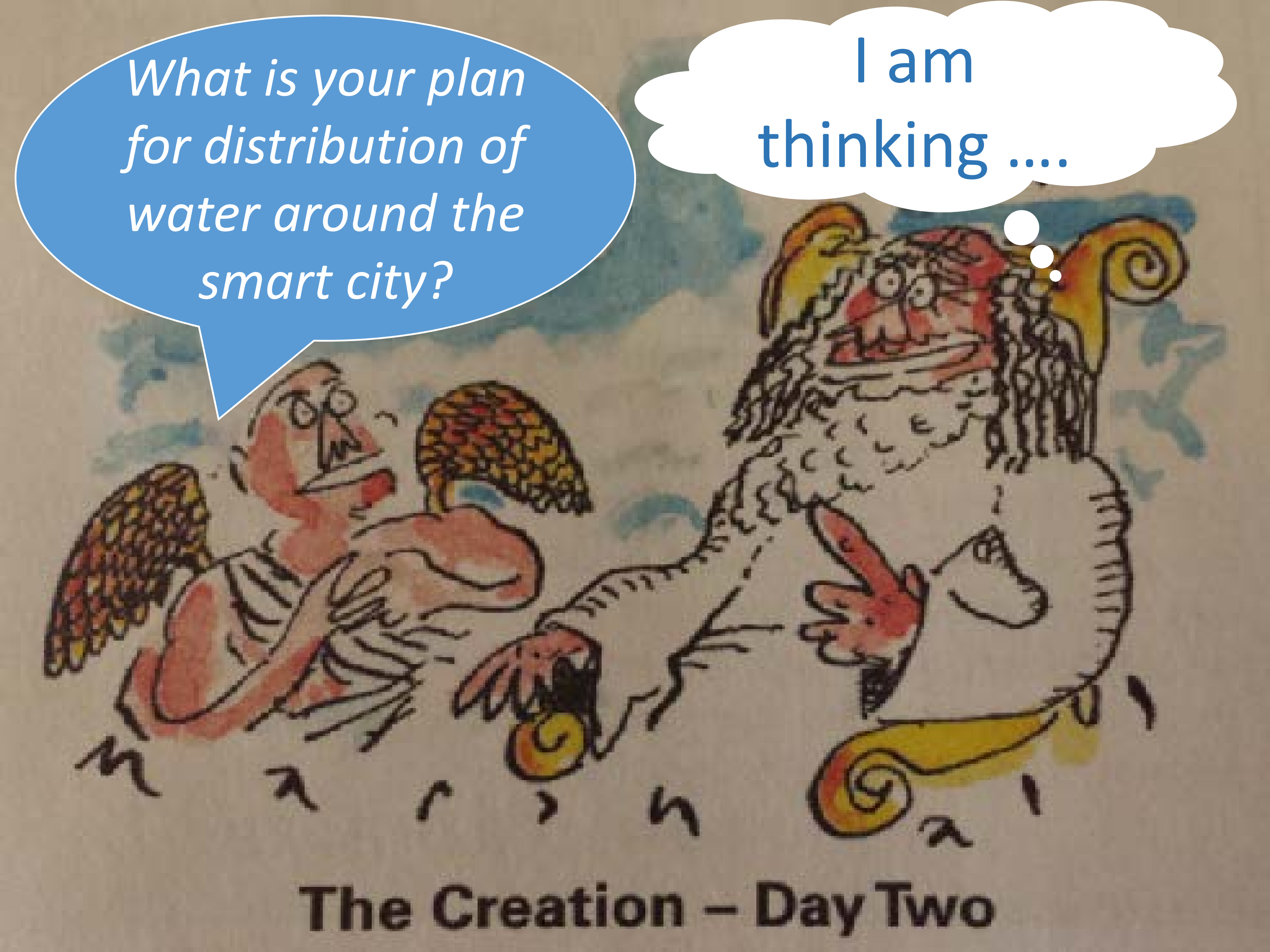

ACME Smart Farm
Home
Log Out
ThingWorx
Farm: Happy Days Farm
Moisture
Yield
Seed Density
Fertilizer Density
Volumetric Soil-Water
< 20 %
< 30 %
< 40 %
< 50 %
< 60 %
Map
Satellite
Heard Pond
Sandy Burr Country Club
Map Data
Terms of Use
Report a map error
Address
1 Corn Way, Wayout, Mass 12345
Last Planting Date
2014-05-03 00:00:00
Last Harvest Date
2013-09-20 10:00:00
Expected Harvest Date
2014-08-30 00:00:00
Seed
Avalon Triple Sweet Hybrid Corn
Current Conditions
65.0
Fair
Jun 6 2014
82.0
Mostly Sunny
Jun 7 2014
83.0
Mostly Sunny
Jun 8 2014
80.0
AM Clouds/PM Sun
Jun 9 2014
77.0
Partly Cloudy
Jun 10 2014
Moisture Percentage : 48
Google
Imagery ©2014, DigitalGlobe, MassGIS, Commonwealth of Massachusetts EOEA, USDA Farm Service Agency
80.0
40.0
0.0


80
60
40
20
0
NASA SMAP

Smart Cow in the Food Supply Chain ● Farm 2 Fork



What about water?


What is your plan for distribution of water around the smart city?
I am thinking ….
The Creation – Day Two


What is your plan for distribution of water around the smart city?
I am thinking of a cloud-based solution
The Creation – Day Two

Reality Check ☑ Water

San Francisco top earning $423,000 ● San Francisco water pipes

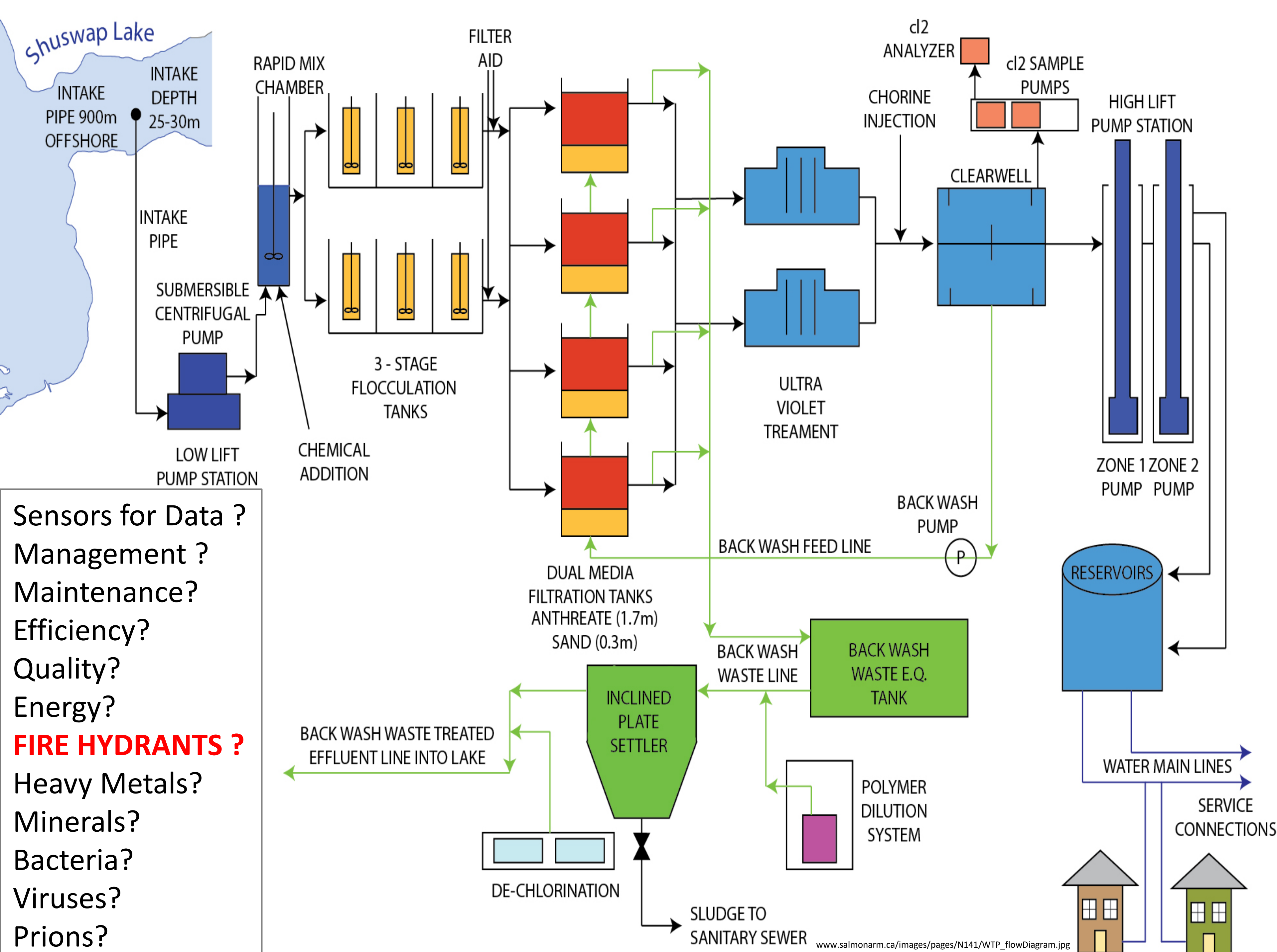
NBC Bay Area
@nbcbayarea

Pipes old as the Civil War deliver water to the #BayArea. NOW they're failing. #WeInvestigate tonight at 11

The nonpartisan Brookings Institution looked at the 2013 incomes for households at the top (95th percentile) and closer to the bottom (20th percentile), then calculated the ratio between the two numbers. The higher the ratio, the worse the inequality. It's a little broader than the notorious 1 percent, but you get the idea.

For San Francisco, the top households earned a staggering $423,171 - by far the highest income of any city. That was 17 times the lower income group's $24,815. It's as if the city is full of tech CEOs and lowly baristas.

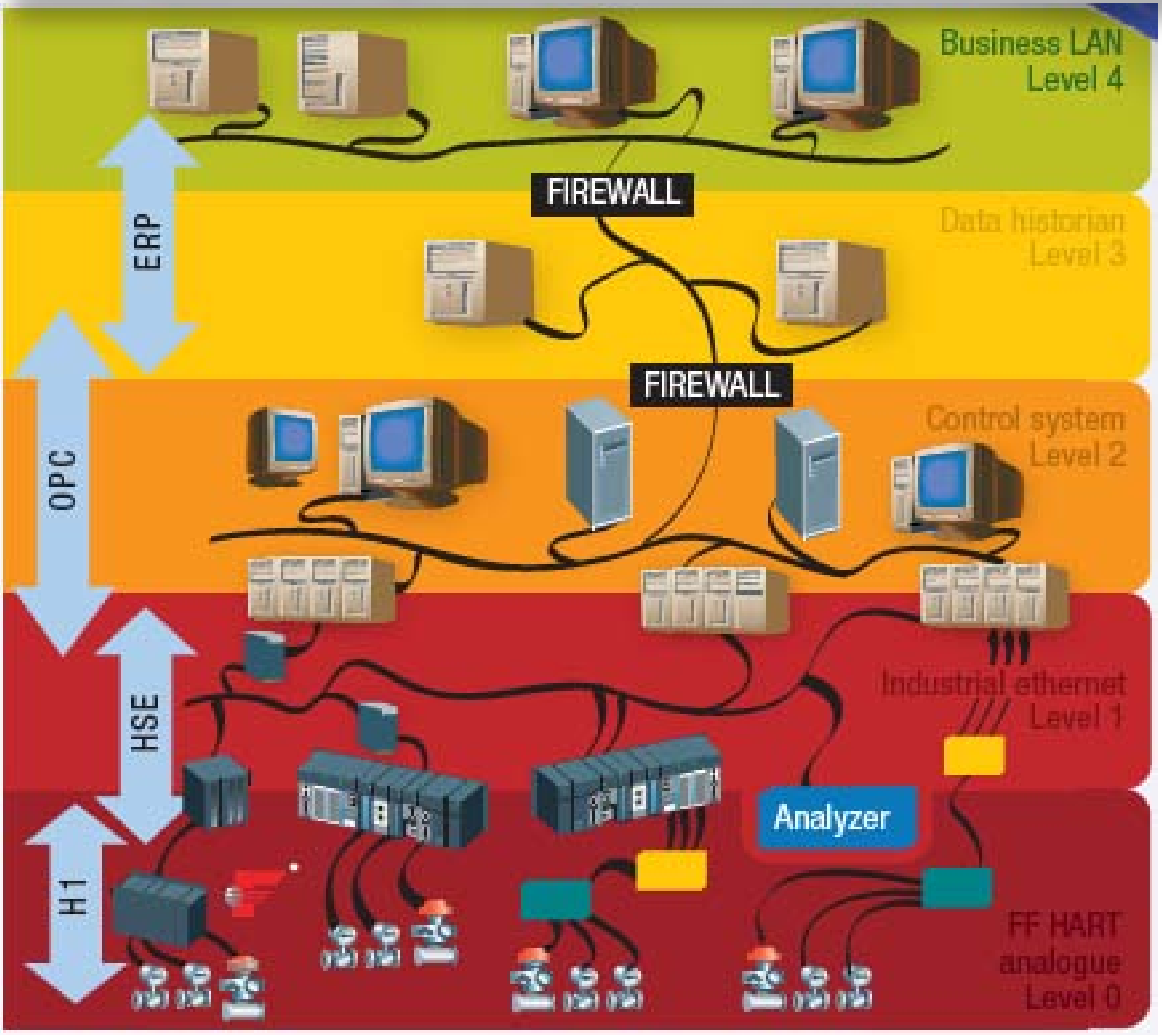
www.sacbee.com/opinion/opn-columns-blogs/foon-rhee/article15518342.html



Sensors for Data ?
Management ?
Maintenance?
Efficiency?
Quality?
Energy?
FIRE HYDRANTS ?
Heavy Metals?
Minerals?
Bacteria?
Viruses?
Prions?

www.salmonarm.ca/images/pages/N141/WTP_flowDiagram.jpg

Water Systems Management (illustration based on chemical plant from NIST CPS PWG)

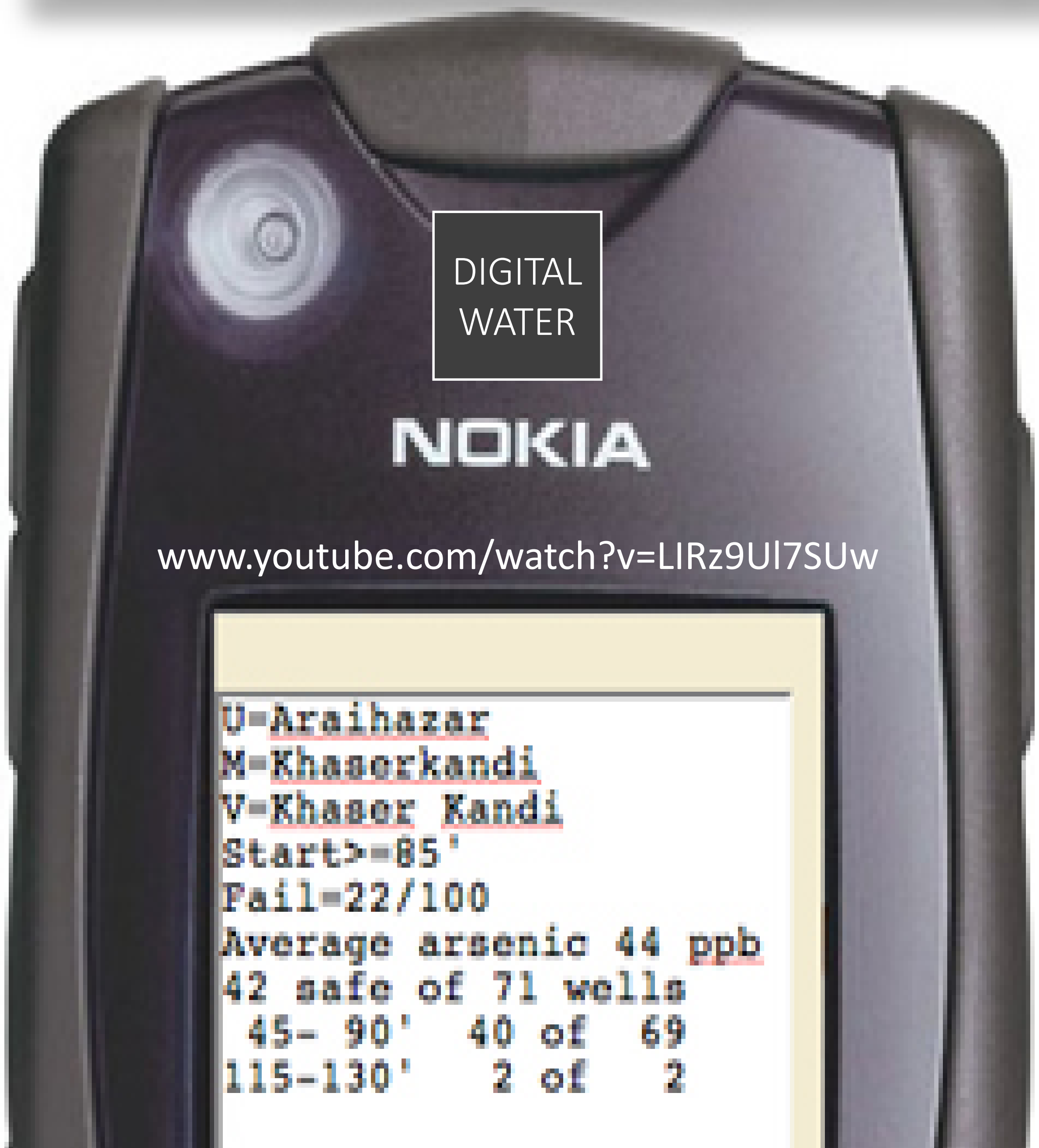


Sensors for Data ?
Management ?
Maintenance?
Efficiency?
Quality?
Energy?
FIRE HYDRANTS ?

Reality Check ☑ Arsenic in Water in Bangladesh causes acute morbidity

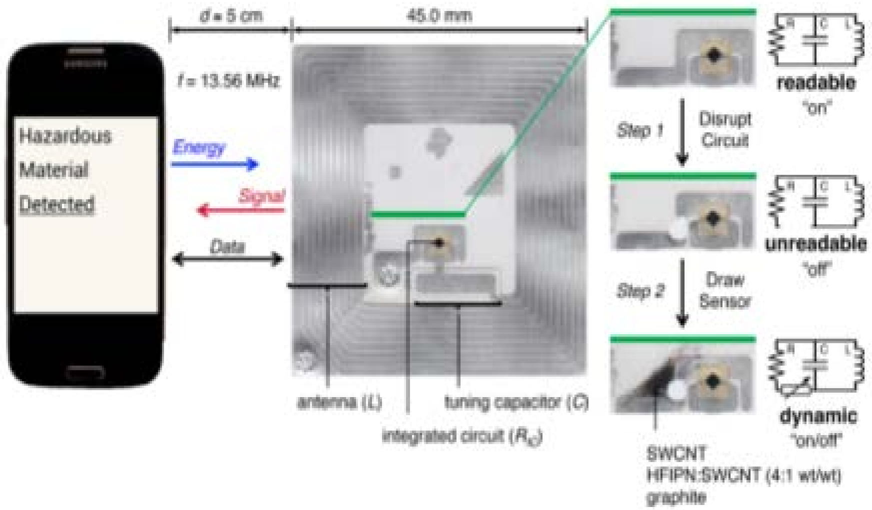
Internet of Things → Internet of Systems

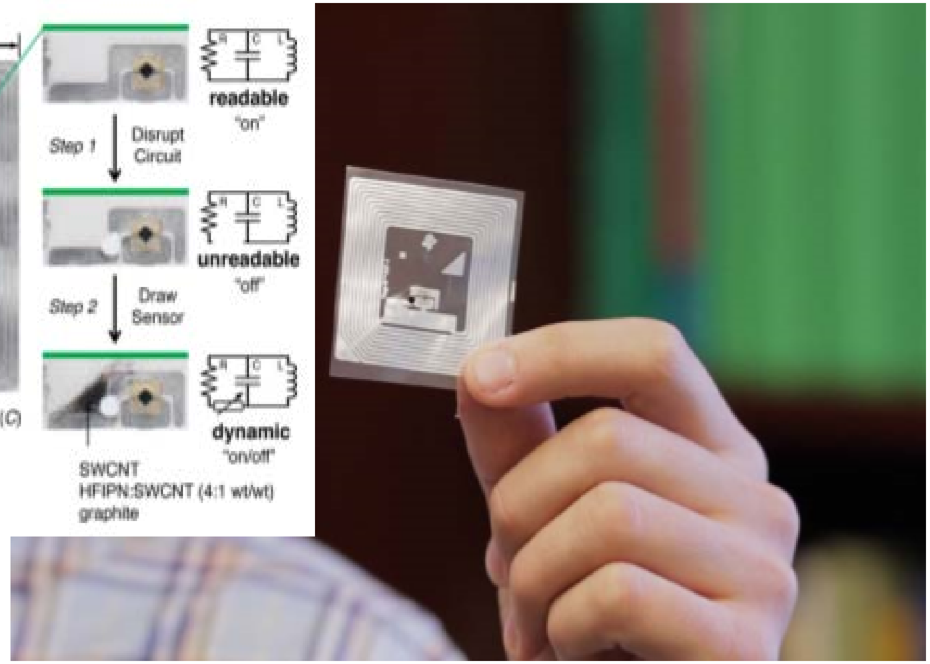
Socio-Economic Impact and Healthcare Improvement due to Medical IoT



MIT News

ON CAMPUS AND AROUND THE WORLD





The MIT researchers' wireless chemical sensor.

Photo: Melanie Gonick

MIT News

ON CAMPUS AND AROUND THE WORLD

Detecting gases wirelessly and cheaply

New sensor can transmit information on hazardous chemicals or food spoilage to a smartphone.

Wireless gas detection with a smartphone via rf communication

Joseph M. Azzarelli, Katherine A. Mirica, Jens B. Ravnsbæk[1], and Timothy M. Swager[2]

Department of Chemistry, Massachusetts Institute of Technology, Cambridge, MA 02139

Edited by Chad A. Mirkin, Northwestern University, Evanston, IL, and approved November 5, 2014 (received for review August 10, 2014)

Wireless, wearable toxic-gas detector **www.pnas.org/content/111/51/18162.full.pdf**

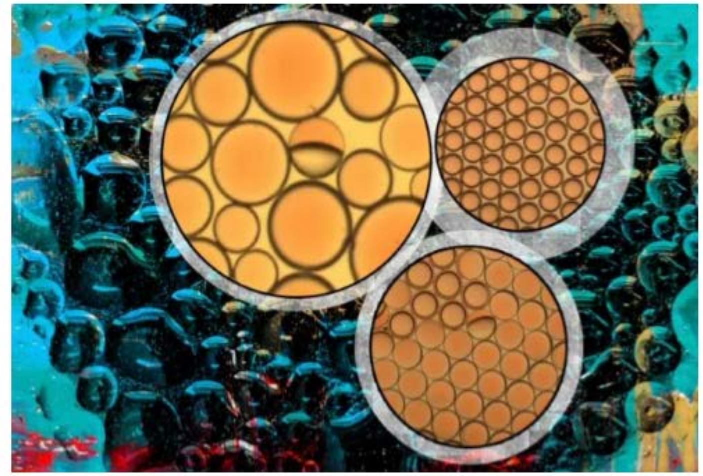
MIT News

ON CAMPUS AND AROUND THE WORLD

Food Testing. Blood Testing? Sputum? Mucus? Fluids?

MIT News

ON CAMPUS AND AROUND THE WORLD



A simple way to make and reconfigure complex emulsions

Anne Trafton | MIT News Office
February 25, 2015

Janus Emulsions for the Detection of Bacteria

Qifan Zhang,[†] Suchol Savagatrup,[†] Paulina Kaplonek,[‡,§] Peter H. Seeberger,[*,‡,§] and Timothy M. Swager[*,†]

[†]Department of Chemistry and Institute for Soldier Nanotechnologies, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, United States

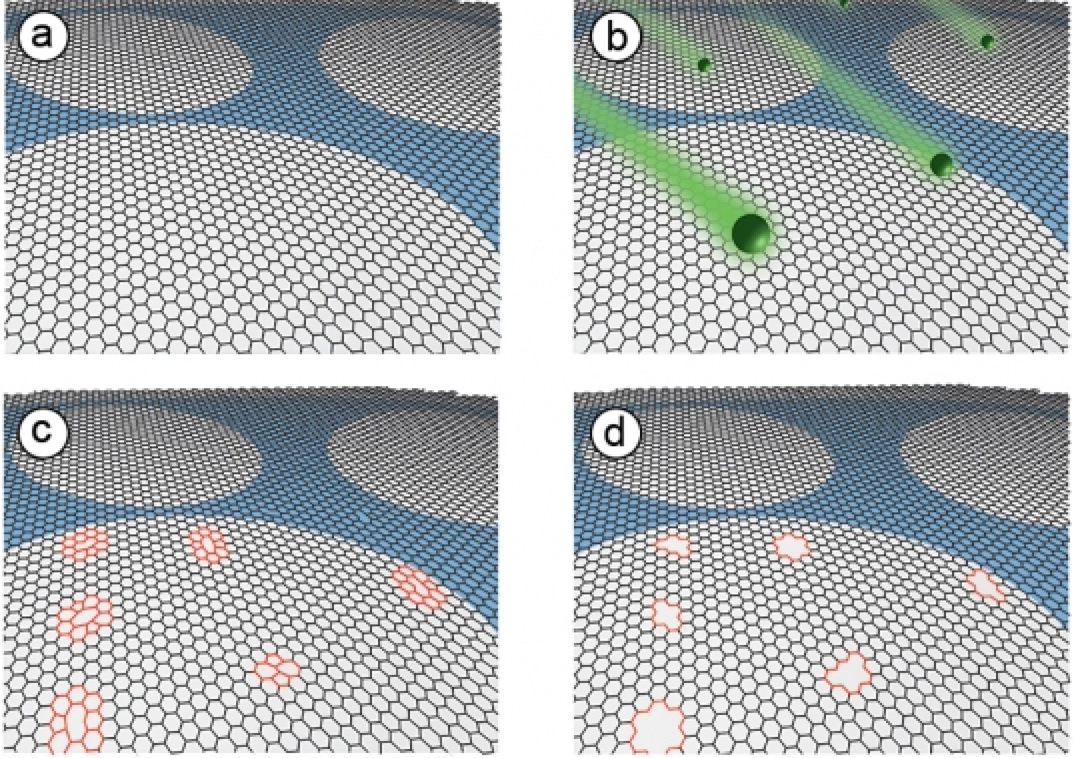
[‡]Department of Biomolecular Systems, Max Planck Institute of Colloids and Interfaces, Am Mühlenberg 1, 14476 Potsdam, Germany

[§]Institute of Chemistry and Biochemistry, Free University Berlin, Arnimallee 22, 14195 Berlin, Germany

Specialized droplets interact with bacteria and can be analyzed using a smartphone.

Anne Trafton | MIT News
April 5, 2017

http://pubs.acs.org/doi/abs/10.1021/acscentsci.7b00021



The MIT researchers used a four-step process to create filters from graphene (shown here): (a) a one-atom-thick sheet of graphene is placed on a supporting structure; (b) the graphene is bombarded with gallium ions; (c) wherever the gallium ions strike the graphene, they create defects in its structure; and (d) when etched with an oxidizing solution, each of those defects grows into a hole in the graphene sheet. The longer the material stays in the oxidizing bath, the larger the holes get.

How to create selective holes in graphene

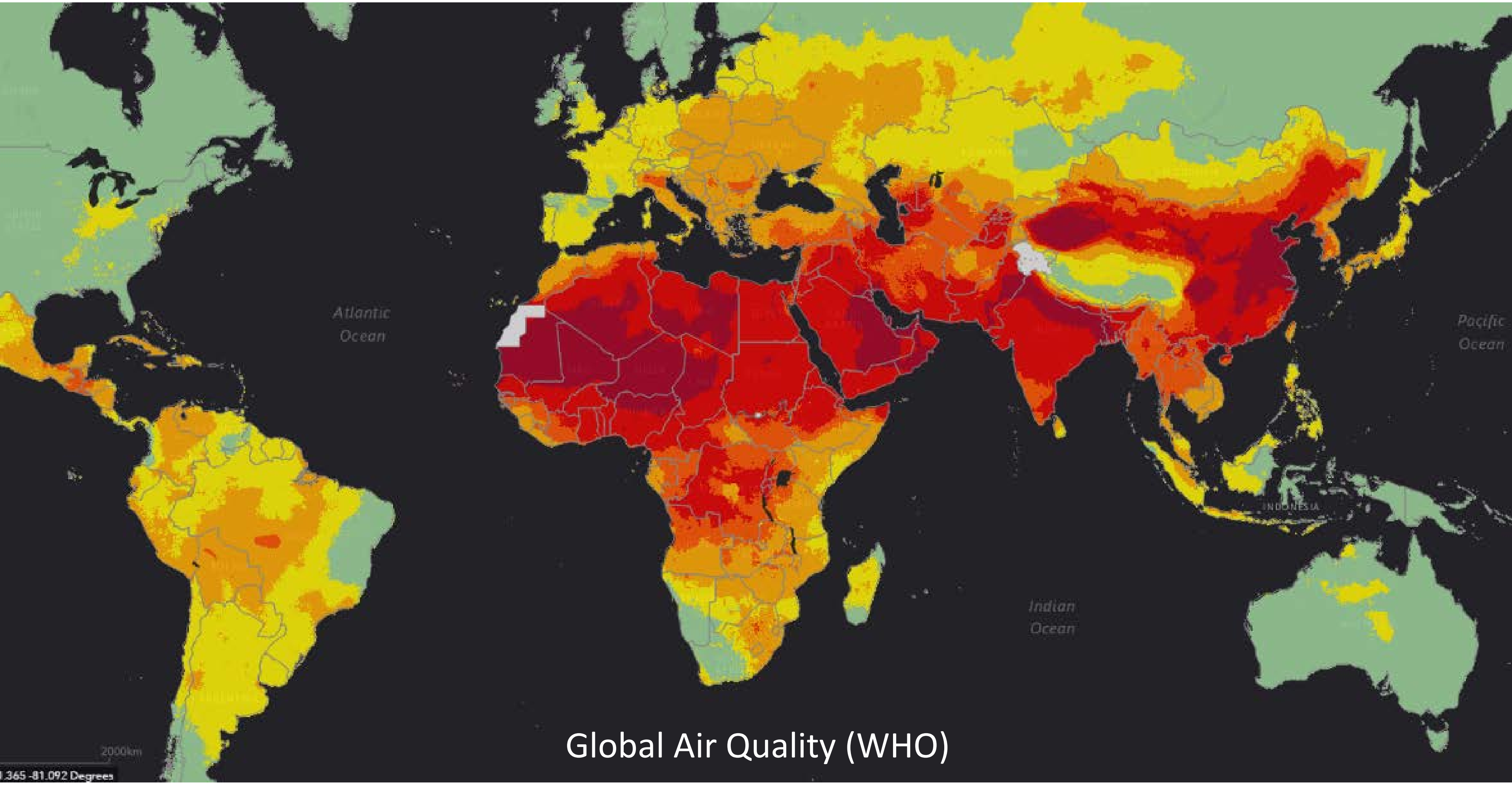
New technique developed at MIT produces highly selective filter materials, could lead to more efficient desalination.

David L. Chandler, MIT News Office
February 25, 2014

Researchers have devised a way of making tiny holes of controllable size in sheets of graphene, a development that could lead to ultrathin filters for improved desalination or water purification.

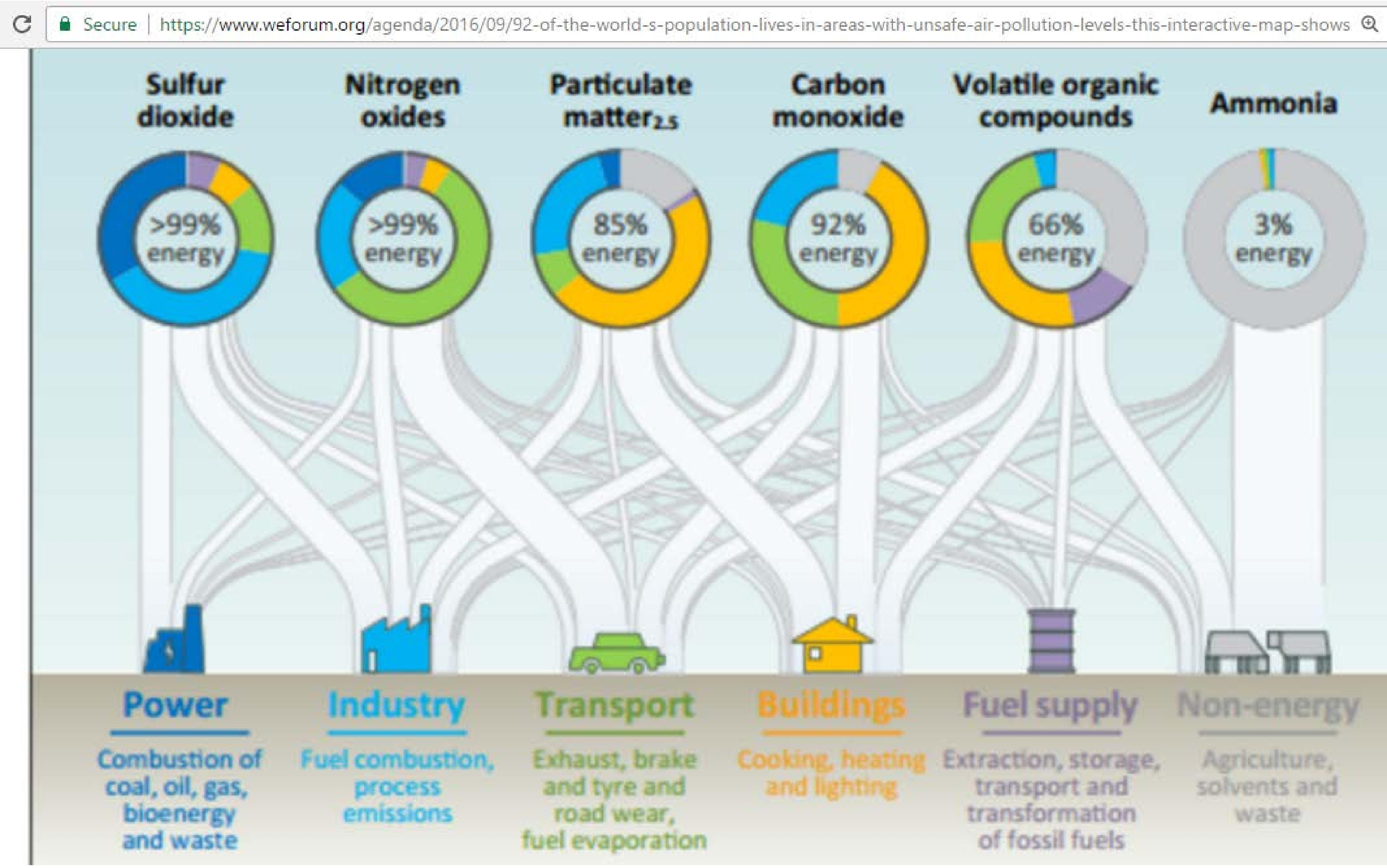
Smart City Air Quality?

Pollution sensor data may indicate need to plant trees

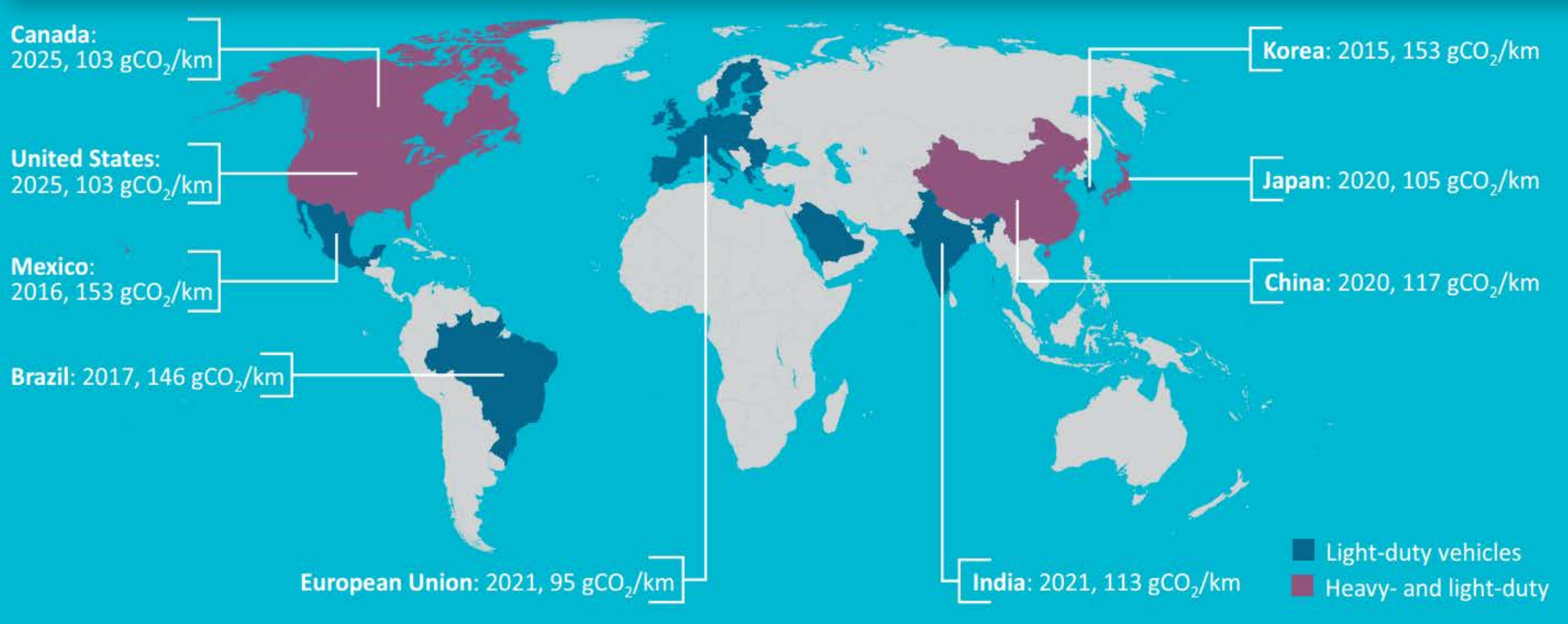


Global Air Quality (WHO)

Polluters and Pollutants

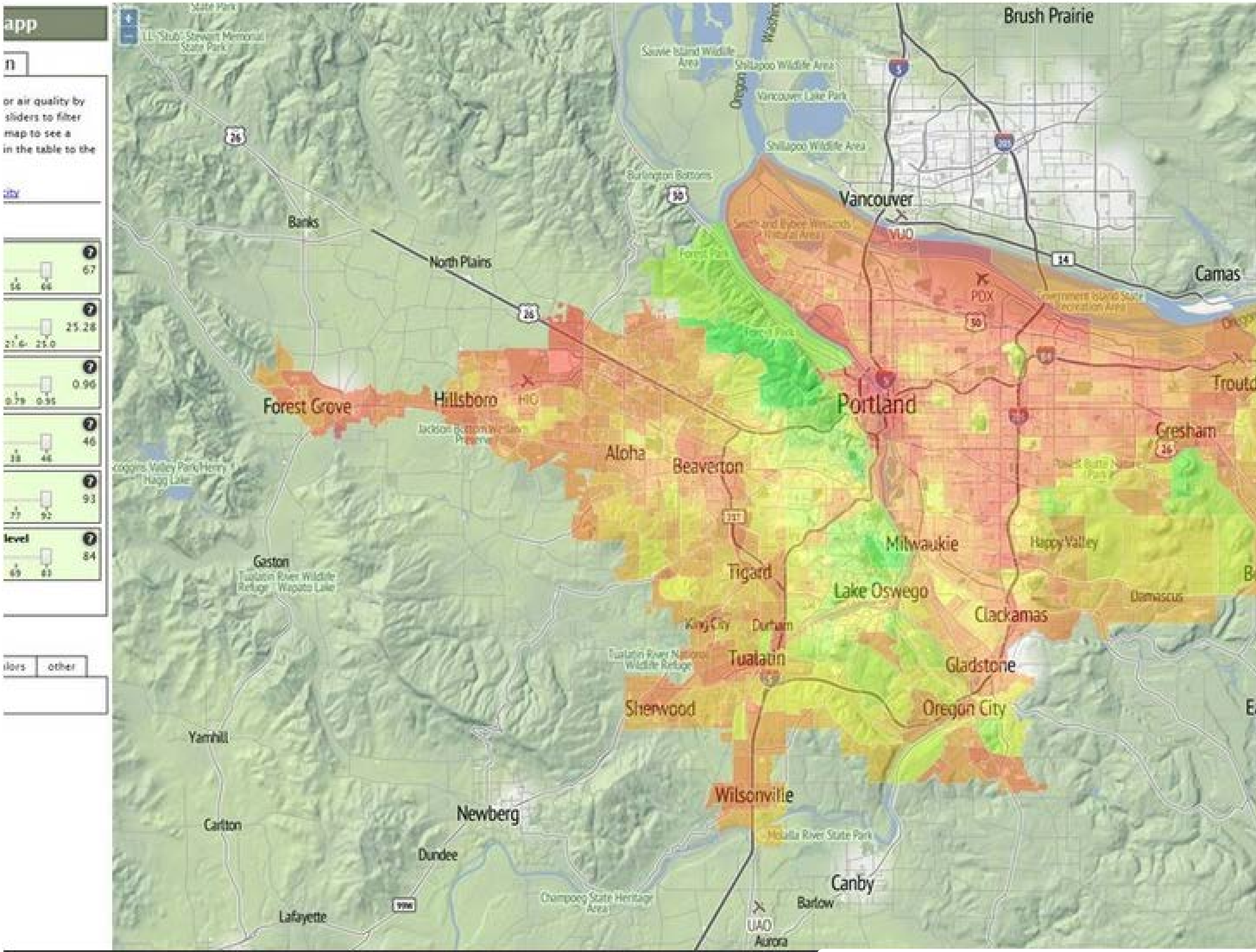


Global Fuel Economy Standards



LOCAL AIR QUALITY

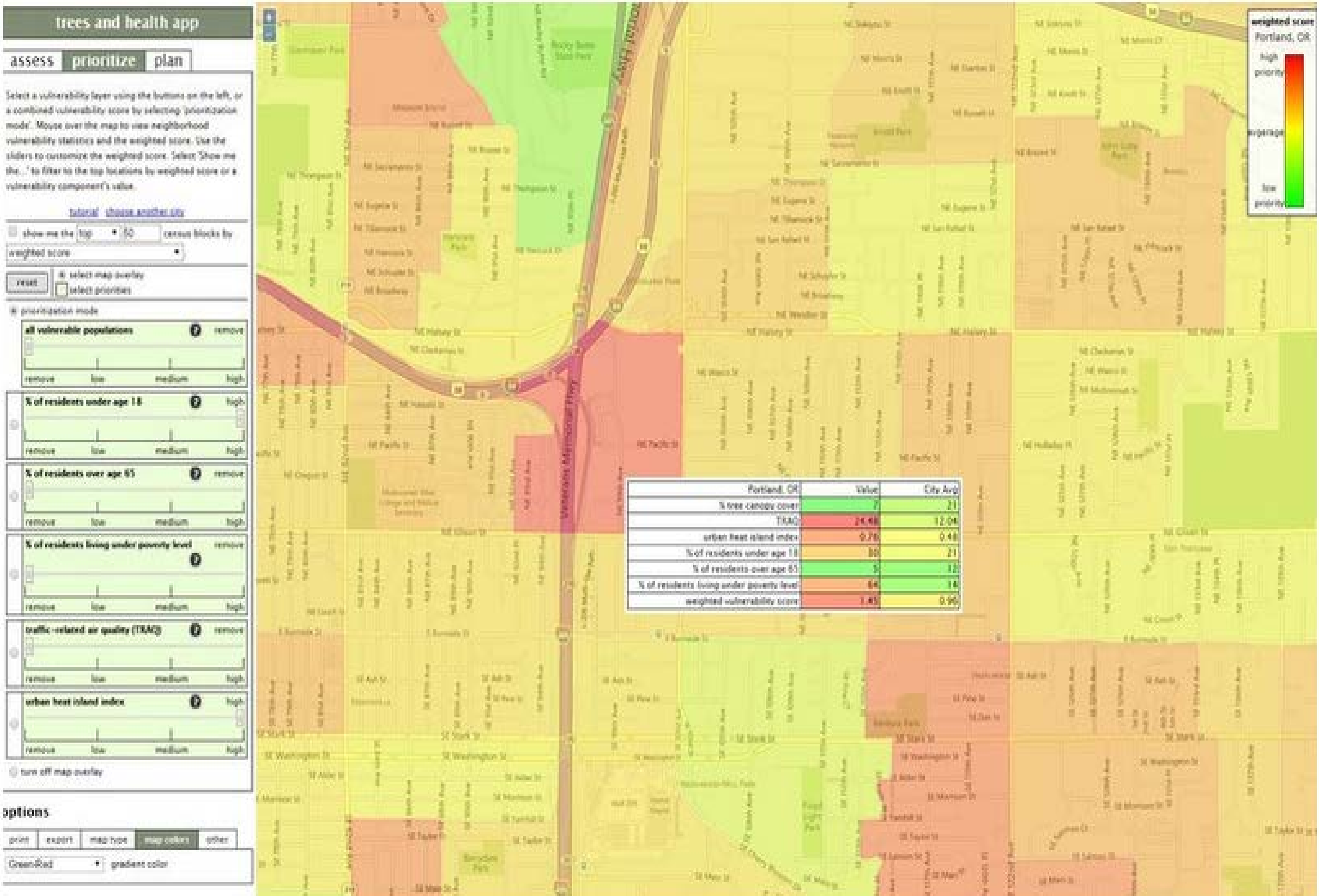
Researchers at Portland State University have created an app that looks at tree density in respect to neighborhood, population and pollution



Looking at tree density on a city scale. (Vivek Shandas)

http://bit.ly/SMART-CT-TREES

Source: Heather Hansman



Pollution levels and tree cover can change significantly from neighborhood to neighborhood. (Vivek Shandas)

Smart City Healthcare?

http://bit.ly/IOT-MIT

See PDFs

Healthcare

and

Medical IoT

Dr Shoumen Palit Austin Datta

MIT Auto-ID Labs and Research Affiliate, Department of Mechanical Engineering, Massachusetts Institute of Technology ● shoumen@mit.edu

Senior Scientist, MD PnP Lab, Medical Device Interoperability, Massachusetts General Hospital, Harvard Medical School ● www.mdpnp.org

Monitor and Predict Physiological Status of Humans in Vehicles Transport Connects to Healthcare through Smart City Platform

Plessey has been working on a heart-rate monitor that would be built into car seats

Dr Leslie Saxon, University of Southern California

PHONE ECG DETECTS IRREGULAR HEARTBEAT

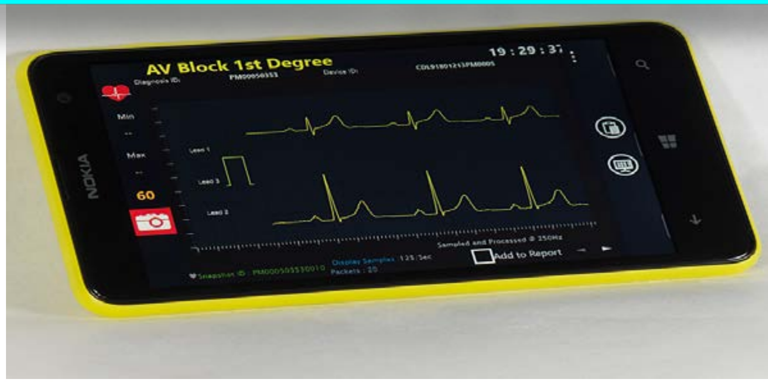
MIT News
ON CAMPUS AND AROUND THE WORLD

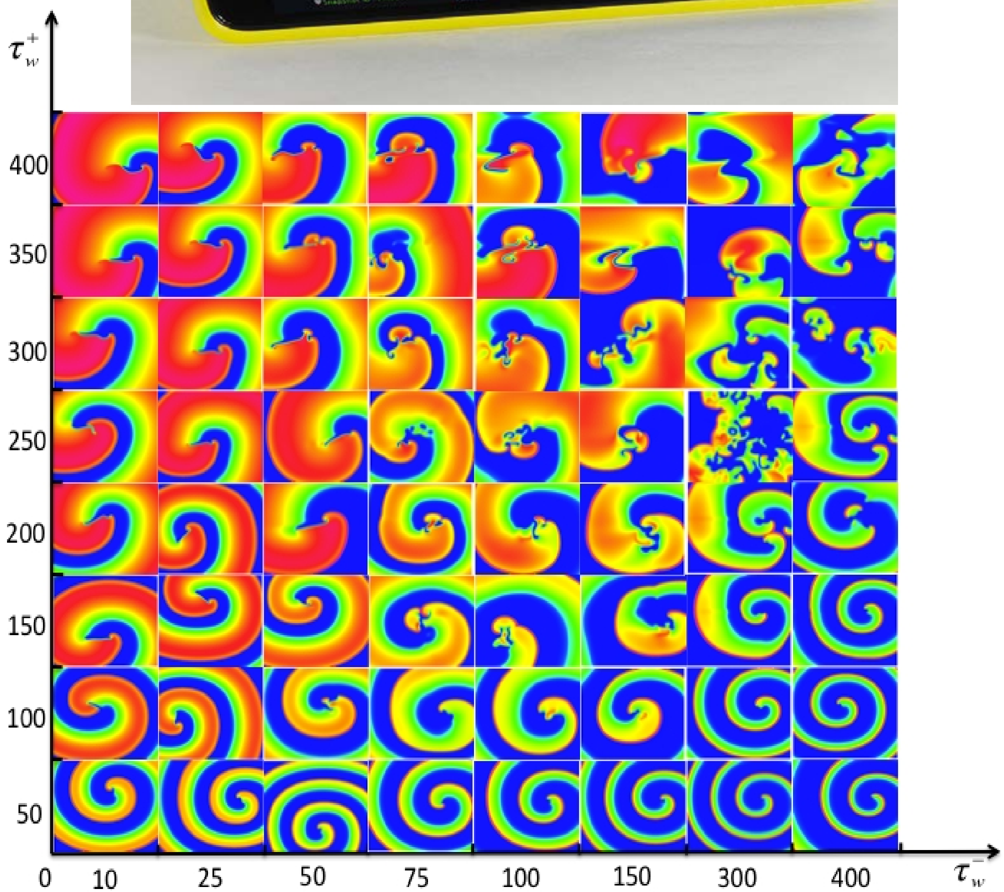
MIT Media Lab spinout Cardiio has developed a mobile app that uses a smartphone camera to detect facial signs of a heart arrhythmia associated with strokes.

Courtesy of Cardiio

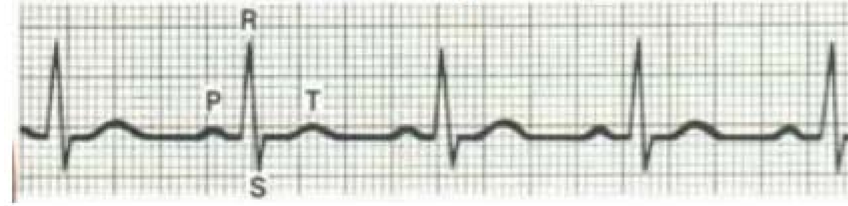
App screens for arrhythmia using smartphone

CARDIAC ARRHYTHMIA DIAGNOSIS & REPORTING CARDIOLOGIST-in-a-POCKET



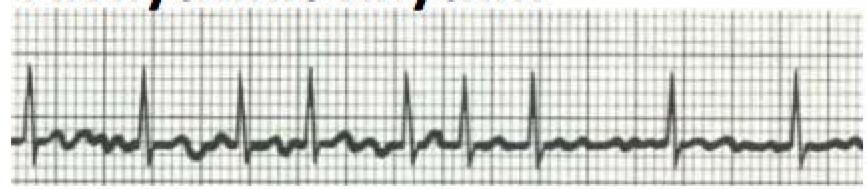


Normal Sinus Rhythm

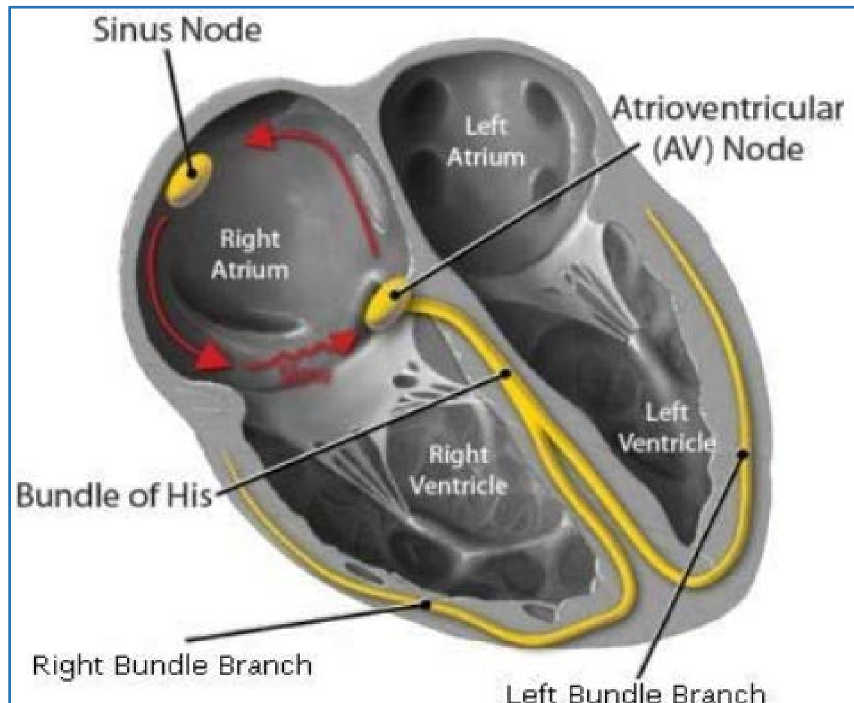


Circular pathways in the heart conduction system is a common cause of arrhythmias

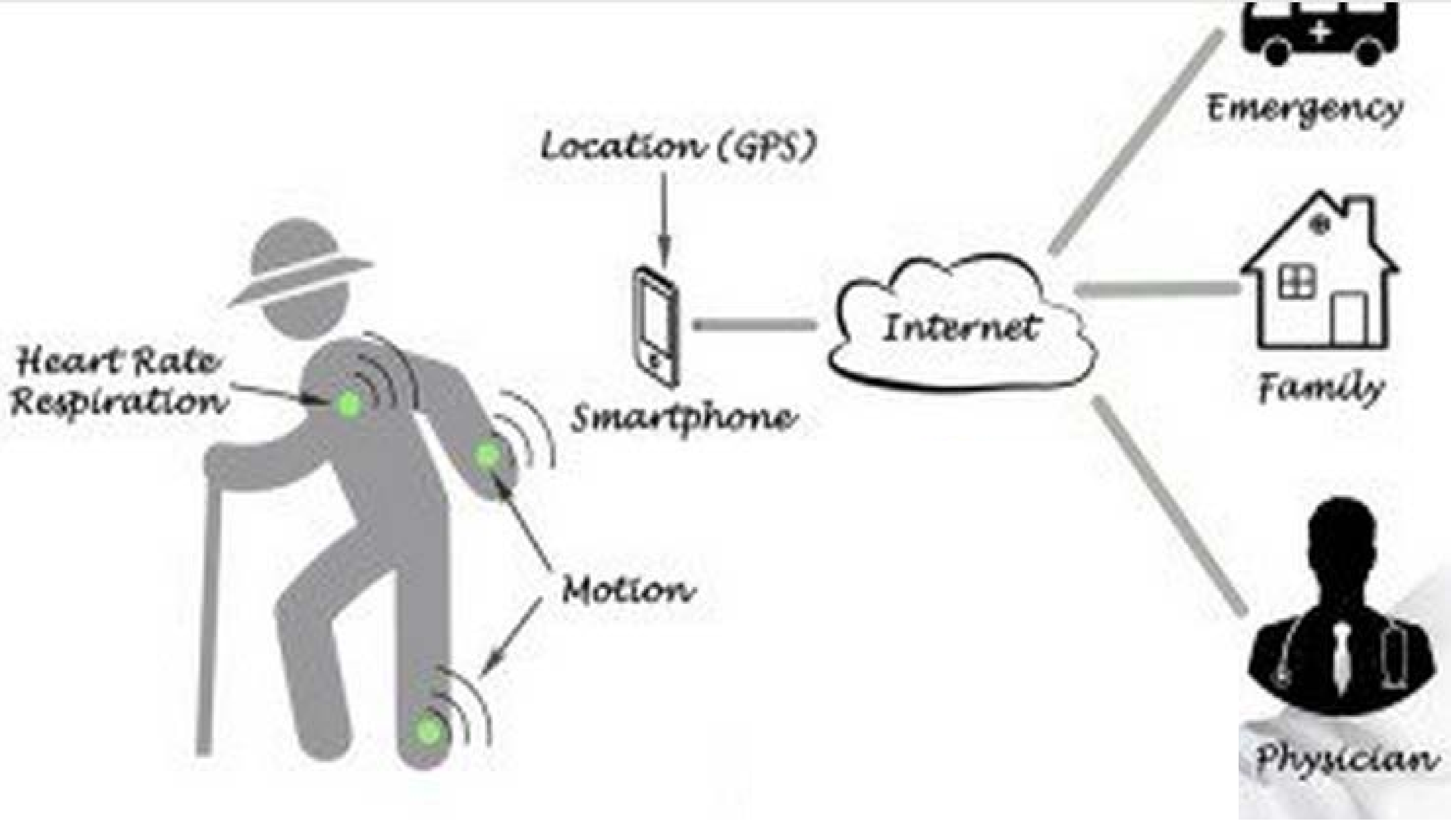
Arrhythmic Rhythm



www.seas.upenn.edu/sunfest/docs/slides/MALAMASPETER.pdf



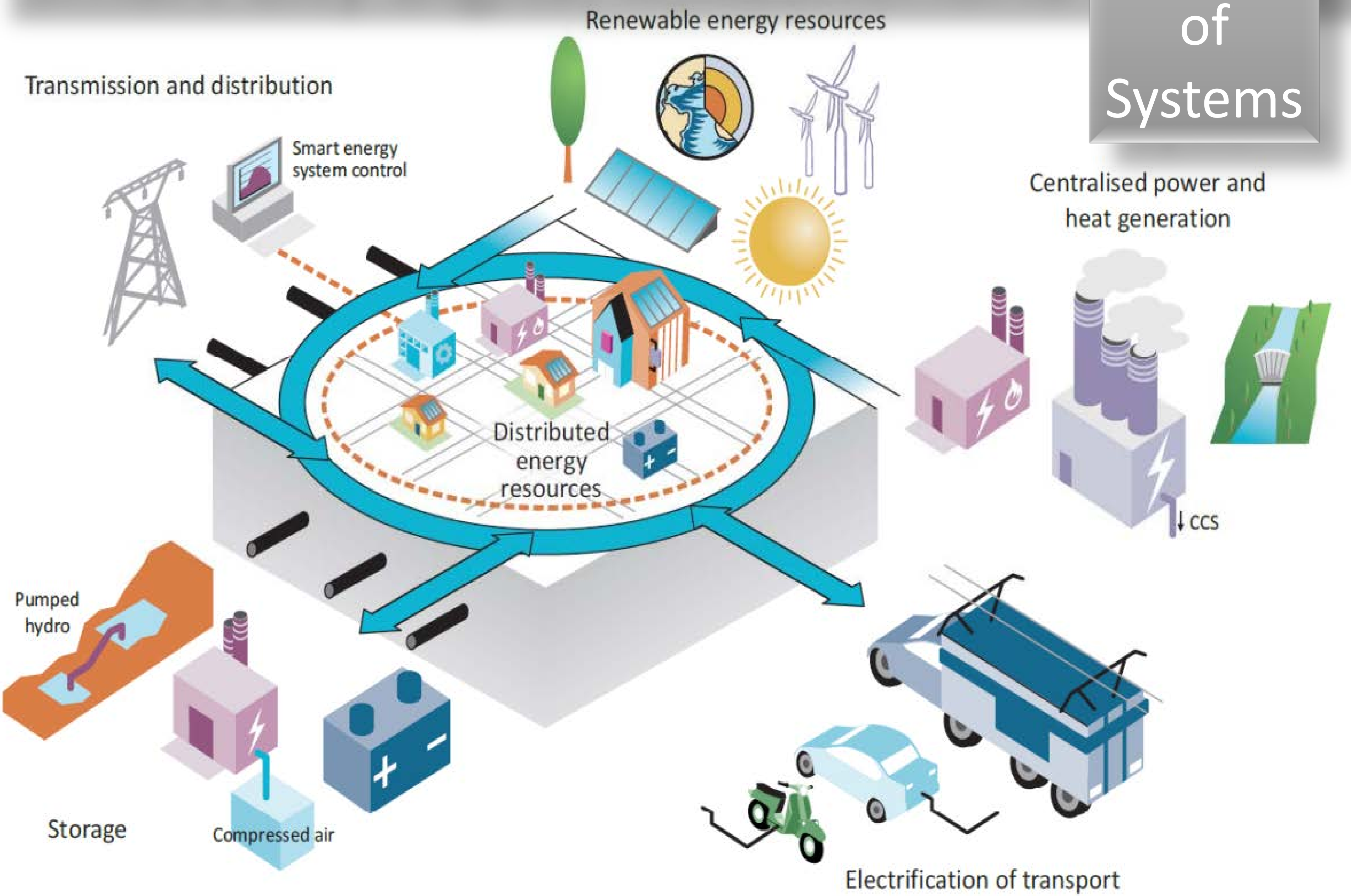
Smart City Healthcare Emergency Network platform, information, context, connectivity



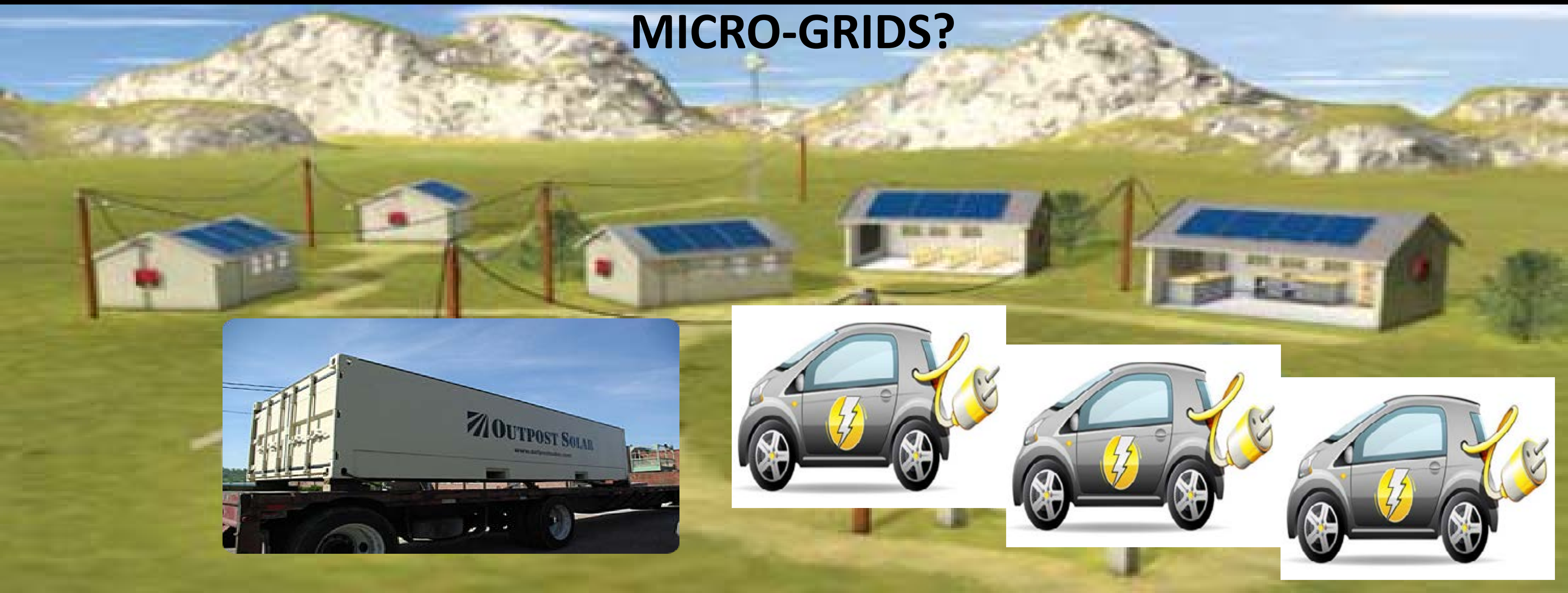
Can a Smart City optimize energy?

Smart City Digital Mitochondria

Internet of Systems

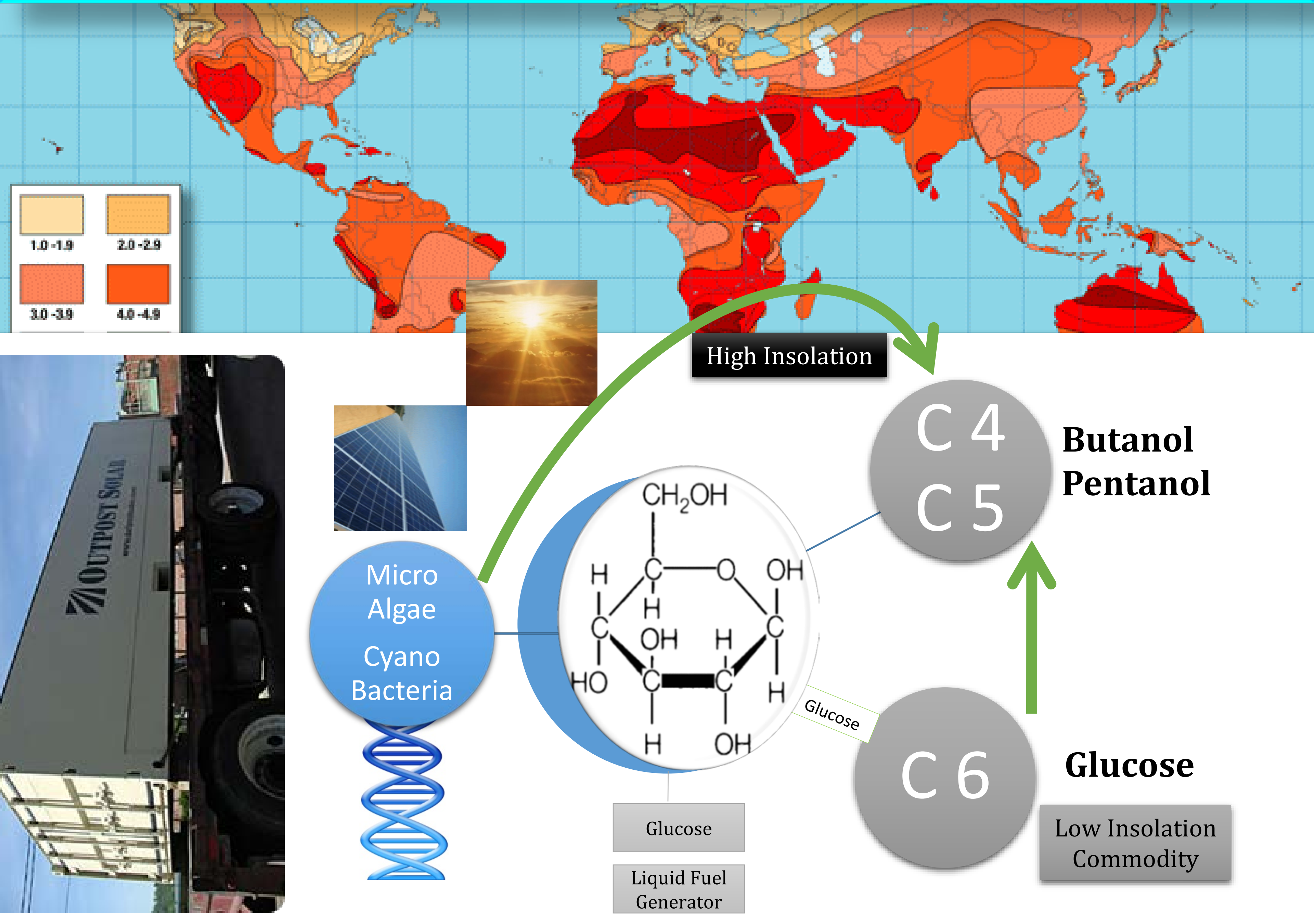


MICRO-GRIDS?

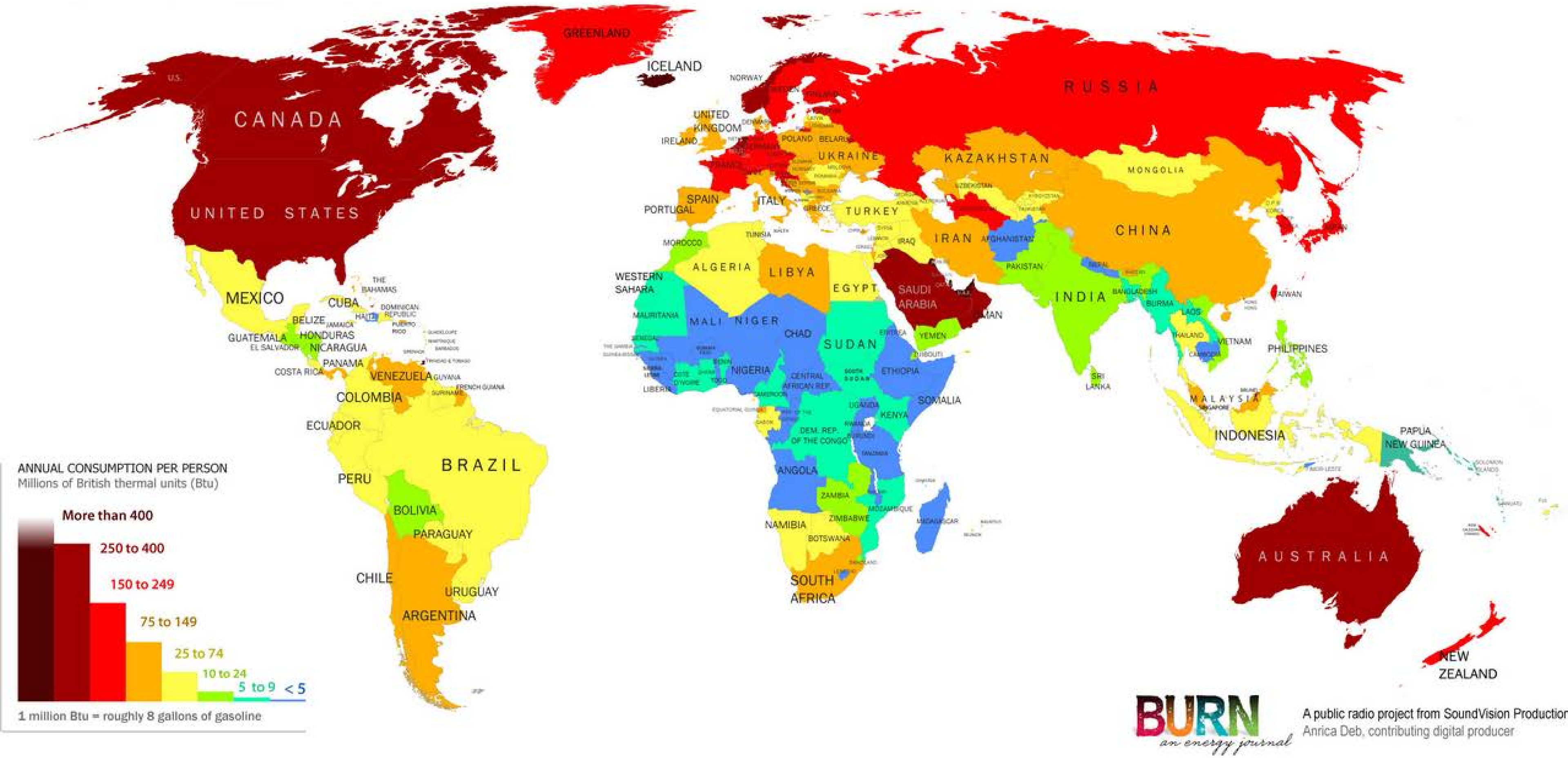


Ubiquitous Energy?

Renewables – Domestic Micro-Manufacturing Non-fossil Carbon-Neutral Liquid Fuel



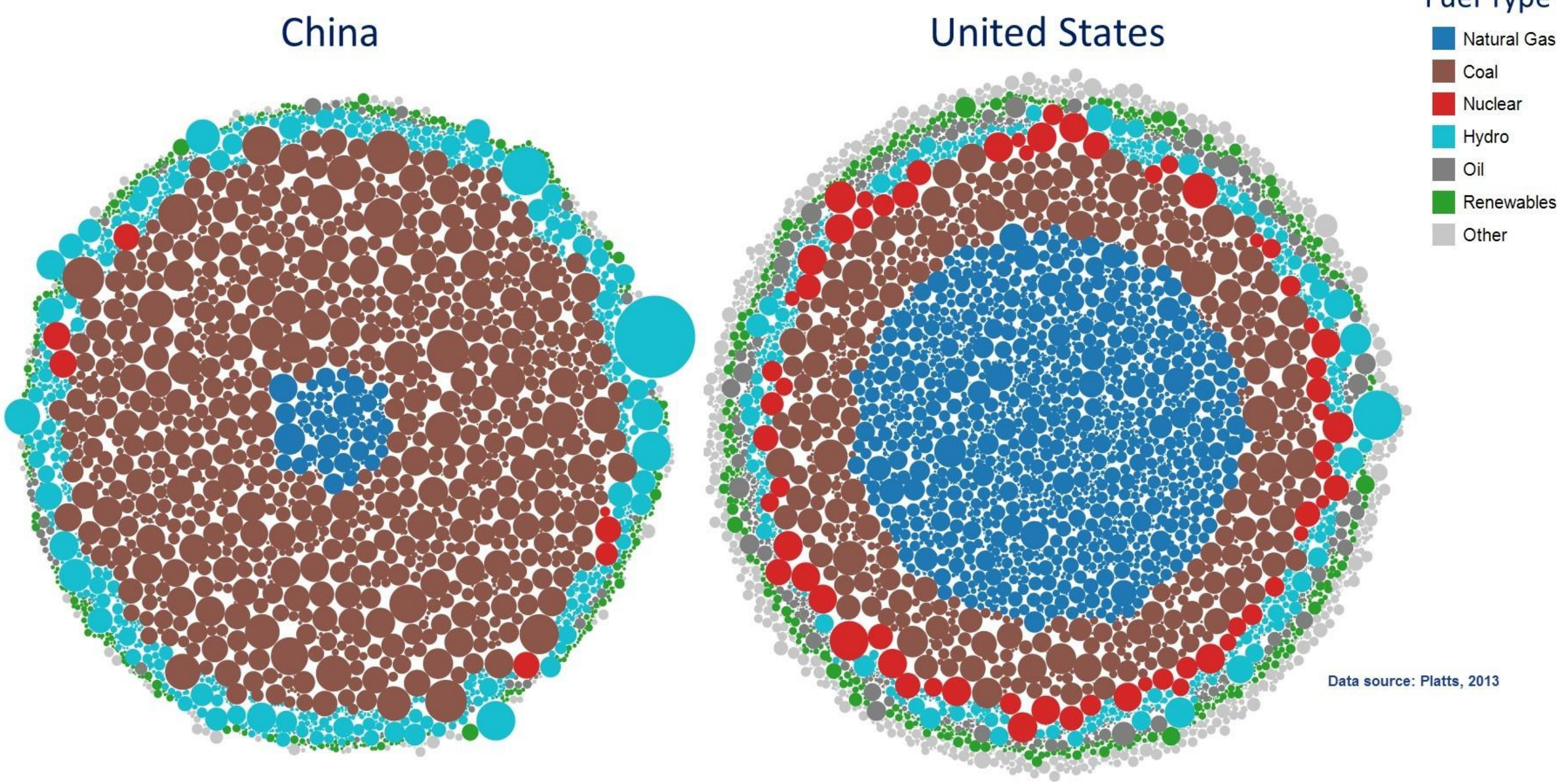
GLOBAL ENERGY CONSUMPTION (2010)



http://burnanenergyjournal.com/wp-content/uploads/2013/03/WorldMap_EnergyConsumptionPerCapita2010_v4_BargraphKey.jpg

Reality Check ☑ G2 favors the GHG producers – Coal and Gas, naturally

Electric Power plants that drive the world's two largest economies



Energy Intelligence

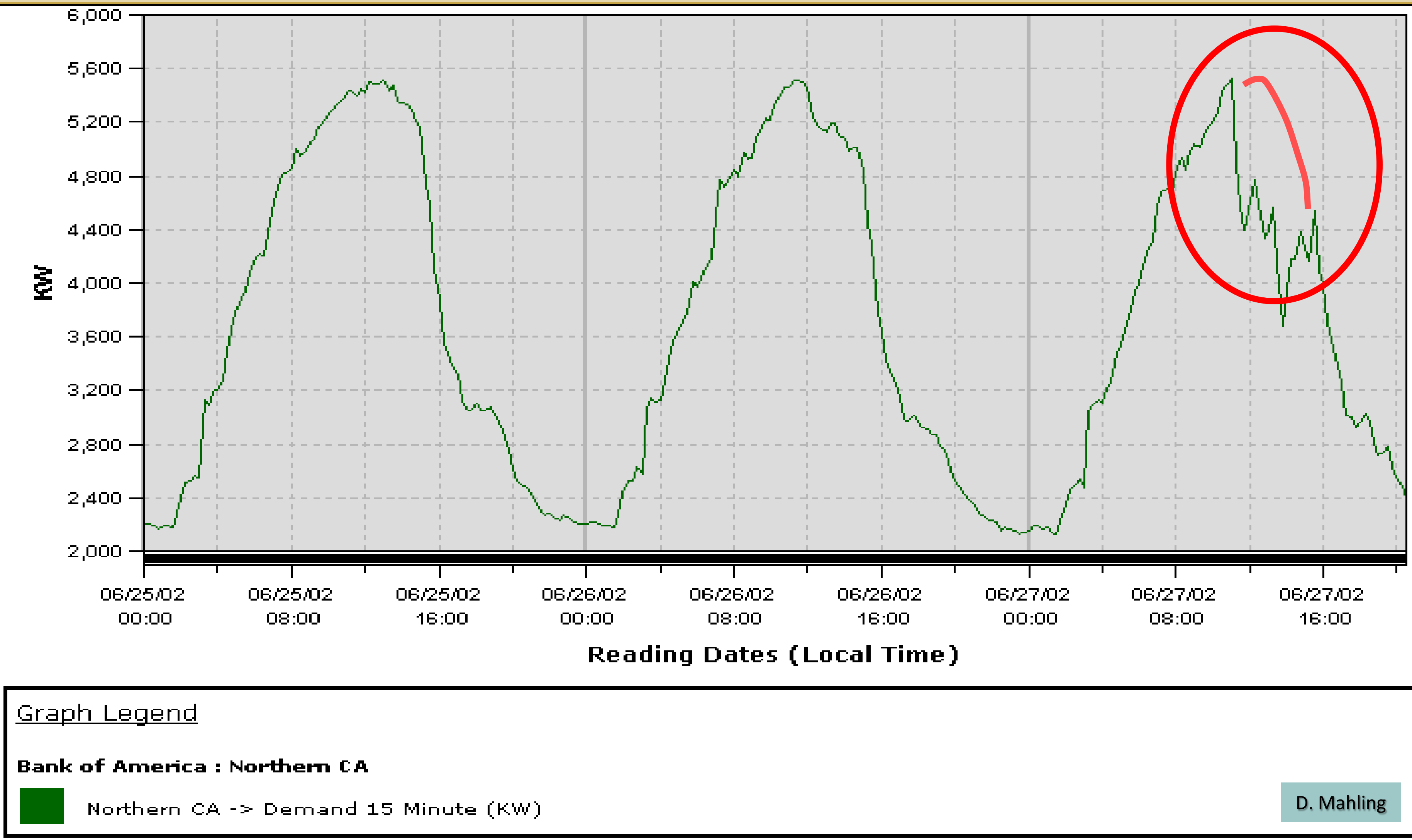
Connecting local to national and may be even global

2002 • MIT Demonstration - AI in Demand Response

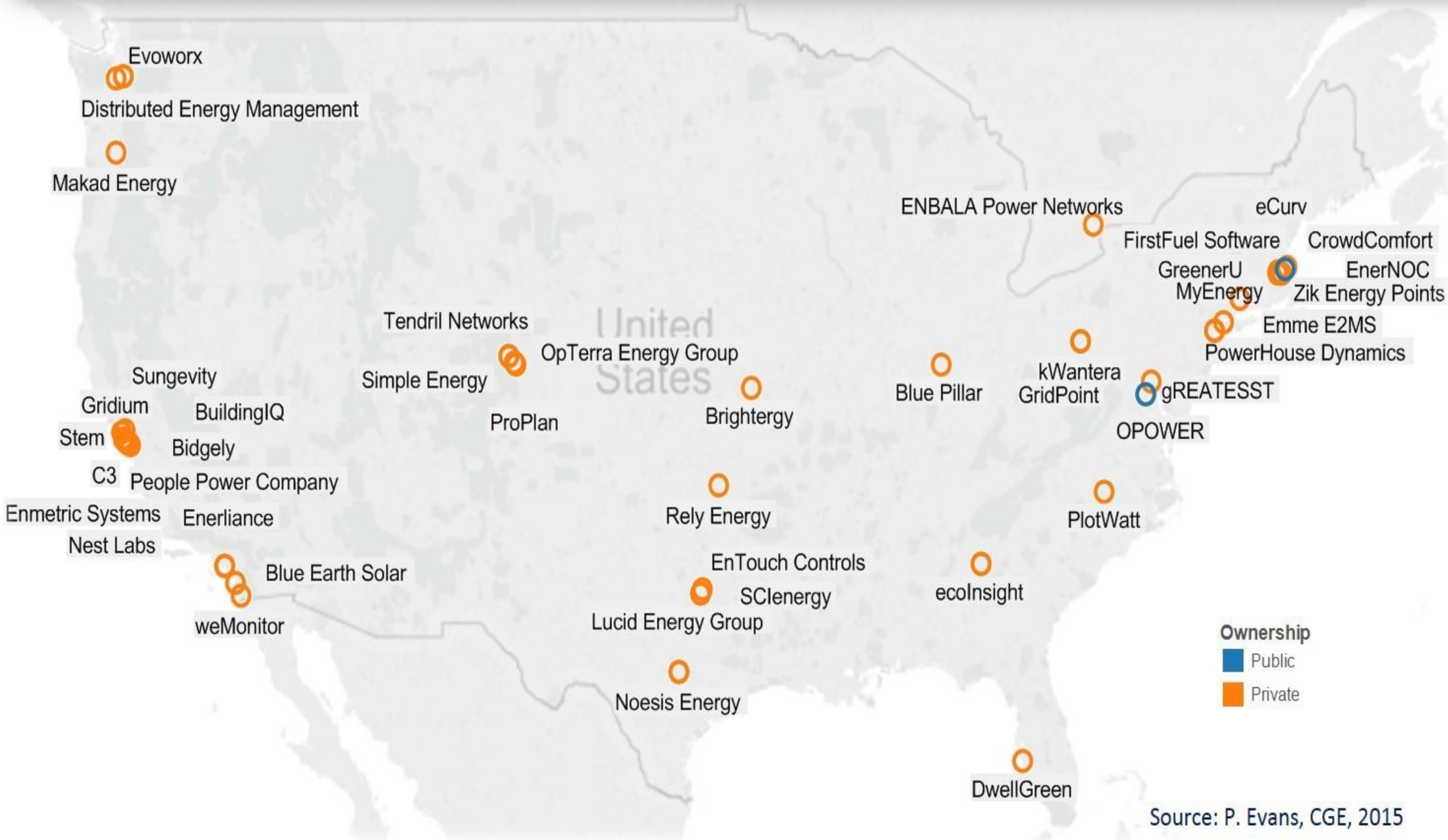
- Electronic signal was sent from CA-ISO to building system
  - Curtail 2 MW for 4 hours across 78 retail sites
- Base load for 78 properties approximately 10 MW
- Signal received at 1:45 PM [15 minutes ahead of the start time of 2PM]
- Curtailment commenced at 2PM and completed at 6PM PDST

- 1:45 – DR signal received
- 1:46 – Agents shift from BAU mode to curtailment mode
- 1:47 – Energy Operator dials in 2 MW curtailment goal
- 2:00 – L/R agent deploys speed reduction on largest fans in North and South
- 2:10 – 1MW reduction
- 2:15 – Agent releases first L/R; Agent assembles second L/R set; deploys
- 2:20 – 2MW reduction
- Repeats until 3pm
- 3:00 – SAT agent raises SAT at select buildings
- 3:15 – SAT shifts buildings
- 3:05 – 1.2 MW reduction
- 3:20 – L/R rotates groups
- Etc

Curtailment: Trend Data and Energy Savings



Emergence of Energy Intelligence Start-ups



Source: P. Evans, CGE, 2015

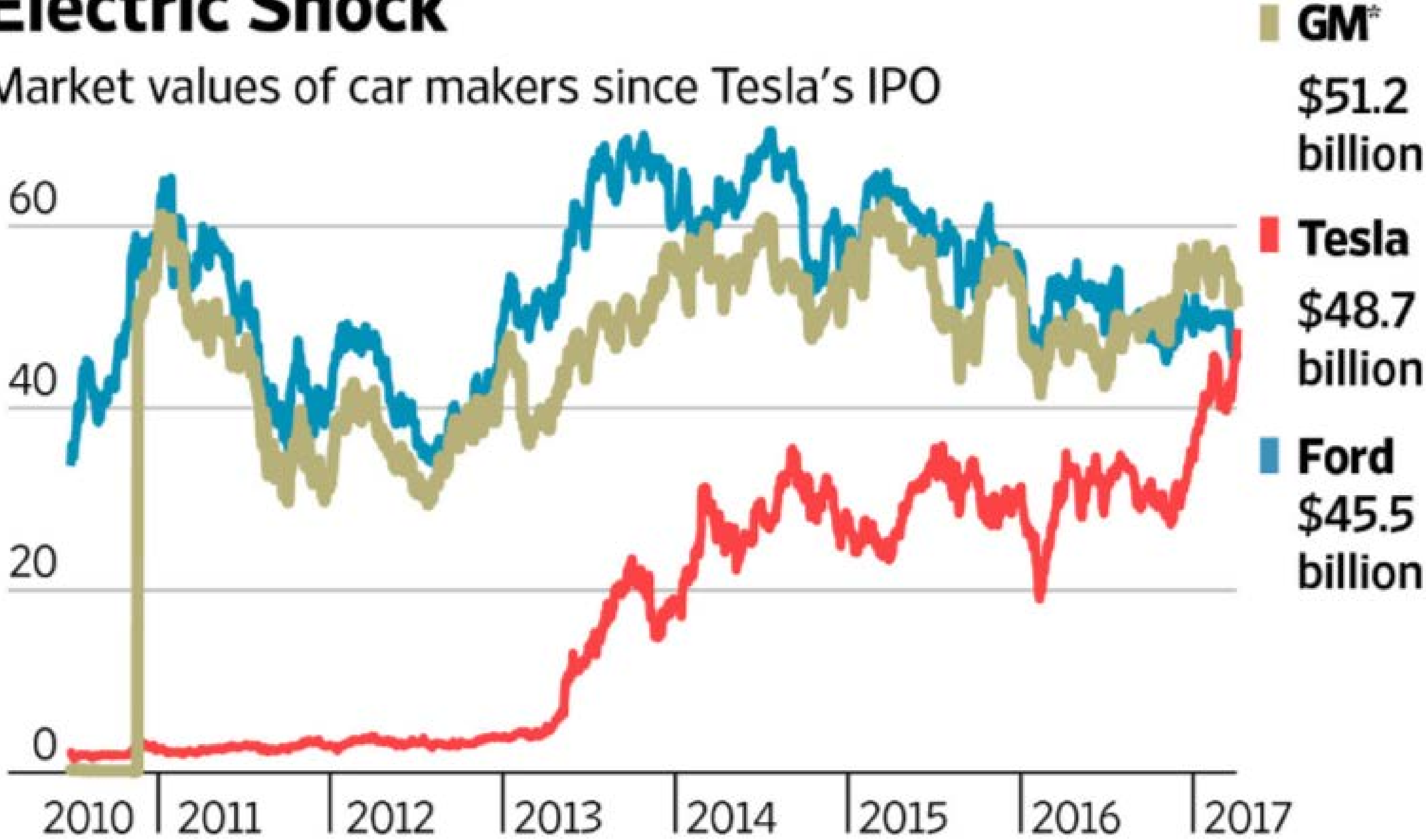
Is the Smart City adaptable to autonomy & disruption?

Flour Mill-on-Wheels

Mobile Church

Electric Shock

Market values of car makers since Tesla's IPO



*The original GM Corporation's common stock became Motors Liquidation Company common stock in July 2009, until the confirmed bankruptcy plan canceled the shares on March 31, 2011. The new GM went public on November 18, 2010.

Source: FactSet

THE WALL STREET JOURNAL.

Rival Robot Cars in California

26 June 2015 | Technology

Google is testing its autonomous driving software in a fleet of 23 modified Lexus SUVs

A rare meeting between two self-driving cars resulted in one taking evasive action, Reuters reports.

The robot cars, one made by Delphi Automotive and one by Google, met on a Californian road in Palo Alto.

The Google car pulled in front of the Delphi vehicle making it abandon a planned lane change.

DIDI KUAIDI

China's top taxi app startup, Didi Kuaidi (the new name for the merger between Didi Dache and Kuaidi Dache), revealed today that it has raised a record-breaking US$2 billion in funding. The money came from Capital International Private Equity Fund and Ping An Ventures, as well as "several other globally renowned investors" that went unnamed. Existing investors like Alibaba, Tencent, and Temasek also contributed to this bumper new investment.

This is the biggest ever funding round for a private company, beating Uber's US$1.2 billion series D and series E rounds, as well as US$1.5 billion private equity rounds for Airbnb and Facebook.

www.techinasia.com/didi-kuaidi-confirms-2-billion-bucks-funding/

10 July 2015

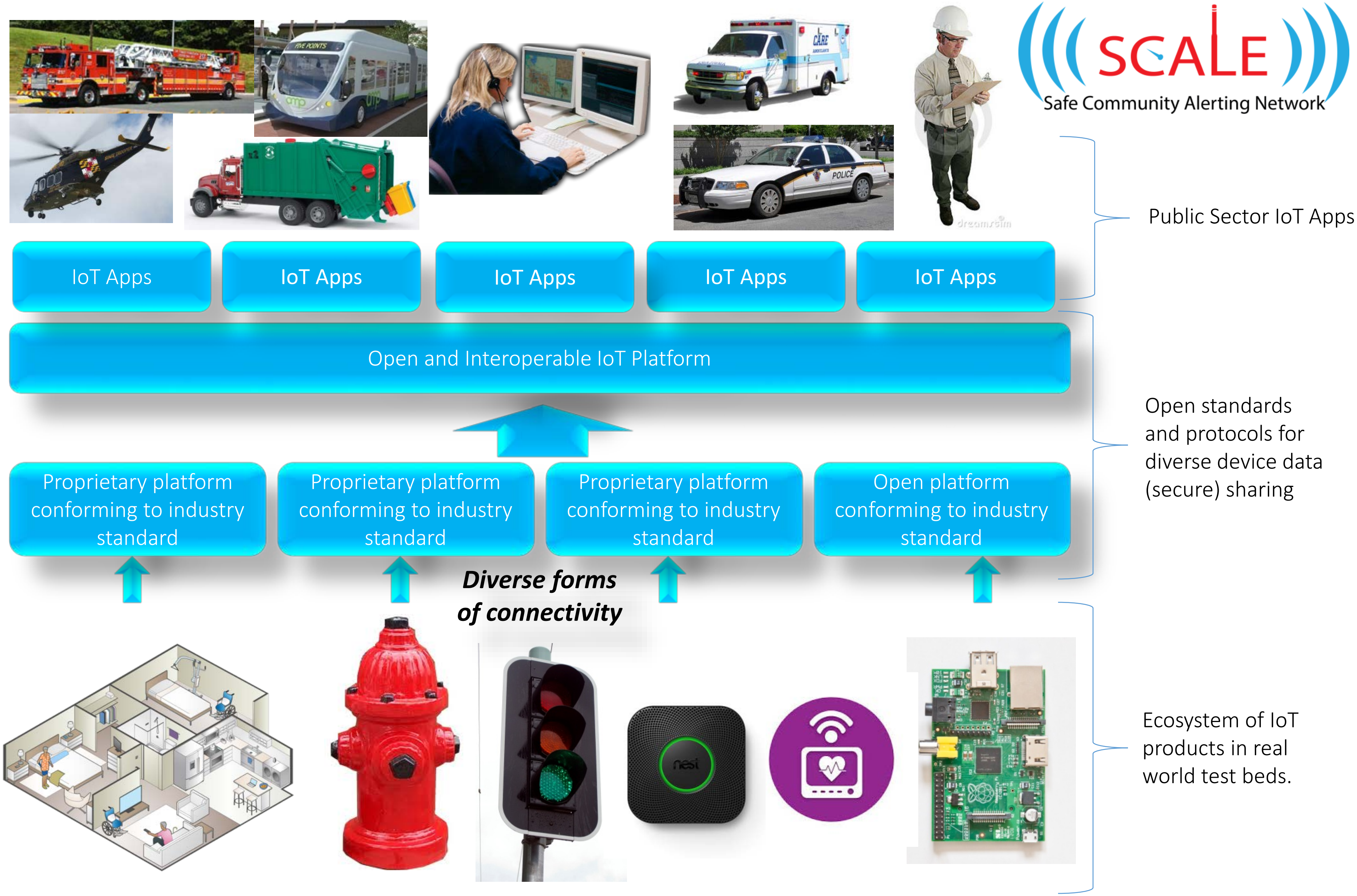
Intelligent Transport Systems ?

Dead-weight of old technologies?

Is the Smart City resilient from disasters?

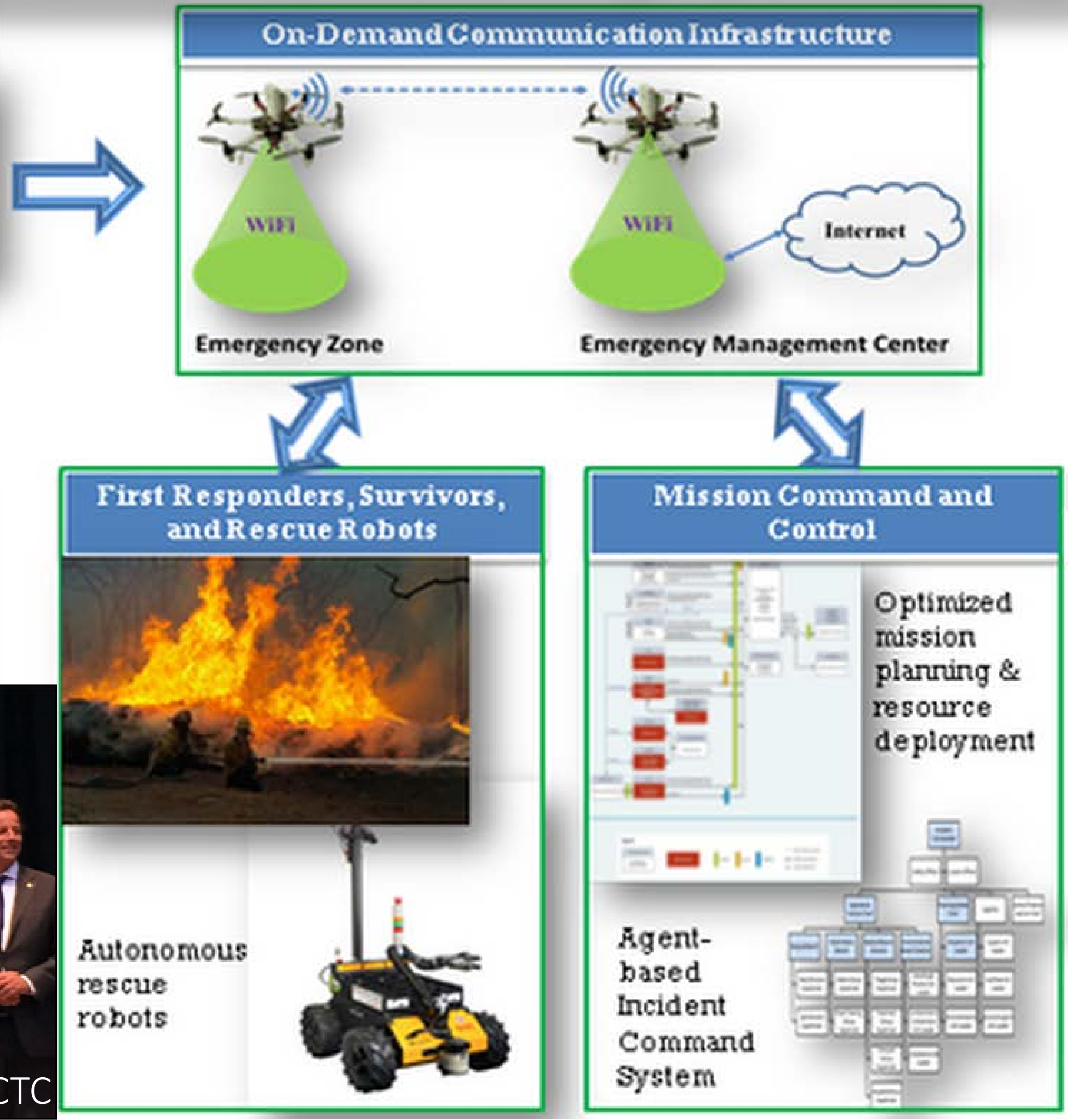
Intelligent Autonomy ● Resiliency and Emergency Response

Systemic foundational compass essential for smart anything



UC Irvine, MIT, IBM, Intel, AT&T, SigFox, Brivo Labs, Senseware, N5 Sensors, Responder, Del Ray Analytics, biobright, EIC Data, IoT DC, Captiva, Earth Networks, US DoD (TATRC), Victory Housing and Montgomery County, Maryland, USA.

SERS ● NIST Global Cities Team Challenge (June 1, DC)



Smart Emergency Response System

To connect cyber-physical technologies with humans in the loop to save lives, rescue people, and attend to their critical needs when disaster strikes.

Queen Maxima of Netherlands at GCTC

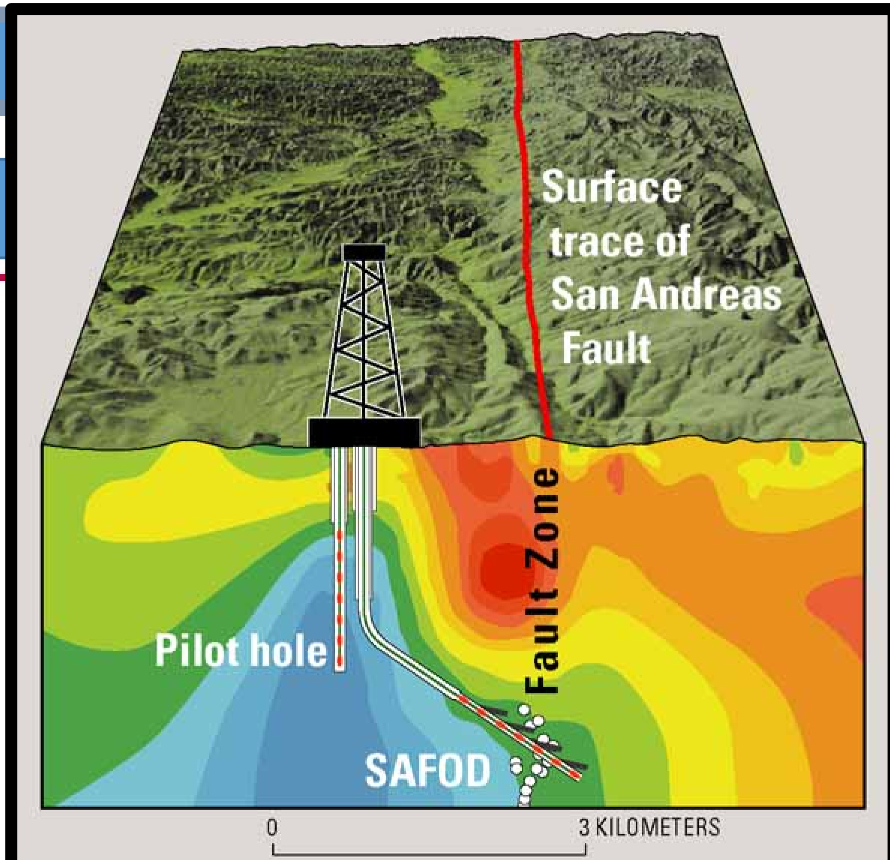
Critical Infrastructure Monitoring (CIM)

Seismic and Infrastructure Monitoring

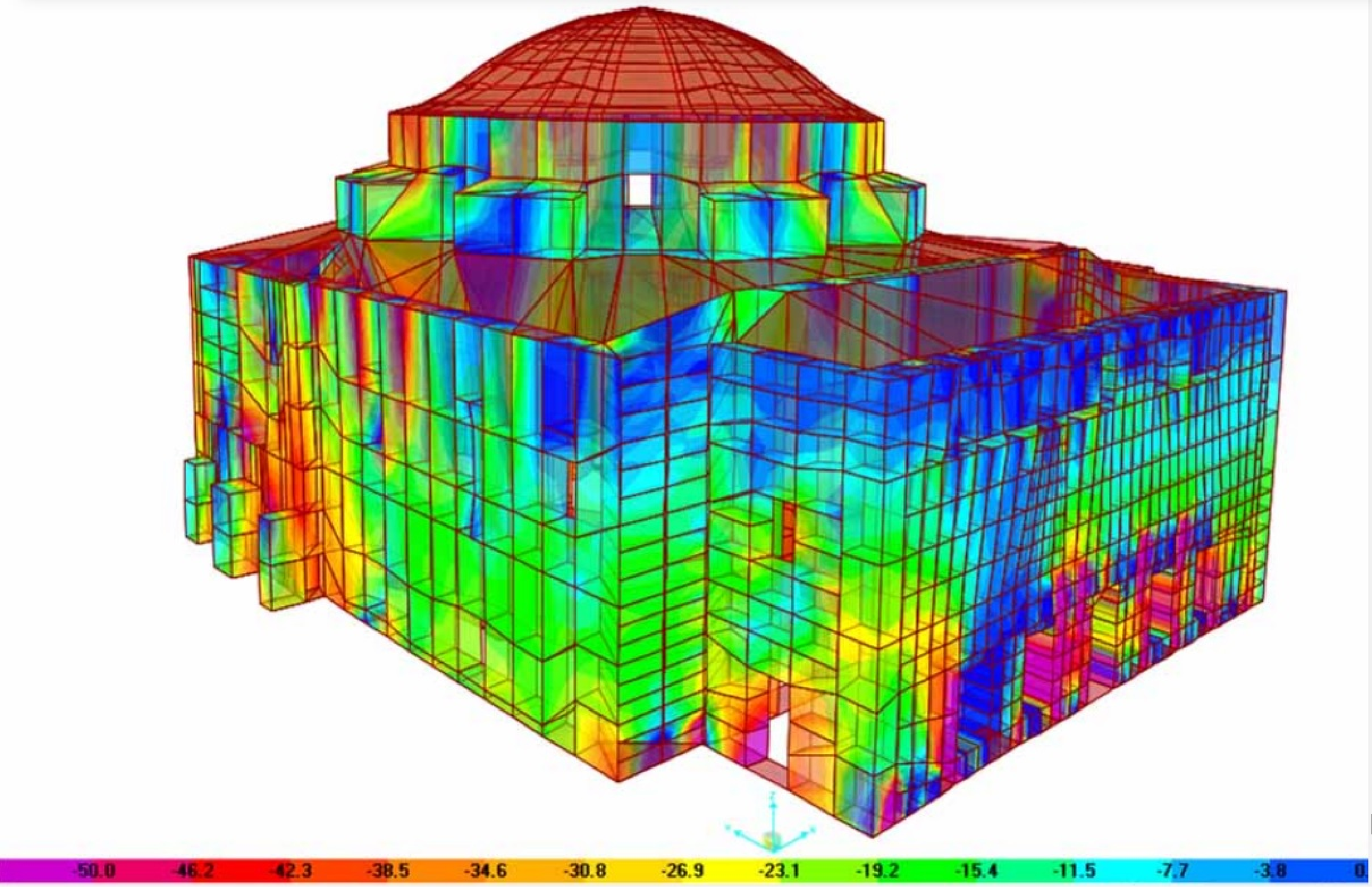
Buildings

Bridges and Roads

Water/Sewer

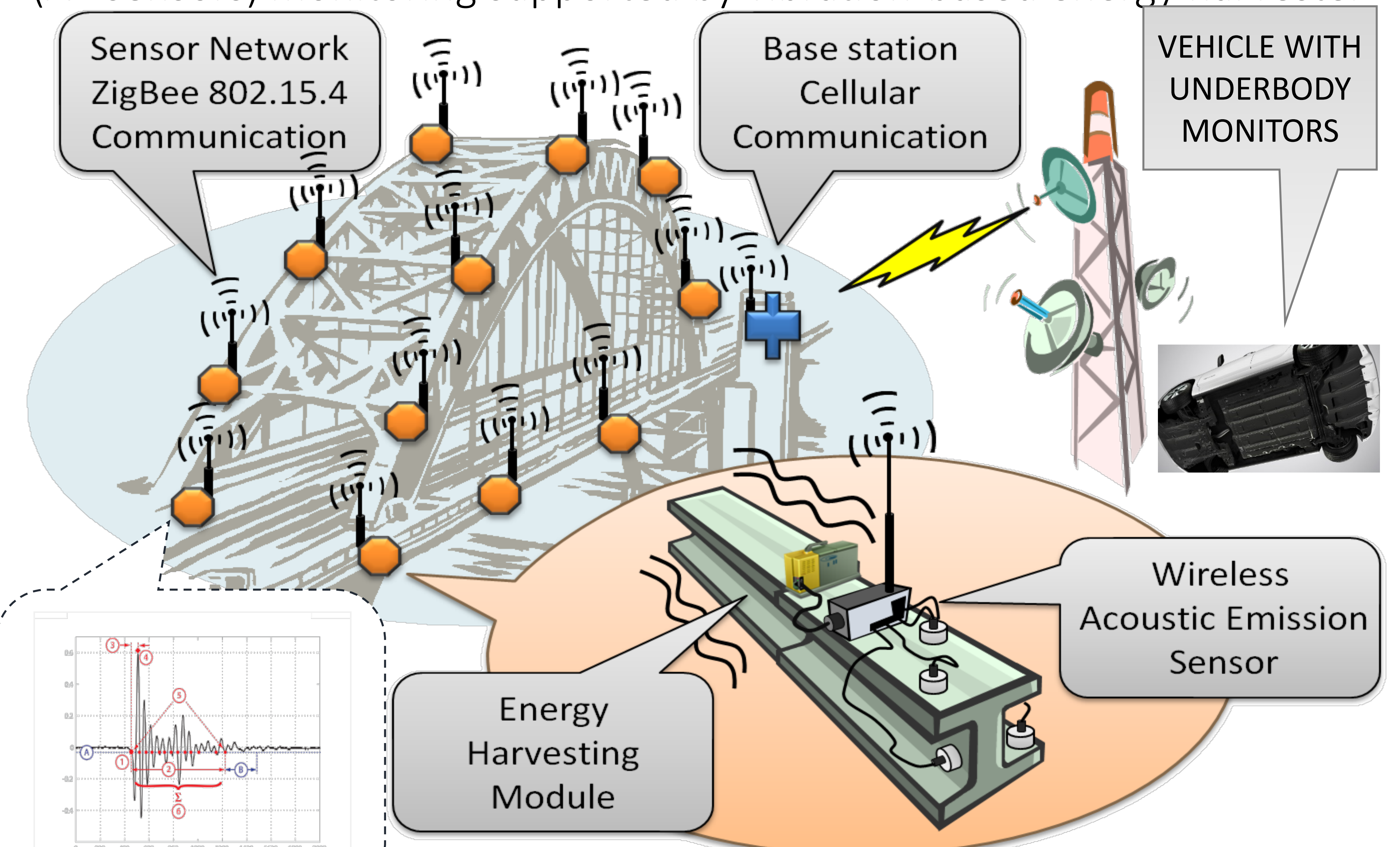


CIM – Hagia Sophia – Axial Stress (North-West)



DATA COLLECTION FROM INFRASTRUCTURE – BRIDGES & OTHER MAJOR CRITICAL STRUCTURES

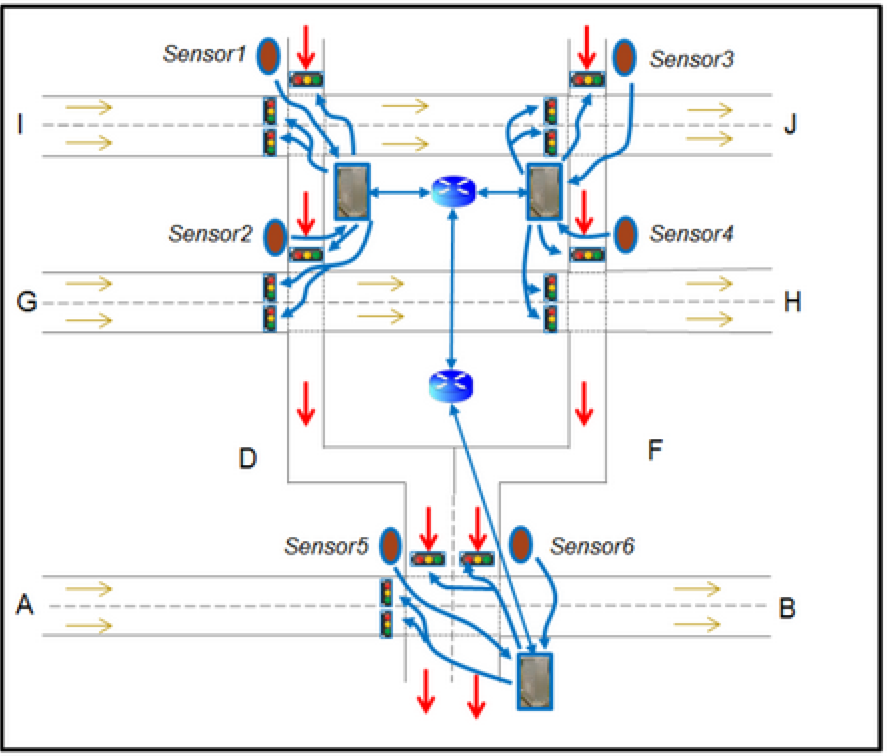
Autonomous vibration (accel-erometers), stress (strain gauges) & cracks (AE sensors) monitoring supported by vibration-based energy harvester



Peter Volgyesi, Vanderbilt University

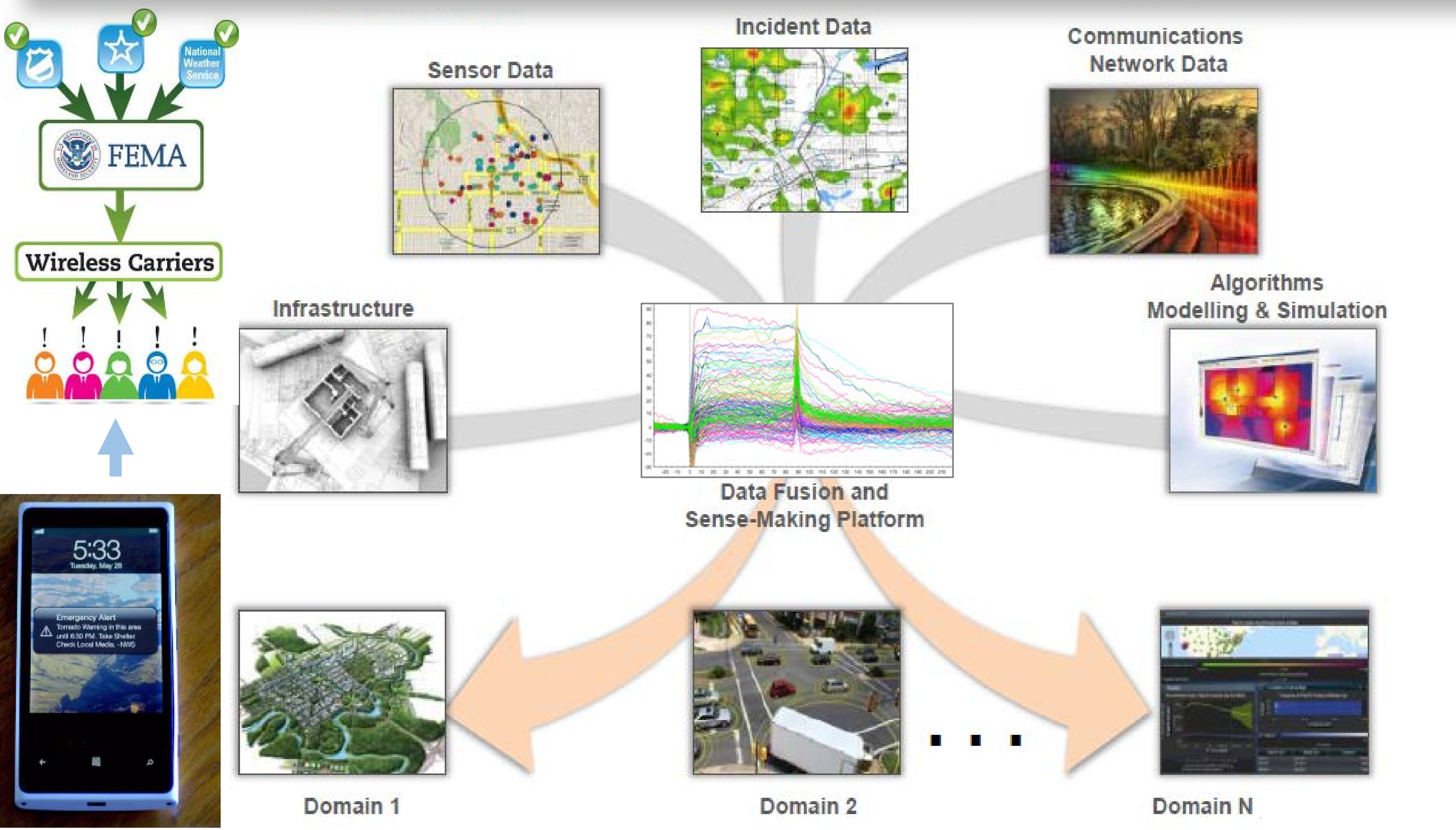
sites.google.com/site/marmoteplatform/

CONNECT DATA and ANALYTICS for EMERGENCY VEHICLE TRAFFIC



- Emergency vehicles need to get through (North-South)
- Significant traffic across (East-West)
- Each intersection is controlled by traffic lights
- Sensors are deployed on vertical streets
- Arbitrary number of controllers can be added, assigning them to sensors and lights and providing control algorithm.
- Arbitrary attacks can be inserted between controllers and their inputs/outputs.
- Simulation ends: last emergency vehicle reaches destination.
- Metrics: emergency vehicle latency vs. overall road occupancy

DATA and ANALYTICS for EMERGENCY & RESILIENCY MANAGEMENT

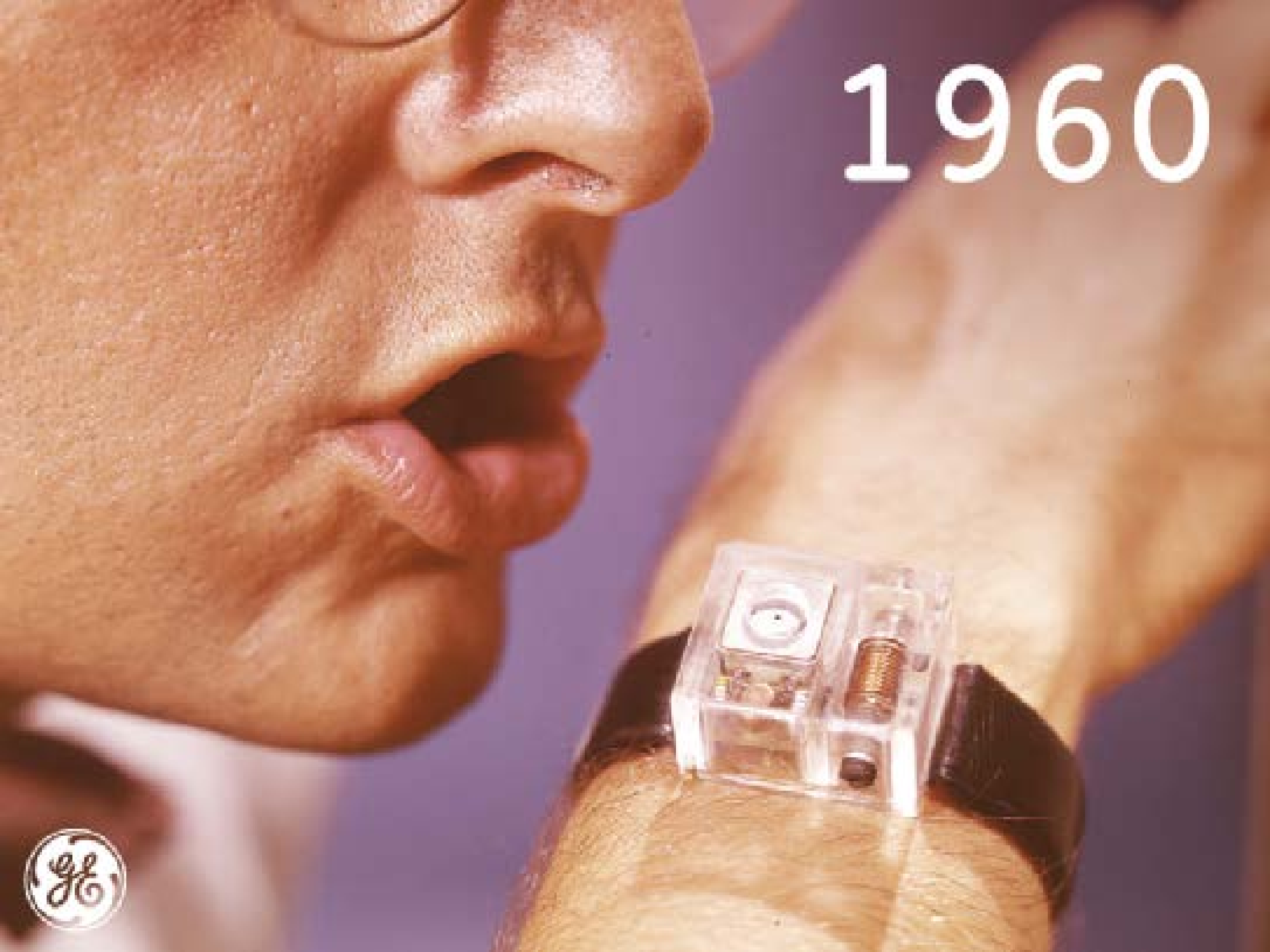


Data, Message, Alert Dashboard for Communities & City Managers

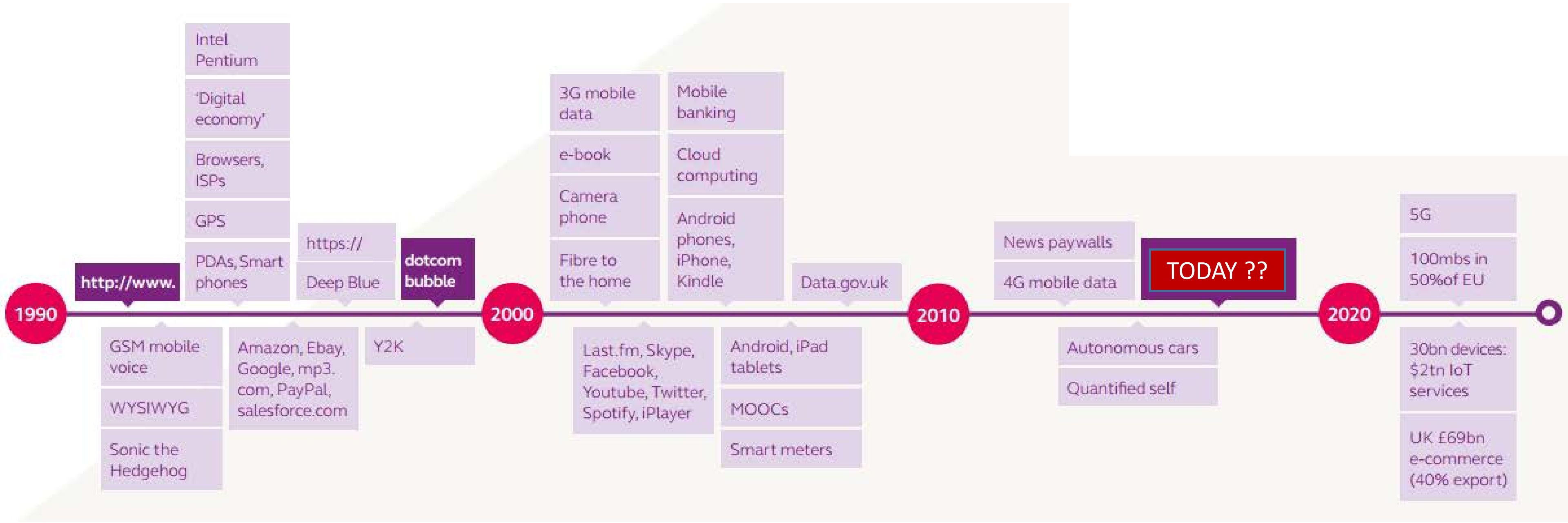
Robotic Tools in Infectious Diseases Management
Need for Medical Device Interoperability Platform

www.gereports.com/post/104422691785/hospital-hack-a-thon-attacks-ebola-with-robots

Is the Smart City data communication secure?


1960

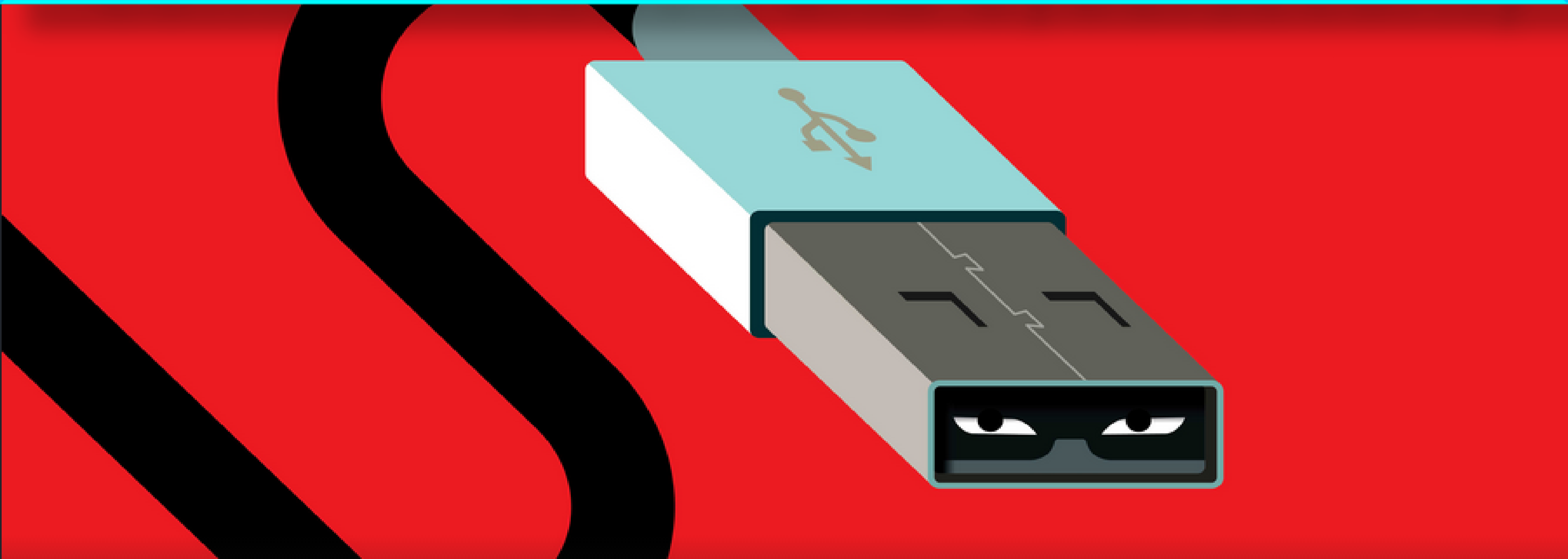
5G



www.gov.uk/government/uploads/system/uploads/attachment_data/file/404743/Digital_Economy_Strategy_2015-18_Web_Final2.pdf

Data

Communication and Cybersecurity



The Agenda
INTERNET OF THINGS

I helped invent the Internet of Things. Here's why I'm worried about how secure it is.

By SANJAY SARMA

Peter Greenwood for POLITICO

I'm a mechanical engineering professor at MIT, and 17 years ago, with my colleagues David Brock, Kevin Ashton and Sunny Siu, I helped launch the research effort that laid some of the groundwork for the Internet of Things. As you might imagine, my life is pretty connected.

http://bit.ly/IOT-MIT

See

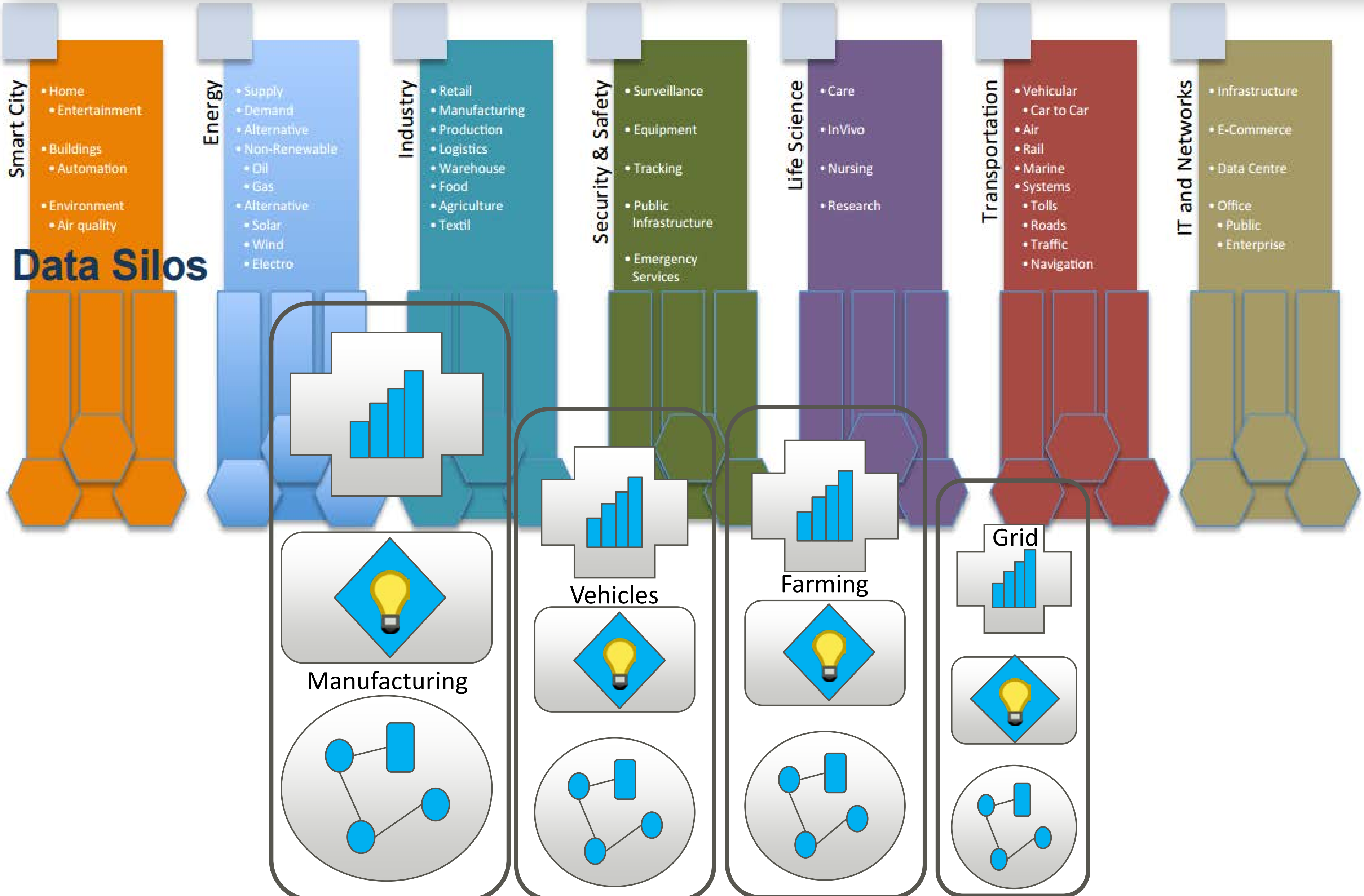
CYBERSECURITY

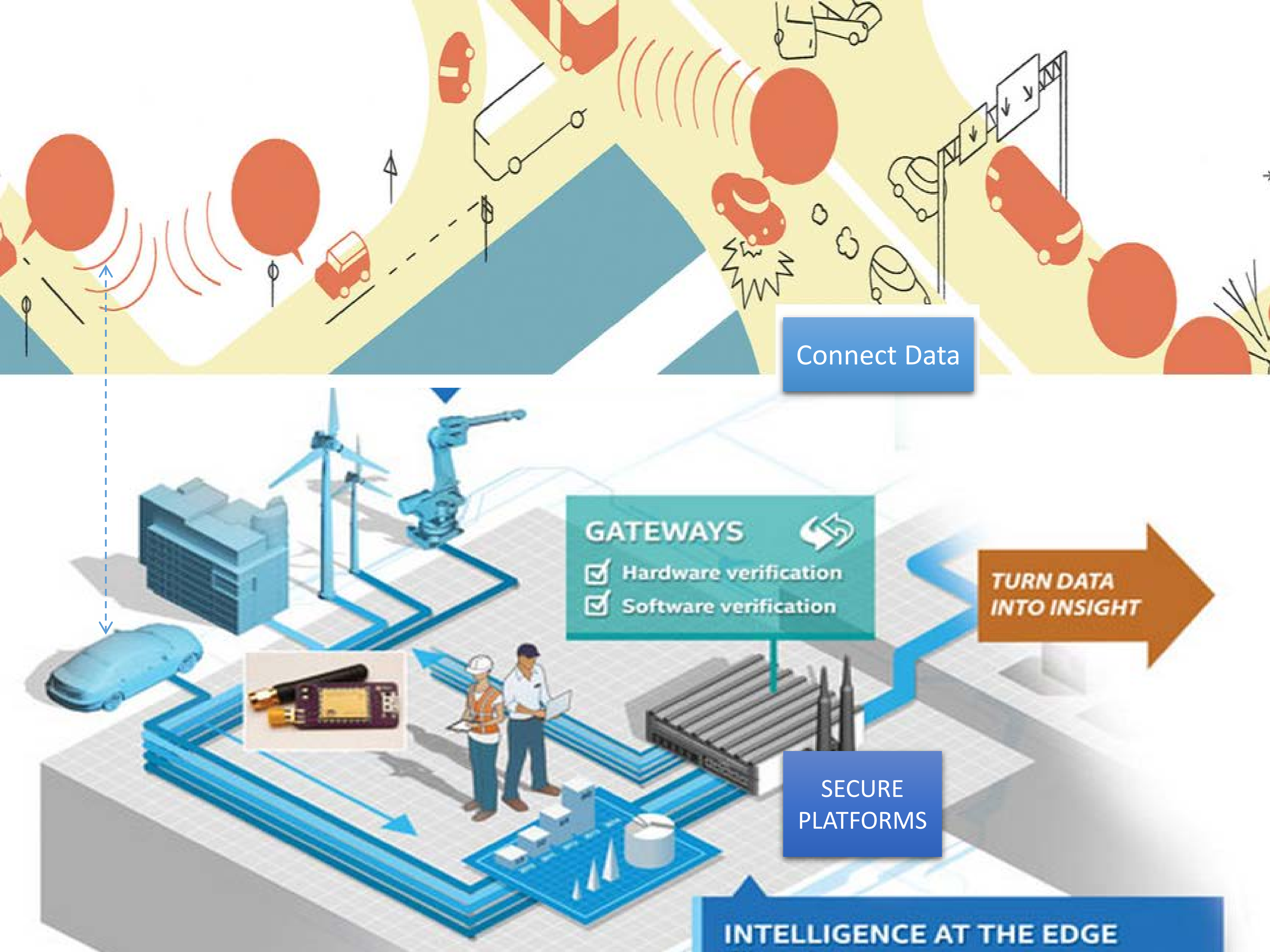
Dr Shoumen Palit Austin Datta

MIT Auto-ID Labs and Research Affiliate, Department of Mechanical Engineering, Massachusetts Institute of Technology ● shoumen@mit.edu

Senior Scientist, MD PnP Lab, Medical Device Interoperability, Massachusetts General Hospital, Harvard Medical School ● www.mdpnp.org

Smart City Data Silos?



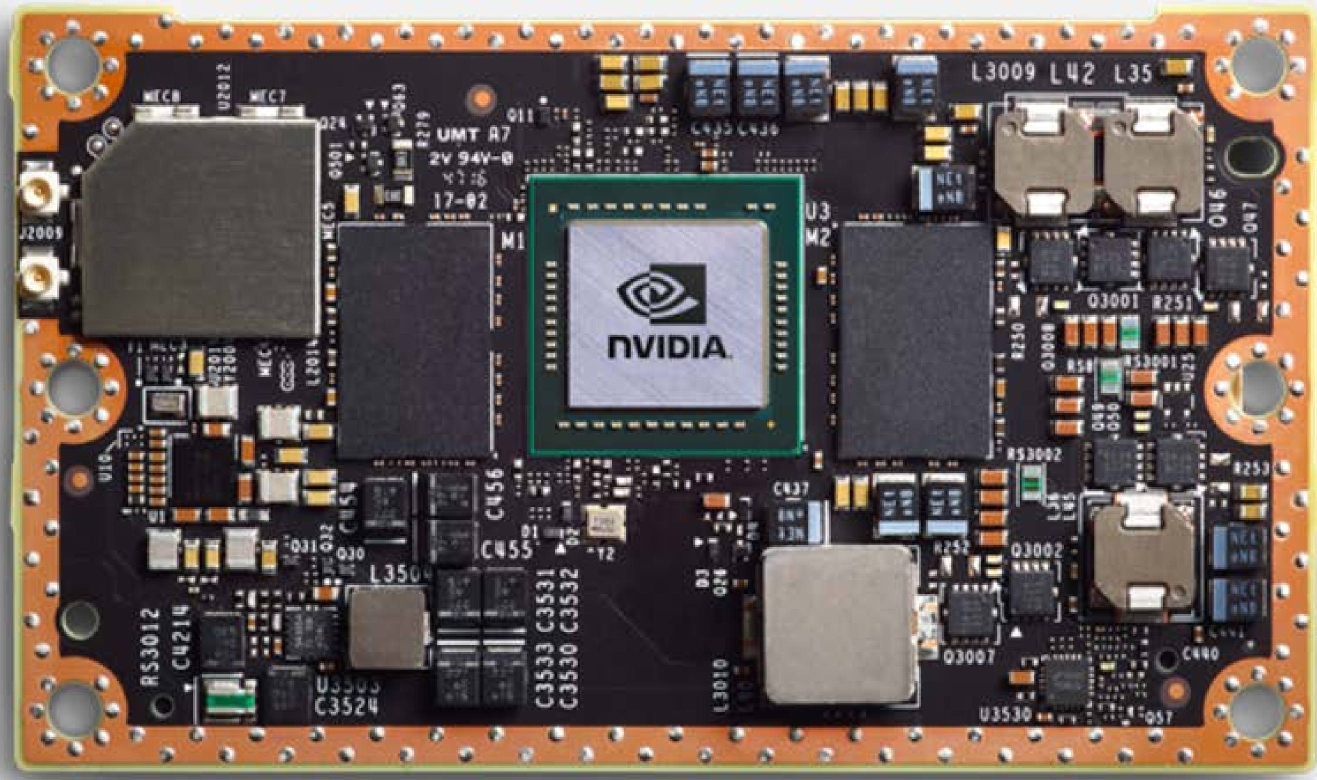

Connect Data
GATEWAYS
Hardware verification
Software verification
TURN DATA INTO INSIGHT
SECURE PLATFORMS
INTELLIGENCE AT THE EDGE

Data from Edge: Analytics and Feedback at the Edge

The Rise of the GPIO - CPU, Memory (16 GB), WiFi, Bluetooth

Edge Ambient Intelligence – Analytics in the Mist

If latency boundaries unsuitable for fog or cloud analytics



Edge Analytics at Point of Customer Value – Grand vision but where are the systems?

Jetson TX2 is the fastest, most power-efficient embedded AI computing device. The latest addition to the industry-leading Jetson embedded platform, this 7.5-watt supercomputer on a module brings true AI computing at the edge. It's built around an NVIDIA Pascal™-family GPU and loaded with 8 GB of memory and 59.7 GB/s of memory bandwidth. It features a variety of standard hardware interfaces

From the Past
For the Future

Transport

Travel Behavior, Transport and Autonomous Vehicles

TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE 47, 75–88 (1994)

Anthropological Invariants in Travel Behavior

C. MARCHETTI

Humans, like animals, are territorial, naturally.

Anthropological studies suggest that there appears to a mean traveling time per day (aka exposure time), when multiplied by mean speed of movement (an animal) it fixes a distance or a range or territory.

http://www.cesaremarchetti.org/archive/electronic/basic_instincts.pdf

How long is the human exposure time aka territory?

1-hour

Yes, of course, there are exceptions and deviations from the hour rule which fuels transport innovation

How far can you travel in

1-hour

5 km if you are walking

25 km if you are in public bus

50 km if you are in a private vehicle

500 km if you are transported by the Hyperloop

Each way commute time is 30 min. Thus, total exposure

1-hour

5 km (1800's) all in a small compact village/town

25 km (1950's) if your office is located downtown

50 km (2000's) if you live in the sprawling suburbs

500 km (2050's) you use the Hyperloop to the office

From horse drawn coaches, electric trams to Hyperloop: mean travelling time per day is 1 hr

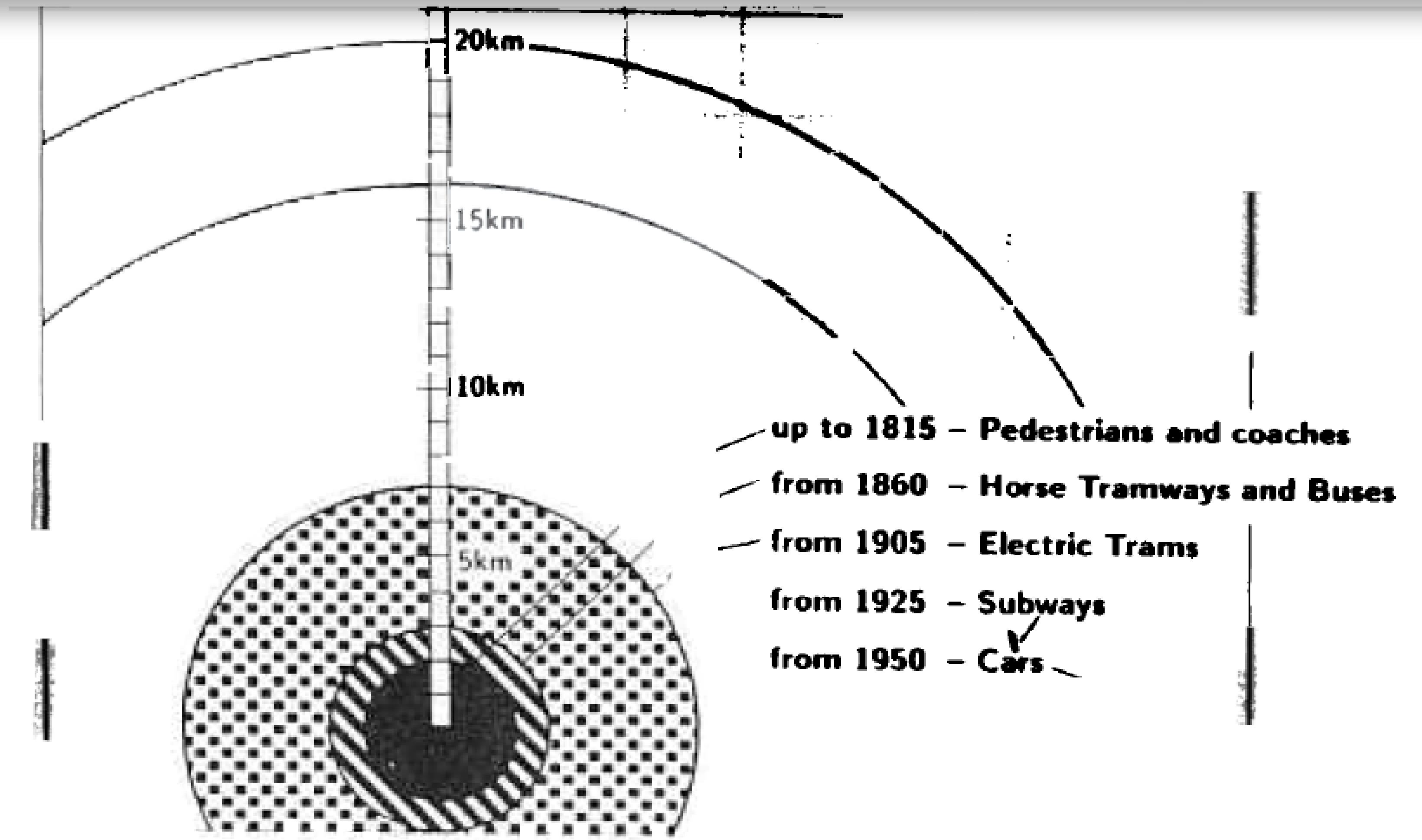


Fig. 2. City dimension and speed of transport: The case of Berlin. The fact that the "daily radius" depends on the speed of transportation is clearly manifested by the evolution of the size of the city of Berlin. The Berlin of 1800 was very compact with a radius of 2.5 km, pointing to a speed of 5 km/hr, the speed of a man walking. With the introduction of faster and faster means of transportation the radius of the city grew *in proportion* to their speed, and is now about 20 km, pointing to a mean speed for cars of about 40 km/hr. The center of the city can be defined, then, as the point that the largest number of people can reach in less than 30 minutes.

http://www.cesaremarchetti.org/archive/electronic/basic_instincts.pdf

Travelling Time Per Day in select global cities exceed Marchetti's Constant (1 hr)

Marchetti's constant, a sturdy observation that humans since the Paleolithic Era have always lived roughly 30 minutes from their work even as transport tech evolved from bare feet to carriage to train to automobile. Current commute times of 90-120 minutes will be changed by Hyperloop. Innovation in transport reverts exposure time to 1 hour.

What can Hyperloop do for these travel times?

Creating Markets

Why we're reaching our limits as a one-hour city

April 26, 2004

How we want to use our time will determine how we want to build a metropolis, argues Peter Newman.

You can relate Marchetti's Constant to your life. The average travel time budget, around the world, in every city, is about one hour, per person, per day. If you take half an hour for the journey to work and home again then that's it. If you take less, you'll probably go walking with the dog or something but you'll take about an hour on average.

This is found to apply everywhere. A recent study in Britain showed it had applied in English cities for the past 600 years. We need to have a restorative, reflective time.

What it means is that the city is always one-hour wide. The walking cities of the past - historic, medieval cities - were five to eight kilometres wide. You could walk across them in an hour. Victorian cities, the industrial revolution cities, spread out because the pipes and the rails meant that we could now travel 20 to 30 kilometres. And the city remained one hour wide.

But the new frontier entered essentially by US traffic engineers was to spread the city out further around highways. So the city spread out and in an hour you could go 50 kilometres.

The Marchetti principle does mean that if you have a good public transport system there will be a market for dense, walkable development.

Sydney's commitment to motorways in recent times has been very extensive. Ten billion dollars in a decade is a major determinant of the city's recent character. It has created a more car-dependent city. It is not possible to do other than that. You have had recent announcements about public transport spending, of about $2 billion. Is it enough? What about new lines, especially light rail, what about local priority for biking or walking? And is there a vision to fit all this into?

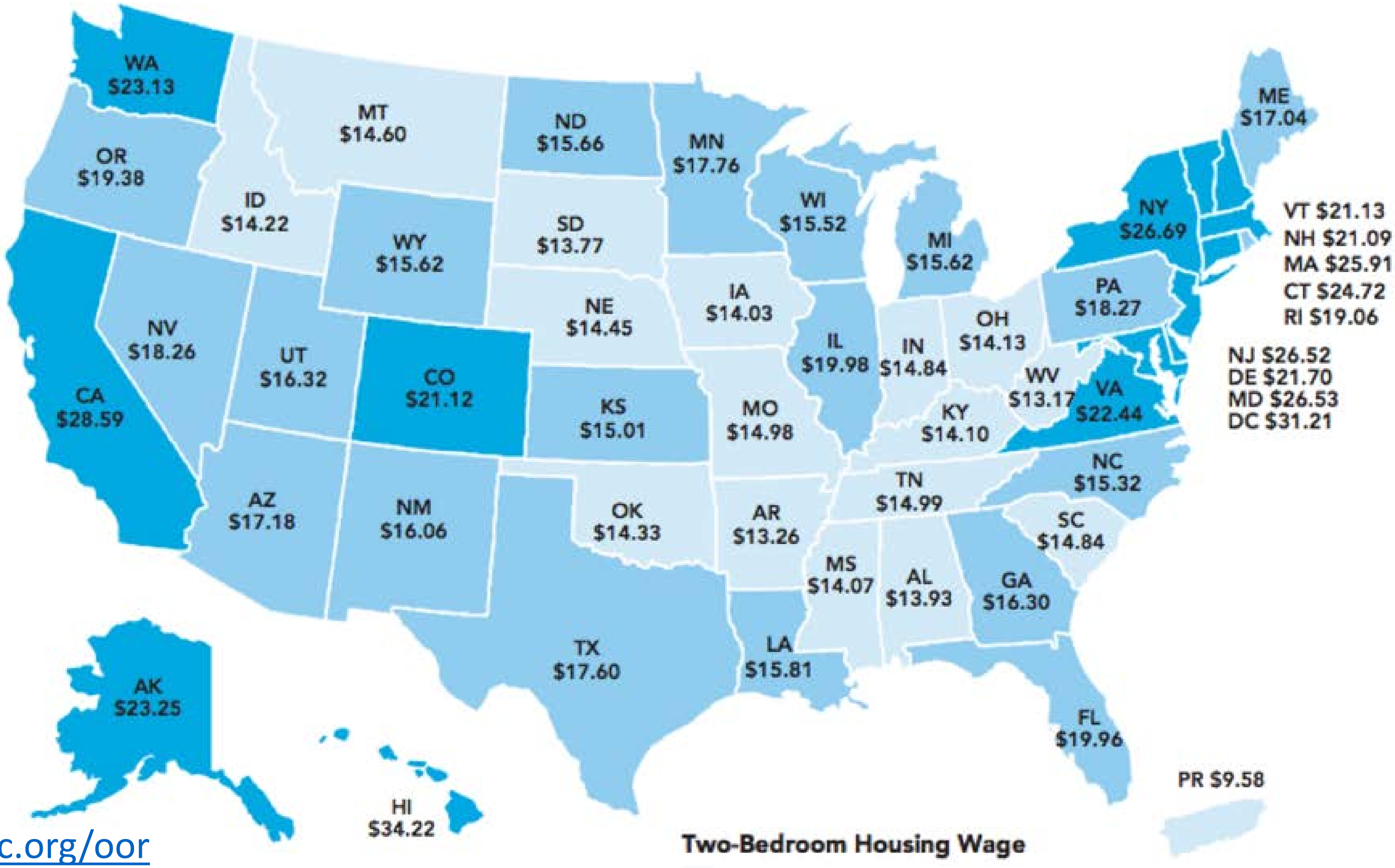
The one-hour-wide city, in Sydney, is reaching its limits. A city that has got 20 people a hectare and 40 kilometres an hour will become dysfunctional after about 2.5 million people. Market-based reurbanisation is flooding in now. There are 100 new rail developments opening in US cities. In Denver, a classic urban-sprawl, car-based city, the light rail is being extended in eight directions.

Sydney is now turning in as its sprawl limits are reached. Public transport options, which are then favoured by that, are at capacity and too slow.

The economics are very powerful. If you look at car use and city wealth, there is no correlation. European cities, which have less than half the car use, are the wealthiest. And even in the US there is very little correlation at all. Some cities put their wealth into public transport and use it - and it works.

Can Hyperloop impact the 2-bedroom housing wage?

Represents the hourly wage that a household must earn (working 40 hours a week, 52 weeks a year) in order to afford the Fair Market two-bedroom rental unit, without paying more than 30% of their income.



http://nlihc.org/oor

California Commutes are 80km or 50miles Approx 1-hour drive

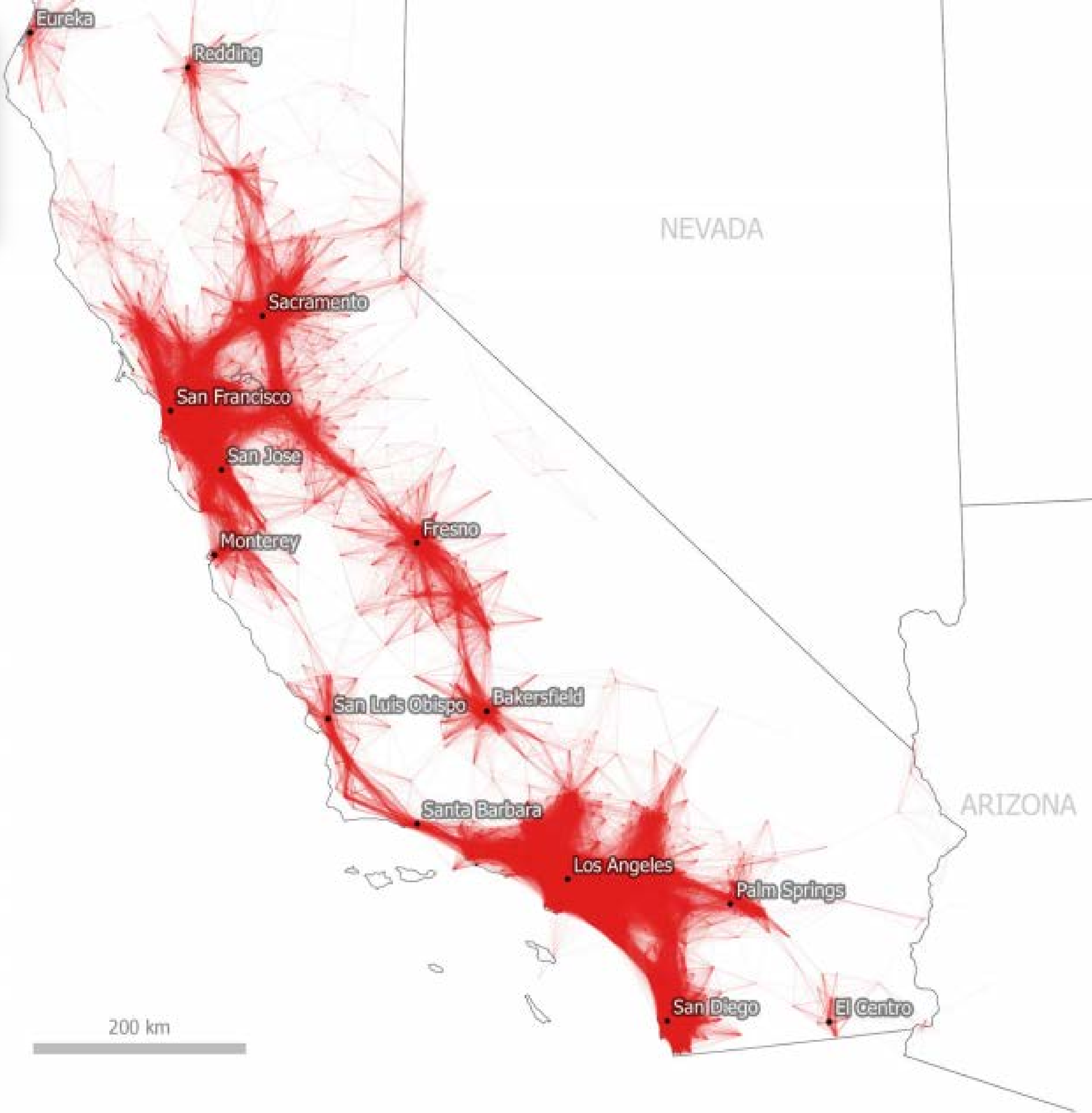


Fig 2. Tract-to-Tract Commutes of 80km/50 miles or less in California.

http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0166083&type=printable

Bay Area Commutes are 80km or 50miles Approx 1-hour drive

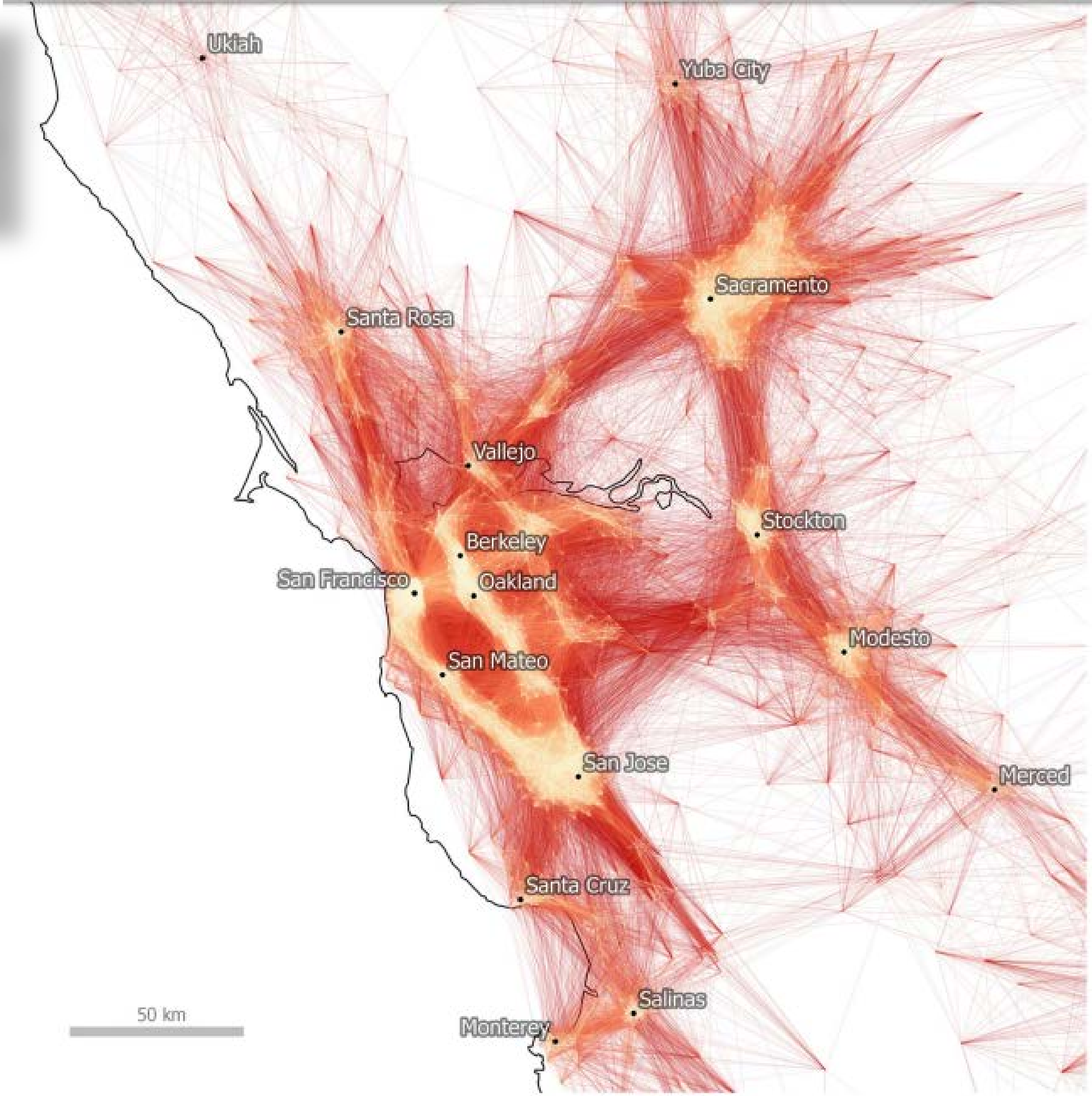
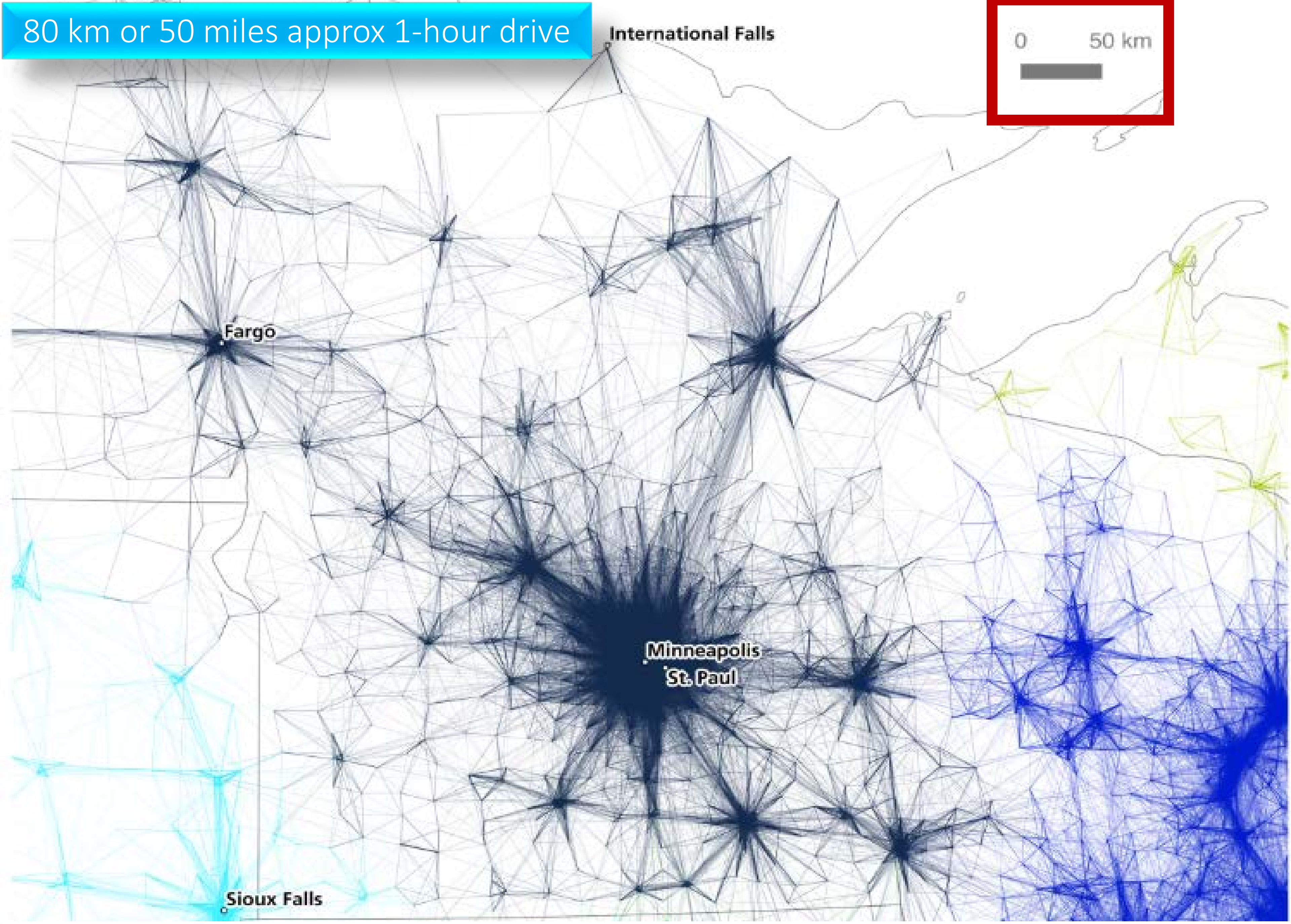
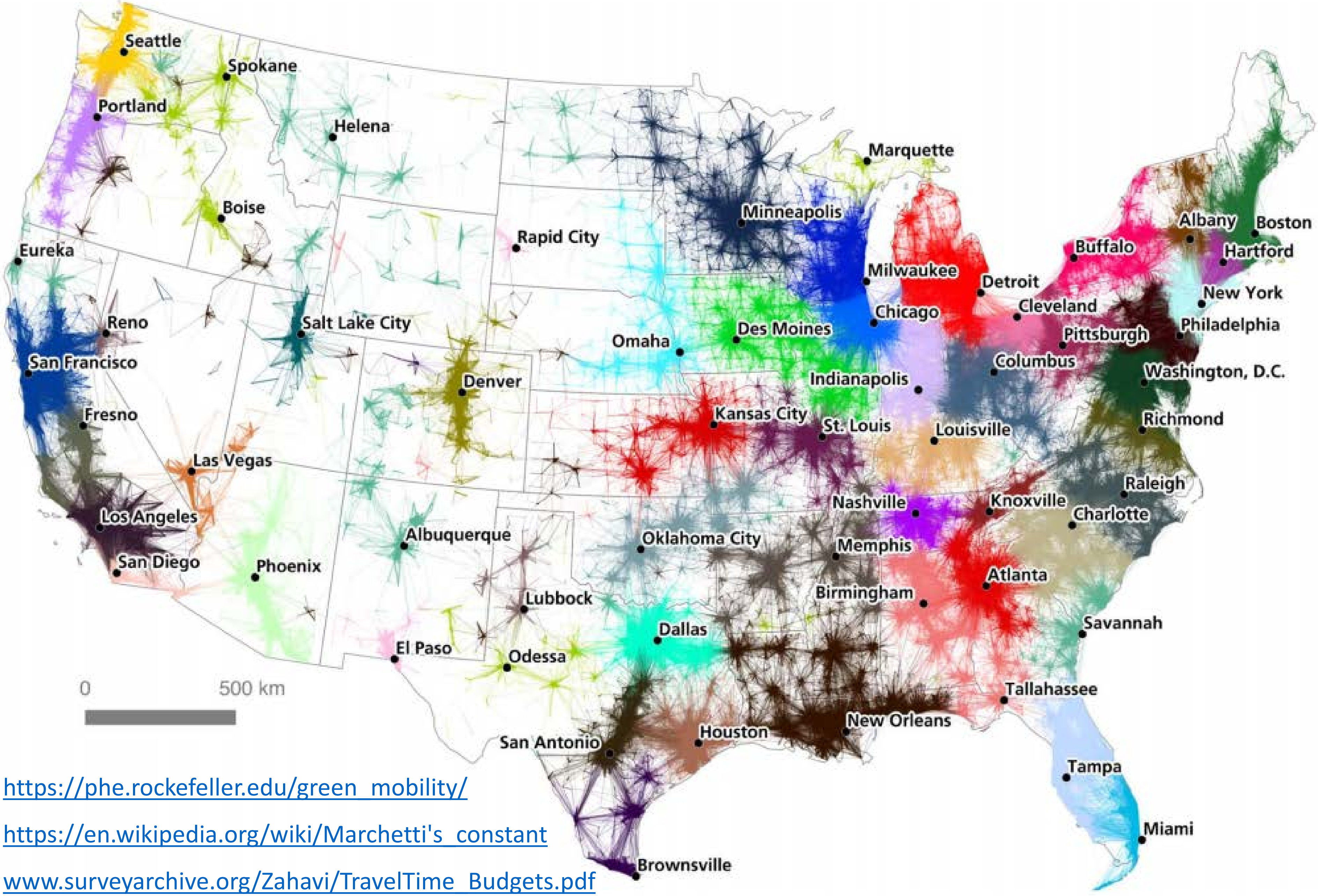


Fig 3. Tract-to-Tract Commutes of 80km/50 miles or less in the Bay Area.

http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0166083&type=printable



http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0166083&type=printable



https://phe.rockefeller.edu/green_mobility/

https://en.wikipedia.org/wiki/Marchetti's_constant

www.surveyarchive.org/Zahavi/TravelTime_Budgets.pdf

Fig 6. A commuter flow-based regionalization of the United States.

http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0166083&type=printable

Mean Speed (30 mph) has not changed since Henry Ford's times. The use of cars (10,000 miles per year or about 1 hour per day) is still the current average for calculating vehicle use by auto insurance companies in the US

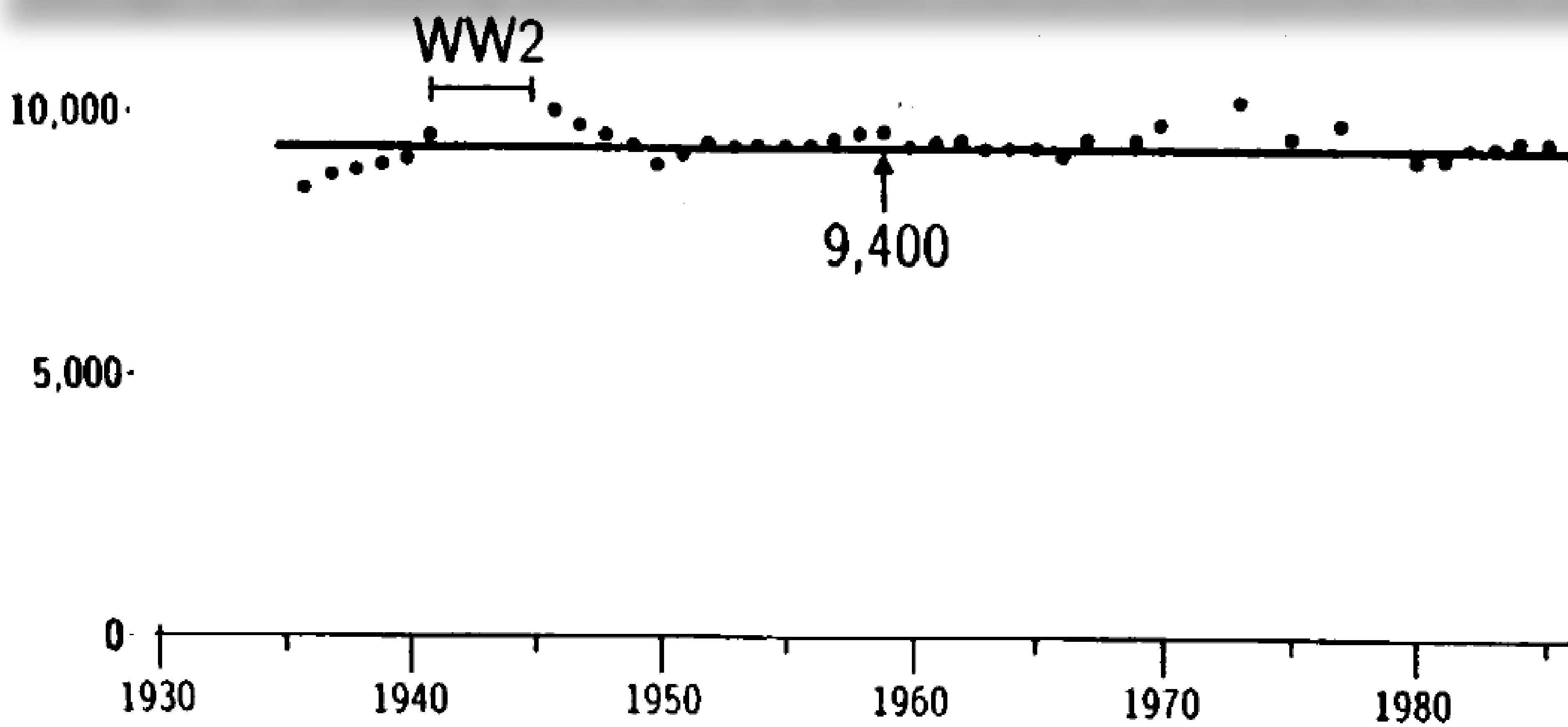


Fig. 13. A historical overview of car mileage in the USA (miles/year). The regularity in the use of cars (about one hour per day) is mirrored in the stability of mileage per year, reported here for the USA. This implies a curious stability in the mean speed, about 30 miles/hr – since Henry Ford's times. Data

www.cesaremarchetti.org/archive/electronic/basic_instincts.pdf

My *Gedankenexperiment*, which I presented at Marrakech in a congress related to the problems of linking Africa (or better the Magreb) to Europe with a bridge or a tunnel across the Gibraltar Strait, was based on the exploitation of the maximum potential of the *Maglev*, the magnetically levitated and driven train. At the Polytechnic of Lausanne a Maglev transportation system about 700-km long linking the major Swiss cities with transit times of 10 minutes has been proposed (Figure 8), with the characteristic of running in an evacuated pipe (air pressure equivalent to a height of 15,000 meters) [3]. The rationale is to have a *small tunnel*, almost fitting the size of the train. Due to the mountainous conformation of Switzerland, such connections have to be made in tunnels for the most part, and the cost of tunneling is dominant over every other component of the system.

Operating in a partial vacuum, however, removes the most important constraint to vehicle speed, as Maglevs move more or less in a frictionless manner on a magnetic cushion. We still have a limitation on the acceleration that humans can take. I assumed 0.5 G or 5 m/sec^2 as an acceptable one. It is the acceleration (for a few precious seconds) of extremely expensive cars, like Ferraris and Porsches.

Operating a Maglev between Casablanca and Paris at constant acceleration (CAM), that is, by accelerating halfway and braking the other half at 0.5 g, the train would cover the distance in about 20 minutes. In other words a woman in Casablanca could go to work in Paris, and cook dinner for her children in the evening. Vice versa for shopping for special items in a special cultural atmosphere. With appropriate interfaces, such trains could carry hundreds of thousands of people per day. *The idea behind this is to save cultural roots without impeding work and business in the most suitable places*. Incidentally, businessmen who can afford the extraordinary cost of air travel in Europe do exactly

www.cesaremarchetti.org/archive/electronic/basic_instincts.pdf

The next logistics evolution - 13 km long - Bridge Africa with Eurasia

The next logistics evolution – 13 km long – Why delay the construction?

They didn't quite meet in the middle - the English side tunnelled farther

By **Oliver Smith**, DIGITAL TRAVEL EDITOR

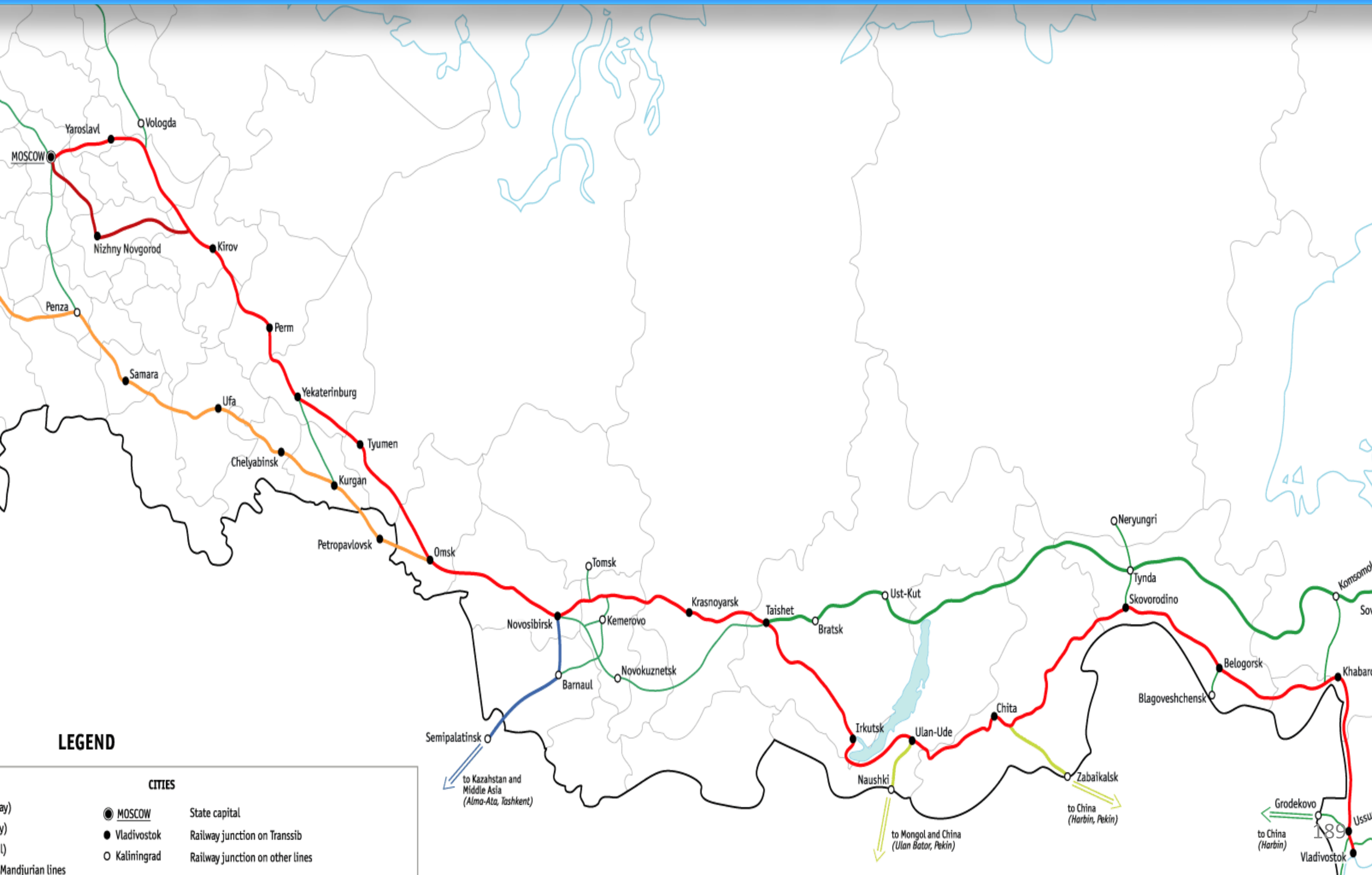
1 DECEMBER 2015 • 12:00AM

1. The Channel Tunnel is 31.4 miles long, making it the 11th longest tunnel in use (the longest is the Delaware Aqueduct, at 85.1 miles), and the fourth longest used by rail passengers. It has the longest undersea portion of any tunnel in the world (23.5 miles).

Engineering marvel..Beneath a mountain in Switzerland lies the world's longest shortcut. The 35.4-mile Gotthard Base Tunnel, the longest tunnel on earth, a $12 billion marvel, took 17 years to dig. Drill heads with 58 seventeen-inch rock-chomping steel "roller cutters" pushed against the stone with a 26-ton force.Swiss Federal Railways trains will whisk up to 15,000 passengers/day through it at 155/hour. One result will be cleaner air: 40 M tons of freight will travel through the tunnel annually, shifting cargo hauled by 650,000 trucks each year from roads onto rails.!! show less

The next logistics revolution – South Africa connects to China

Kouvola to Beijing - TRANS-SIBERIAN / TRANS-MONGOLIAN RAIL



MIT Students Win Competition to Design Hyperloop Pods

14:00 - 1 February, 2016 | by Karissa Rosenfield

the *Maglev*, the magnetically levitated and driven train. At the Polytechnic of Lausanne a Maglev transportation system about 700-km long linking the major Swiss cities with transit times of 10 minutes has been proposed (Figure 8), with the characteristic of running in an evacuated pipe (air pressure equivalent to a height of 15,000 meters) [3]. The rationale is to have a *small tunnel*, almost fitting the size of the train. Due to the mountainous conformation of Switzerland, such connections have to be made in tunnels for the most part, and the cost of tunneling is dominant over every other component of the system.

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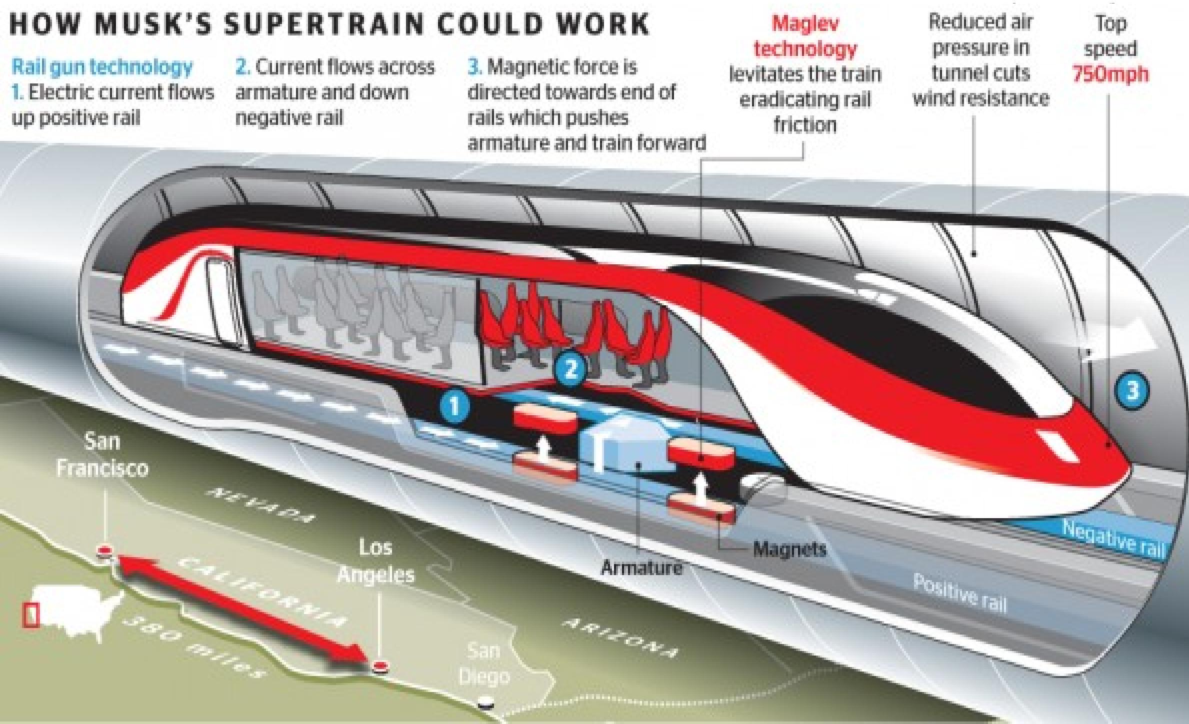


Hyperloop started 1897 by the NY Postal Service

Elon Musk's futuristic vision of a Hyperloop transportation system seems to be inspired from the past. About 100 years ago, large cities around the world used system of pneumatic tubes to send and receive mail (not people).

As part of a demonstration to inaugurate the high-tech mail delivery, pranksters stuffed a live black cat into one of the tubes to send over to the General Post Office in New York.

https://en.wikipedia.org/wiki/Pneumatic_tube_mail_in_New_York_City
http://www.pbs.org/newshour/updates/is-traveling-on-hyperloop-a-ticket-to-puke-city/
https://www.yahoo.com/style/bp/hyperloop-inspired-100-years-ago-pneumatic-tubes-cat-204600601.html
http://www.theatlantic.com/technology/archive/2013/08/that-time-people-sent-a-cat-through-the-mail-using-pneumatic-tubes/278629/

As described by an eyewitness , Howard Wallace Connelly, in his 1931 self-published autobiography, "Fifty-Six Years In The New York Post Office — A Human Interest Story of Real Happenings in the Postal Service":

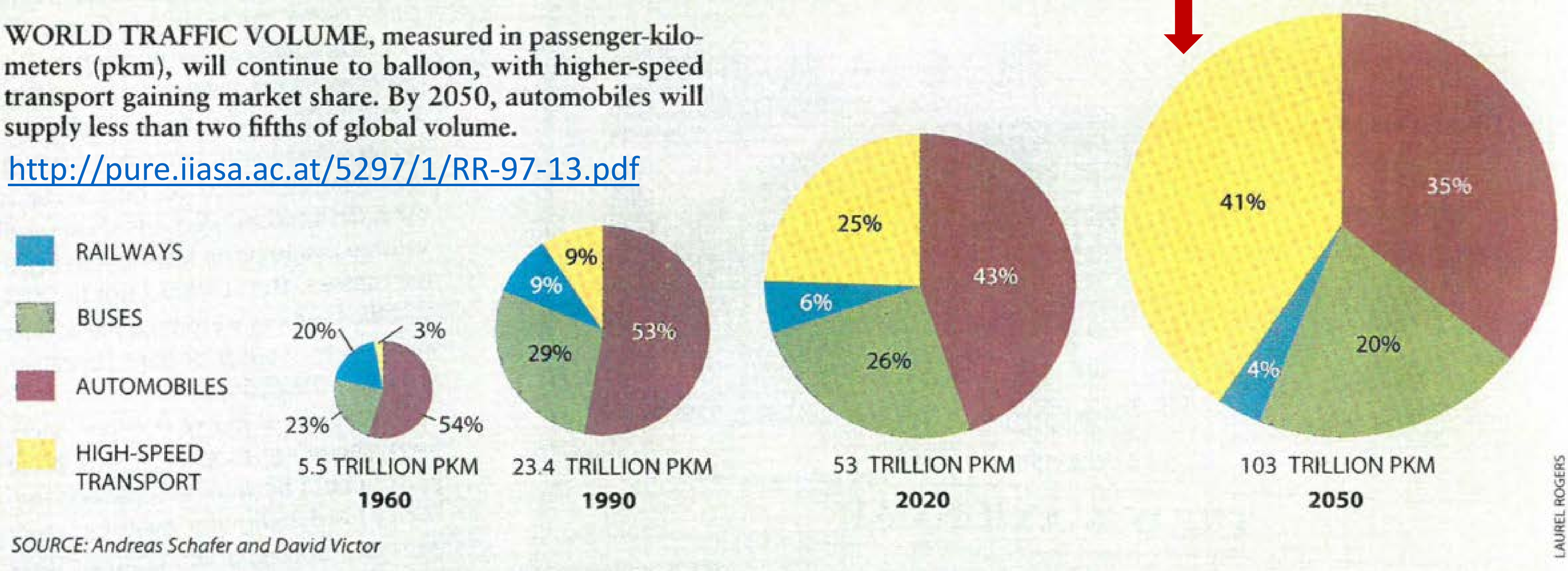
1997 - Prediction by Schafer and Victor (MIT)

By 2050, automobiles will supply less than two fifths of global volume

Share of High Speed Transport in 2050 = 41%

WORLD TRAFFIC VOLUME, measured in passenger-kilometers (pkm), will continue to balloon, with higher-speed transport gaining market share. By 2050, automobiles will supply less than two fifths of global volume.

http://pure.iiasa.ac.at/5297/1/RR-97-13.pdf

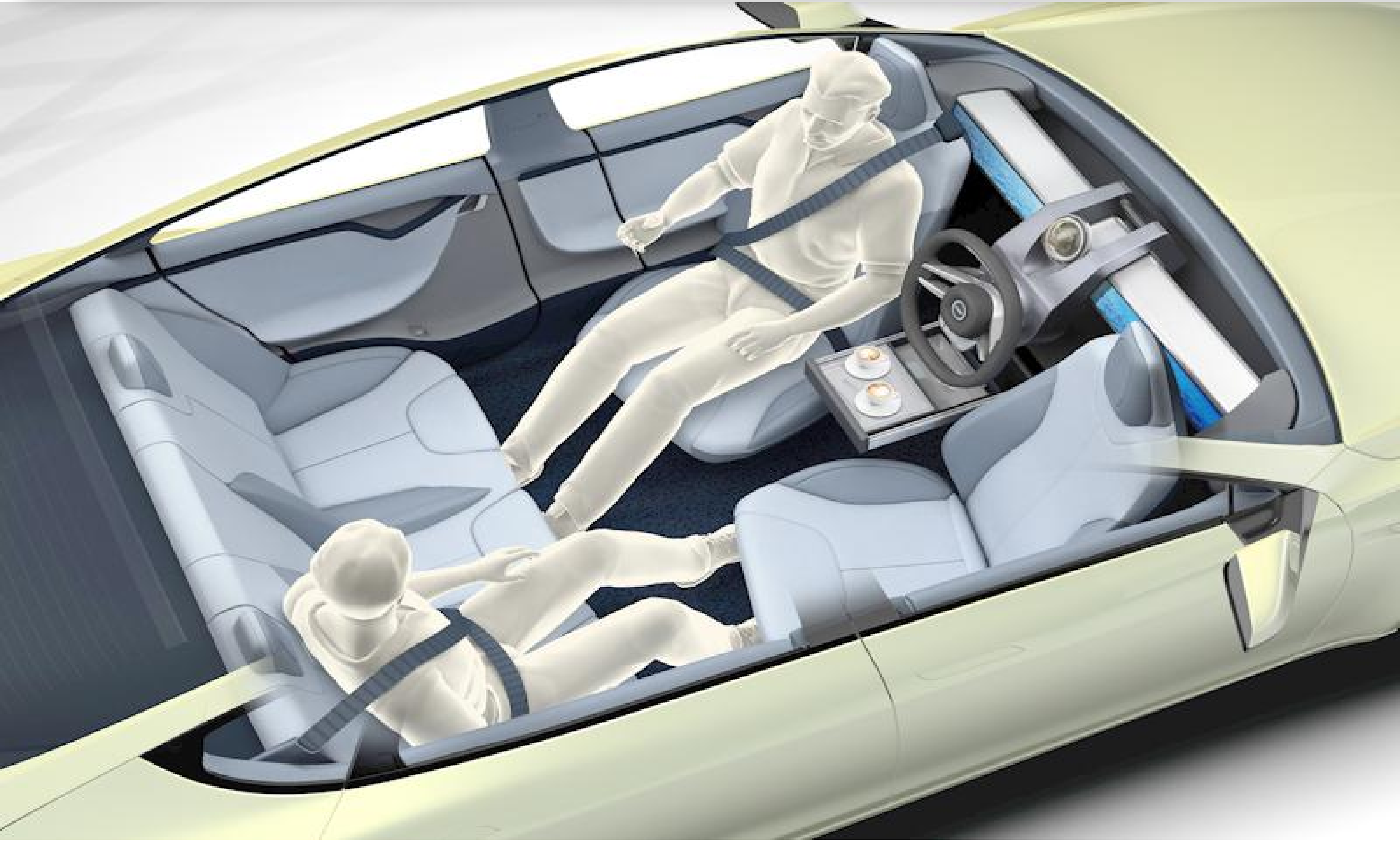


There are many others steps and stations ahead

Autonomous Cars?

What happens to
them in 2050 ?

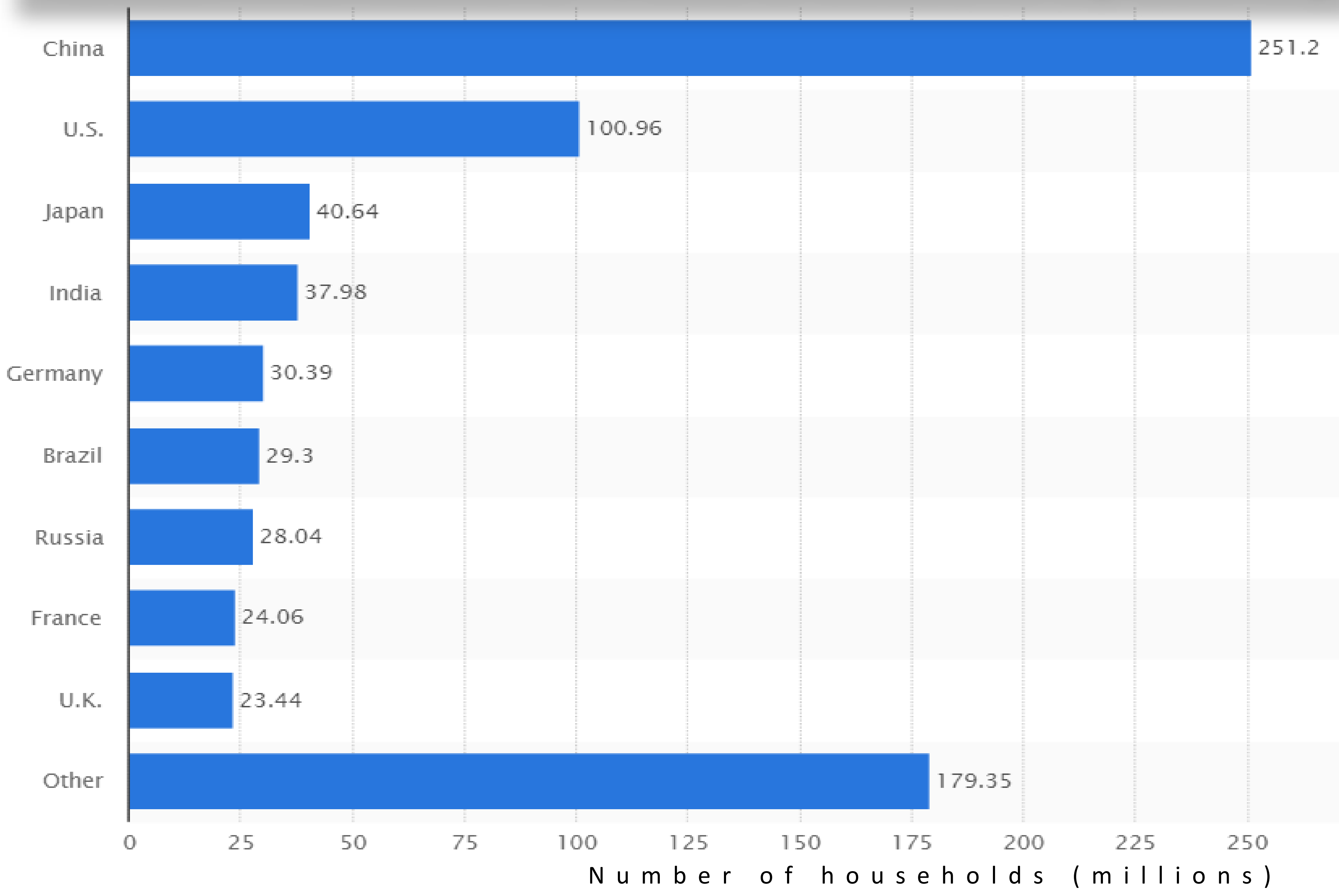
Autonomous Vehicles
Let us explore the journey on the road ahead



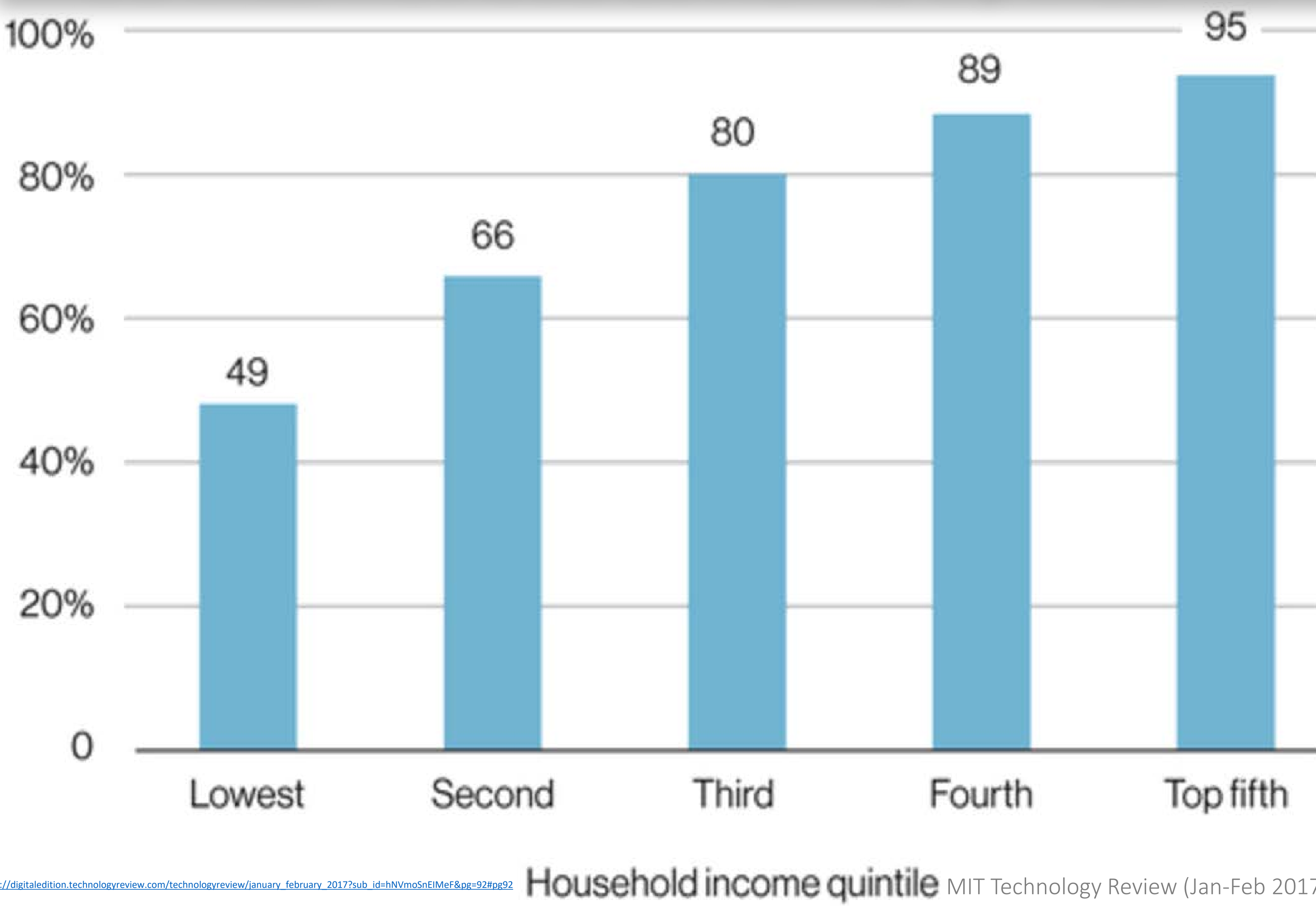

35153
57041

This happened in 13 years! We will have autonomous cars in a couple years. Correct?

Telecommunications - Fixed Broadband by Country

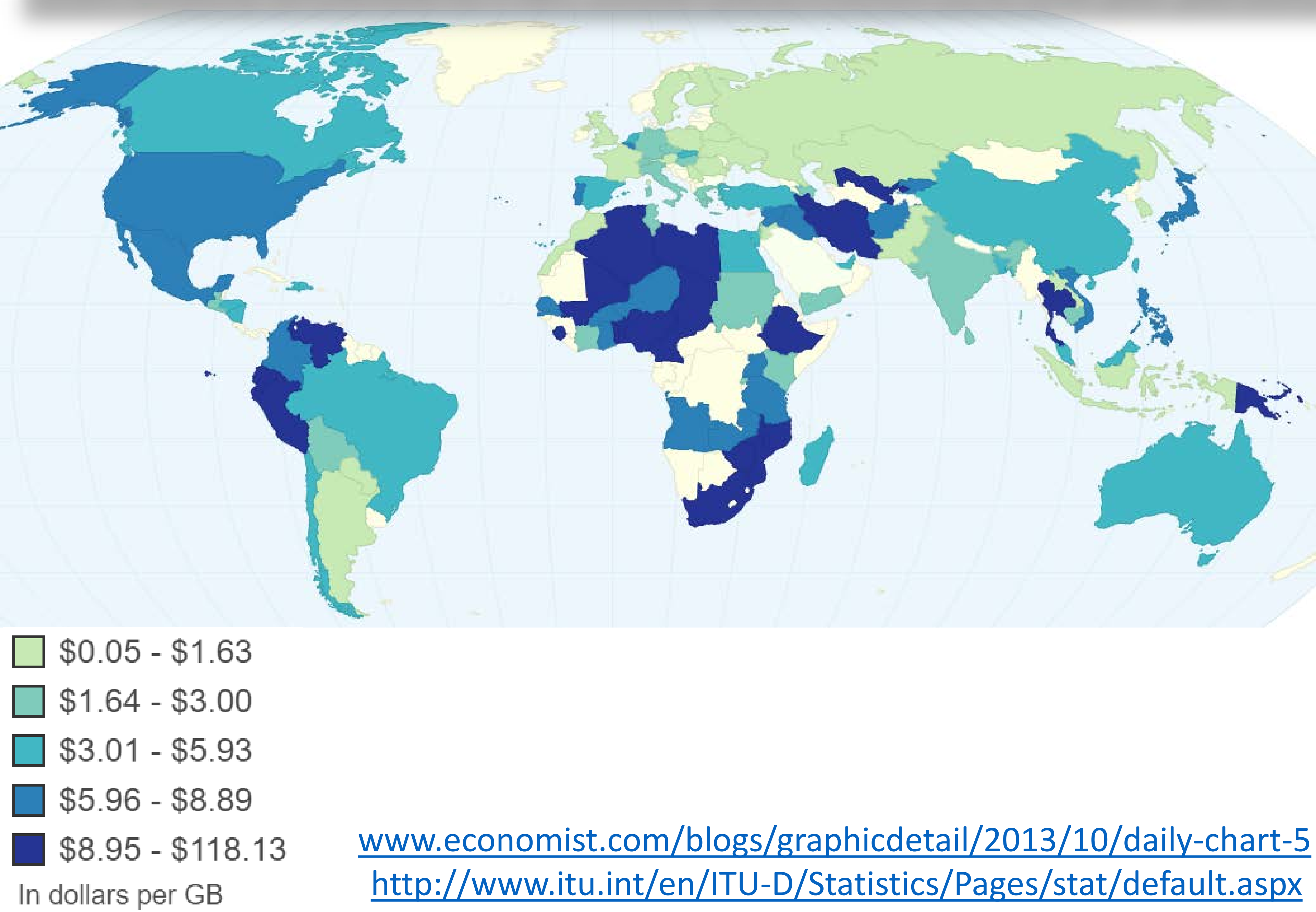


US Internet Use at Home by Income



http://digitaledition.technologyreview.com/technologyreview/january_february_2017?sub_id=hNVmoSnEIMeF&pg=92#pg92 MIT Technology Review (Jan-Feb 2017)

USA Mobile Broadband Plan 10GB=$85/month (2% GNI per person)



www.economist.com/blogs/graphicdetail/2013/10/daily-chart-5

http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Cost of 3G (2013) vs 3G/4G (2016) US Data Plans

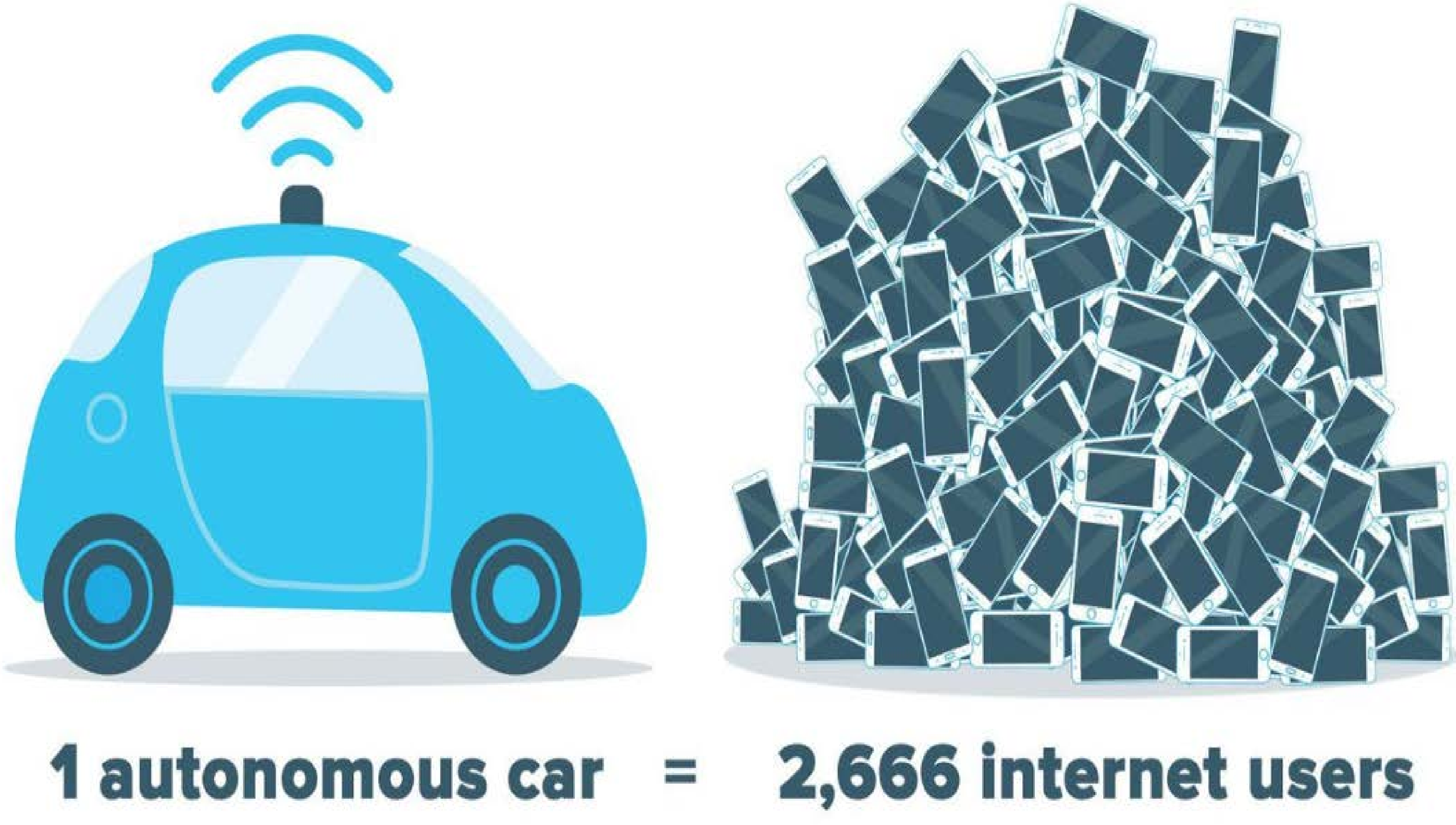
Bandwidth (Gb)	AT&T	Verizon	Sprint	T-mobile
.5				$20
1				
2				
2.5				$30
3			$34.99	
4	$30	$30		
4.5				$40
6	$40	$40	$49.99	
6.5				$50
8		$50		
8.5				$60
10	$60	$60		
10.5				$70
12		$70	$79.99	
14		$80		
15	$90			
16		$90		
18		$100		Not Available
20	$110	$110		
30	$185	$185		
40	$260	$260		
50	$335	$335		

Affordability	B+	C	A+
1GB - 1.5GB			
2GB - 3GB	$40		$20
4GB - 5GB	$50	$50	
6GB - 7GB	$60	$70	$35
8GB	$70		
10GB	$80	$90	$50
12GB	$90		

http://www.toptenreviews.com/services/internet/best-mobile-broadband-providers/

Autonomous car data

In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

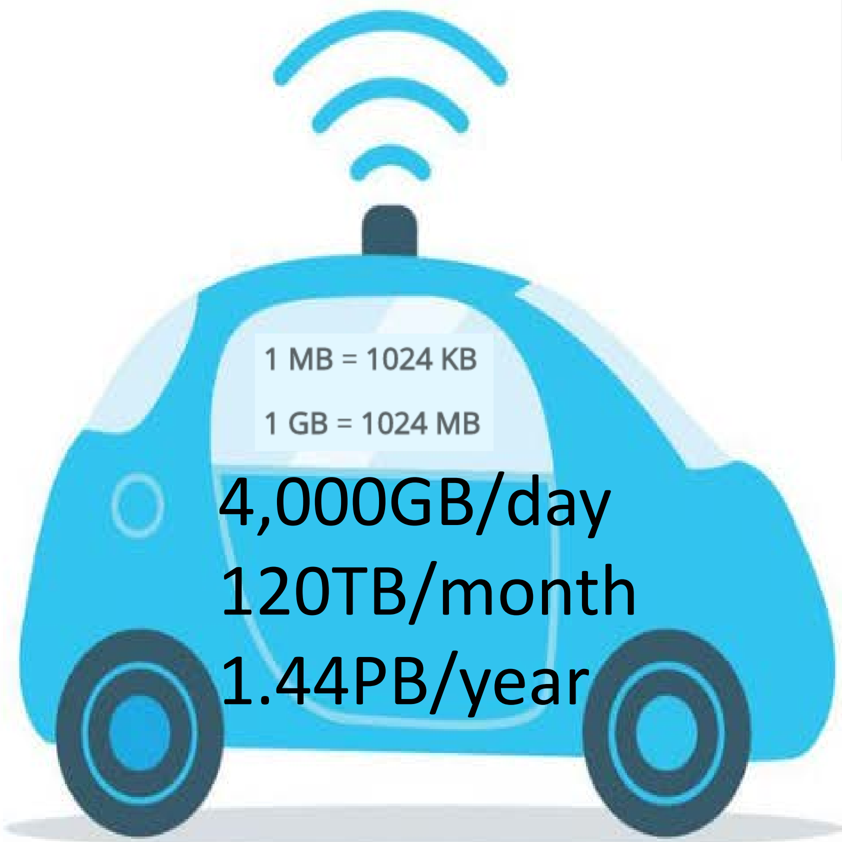


Autonomous car data $12.41 million per car per year

In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

2016 US Data Plans 10 GB data (per month) = $85 or 2% of GNI per person

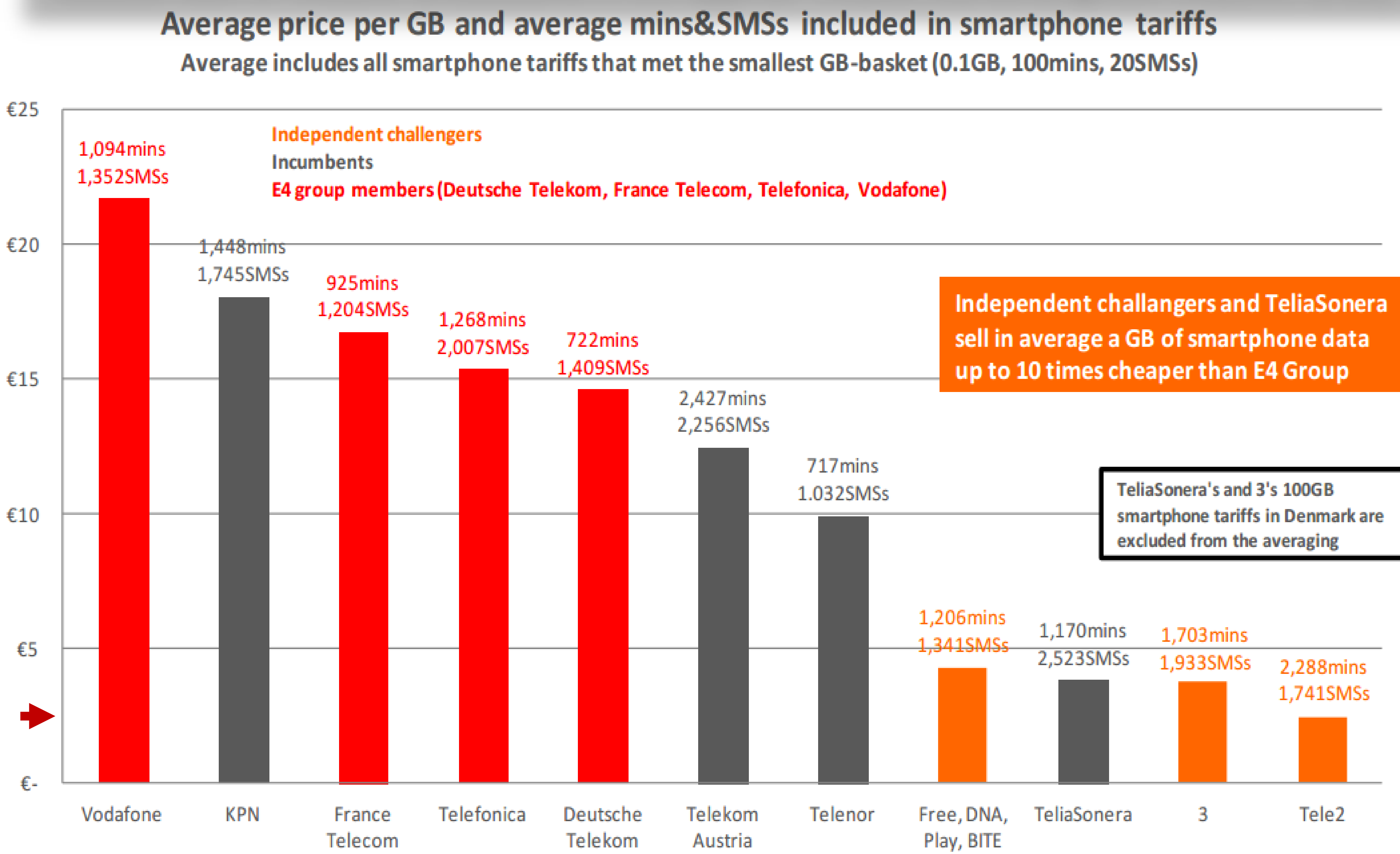
US



- African fixed broadband prices are, on average, 64% of GNI per capita

www.oafrica.com/broadband/african-internet-and-broadband-facts-from-measuring-the-information-society-2013-report/

Lowest cost of Mobile Broadband in EU approx. US$26.30/GB (highest US$231.4/GB)



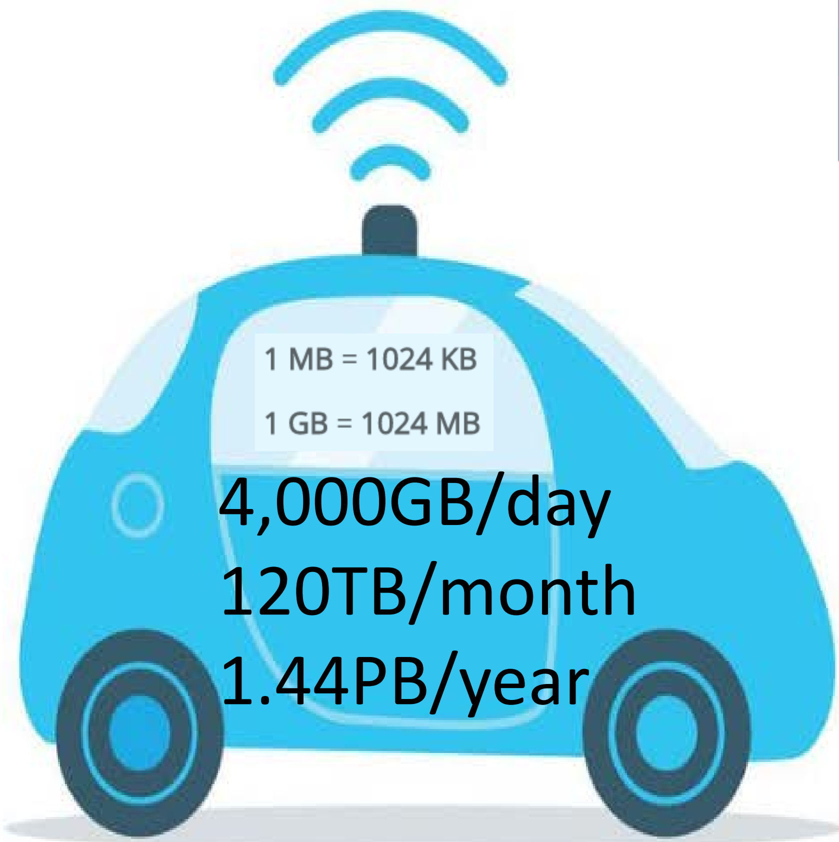
https://ec.europa.eu/digital-single-market/en/news/mobile-broadband-prices-europe-2016
http://www.rewheel.fi/downloads/Rewheel_EU27_mobile_data_cost_competitiveness_report_May_2013_FINAL.pdf

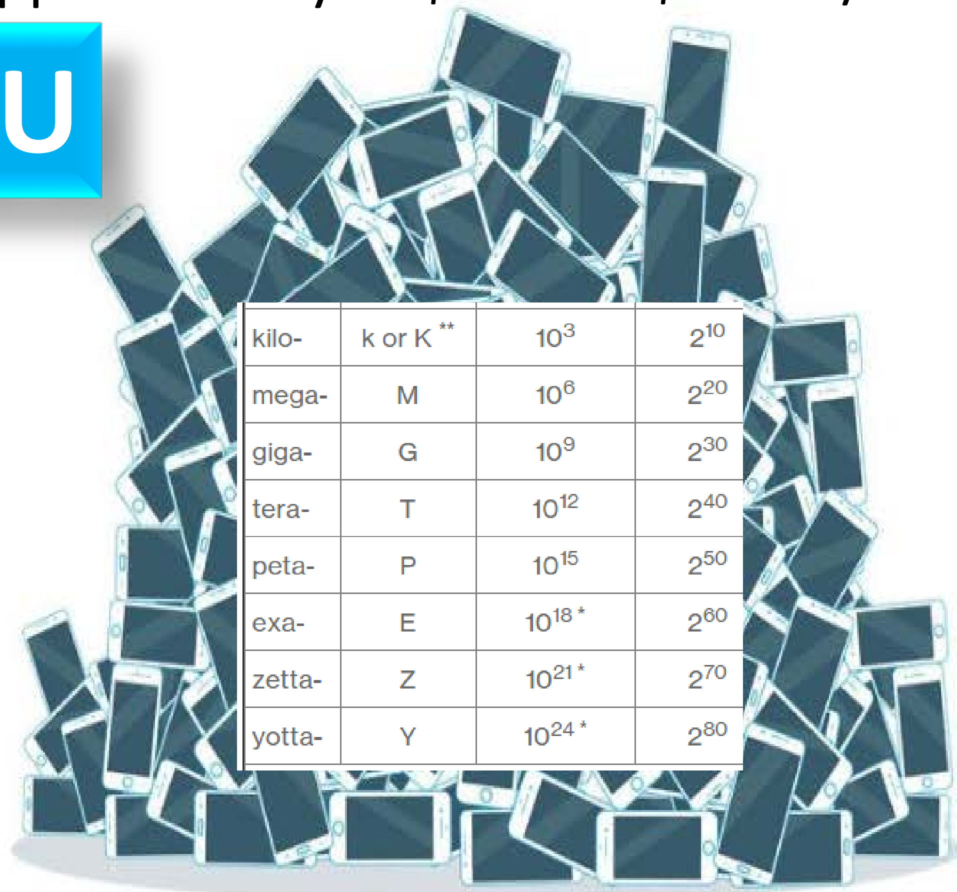
Autonomous car data $38.40 million per car per year

In 2020, the average autonomous car may process 4,000 gigabytes of data per day, while the average internet user will process 1.5 gigabytes.

Lowest cost of 0.1GB data in EU27 approximately US$2.63 or $26.30 / GB

EU





kilo-	k or K **	10^3	2^{10}
mega-	M	10^6	2^{20}
giga-	G	10^9	2^{30}
tera-	T	10^{12}	2^{40}
peta-	P	10^{15}	2^{50}
exa-	E	10^{18} *	2^{60}
zetta-	Z	10^{21} *	2^{70}
yotta-	Y	10^{24} *	2^{80}

1 autonomous car = 2,666 internet users

What may be the key trigger for mass adoption of autonomous vehicles?

US	**$12.41 million per car per year**
EU	**$38.40 million per car per year**

SIX ORDERS OF MAGNITUDE DECREASE IN COST FOR MOBILE 5G DATA

US	**$12.41**	**per car per year**
EU	**$38.40**	**per car per year**

Do you think data usage will be limited to 4,000GB/day or 1.44PB/year?

US	$12.41	per car per year
EU	$38.40	per car per year

6 ORDERS OF MAGNITUDE DECREASE IN COST + 10-FOLD DATA INCREASE

US	$124.10	per car per year
EU	$384.00	per car per year

In reality expect 1000-FOLD INCREASE in DATA for autonomous vehicles

US	**$12,410**	**per car per year**
EU	**$38,400**	**per car per year**

1 Email (Plain Text) = 35 KB → Today's estimate of autonomous vehicle data

1 Minute of Facebook = 1 MB

1 Minute of Web-surfing = 2.5 MB

1 Minute of streaming YouTube (480p) = 4 MB → By 2020, estimate of autonomous vehicle data

1 Minute of streaming music = 1 MB

1 Minute of Skype Call = 360 KB

You earn €35K pa. Can you afford to pay €35K pa for your car's data plan?

$53K
GNI per capita

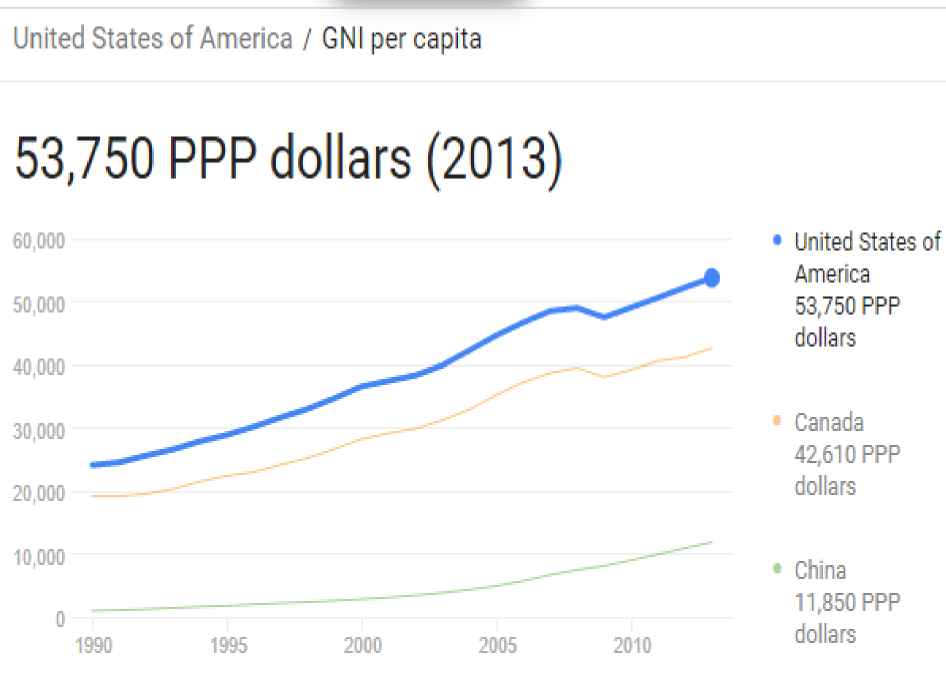
US

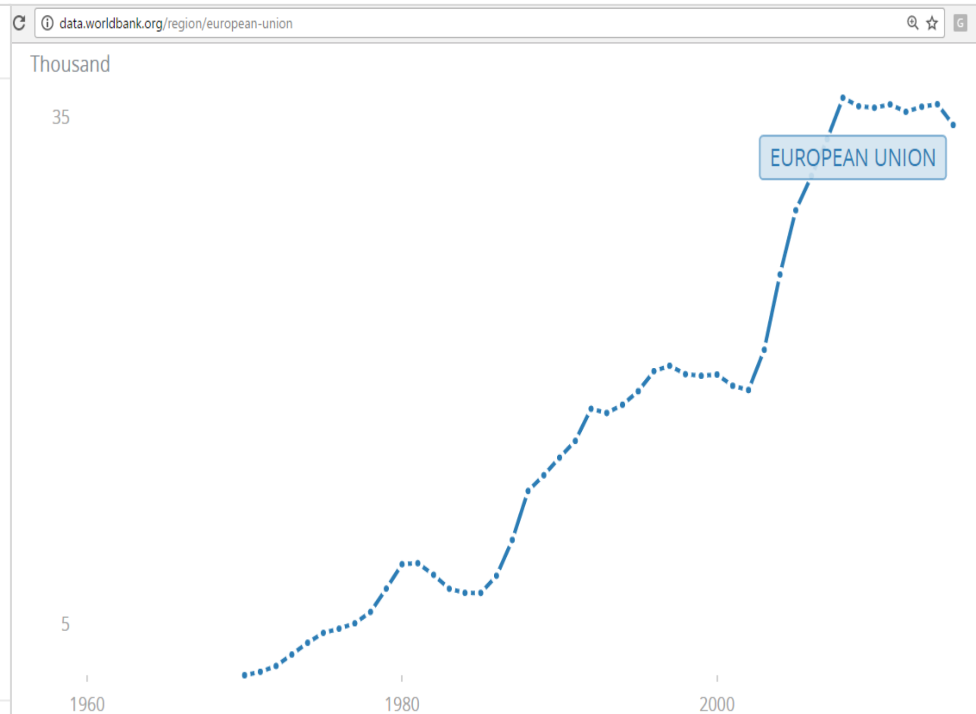
$12,410.00 per car per year

€35K
GNI per capita

EU

€35,600.00 per car per year



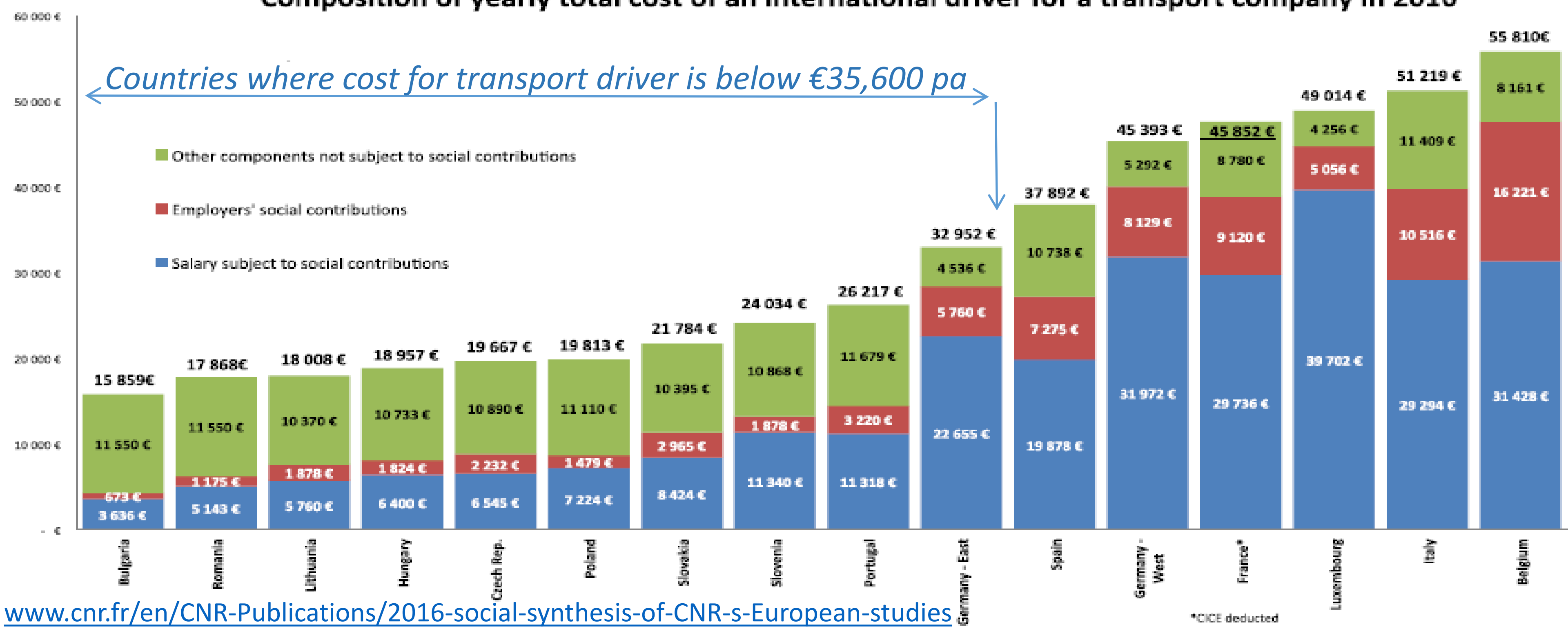


Do you want to own a car or share? At what cost will your autonomous car's data plan fit your budget? 2% of GNI per person? Can technology & economy drive down the cost to that level?

Where is the tipping point for autonomy in freight transport if €35,600 per year is a estimate for (personal use) a private vehicle's data plan?

$53K GNI per capita	US	$12,410.00	per car per year
€35K GNI per capita	EU	€35,600.00	per car per year

Composition of yearly total cost of an international driver for a transport company in 2016



www.cnr.fr/en/CNR-Publications/2016-social-synthesis-of-CNR-s-European-studies

If you live in the EU when will you be able to afford your car's data plan?

https://www.nytimes.com/2017/02/09/business/europe-jobs-economy-youth-unemployment-millenials.html

BUSINESS DAY | Feeling 'Pressure All the Time' on Europe's Treadmill of Temporary Work

After graduating with degrees in accounting and finance from a university in Finland, Ville Markus Kieloniemi thought he would at least find an entry-level job in his field. He studied potential employers, tailoring his applications accordingly.

He wound up churning through eight temporary jobs over the next three years. He worked variously as a hotel receptionist and as a salesman in men's clothing stores, peddling tailored suits and sportswear.

"It's hard to manage your finances or even get housing, let alone start a career," said Mr. Kieloniemi, 23, who added depth to his résumé by accepting unpaid office jobs and internships in New York and Spain, mostly at his own expense. "You feel pressure all the time."

Meet the new generation of permatemps in Europe.

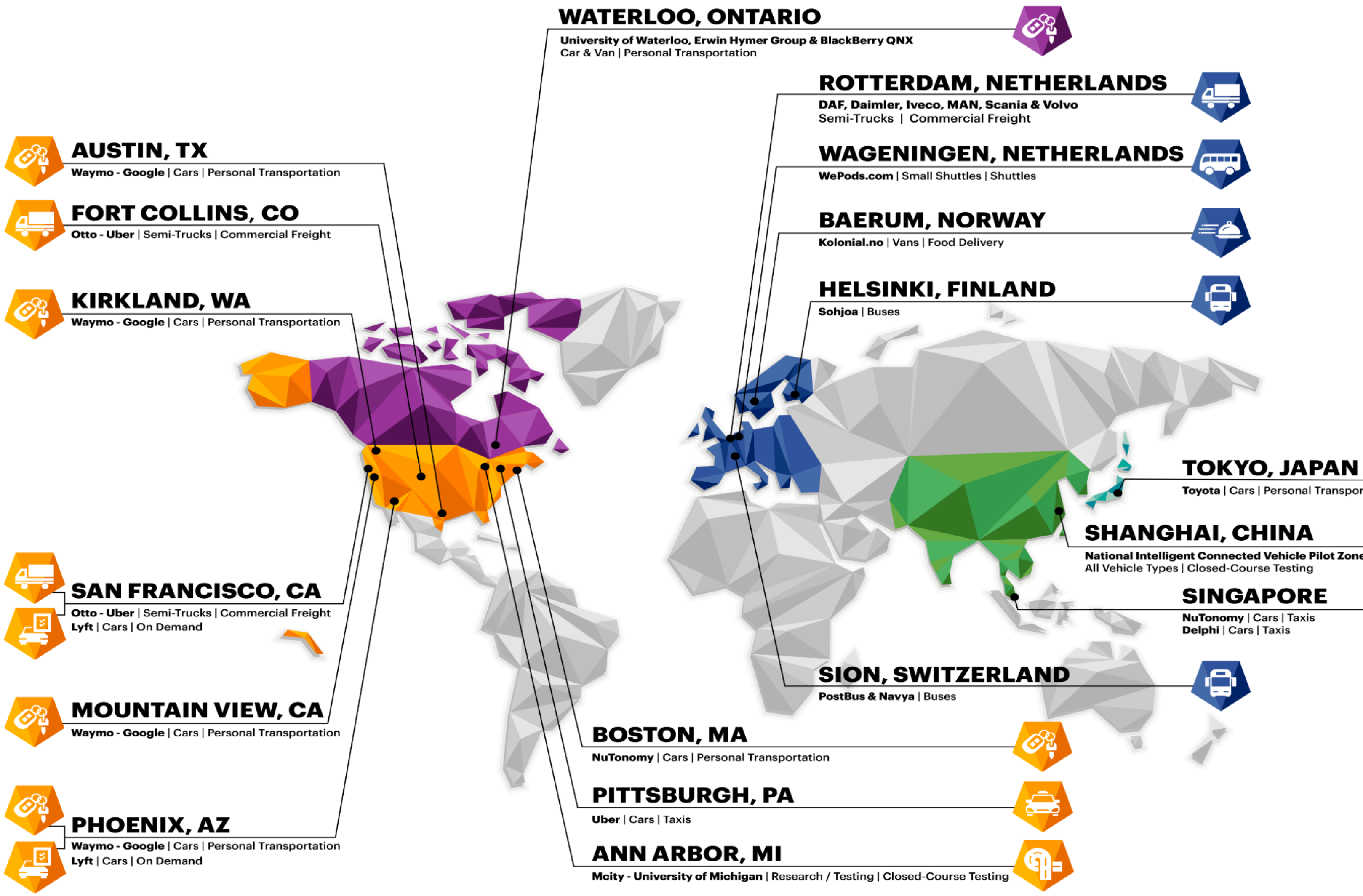
While the region's economy is finally recovering, more than half of all new jobs created in the European Union since 2010 have been through temporary contracts. This is the legacy of a painful financial crisis that has left employers wary of hiring permanent workers in a tenuous economy where growth is still weak.

SELF-DRIVING CARS?

Transportation as we know it is starting to change with the proliferation of self-driving vehicles and technology developed by high-profile companies. This is becoming more evident with new testing sites on public roads and closed courses popping up across the globe every month.

The United States has been at the forefront of the autonomous-vehicle live trial movement, with more than half a dozen sites already in operation. Europe moved first with controlled-environment testing, and is focusing mainly on public transportation projects. In Asia, there are three testing locations with plans for expansion. Late in 2016, the first Canadian testing of self-driving vehicles began in Ontario.

This map charts the current self-driving vehicle testing and deployment locations worldwide.



SOURCES

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http://www.telegraph.co.uk/technology/2016/01/28/first-driverless-buses-travel-public-roads-in-the-netherlands/

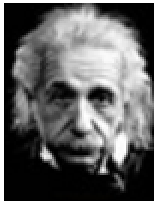
http://www.shanghaidaily.com/business/biz-special/Autonomous-connected-cars-on-their-way/shdaily.shtml

http://www.cbc.ca/news/business/automated-vehicles-1.3870605

FOR MORE INFORMATION, VISIT: http://insuranceblog.accenture.com/where-in-the-world-are-self-driving-cars/

How long it may take for creative destruction and cannibalization to restructure the global auto industry employing ~50 million people?

www.oica.net/category/economic-contributions/auto-jobs/



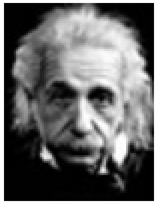
"We can not solve our problems with the same level of thinking that created them"

Autonomous Vehicles

NEW tools, NEW technologies, NEW economic models, NEW transaction cost structures, NEW digital businesses, NEW engineering design, NEW computational paradigms

The NEW normal – SERVICES – not products

Adoption (of autonomous cars) is unrelated to cost of product (car) but determined by the cost of essential services (zero latency, mobile computation, connectivity, cybersecurity, energy recharge)

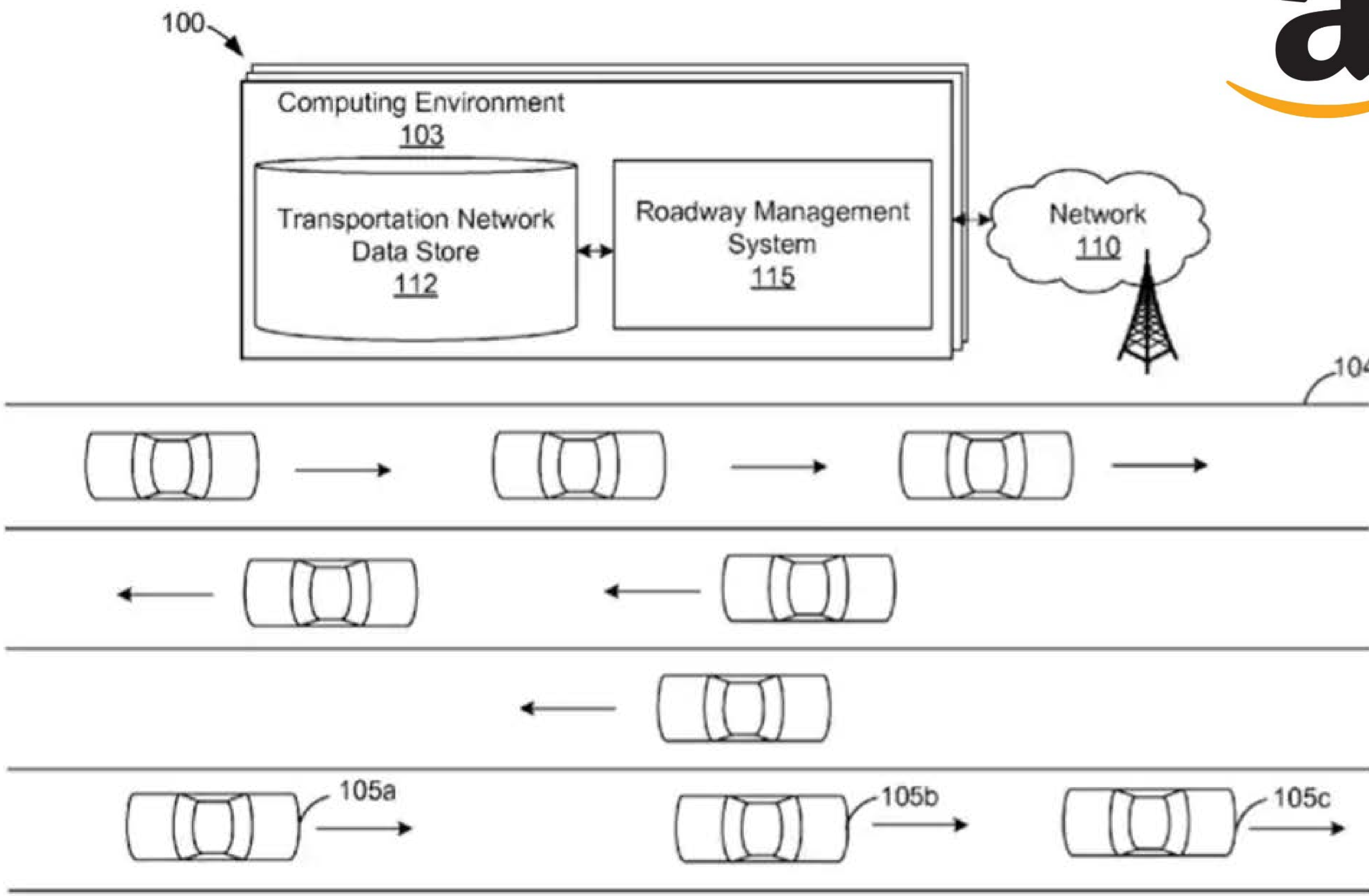


"We can not solve our problems with the same level of thinking that created them"

No large innovation has come from within a system. Tesla didn't come out of the automotive industry. SpaceX didn't come out of Boeing or Lockheed and by the way GM spent millions of dollars trying to do an electric car before Tesla. More money, more resources, more knowledge, too much knowledge. Wal-Mart didn't innovate retail. Amazon did. NBC and CBS didn't innovate media. Facebook, Twitter and YouTube did. Genentech didn't come out of Pharma. It came from a guy who was an associate at Kleiner – Bob Swanson *(in partnership with Herbert Boyer of UCSF).*

http://medcitynews.com/2017/01/vinod-khosla-healthcare-startups-hate/

Reversible lanes pose problem for autonomous cars and trucks, but Amazon has worked out a possible solution

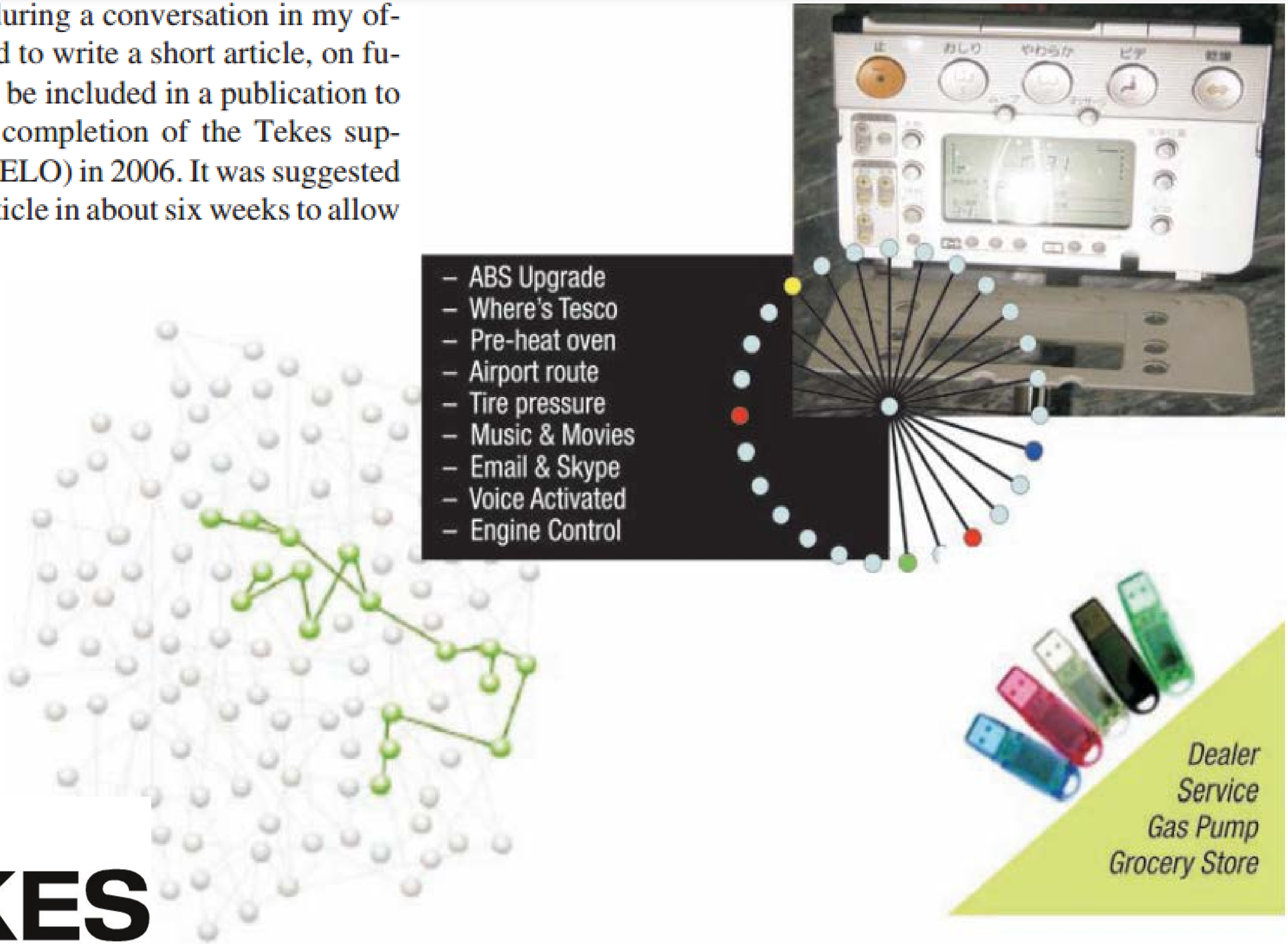


Amazon's self-driving patent proposes a centralised roadway management system that communicates with self-driving cars to help coordinate vehicle movement at a large scale. Photograph: USPTO

2005 – Swap form factor for “atoms” (connect bits, cars, engines, toilets)

12 years later, swappable car batteries are in discussion, but form factor for energy is still large.

On 17th November 2005, during a conversation in my office at MIT, I was requested to write a short article, on future trends in e-business, to be included in a publication to accompany the successful completion of the Tekes supported e-logistics program (ELO) in 2006. It was suggested that I send the completed article in about six weeks to allow for translation in Finnish.



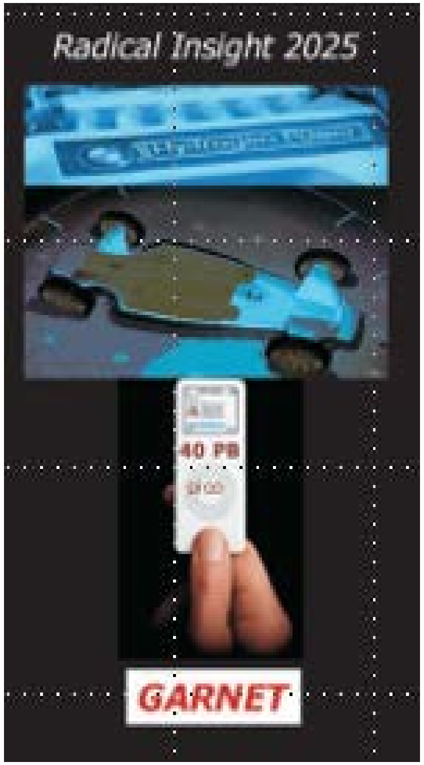
TEKES

2006 Paradigm Shift in Interoperability? https://dspace.mit.edu/handle/1721.1/56251

Swap "atoms" form factor

19. Wigner E. and Huntington H.B. On the possibility of a metallic modification of hydrogen. *J. Chem. Phys.*, 1935, v.3, 764–770.

12 years ago, the idea was of "portability" of atoms [eg: running your car on (metallic) hydrogen]



S. Datta, published (by TEKES in 2006)
https://dspace.mit.edu/handle/1721.1/56251

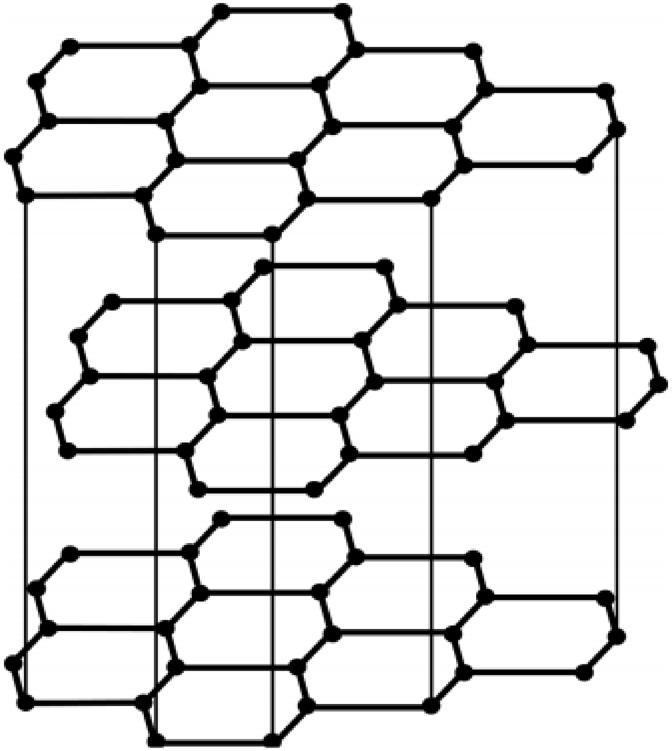


Fig. 1: Schematic representation of the layered lattice of graphite. Wigner and Huntington [19] would propose that most energetically favorable form of metallic hydrogen would assume this crystal structure. http://www.ptep-online.com/index_files/2011/PP-26-07.PDF

J. D. Bernal who first put forward the view that all substances go over under very high pressure into metallic or valence lattices" [19].

The rationale of "portability" of atoms was based on the theory of metastable metallic hydrogen

Harvard scientists announce they've created metallic hydrogen, which has been just a theory

January 26, 2017 |

19. Wigner E. and Huntington H.B. On the possibility of a metallic modification of hydrogen. *J. Chem. Phys.*, 1935, v.3, 764–770.

http://news.harvard.edu/gazette/story/2017/01/a-breakthrough-in-high-pressure-physics/

Swap “atoms” form factor – a different way of thinking about inventory at hand

12 years ago, the idea was of “portability” of atoms [eg: running your car on (metallic) hydrogen]

Drive any vehicle – car, ship, plane, rocket
Use metallic hydrogen in a USB drive form

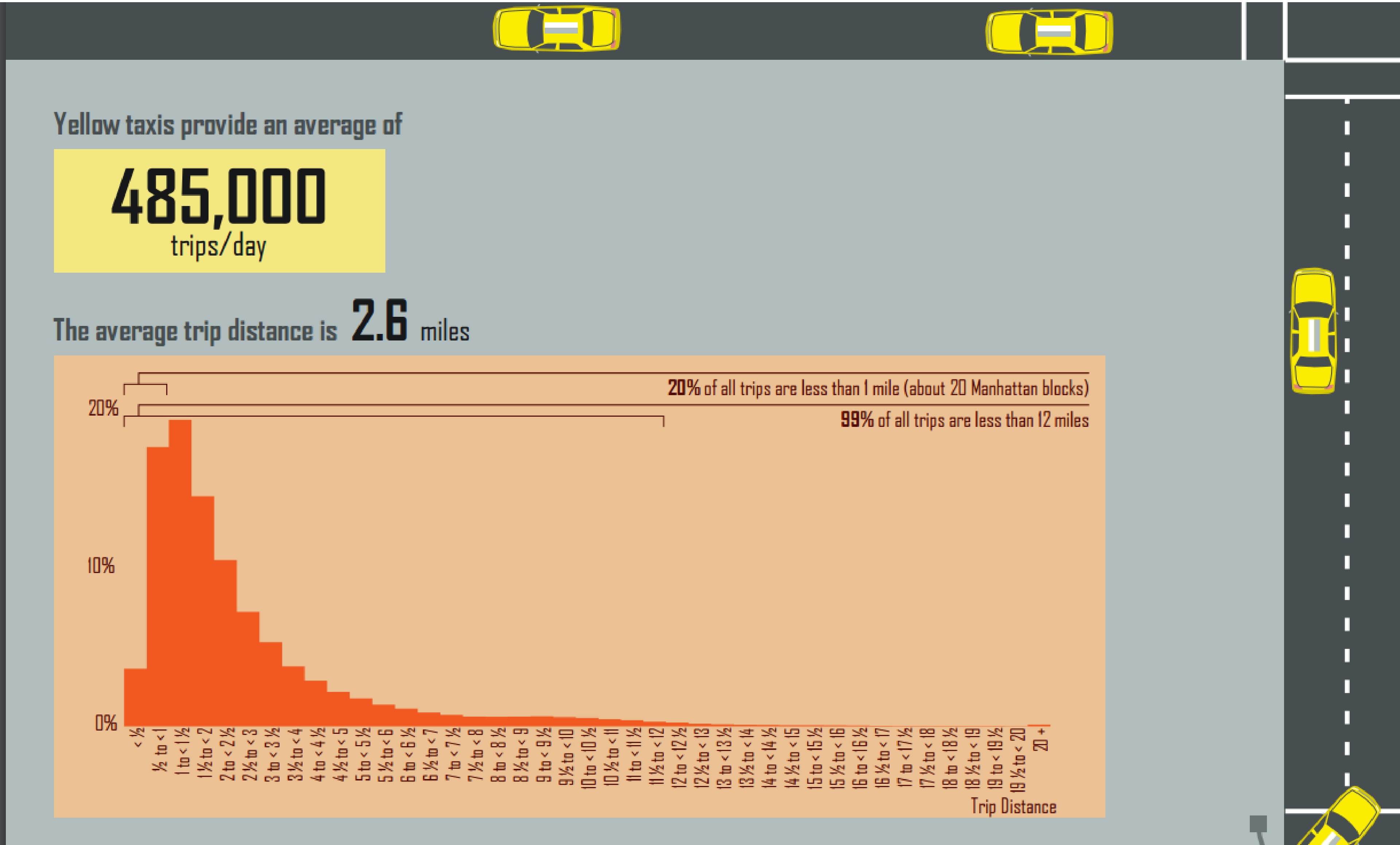
Swap it anywhere to replenish

Think SCM - near-zero inventory of fuel, the weight of fuel, inventory carrying cost and energy used to carry inventory

https://dspace.mit.edu/handle/1721.1/56251

Swap “atoms” form factor – a different way of thinking about a typical taxi ride

http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf



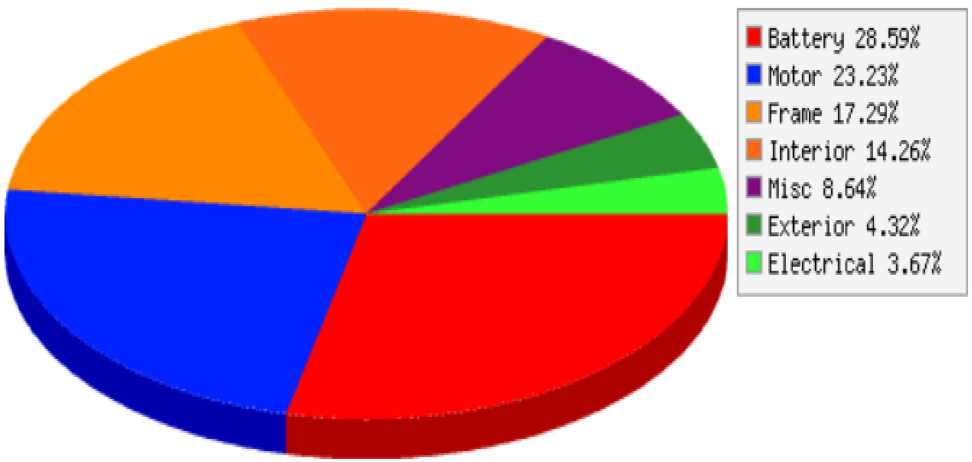
http://map.mathshell.org/download.php?fileid=1706

12 gallons

72 lb @ 6 lb/gal

Smaller cars generally have gas tanks that hold **12 gallons** worth of gas, while larger cars can hold 15 or **16 gallons**. For the purpose of this story, let's say gas costs $3.85 a gallon. A car with a **12**-gallon tank costs $46.20 to fill up while a larger car with a 15-gallon tank costs $57.75. Jul 5, 2013

TESLA MODEL S WEIGHT – 4,600+ LB



How much energy (inventory) and weight of energy (gas or battery) is a vehicle carrying for an average 2.6 mile trip?

Battery Pack **1323 lb**

- 1323 lb (1)

Aluminum Space Frame

- ~ 800 lb

Motor / Drivetrain

- ~ 350 lb – electric motor + inverter
- ~ 175 lb – differential
- ~ 250 lb – wheels + tires
- ~ 120 lb – brakes calipers, discs, lines
- ~ 80 lb – air suspension

Interior

- ~ 200 lb – front powered seats + rears
- ~ 190 lb – windshield, windows, hatch
- ~ 150 lb – pano glass and assembly
- ~ 80 lb – carpet, padding, mats
- ~ 40 lb – dash, trim, panels

Exterior

- ~200 lb – doors, frunk, hatch, body

Misc

www.teslarati.com/tesla-model-s-weight/

Swap “atoms” form factor – a different way of thinking about a typical taxi ride

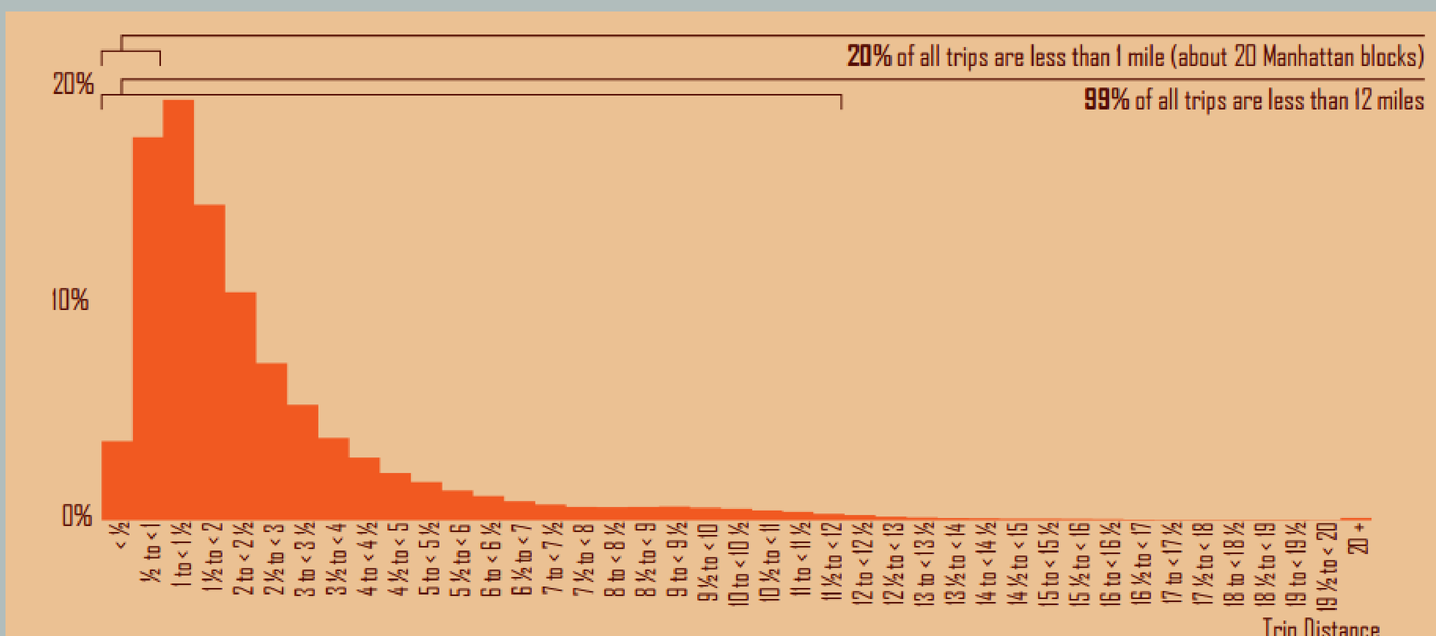
http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf

Yellow taxis provide an average of

485,000
trips/day

1300 lb battery for a 2.6 mile trip?

The average trip distance is **2.6** miles



http://map.mathshell.org/download.php?fileid=1706

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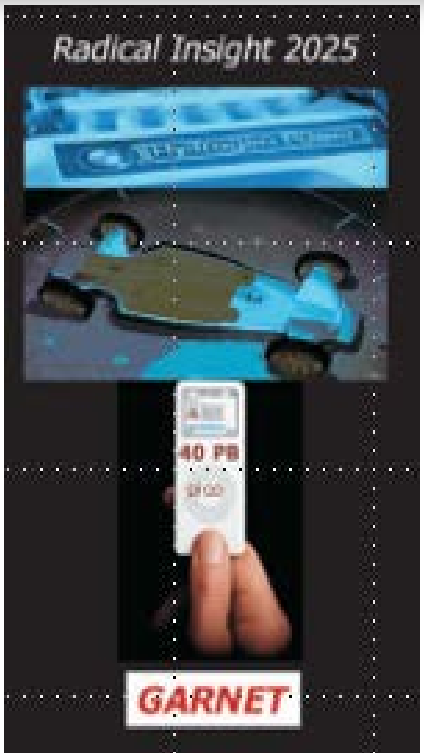
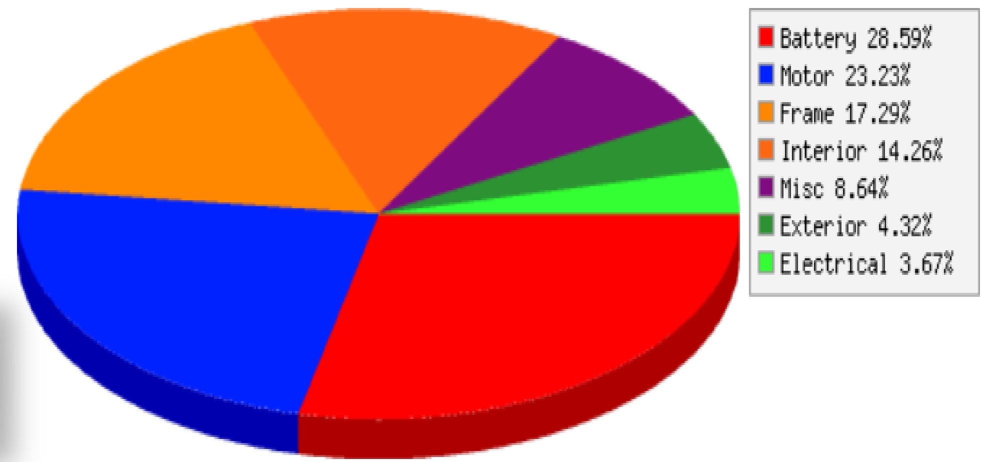
Change the equation!



10 gram Hydro-Stick
(Shoumen Datta, 2017)

TESLA MODEL S WEIGHT – 4,600+ LB



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- ~200 lb – doors, frunk, hatch, body

Misc

www.teslarati.com/tesla-model-s-weight/

Swap "atoms" form factor – Hydro-Stick of metallic Hydrogen is not a panacea

The form factor of energy and its source for transportation may undergo many radical metamorphoses because one solution may not suit all the different type of needs. Tesla's approach may be overdue for an overhaul.

New ideas. New solutions. New engineering.

Swap "atoms" form factor – a different way of thinking about mobility of matter

Secure | https://www.technologyreview.com/s/531911/isaac-asimov-asks-how-do-people-get-new-ideas/

A person willing to fly in the face of reason, authority, and common sense must be a person of considerable self-assurance. Since he occurs only rarely, he must seem eccentric (in at least that respect) to the rest of us. A person eccentric in one respect is often eccentric in others.

Consequently, the person who is most likely to get new ideas is a person of good background in the field of interest and one who is unconventional in his habits. (To be a crackpot is not, however, enough

ISAAC ASIMOV

The NEW normal – SERVICES – not “things”

Why the Internet of Things is not only about “Things”

IoT is a design metaphor

IoT needs identity of things

IoT is identification of things

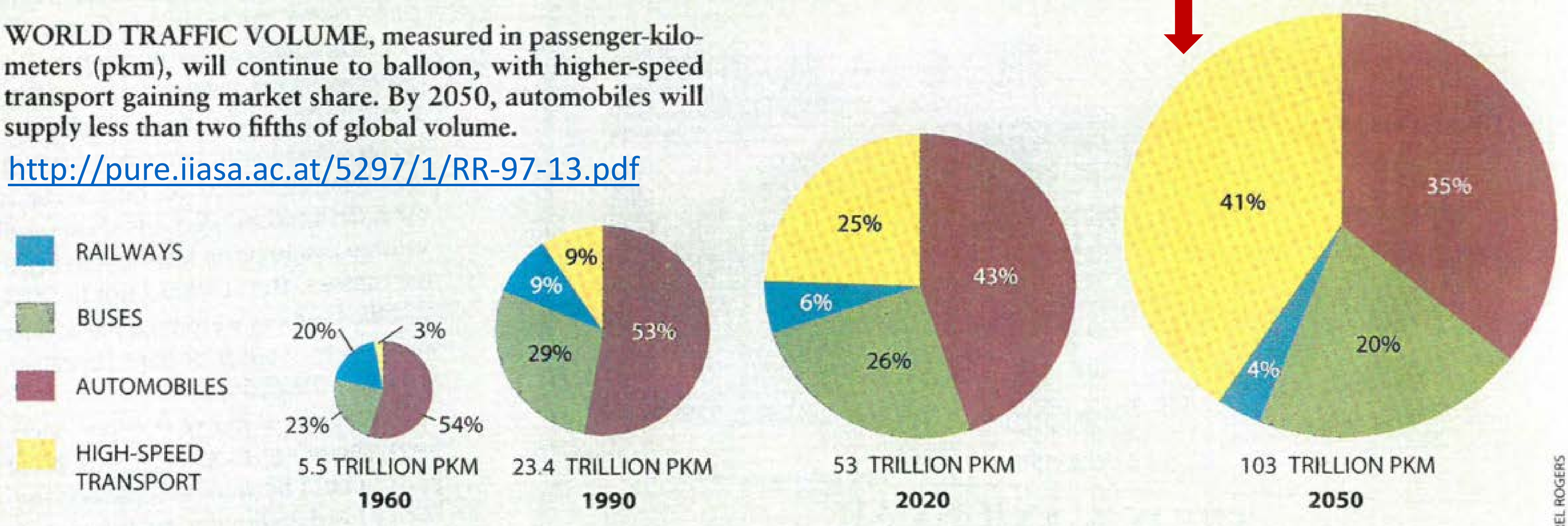
1997 - Prediction by Schafer and Victor (MIT)

By 2050, automobiles will supply less than two fifths of global volume

Share of High Speed Transport in 2050 = 41%

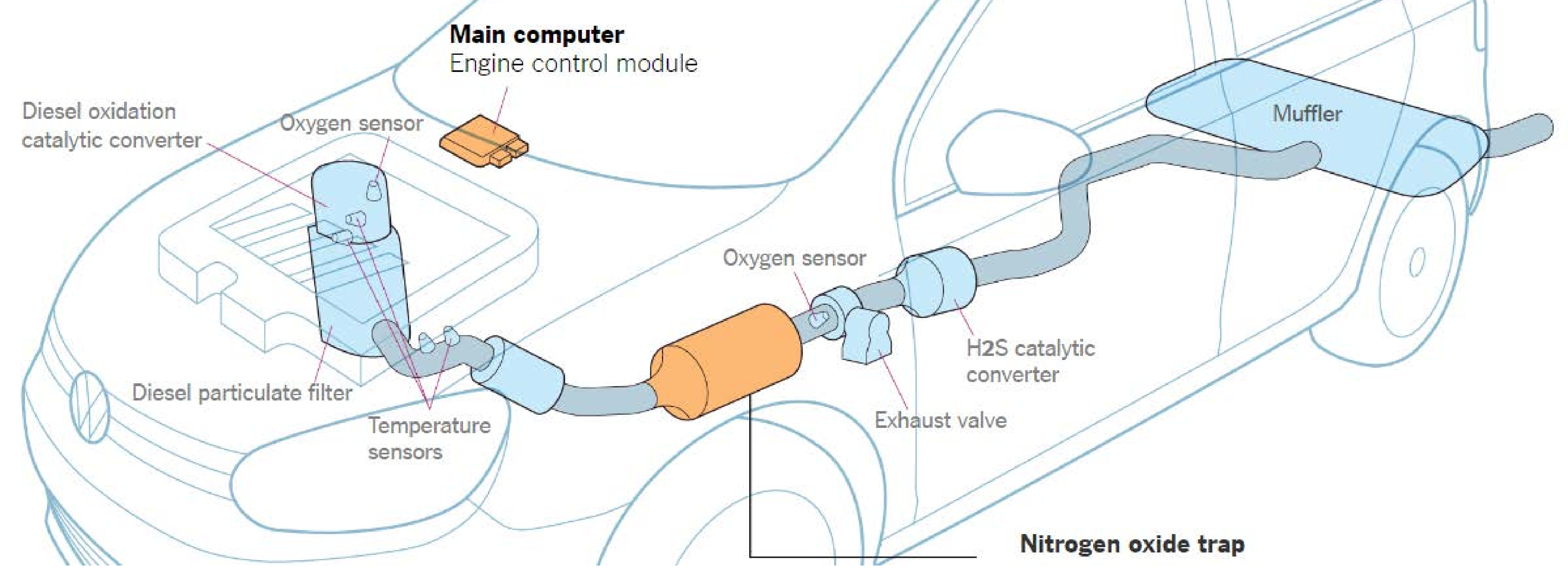
WORLD TRAFFIC VOLUME, measured in passenger-kilometers (pkm), will continue to balloon, with higher-speed transport gaining market share. By 2050, automobiles will supply less than two fifths of global volume.

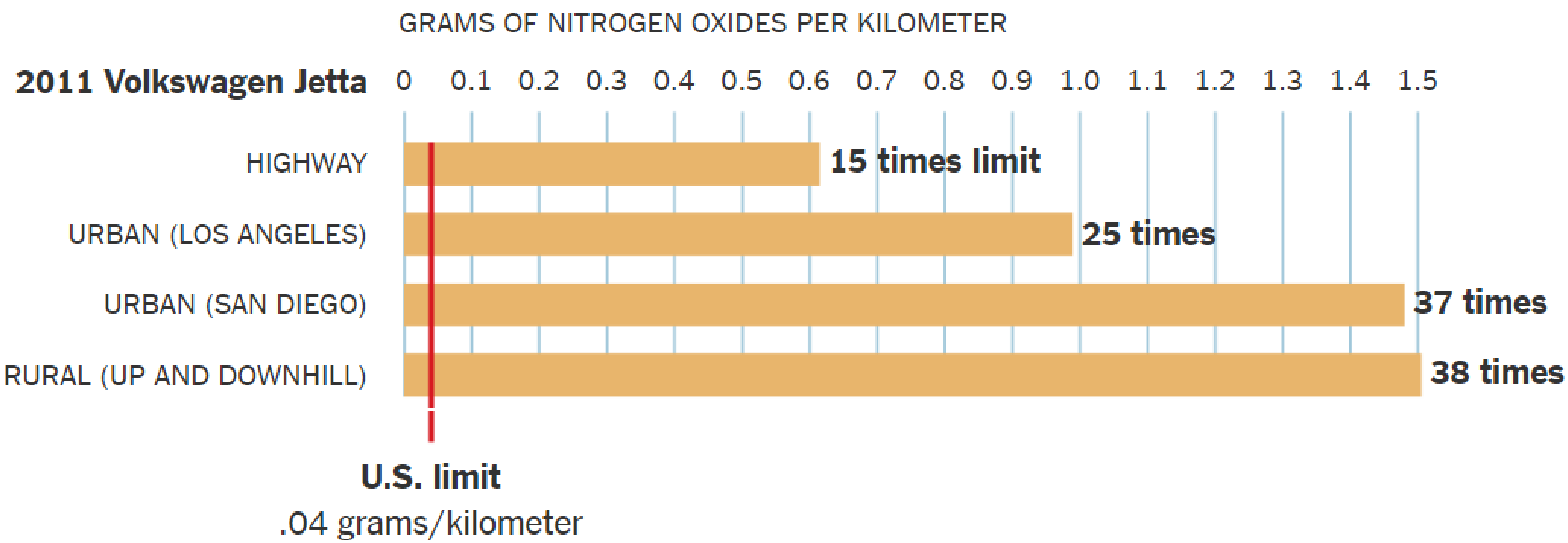
http://pure.iiasa.ac.at/5297/1/RR-97-13.pdf



SOURCE: Andreas Schafer and David Victor

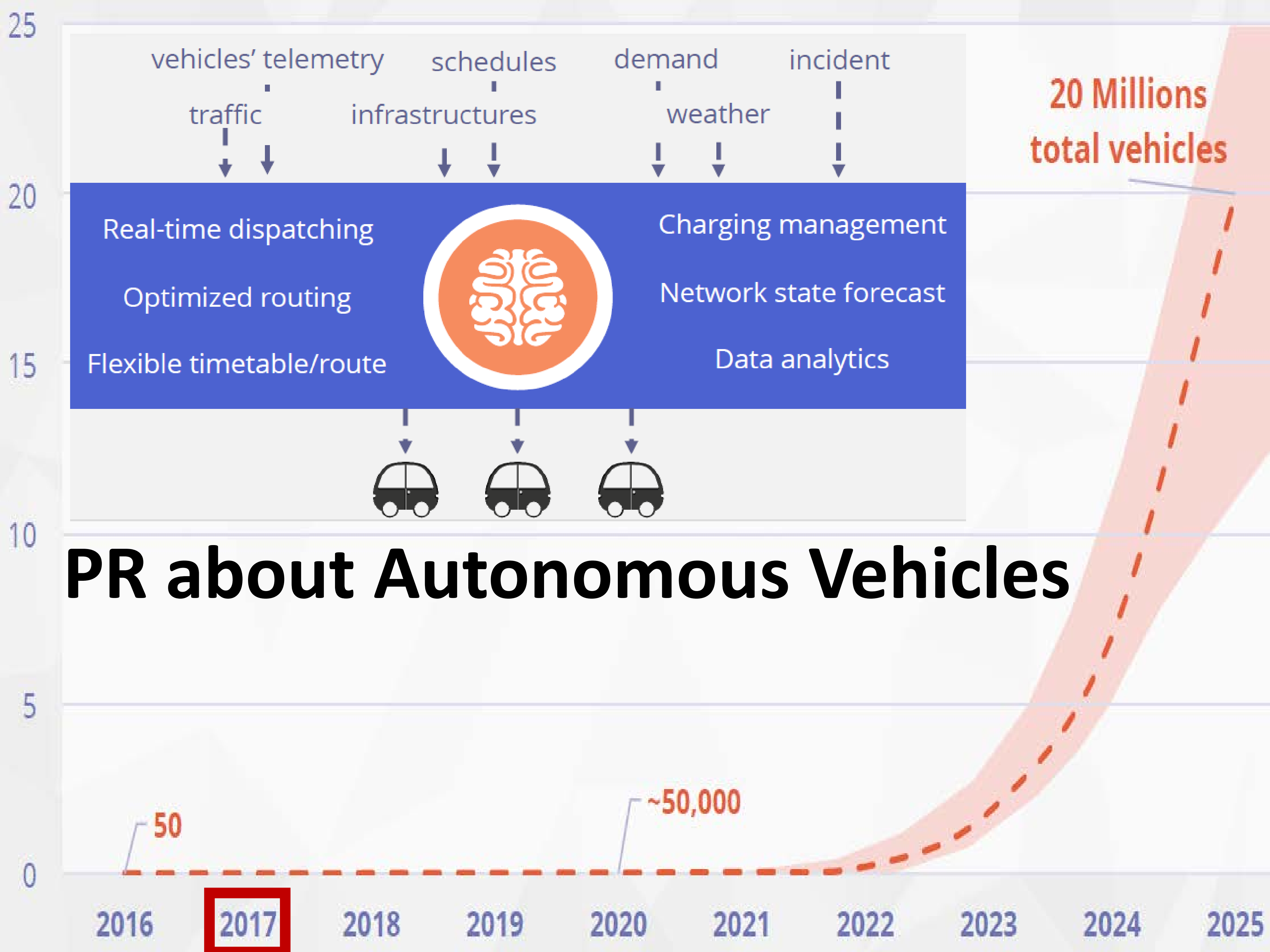
Problems at hand



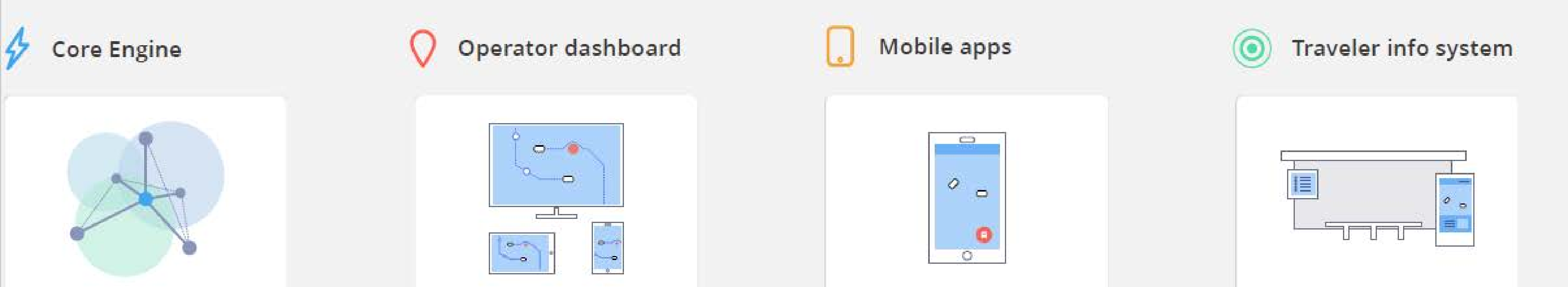


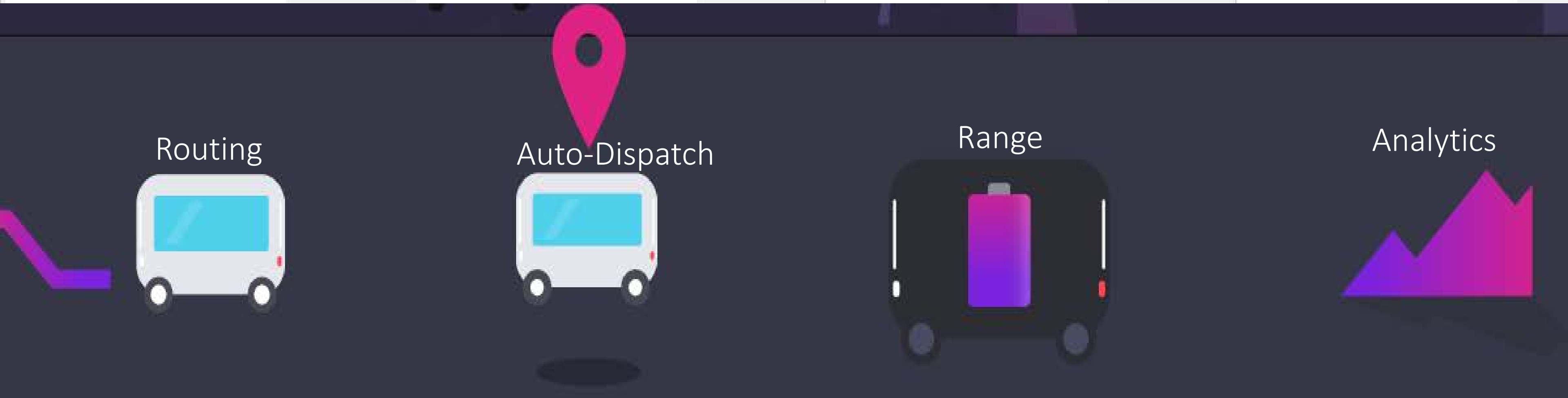
Source: Arvind Thiruvengadam, Center for Alternative Fuels, Engines and Emissions at West Virginia University

PR about Autonomous Vehicles



PR about Autonomous Vehicles



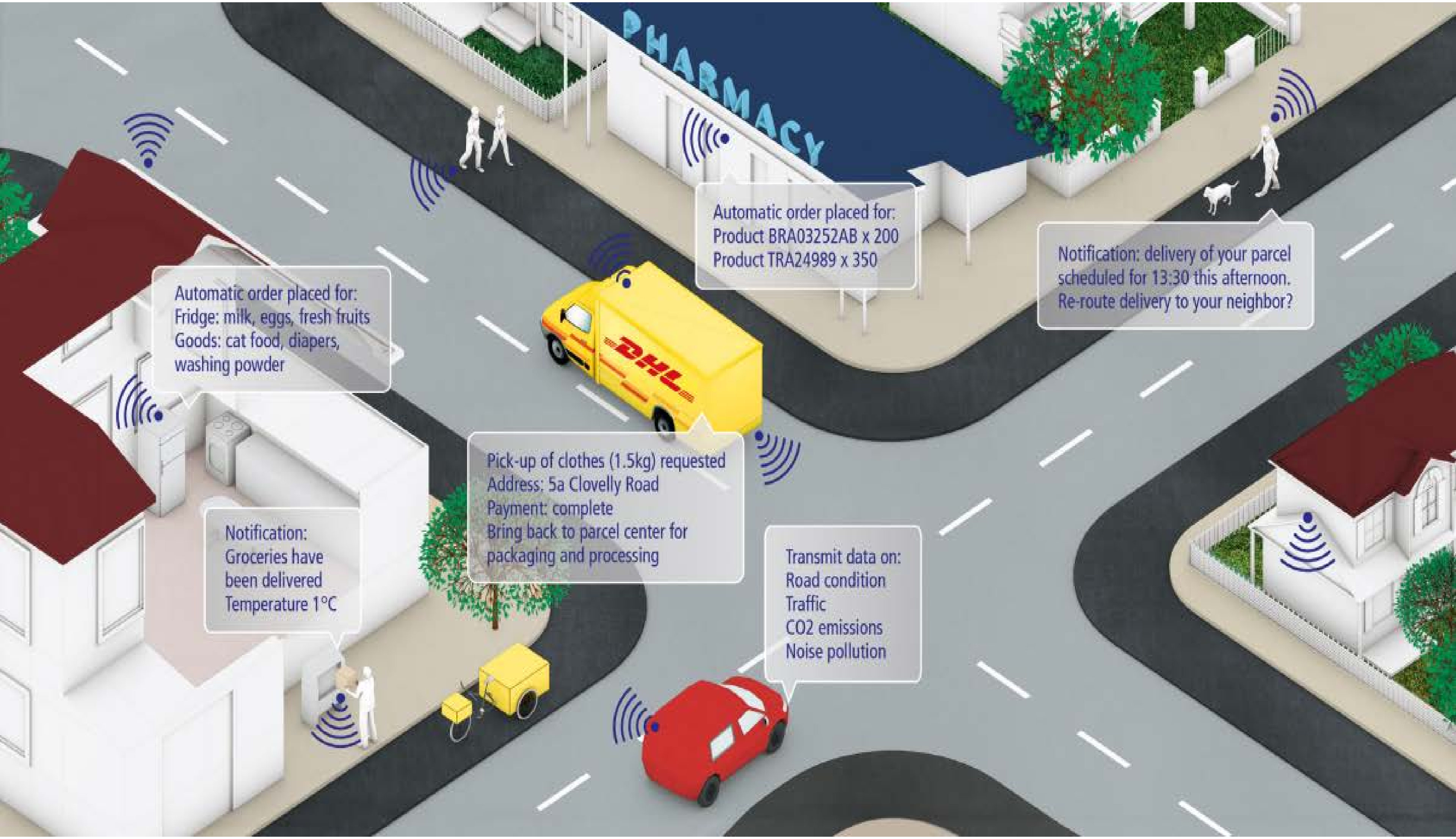


Autonomous Vehicles

May start to become useful 2035-2040

Can Smart Cities improve supply chain, logistics and transportation of freight?

SMART CITY LOGISTICS - REQUIRE UBIQUITOUS SYSTEMIC CONNECTIVITY



http://bit.ly/DHL-IOT

Focus on Freight

http://bit.ly/ALIBABA-AND-40-DRONES

Ports of LA and Long Beach, CA
February 6, 2015

In praise of inefficiency - Average speed of trucks

5.60 mph

3.46 million class 8 trucks in the US travelled 169.8 billion miles in 2014

1.01 mph

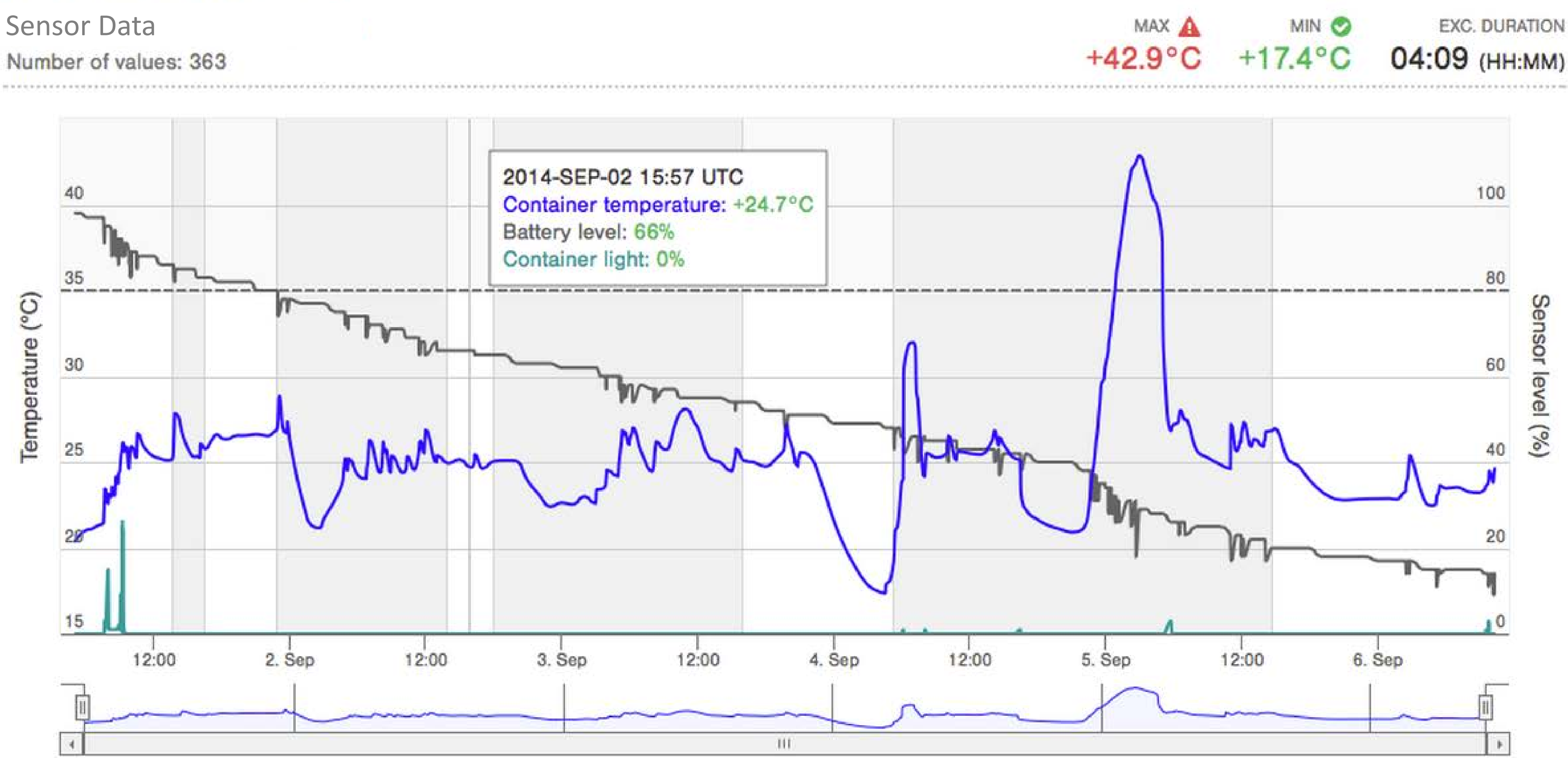
31.4 million trucks registered in US travelled 279.1 billion miles in 2014

http://www.trucking.org/News_and_Information_Reports_Industry_Data.aspx

Autonomous Transportation ? Analyze This !!

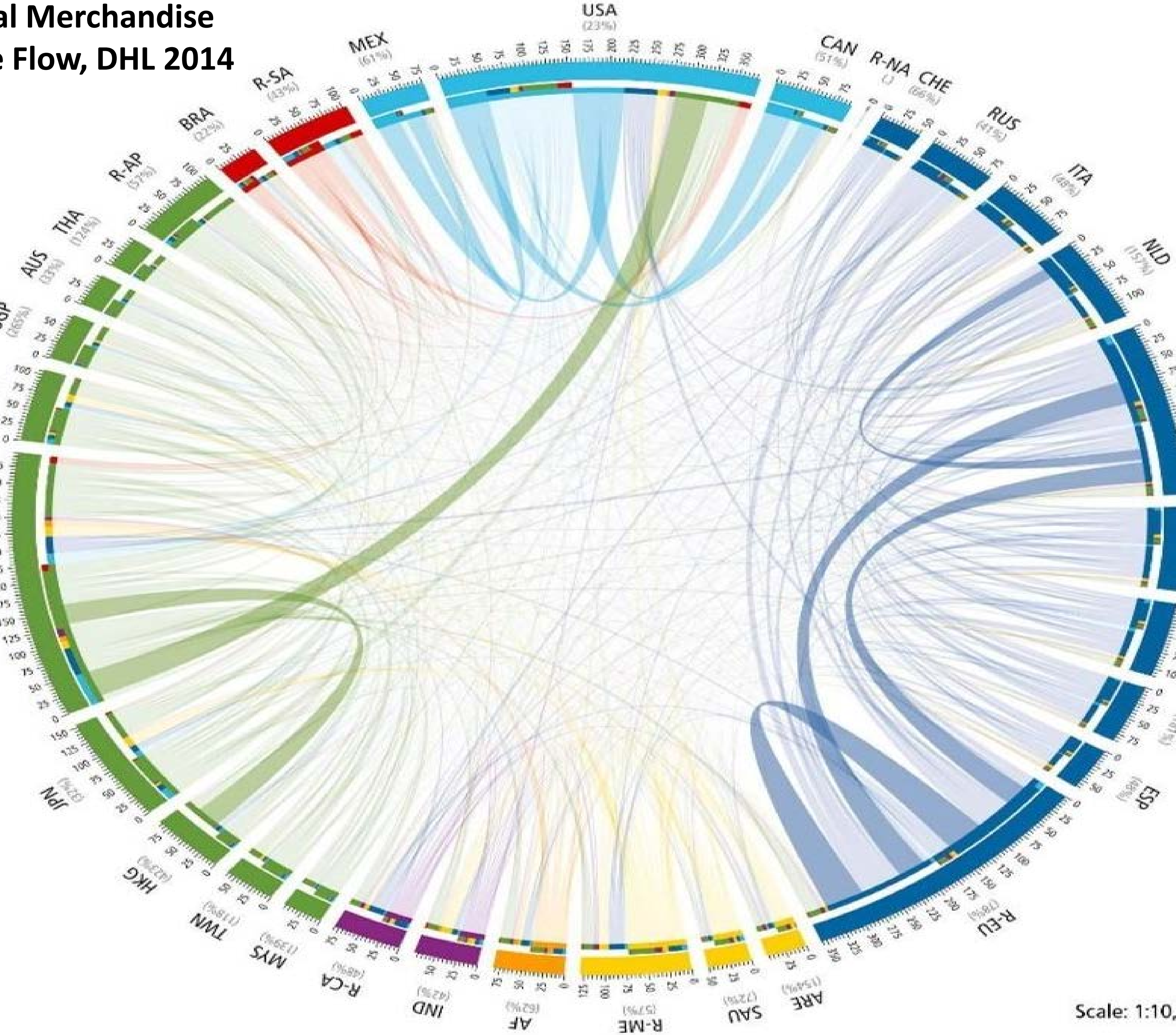
Why focus on freight ?

Refrigerated transport of perishable food items and bio-pharmaceuticals (vaccines) critical to life



www.starbright.se/growth-in-refrigerated-transports/

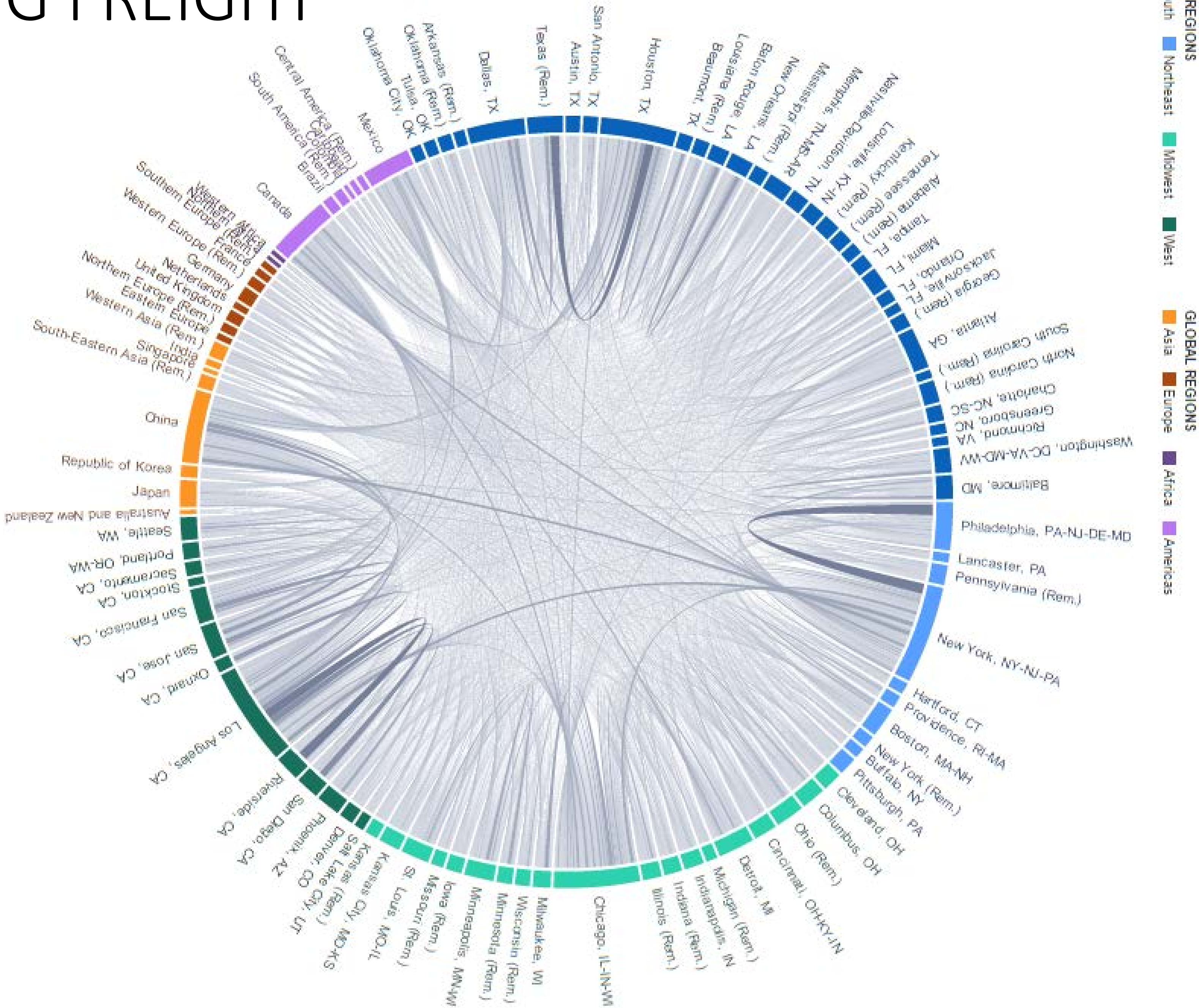
Global Merchandise Trade Flow, DHL 2014



Scale: 1:10,000,000,000

www.dhl.com/content/dam/Campaigns/gci2014/downloads/dhl_gci_2014_study_high.pdf

MAPPING FREIGHT



www.brookings.edu/~/media/Research/Files/Reports/2014/11/freight%20networks/Srvy_GCIFreightNetworks_Oct24.pdf

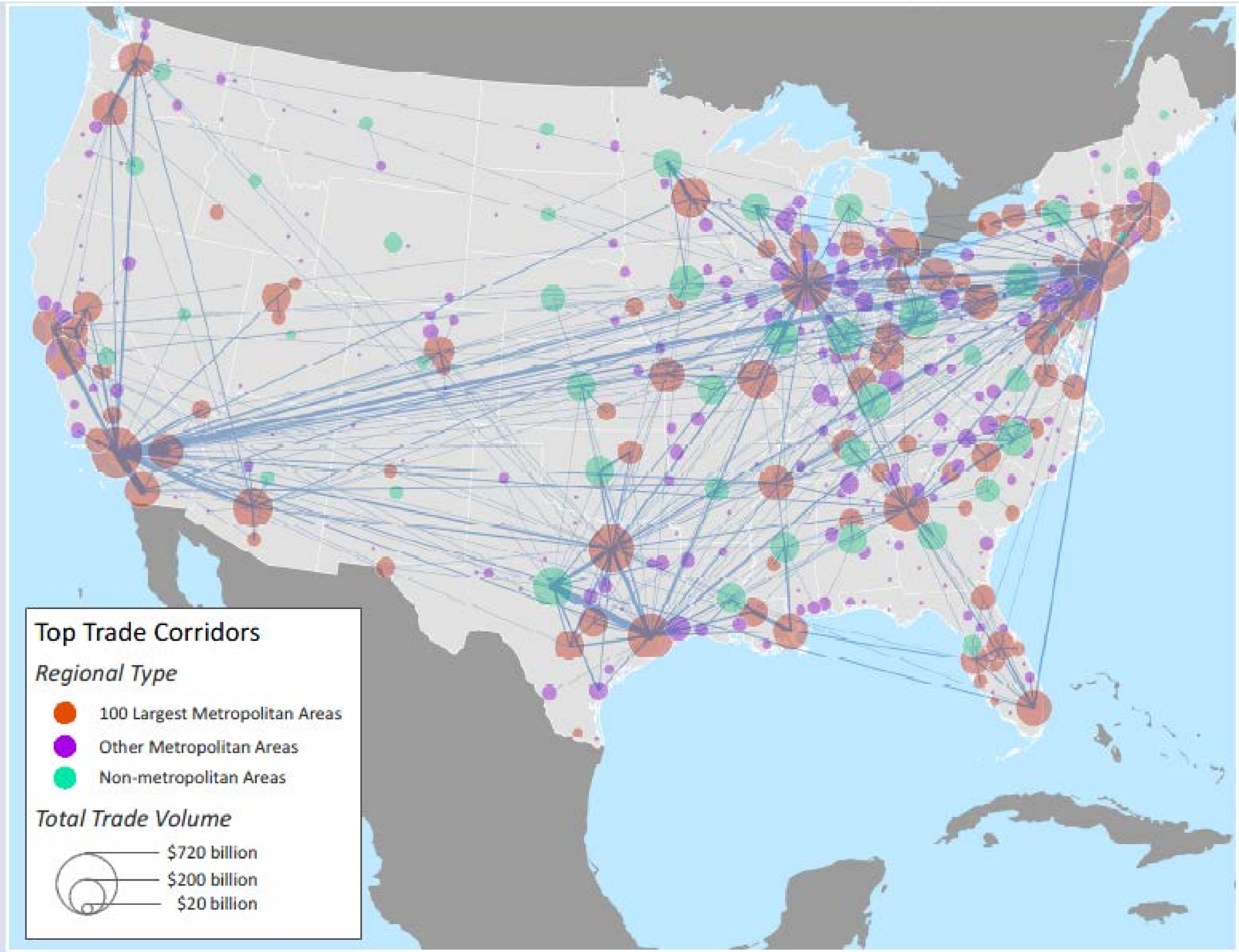
National Goods Trade ($20 trillion) exceeds GDP $15 trillion

		Destination				
		100 Metro Areas	Other Metro Areas	Non-Metro Areas	International	Total $ (millions)
Origin	100 Metro Areas	$6,345,676.8	$2,120,203.7	$1,755,438.9	$746,583.5	$10,967,902.9
	Other Metro Areas	$2,074,231.9	$824,166.1	$754,764.3	$258,508.2	$3,911,670.6
	Non-Metro Areas	$1,967,359.5	$865,213.4	$526,407.0	$240,862.9	$3,599,842.7
	International	$1,183,735.7	$363,097.0	$267,598.8	---	$1,814,431.4
	Total	*$11,571,003.9*	*$4,172,680.2*	*$3,304,208.9*	*$1,245,954.6*	*$20,293,847.6*

10% of US trade corridors move ~80% of all goods, the most valuable of which are concentrated in the country's 100 largest metropolitan areas. The national trade network—which includes the exchange of goods between different metropolitan areas, non-metropolitan areas, and foreign countries—moved $20.3 trillion worth of goods in 2010 (Brookings Institution, November 2014)

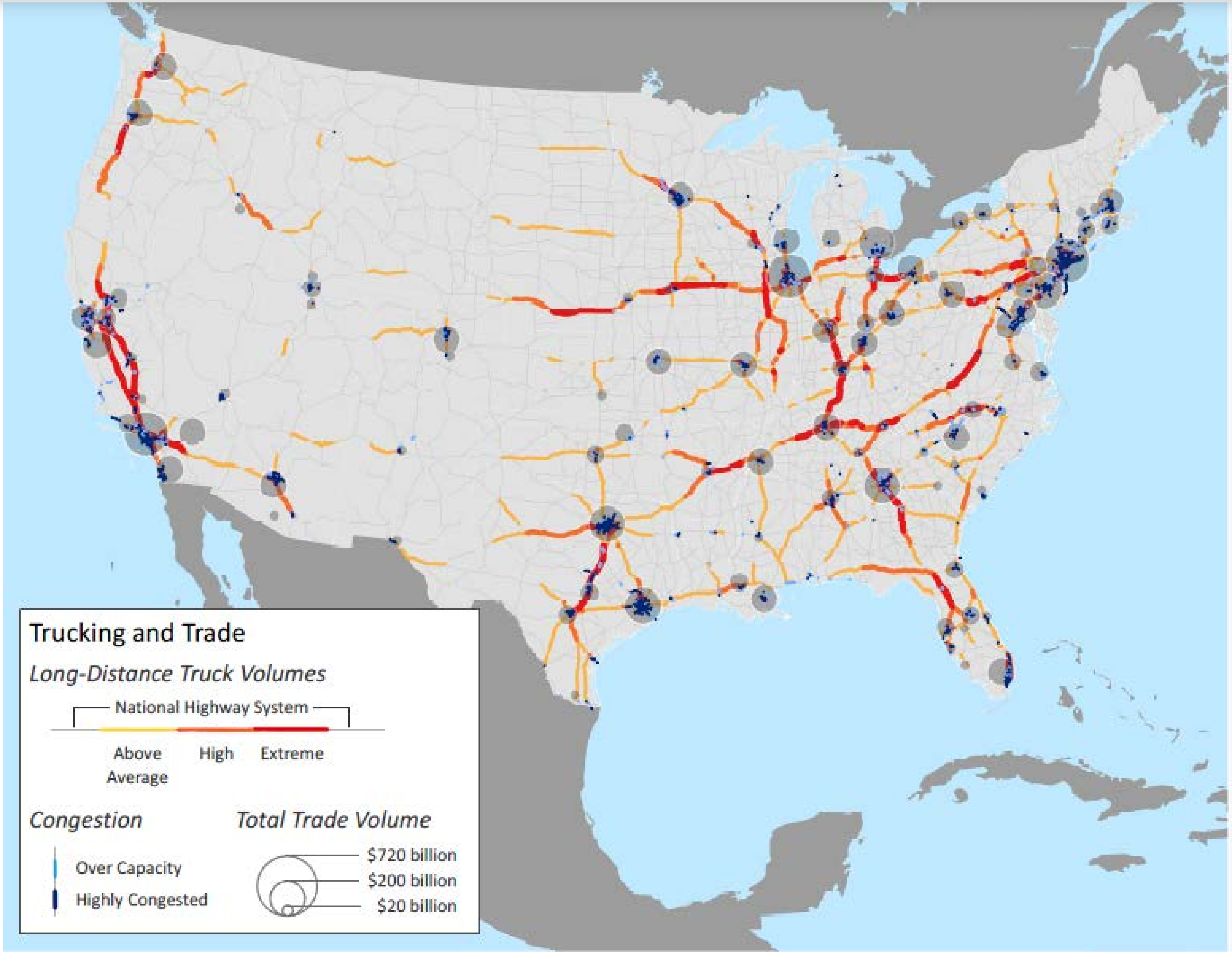
www.brookings.edu/~/media/Research/Files/Reports/2014/11/freight%20networks/Srvy_GCIFreightNetworks_Oct24.pdf

Top 1% of corridors (888 corridors) traded goods worth $4.4 trillion (2010)

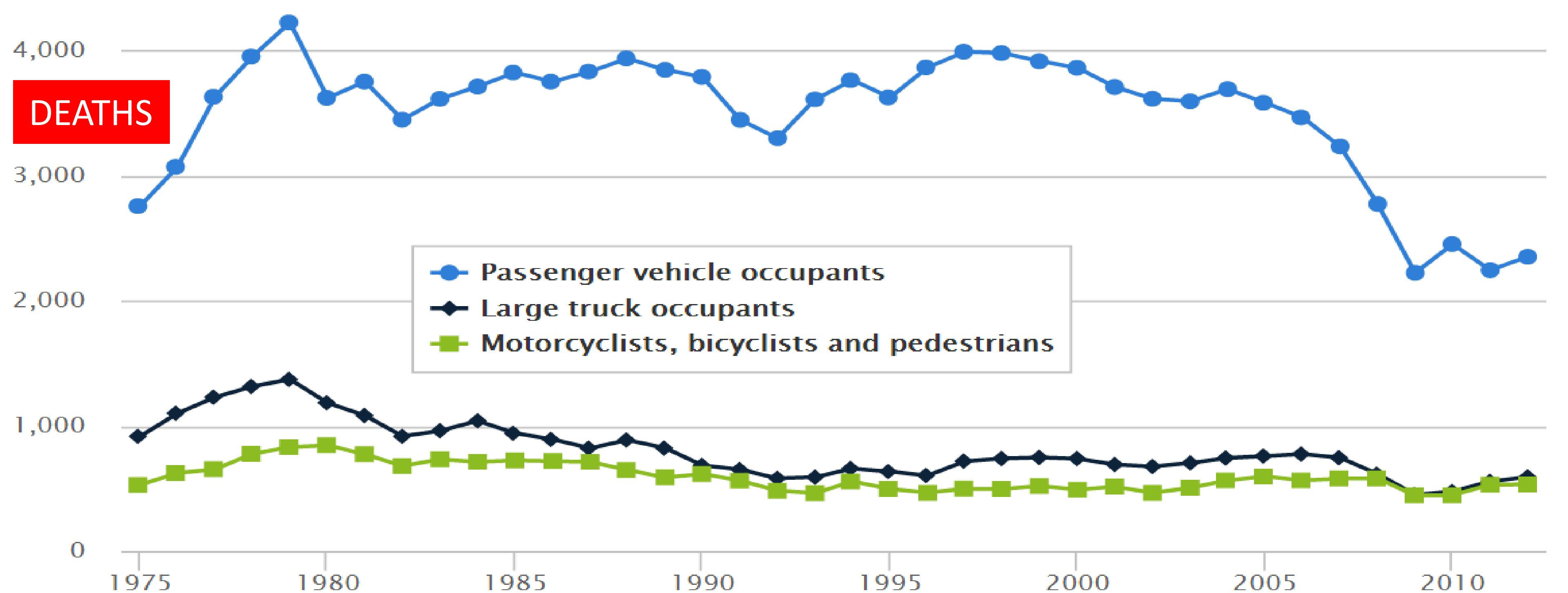


www.brookings.edu/~/media/Research/Files/Reports/2014/11/freight%20networks/Srvy_GCIFreightNetworks_Oct24.pdf

Long Distance Truck Loads and Highway Congestion

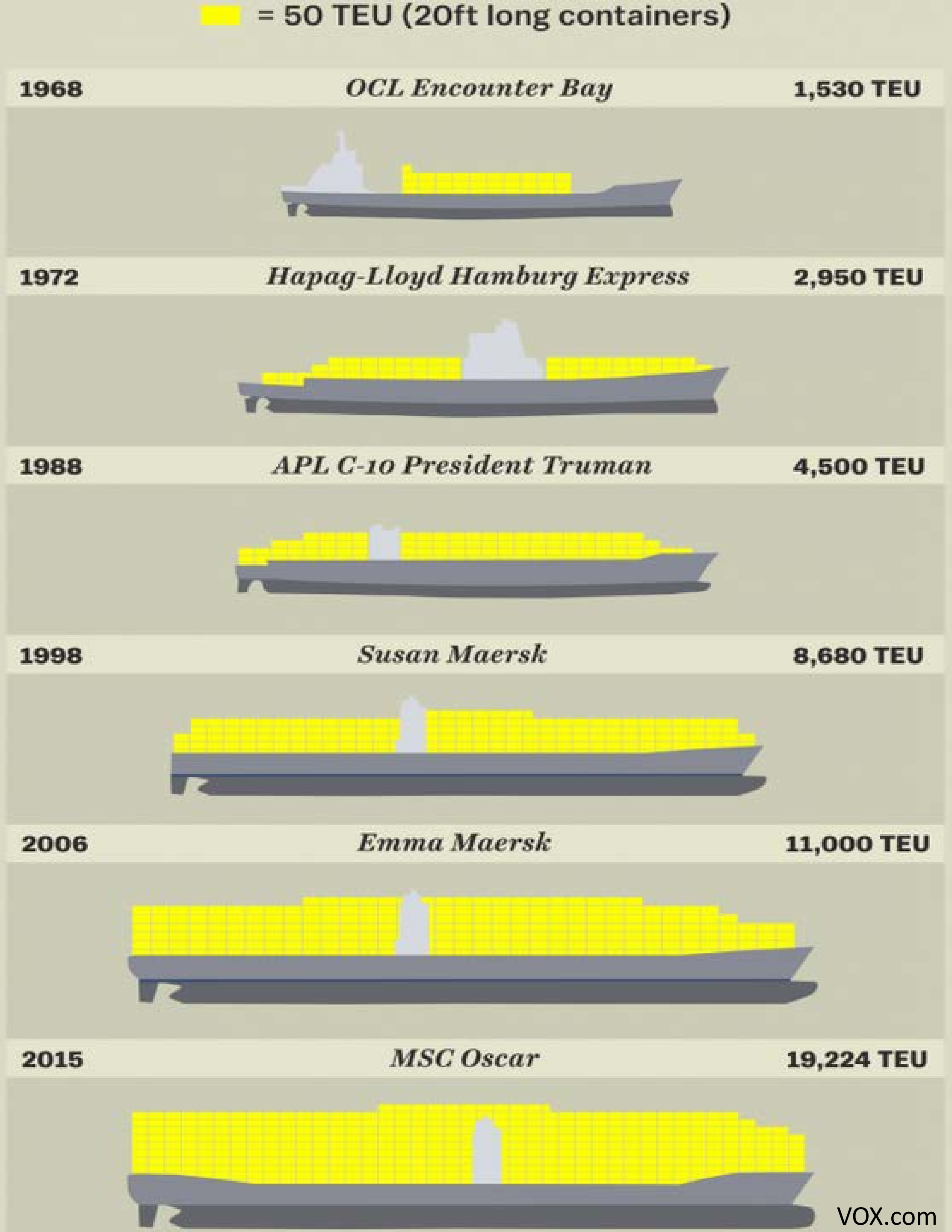


www.brookings.edu/~/media/Research/Files/Reports/2014/11/freight%20networks/Srvy_GCIFreightNetworks_Oct24.pdf



www.iihs.org/iihs/topics/t/large-trucks/fatalityfacts/large-trucks

PORTS



= 50 TEU (20ft long containers)
1968 OCL Encounter Bay 1,530 TEU
1972 Hapag-Lloyd Hamburg Express 2,950 TEU
1988 APL C-10 President Truman 4,500 TEU
1998 Susan Maersk 8,680 TEU
2006 Emma Maersk 11,000 TEU
2015 MSC Oscar 19,224 TEU
VOX.com

Smarter Planning Tools?

When the concept of smart cities matures from models to mainstream, city planners will need tools that may not exist within their knowledge base, at present. This section proposes creation of tools which may be useful to determine requirements of cities on their journey to become smart cities or participate in smart ecosystems.

If we build a 10 floor apartment complex or a 25-story office tower with a retail floor or a shopping arcade plus a playground

How does it affect the neighborhood, facilities, transportation, energy load balancing, water and sewer systems, carbon dioxide and noise pollution?

Can you answer the question?

Yes, we’ll have to work out each version of the plan.

What if you had a tool where you plug in your numbers, criteria and the user requirements?

This is a tool Smart Cities can use globally, rather than re-inventing the wheel for every configuration

AVM Component Model

The creation of a digital duplicate as an entity level agent based model is essential to analytics and simulation of what-if scenarios (deterministic) to better prepare for the non-deterministic states (emergency). This approach is not limited to any field but crucial for any “atom” with connected bits (data).

Digital duplication will be the underpinning of all most all elements in the context of connectivity (IoT, IIoT). Data from each individual node of this model (eg sensor data from each part in a machine with hundreds of parts) will feed the digital duplicate connected to algorithm engines in the cloud to drive real-time analytics, provide feedback to improve efficiency or precision of the machine or device or process or decision support system in a manner that is context-aware and delivers intelligence at the edge to boost autonomy.

Meta Tool Suite Architecture

Can we create that tool?

http://norvig.com/design-patterns/design-patterns.pdf


YES, WE CAN.

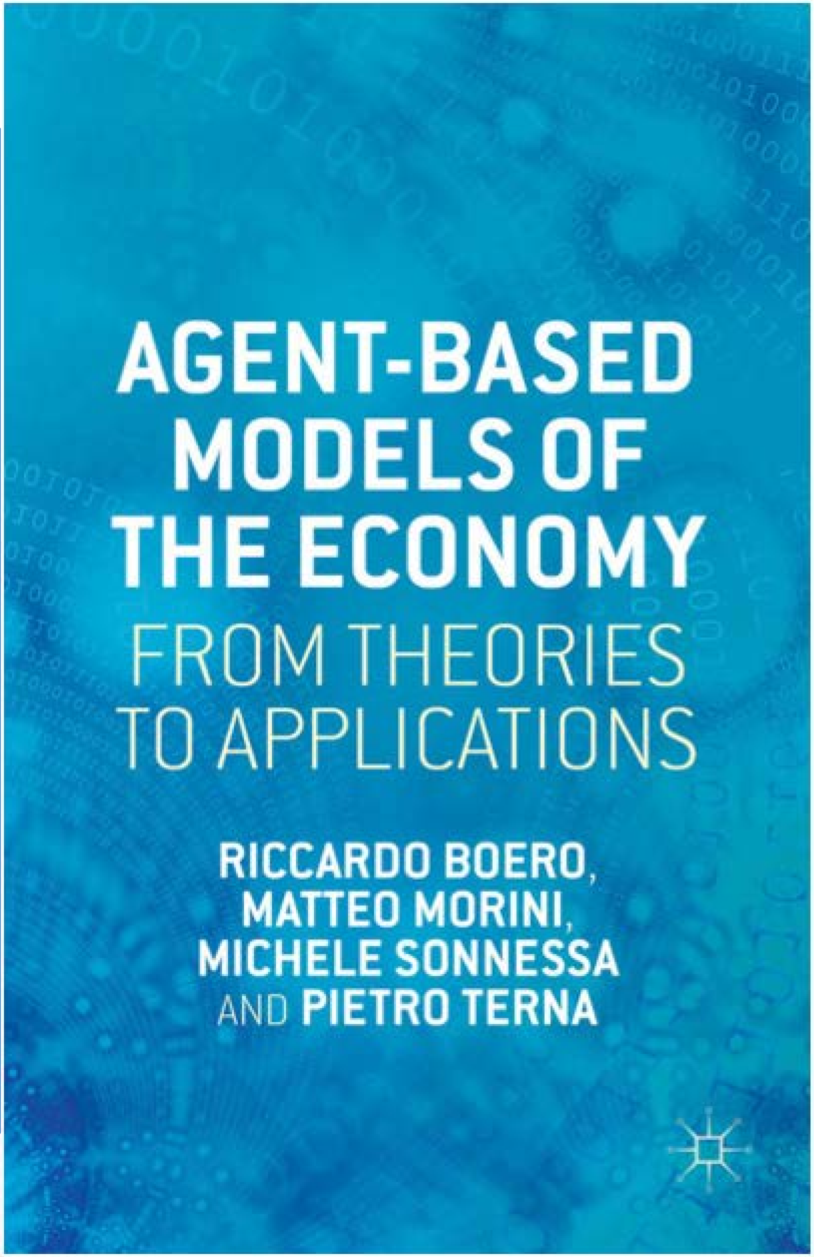
Nature **460**, 685-686 (6 August 2009) | doi:10.1038/460685a
5 August 2009 http://tuvalu.santafe.edu/~jdf/papers/EconomyNeeds.pdf

The economy needs agent-based modelling

J. Doyne Farmer[1] & Duncan Foley[2]

The leaders of the world are flying the economy by the seat of their pants, say J. Doyne Farmer and Duncan Foley. There is, however, a better way to help guide financial policies.

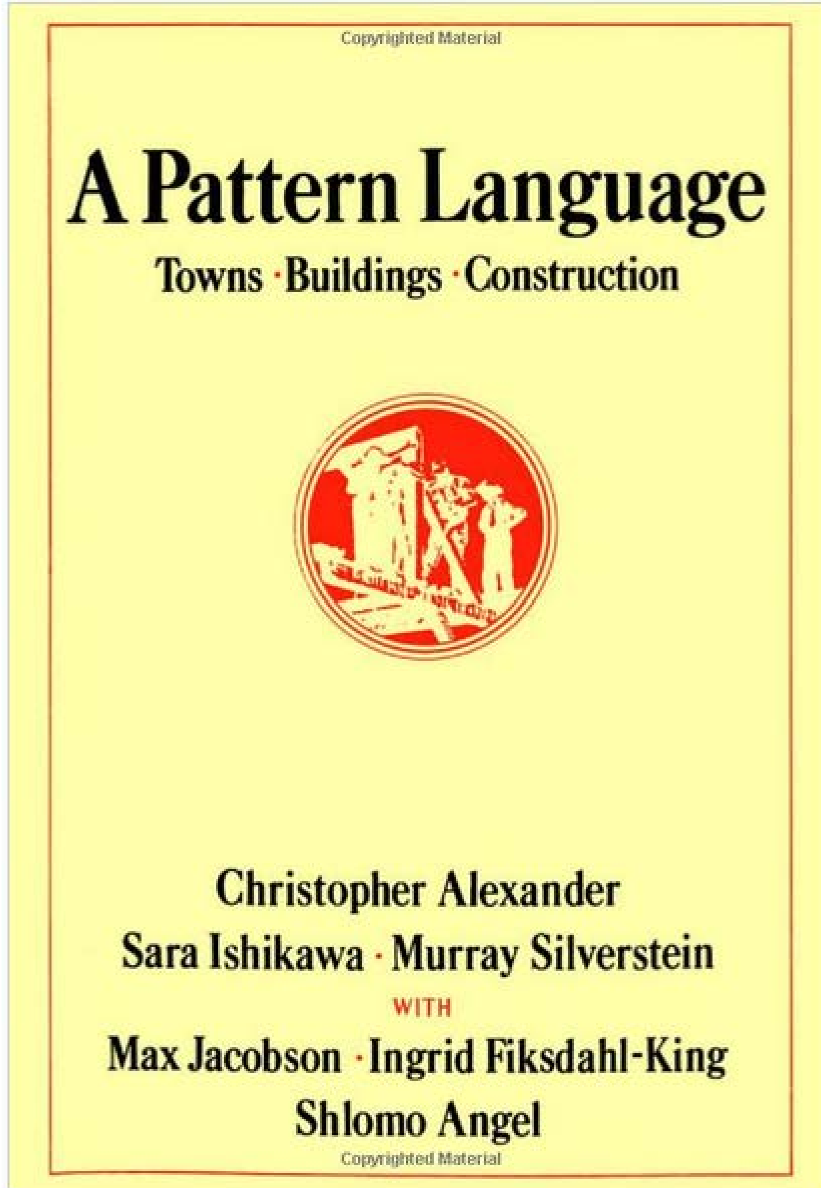
In today's high-tech age, one naturally assumes that US President Barack Obama's economic team and its international counterparts are using sophisticated quantitative computer models to guide us out of the current economic crisis. They are not.



http://rajivsethi.blogspot.com/2010/02/case-for-agent-based-models-in.html

Re-visit an old idea

with new eyes


Copyrighted Material
A Pattern Language
Towns · Buildings · Construction
Christopher Alexander
Sara Ishikawa · Murray Silverstein
WITH
Max Jacobson · Ingrid Fiksdahl-King
Shlomo Angel
Copyrighted Material

1977

The contribution to the street.

Section 246 on page 1137 in Pattern Language by Christopher Alexander (1977)
http://library.uniteddiversity.coop/Ecological_Building/A_Pattern_Language.pdf

Pattern Language

We have to re-visit “pattern” in terms of smart city concepts and apply the same principles in this tool

The "Pattern Language" Revolution

- **Creational patterns:**
  - Deal with initializing and configuring classes and objects
- **Structural patterns**:
  - Deal with decoupling interface and implementation of classes and objects
  - Composition of classes or objects
- **Behavioral patterns**:
  - Deal with dynamic interactions among societies of classes and objects
  - How they distribute responsibility

OOP

UML

JAVA

- *A Pattern Language: Towns, Buildings, Construction,* Christopher Alexander, 1977
- *The Timeless Way of Building,* Christopher Alexander, 1979
- *Using Pattern Languages for Object-Oriented Programs* (a paper at the OOPSLA-87 conference), Ward Cunningham and Kent Beck, 1987
- *Design Patterns,* Erich Gamma, Richard Helm, John Vlissides, and Ralph Johnson (known as the "Gang of Four", or GoF), 1994
- *Refactoring: Improving the Design of Existing Code,* Martin Fowler, 2000

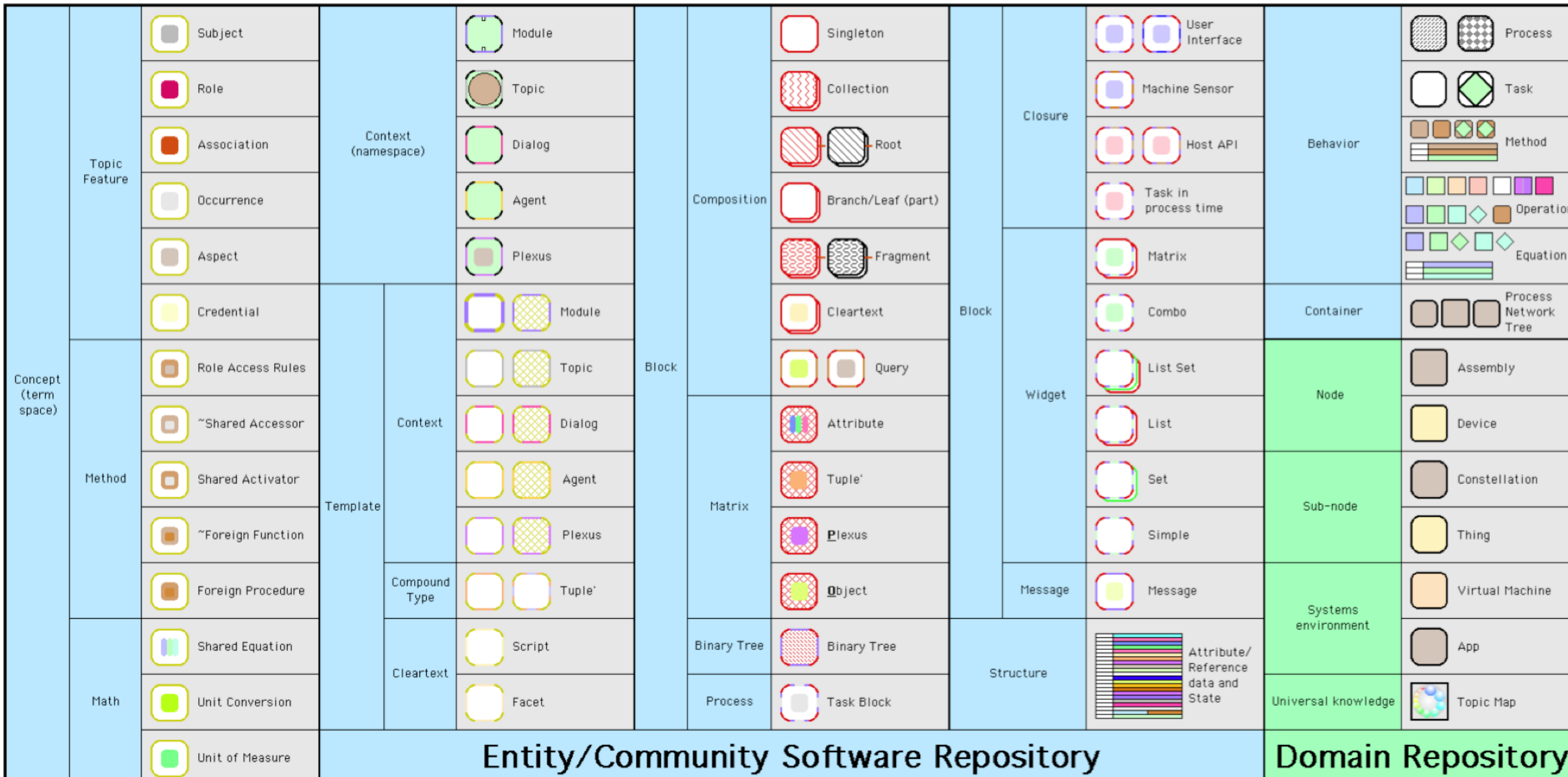
For Smart Cities - elements of this “tool” may need innovation similar to network design and planning

What factors may influence the use and ecosystem of a building (or shopping mall or train station or park area)

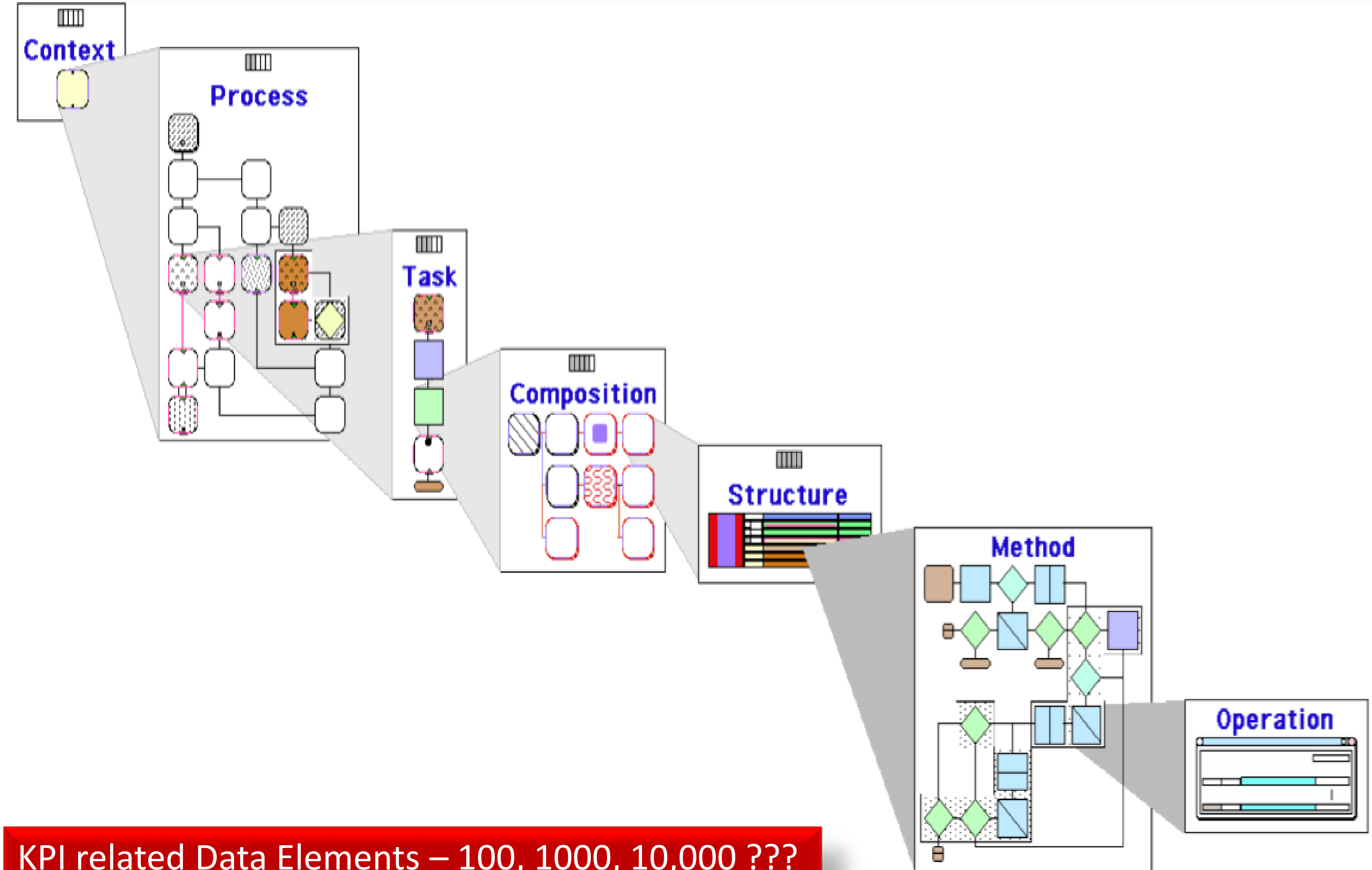
- How many people occupy the building during what hours?
- How many people may visit these offices?
- How many parking spaces will be necessary?
- Where will the occupants and visitors park?
- How long will it take to enter/exit during rush hour?
- What type of traffic condition it may create locally?
- What provisions are there for public transportation?
- How many people may use the toilets at what frequency?
- How much water will be used in the building?
- How much energy will be consumed?
- What type of waste will be generated?

Can we use entity level model building?

The illustration below is only to indicate that each element will have to be decomposed and associated with characteristics or attributes. For example, if a toilet flushes 4.6L of water per use then it is a characteristic associated with that element / object. The number of flushes will be dependent on rate of use which is dependent on occupancy of the area.



Each object associated with attributes, task, process, etc.

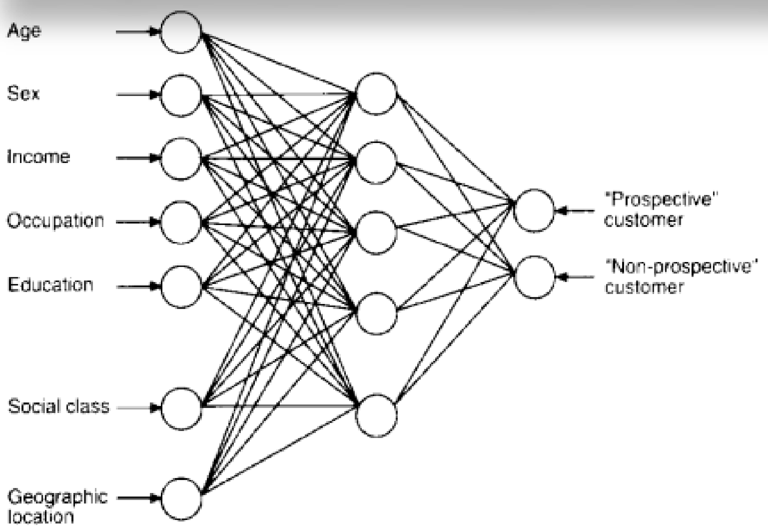


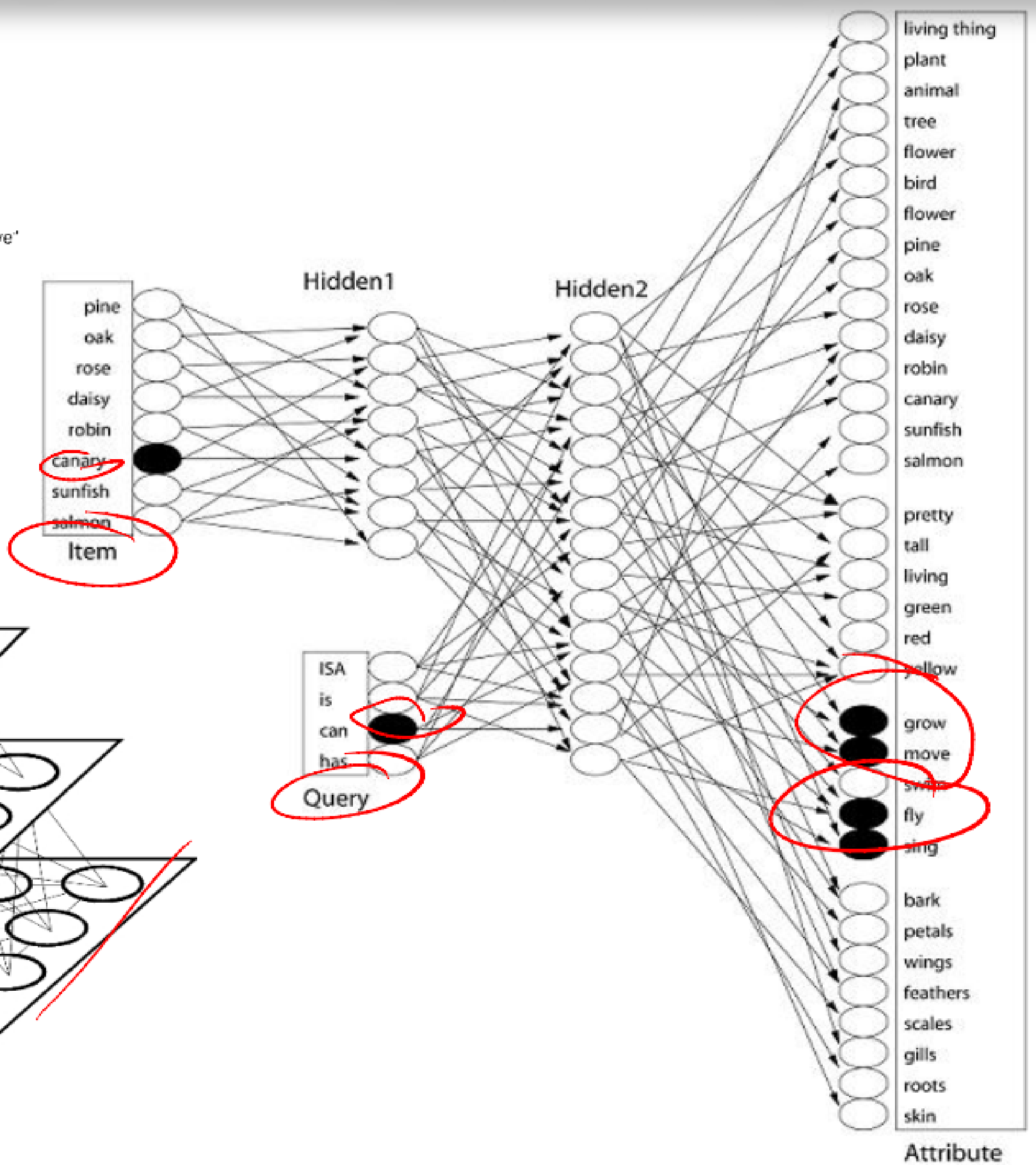
KPI related Data Elements – 100, 1000, 10,000 ???

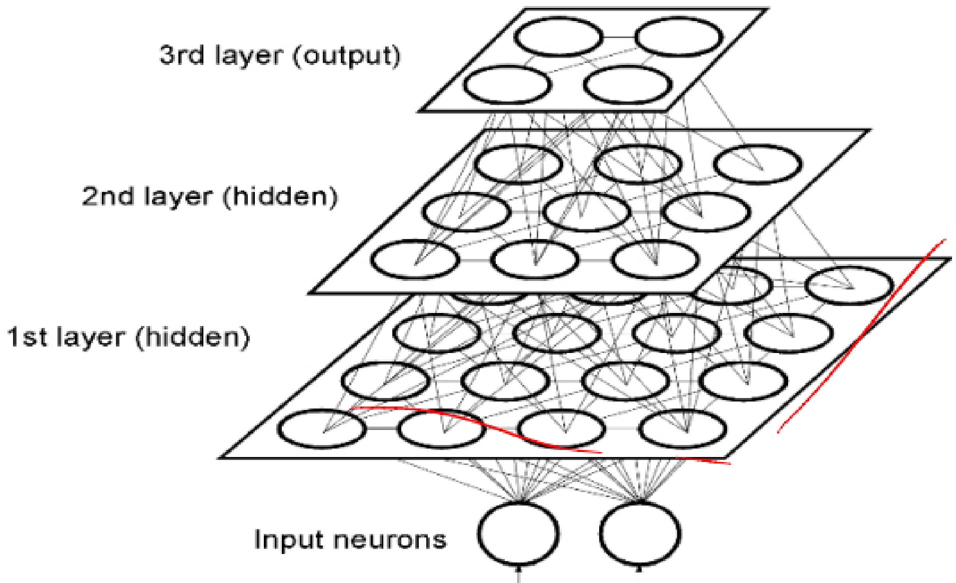
Planners only need to assign (numeric/semantic) values to applicable attributes

- accessibility
- accountability
- accuracy
- adaptability
- administrability
- affordability
- agility
- auditability
- availability
- credibility
- standards compliance
- process capabilities
- compatibility
- composability
- configurability
- correctness
- customizability
- degradability
- demonstrability
- dependability
- deployability
- distributability
- durability
- evolvability
- extensibility
- fidelity
- flexibility
- installability
- integrity
- interchangeability
- interoperability
- learnability
- maintainability
- manageability
- mobility
- modularity
- nomadicity
- operability
- portability
- precision
- predictability
- recoverability
- relevance
- reliability
- repeatability
- reproducibility
- responsiveness
- reusability
- robustness
- safety
- scalability
- seamlessness
- serviceability (a.k.a. supportability)
- securability
- simplicity
- stability
- survivability
- sustainability
- tailorability
- testability
- timeliness
- understandability
- usability

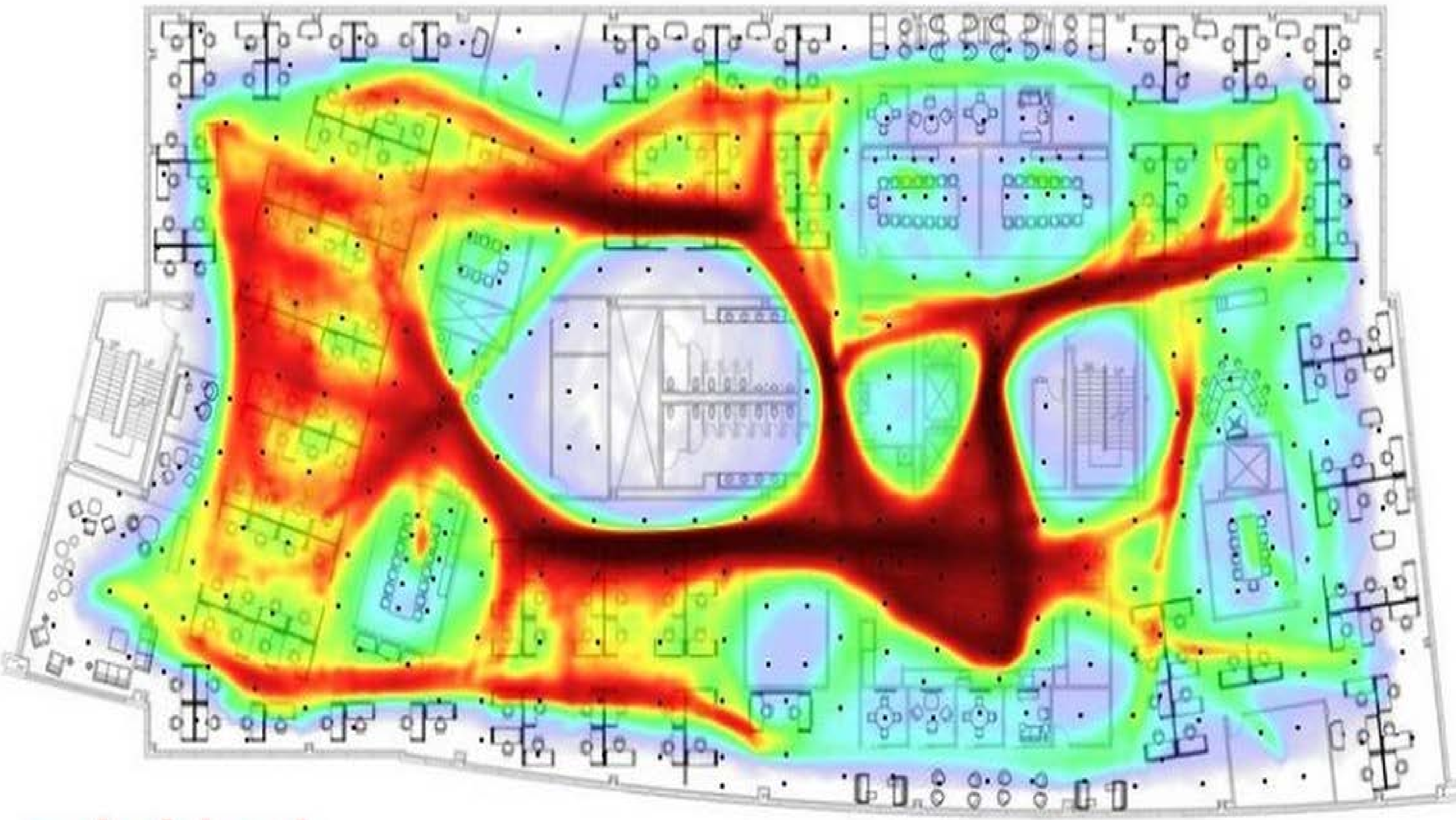
Dependencies, co-dependencies, relationships, levels







Users will only need to input their data – room utilization/floor traffic



Unit level entity then combines with network level entity models for essential functions

and then

VIRTUALIZE

the network

VIRTUALIZATION OF NETWORK AS AN ENTITY

The creation of a digital duplicate as an entity level agent based model is essential to analytics and simulation of what-if scenarios (deterministic) to better prepare for the non-deterministic states (emergency). This approach is not limited to any field but crucial for any “atom” with connected bits (data).

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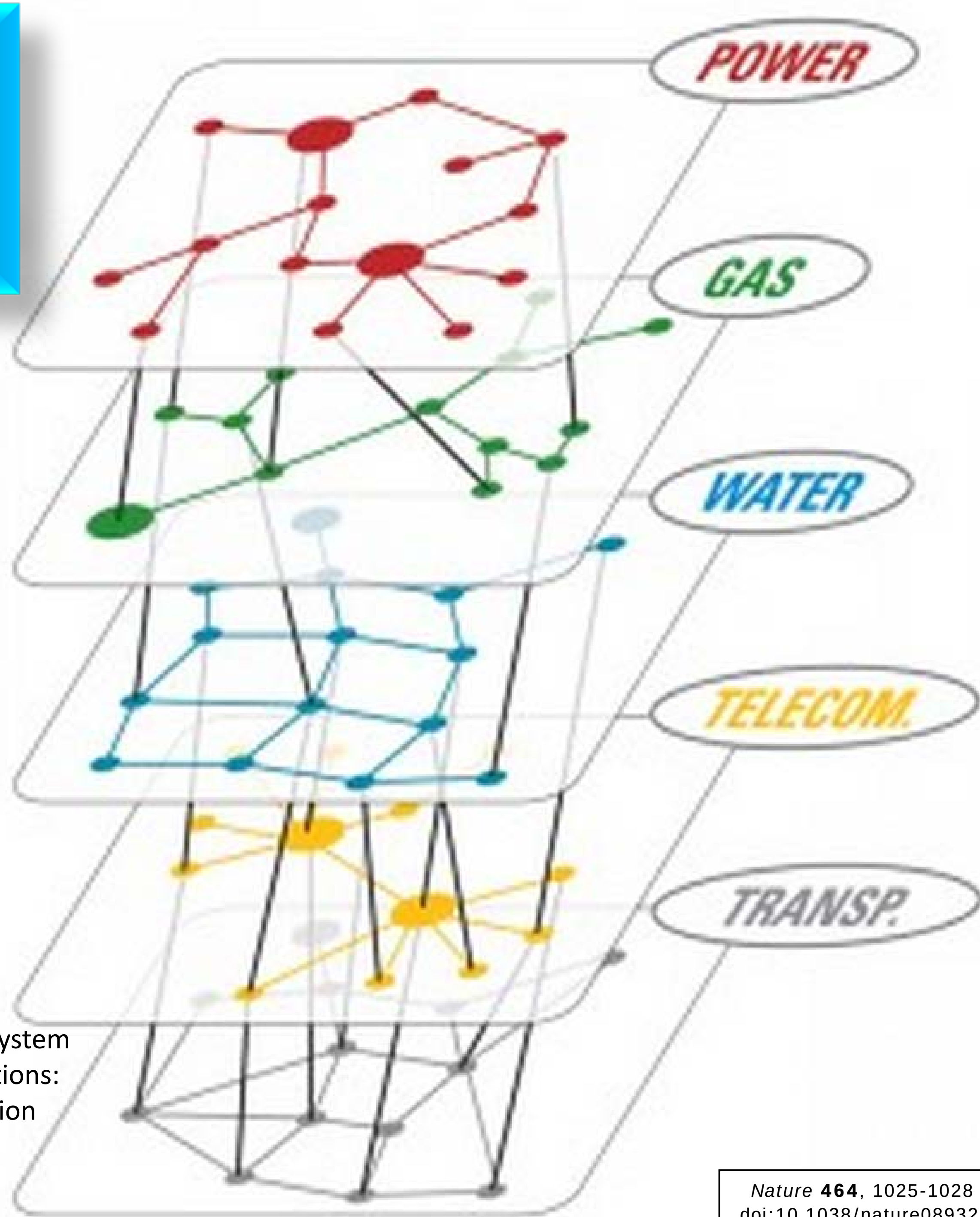
- Cities -
Cascade of Networks



Smart City Emergency Management and Response System
Contingency/Resiliency planning and logistics operations:
Address failure/fault tolerance/redundancy/restoration
each key node in every layer
- data visualization portal
- citizen connectivity app

Nature **464**, 1025-1028
doi:10.1038/nature08932

Combined tool de-mystifies the design of smart cities and disseminates “smart” principles, world-wide.

It will spur the business ecosystem and may trigger economic growth, jobs & improve quality of life and living for communities and ***all*** its citizens.

Look inside

Modeling Cities and Regions as Complex Systems: From Theory to Planning Applications Hardcover – September 11, 2015

by Roger White (Author), Guy Engelen (Author), Inge Uljee (Author)

Cities and regions grow (or occasionally decline), and continuously transform themselves as they do so. This book describes the theory and practice of modeling the spatial dynamics of urban growth and transformation. As cities are complex, adaptive, self-organizing systems, the most appropriate modeling framework is one based on the theory of self-organizing systems -- an approach already used in such fields as physics and ecology. The book presents a series of models, most of them developed using cellular automata (CA), which are inherently spatial and computationally efficient. It also provides discussions of the theoretical, methodological, and philosophical issues that arise from the models. A case study illustrates the use of these models in urban and regional planning. Finally, the book presents a new, dynamic theory of urban spatial structure that emerges from the models and their applications.

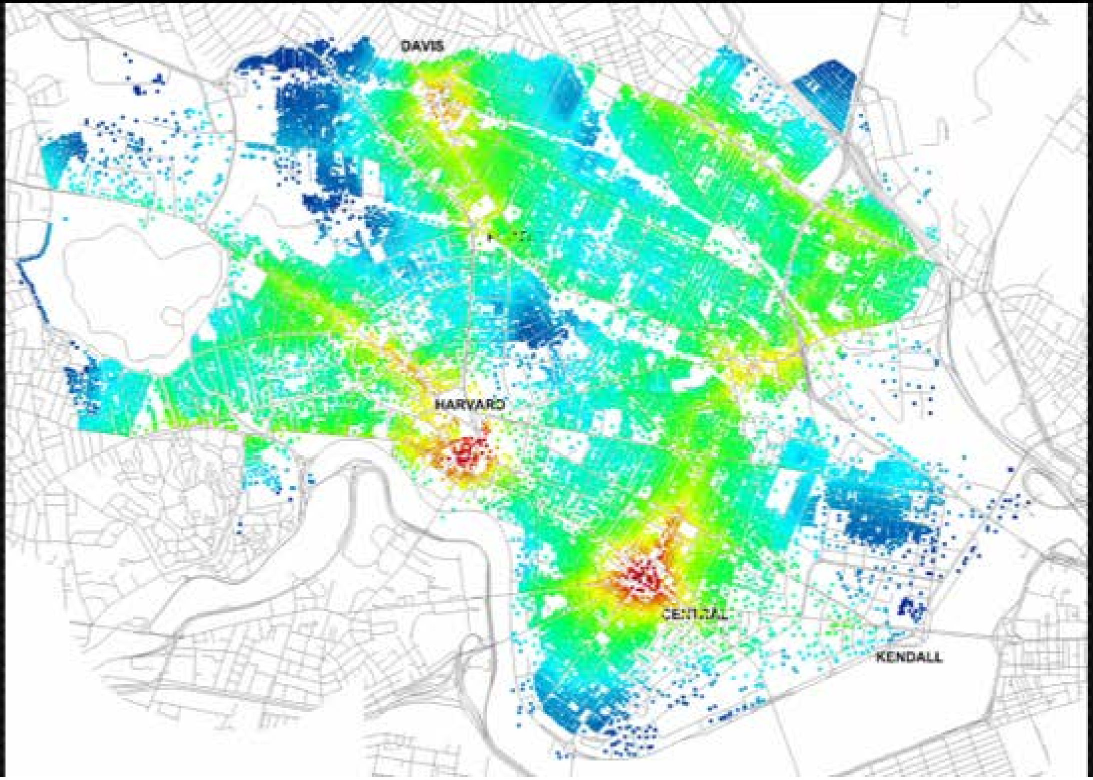
The models are primarily land use models, but the more advanced ones also show the dynamics of population and economic activities, and are integrated with models in other domains such as economics, demography, and transportation. The result is a rich and realistic representation of the spatial dynamics of a variety of urban phenomena. The book is unique in its coverage of both the general issues associated with complex self-organizing systems and the specifics of designing and implementing models of such systems.

Other components of this complex systems tool are

as follows ….

Spatial Network Tool

MIT



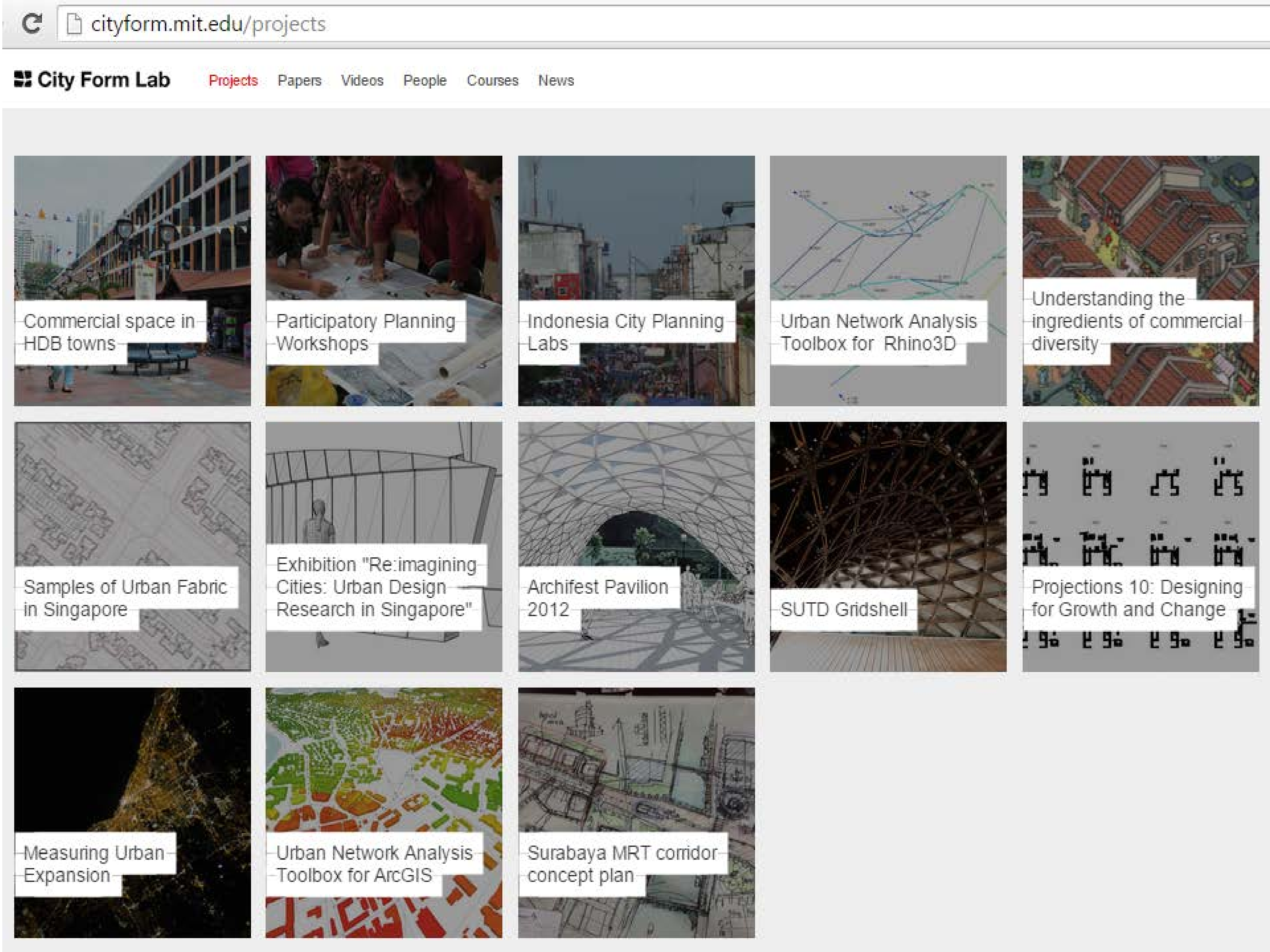
FULL SCREEN

With the new Urban Network Analysis software plugin from the MIT-Singapore International Design Center, architects and urban planners can describe spatial patterns of cities using mathematical network analysis methods. Here, a screen shot from the plugin shows accessibility to public transit (bus and metro) from individual buildings in Cambridge and Somerville, Massachusetts.

Image courtesy of Andres Sevtsuk/City Form Lab.

MIT-Singapore design center creates free software tool to analyze cities as spatial networks

New plugin aids in understanding social and economic consequences of city planning.


cityform.mit.edu/projects
City Form Lab
Projects
Papers
Videos
People
Courses
News
Commercial space in HDB towns
Participatory Planning Workshops
Indonesia City Planning Labs
Urban Network Analysis Toolbox for Rhino3D
Understanding the ingredients of commercial diversity
Samples of Urban Fabric in Singapore
Exhibition "Re:imagining Cities: Urban Design Research in Singapore"
Archifest Pavilion 2012
SUTD Gridshell
Projections 10: Designing for Growth and Change
Measuring Urban Expansion
Urban Network Analysis Toolbox for ArcGIS
Surabaya MRT corridor concept plan

UNDERSTANDING CITIES
as
SPATIAL NETWORKS

Roads and cities of 18th century France

Julien Perret[1*], Maurizio Gribaudi[2], Marc Barthelemy[3,4]

October 1, 2015

1. COGIT, IGN. 73 avenue de Paris, 94165 Saint-Mande Cedex, France. 2. LaDéHiS, EHESS. 190-198 avenue de France, 75013 Paris, France. 3. IPhT, CEA. Orme-des-Merisiers, 91191 Gif-sur-Yvette, France. 4. CAMS, EHESS. 190-198 Avenue de France, 75013 Paris, France.
* Corresponding author (julien.perret@gmail.com)

Abstract

The evolution of infrastructure networks such as roads and streets are of utmost importance to understand the evolution of urban systems. However, datasets describing these spatial objects are rare and sparse. The database presented here represents the road network at the french national level described in the historical map of Cassini in the 18th century. The digitization of this historical map is based on a collaborative methodology that we describe in detail. This dataset can be used for a variety of interdisciplinary studies, covering multiple spatial resolutions and ranging from history, geography, urban economics to network science.

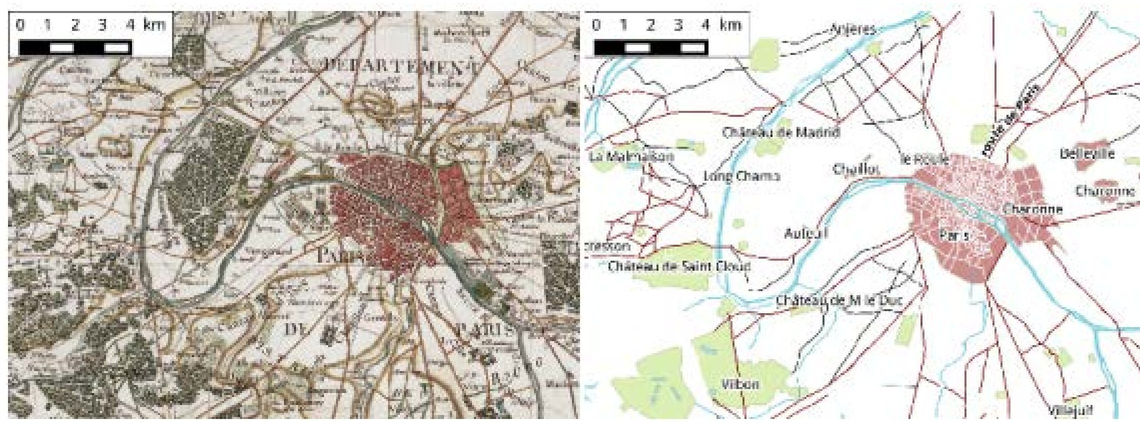


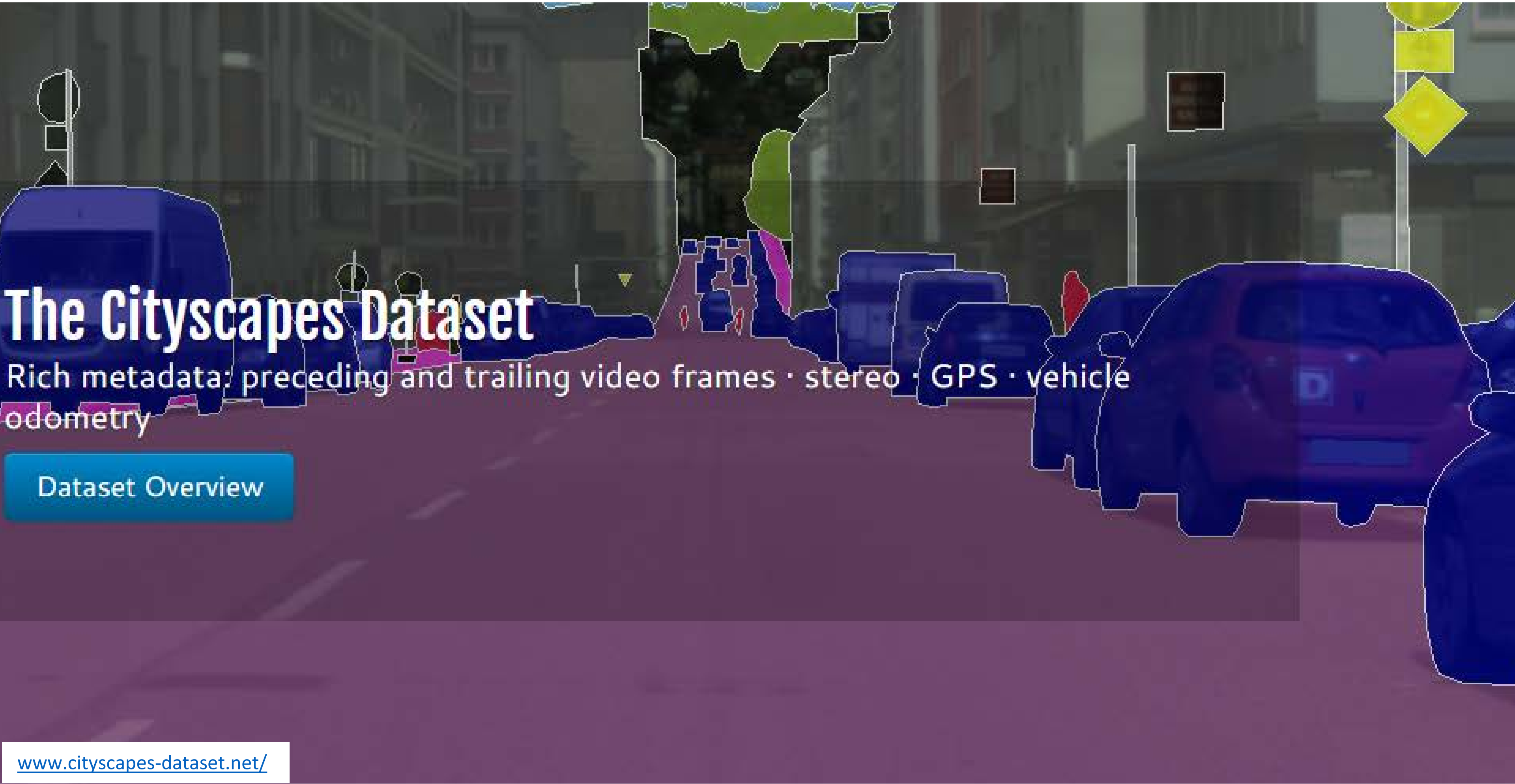
Figure 1: Part of the Cassini map of Paris and its digitization. The map is produced by EHESS, CNRS and BnF [1] and can be freely accessed by web

http://arxiv.org/pdf/1509.09055v1.pdf

Semantic Context Tool

CITYSCAPE

Understanding the context and semantics of the city



www.cityscapes-dataset.net/

Understanding the context and semantics of the city

www.cityscapes-dataset.net/

Understanding the context and semantics of the city

www.cityscapes-dataset.net/

Understanding the context and semantics of the city

www.cityscapes-dataset.net/

CPS Resiliency Tool

UC BERKELEY

FORCES (Foundations of Resilient Cyber Physical Systems) – UC Berkeley

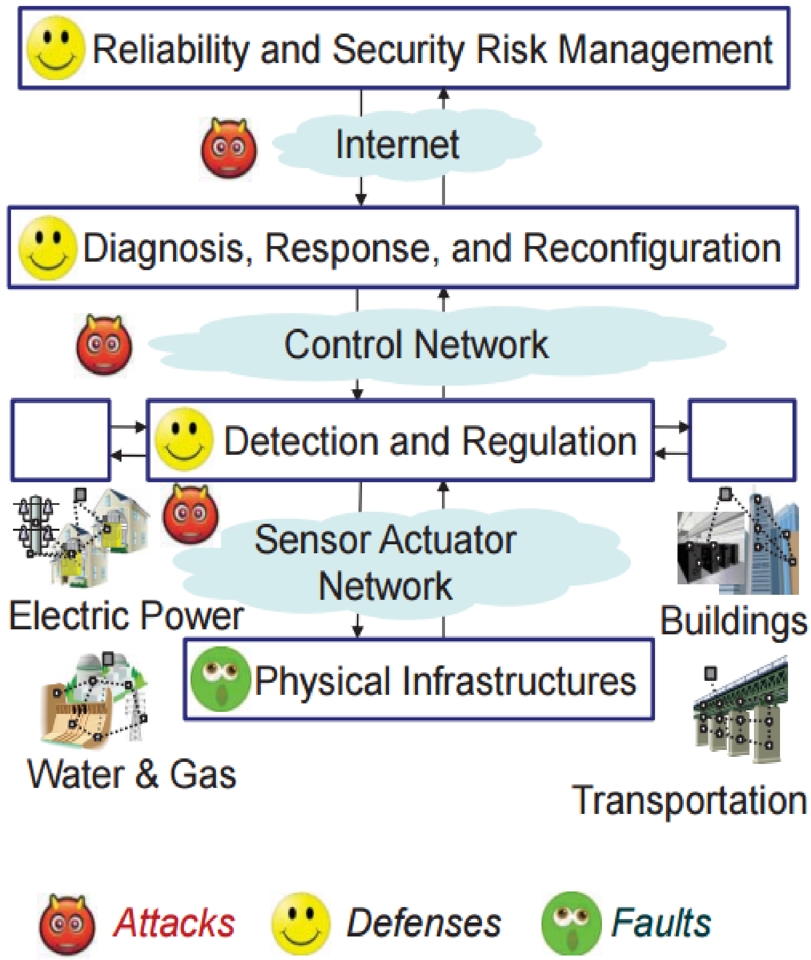
Optimization based on dynamics of infrastructure in smart city simulation – resiliency by design.

Resilient CPS Systems

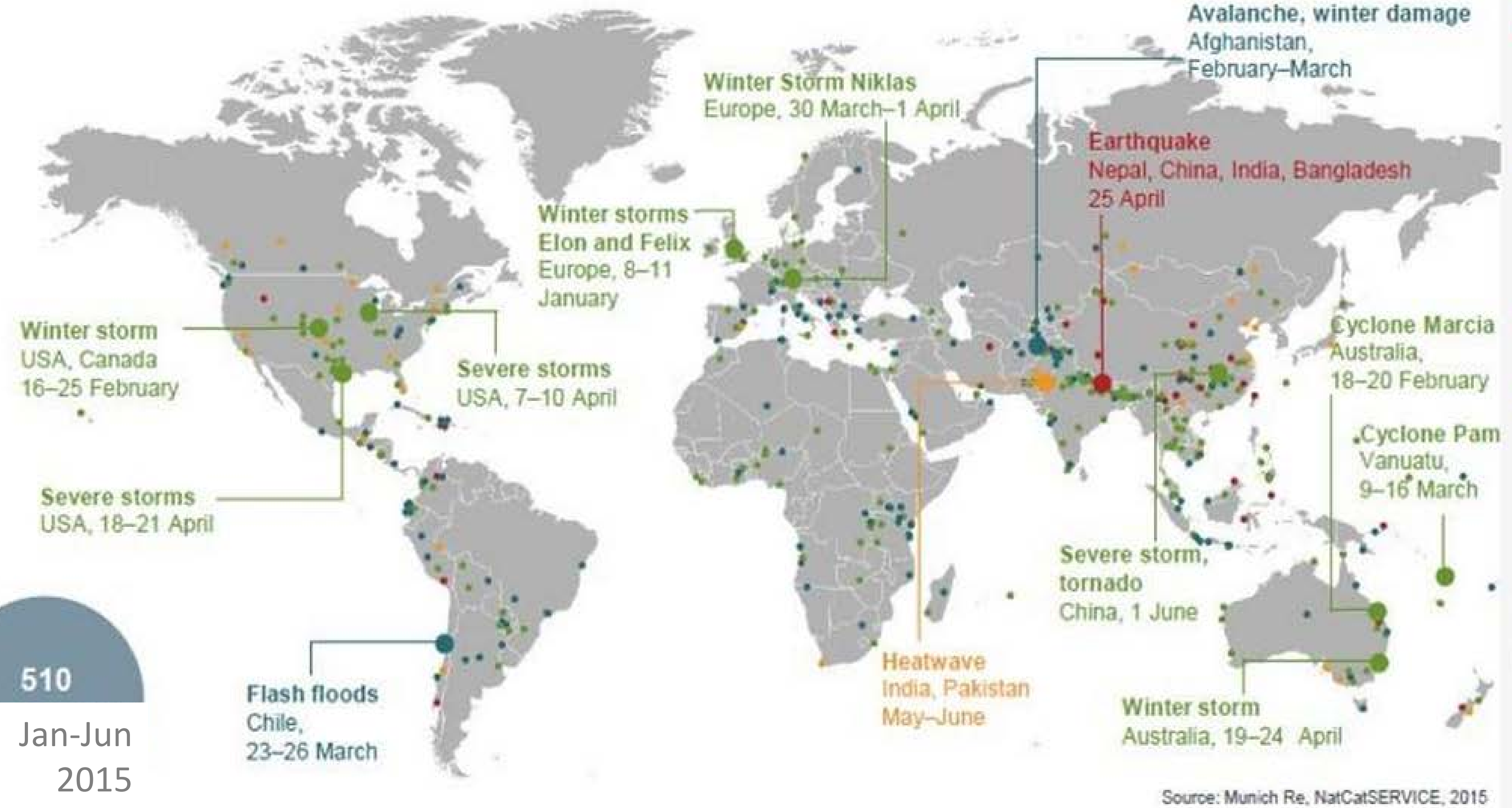
- Assessment, detection & response
- Networked and fault-tolerant control
- Scalable resilient Control algorithms
- Fundamental Limitations

Economic Incentives

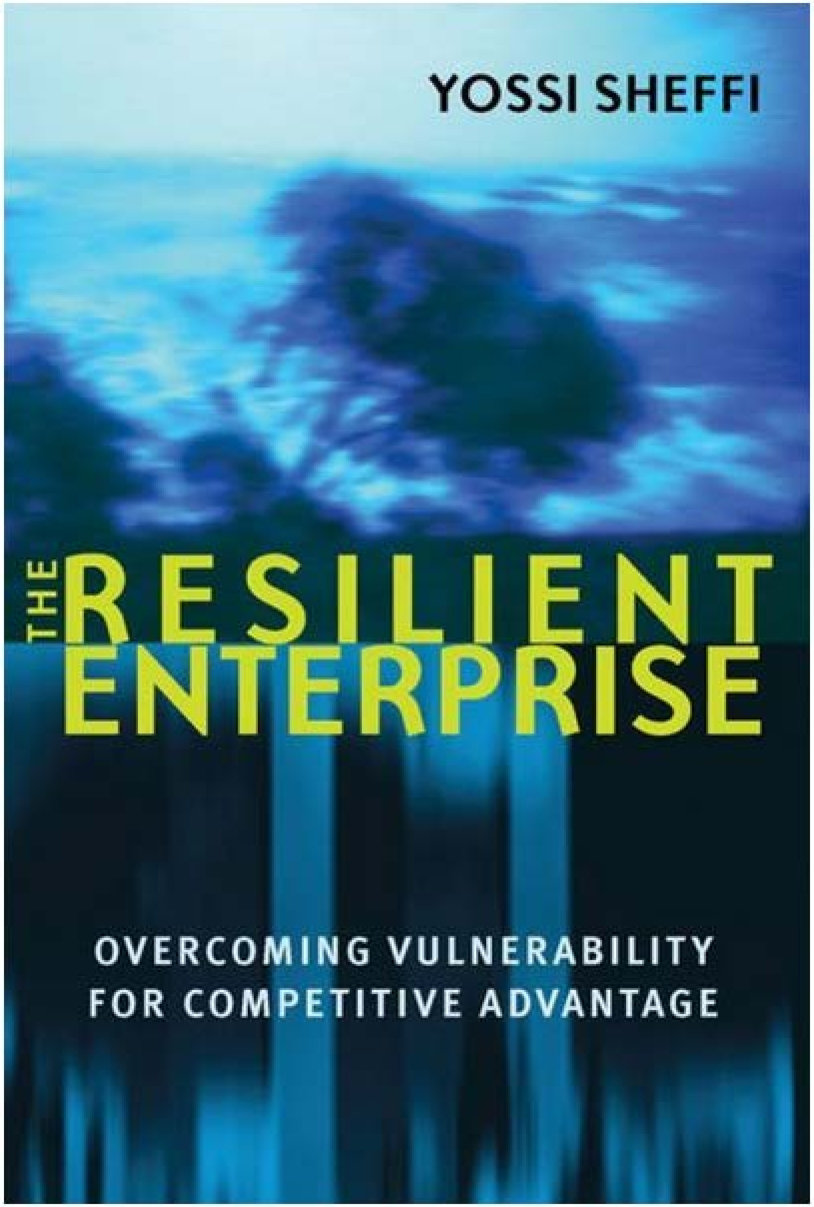
- Incentive Theory for Cost Effective operations of Societal CPS Systems
- Mechanism Design for Reconciling Nash and Societal Optima
- Disaggregation
- Privacy Metrics and Contracts
- Cyber Insurance



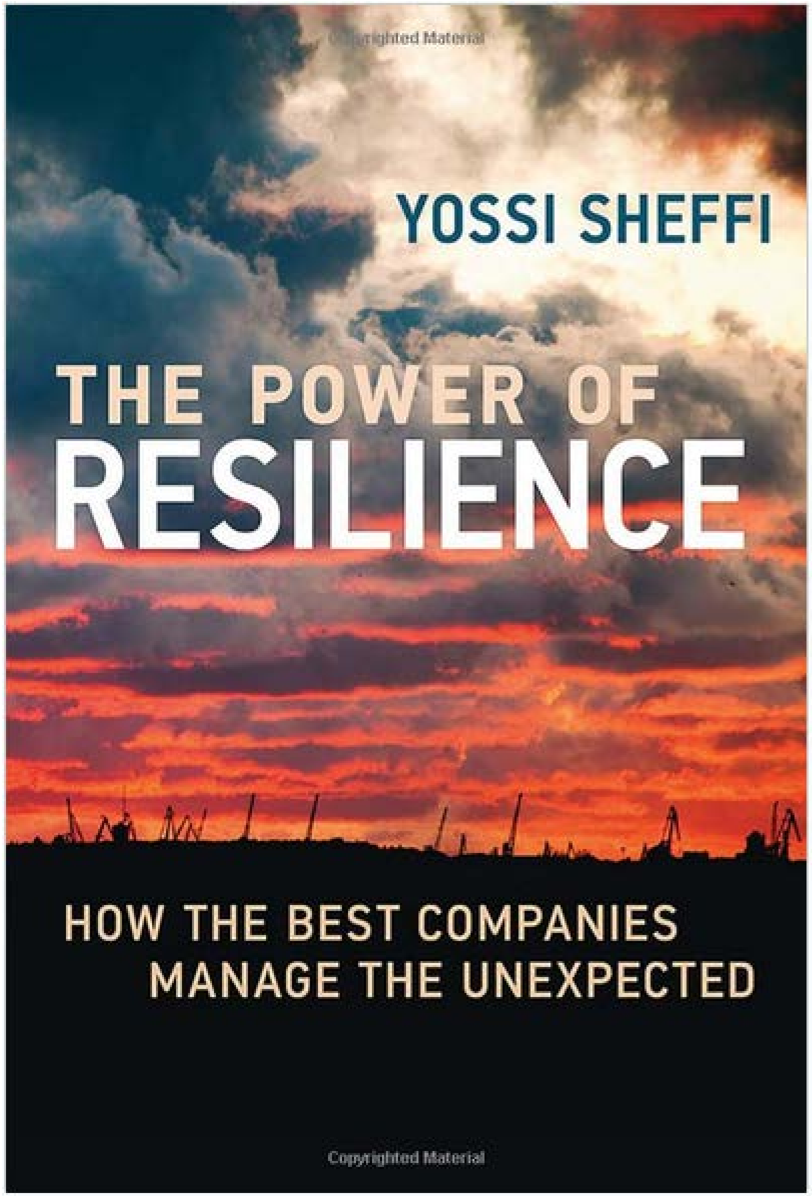
Is resiliency necessary?



Jan-Jun
2015



The MIT Press



www.resilience.osu.edu/CFR-site/pdf/Sheffi.pdf

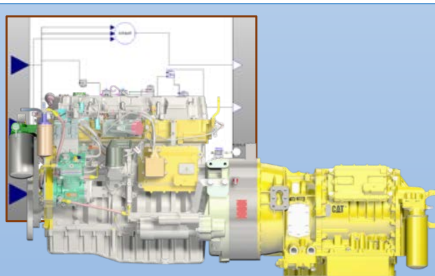
http://sheffi.mit.edu/the-power-of-resilience

Design Automation Tool

VANDERBILT UNIVERSITY

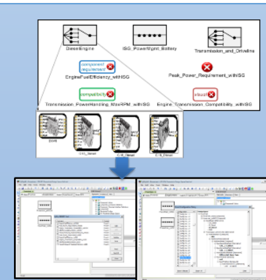
META Approach – Design Automation Substrate for Smart Cities

Component Based Design



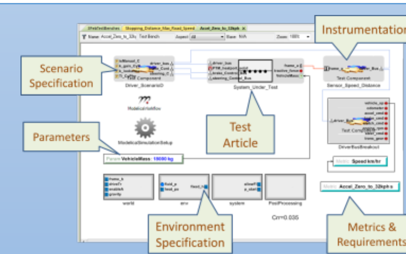
- Design Reuse, Distribute Workload
- Leverage cross-domain Component Libraries

Design Space Exploration

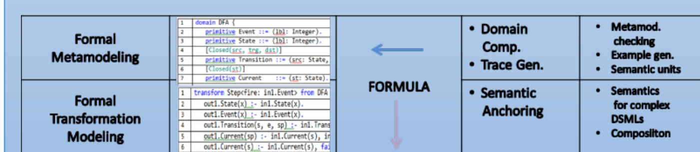


- Explore, Evaluate, Understand Tradeoffs
- Maintain Design Flexibility/Agility

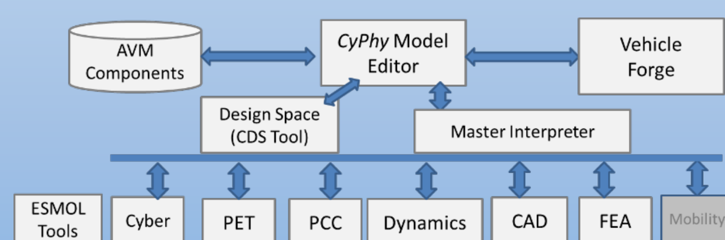
Executable Requirements



- Auto-compose models/invoke domain analysis tools
- Minimize repetitive engineering labor



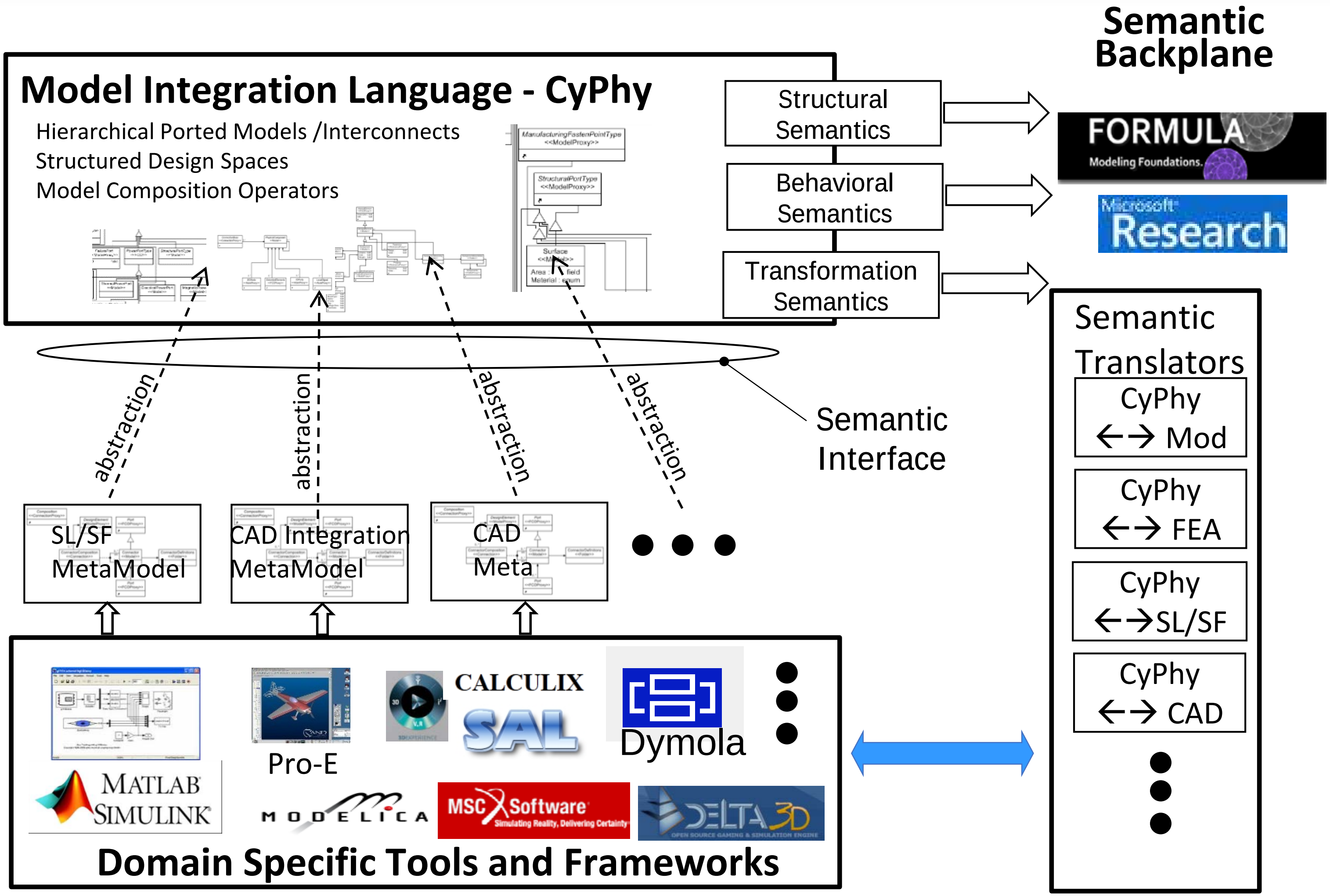
- Support integration of new tools and analysis
- Applicable across new domains and engineering processes



Meta Programmable Tools and Semantic Backplane

http://bit.ly/META-TOOLS

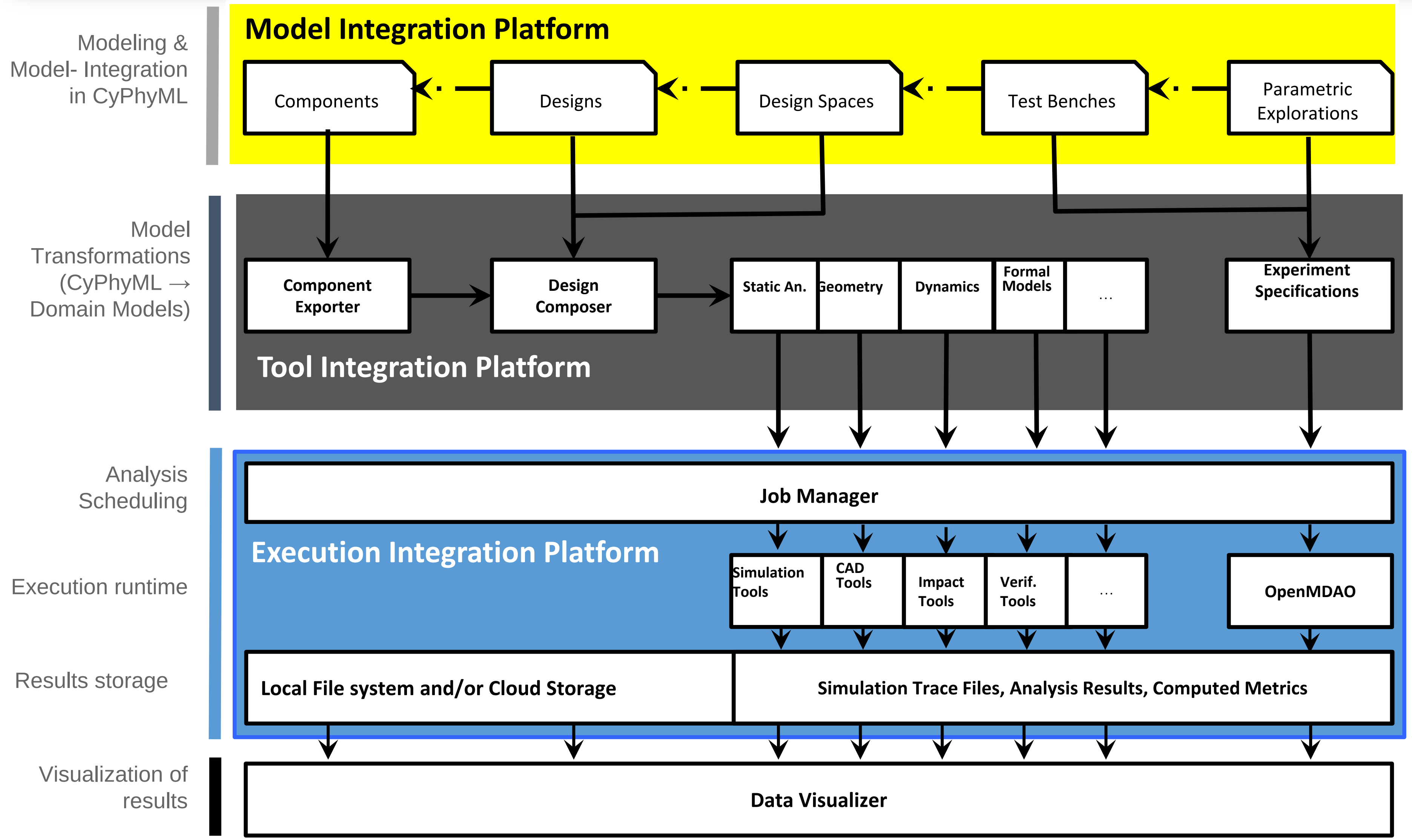
Model Integration Platform for Smart Cities using CyPhyML



Semantically Sound, Open Language Engineering Environment; Accommodates New Tools & Languages

http://bit.ly/META-TOOLS

Meta – Automated Smart City Design Tool



http://bit.ly/META-TOOL-SUITE

Application to Smart Cities?

Agent-based virtualization of entity level models

Systemic Design Tools – Abstraction and Synthesis

The future of autonomy, optimization and intelligent support may involve the process of building entity level models for each granular component (or process), the ability to virtualize the objects and connect component (node) specific data with curated ecosystem data relevant to the context of “things” or function. In principle, it may be applied to machines (cars, planes), smart cities, healthcare, energy, finance and other verticals as well as core horizontals (security). The development of high granular agent based models will be a departure from the traditional software in vogue. Each agent will be part of an hierarchy yet may remain flexible (modular) to adapt when processes change or evolve. The data from agents is expected to be semantically interoperable and feed intelligent analytical frameworks (ANN, ML, AI) to generate profitable information which may offer rich transactional value.

How to converge the tools with context aware data analytics in real time to help city or town planners design requirements for resilient and smarter cities?

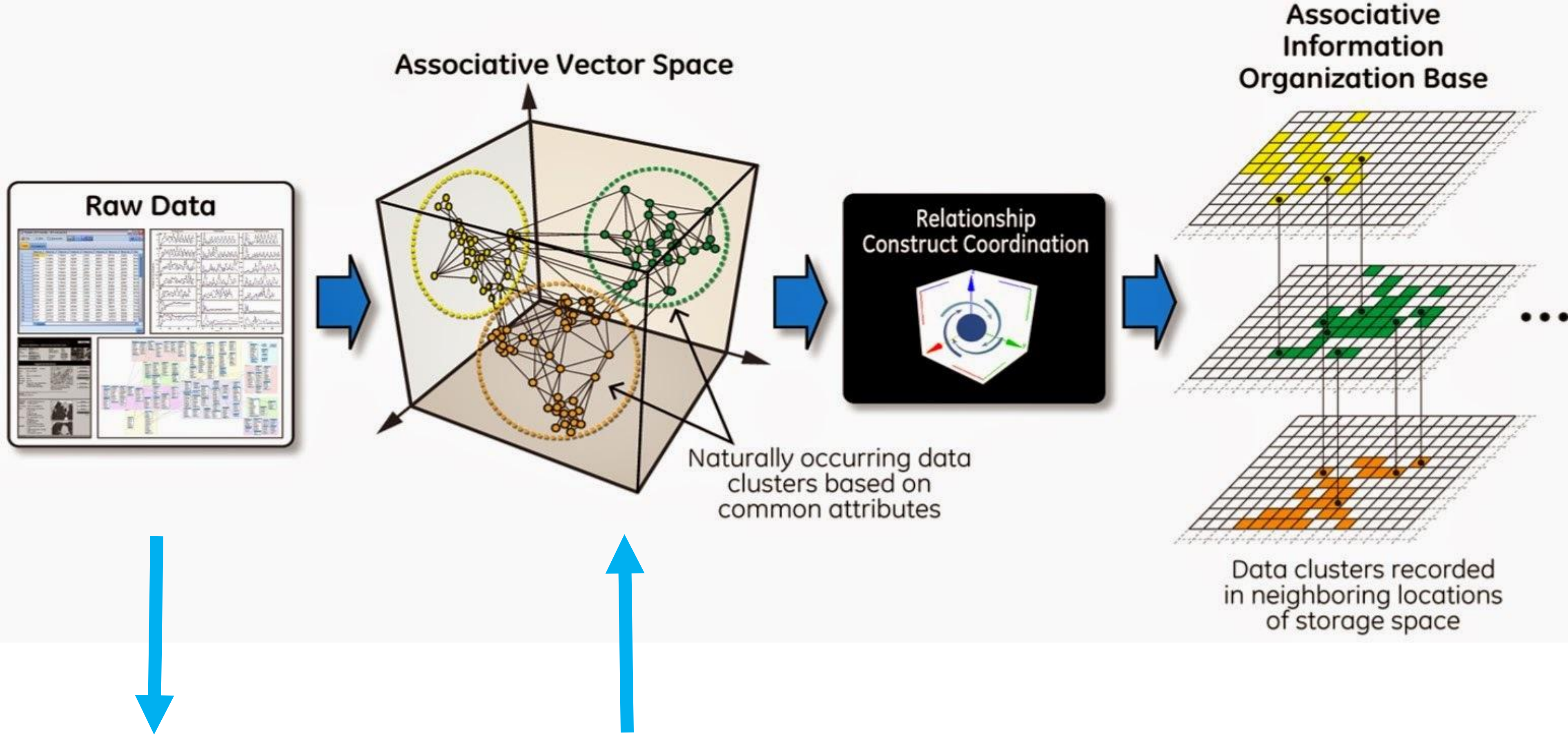
Big Data

Reduce, Reconstruct, Respond

We are drowning in information, while starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices, wisely.

Edward Osborne Wilson

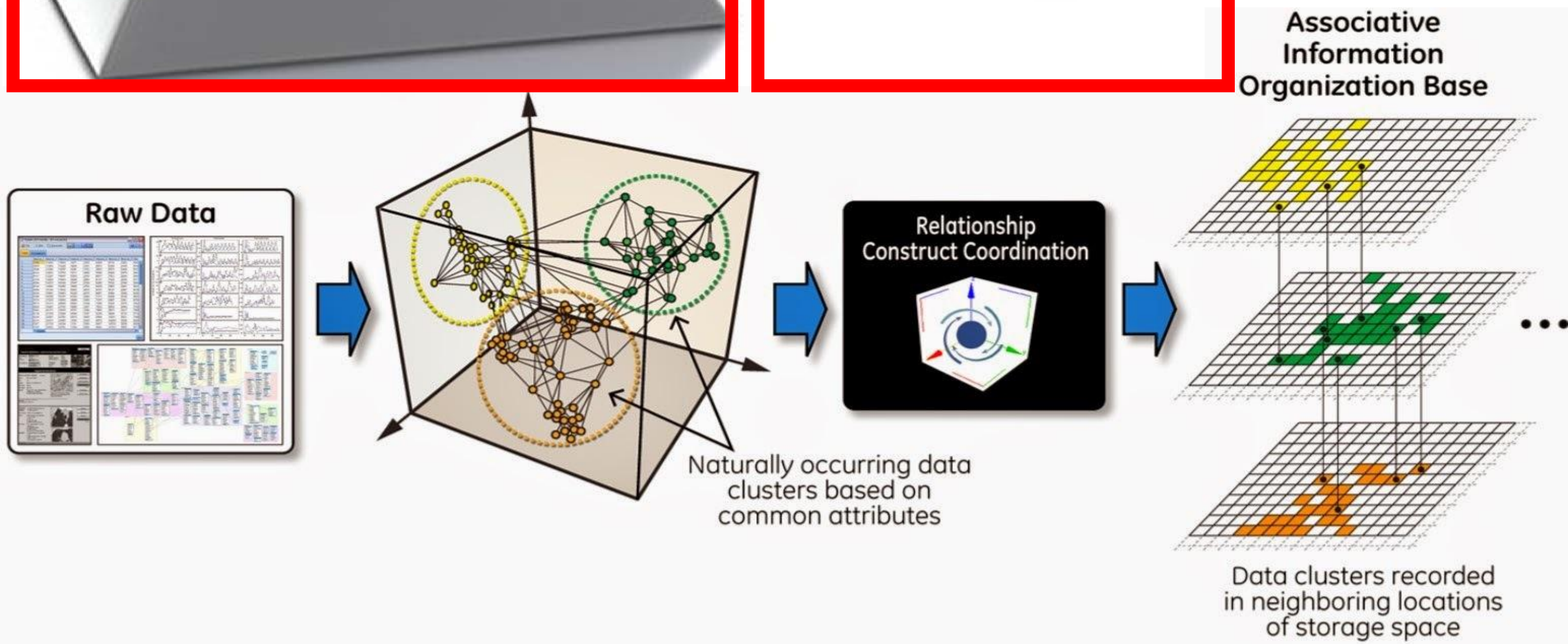
May 2014
Harvard


Raw Data
Associative Vector Space
Naturally occurring data clusters based on common attributes
Relationship Construct Coordination
Associative Information Organization Base
Data clusters recorded in neighboring locations of storage space

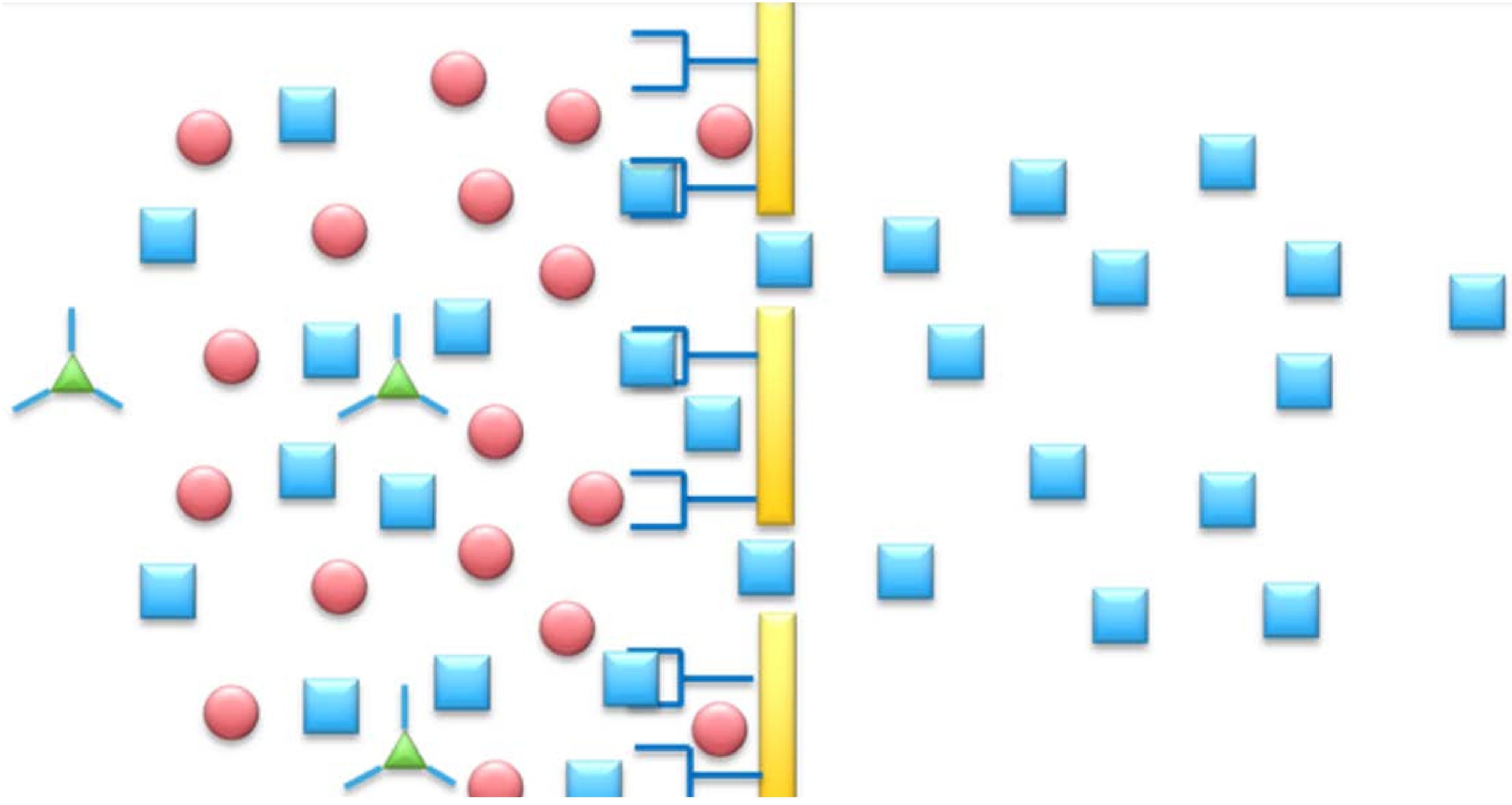
CURATE

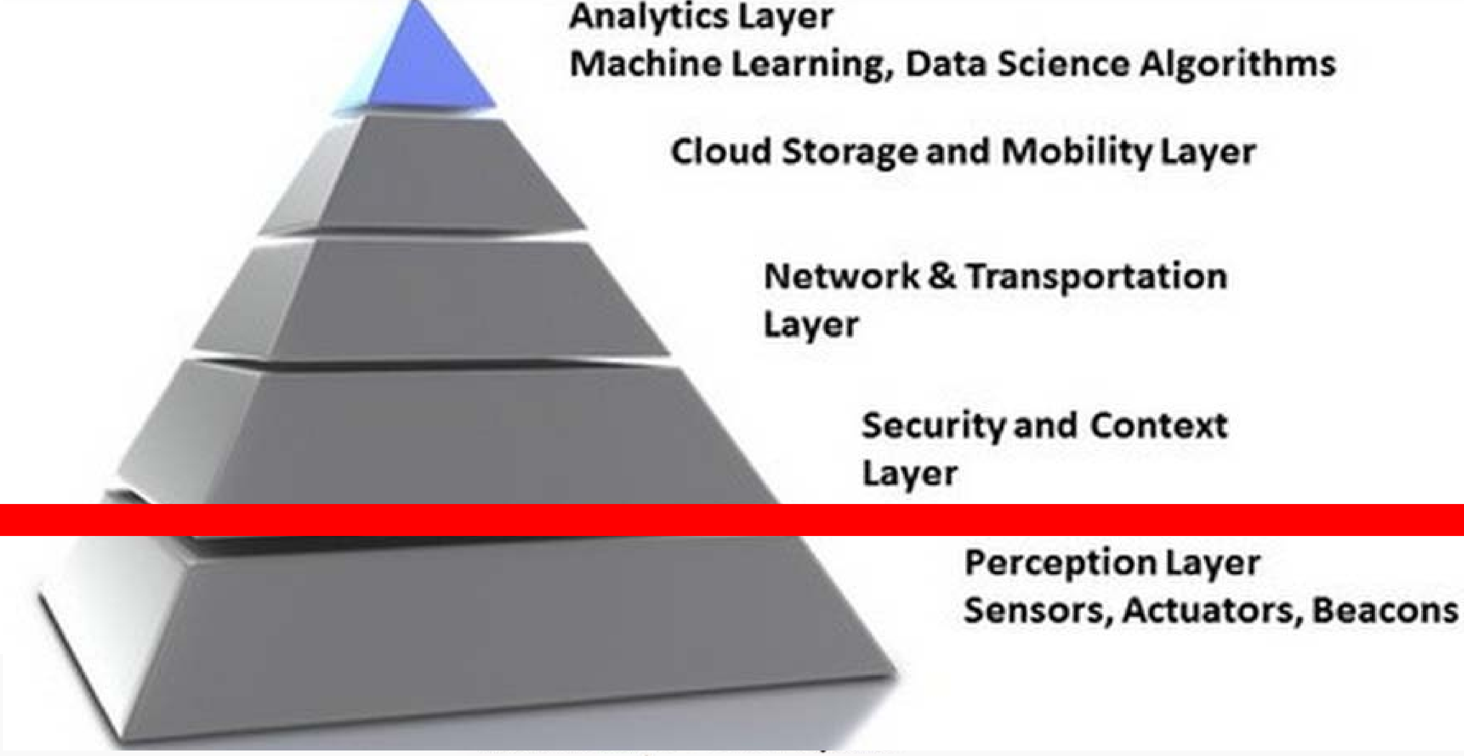
CURATE

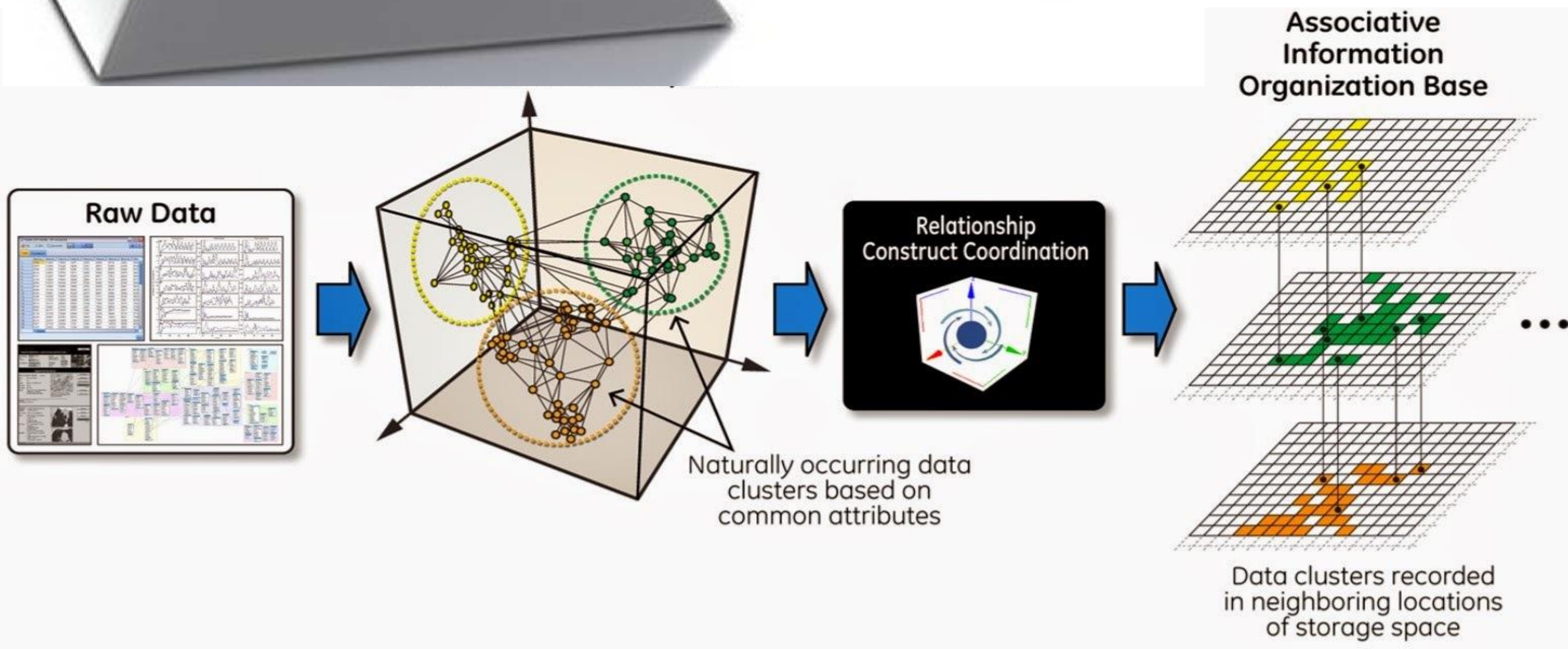
Perception Layer
Sensors, Actuators, Beacons



Principle of Differential Curation and De-identification of Data




Analytics Layer
Machine Learning, Data Science Algorithms
Cloud Storage and Mobility Layer
Network & Transportation Layer
Security and Context Layer
Perception Layer
Sensors, Actuators, Beacons


Raw Data
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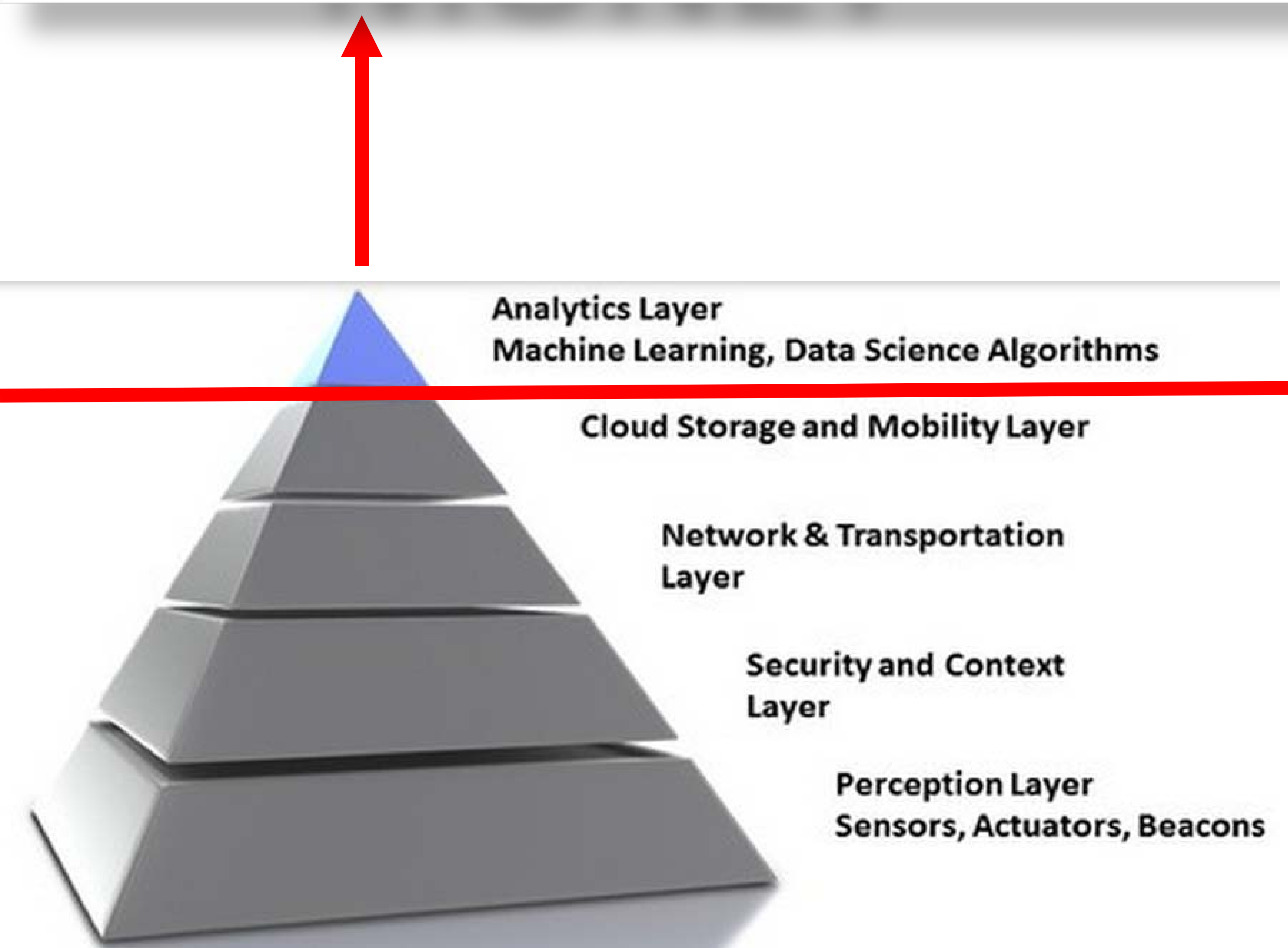
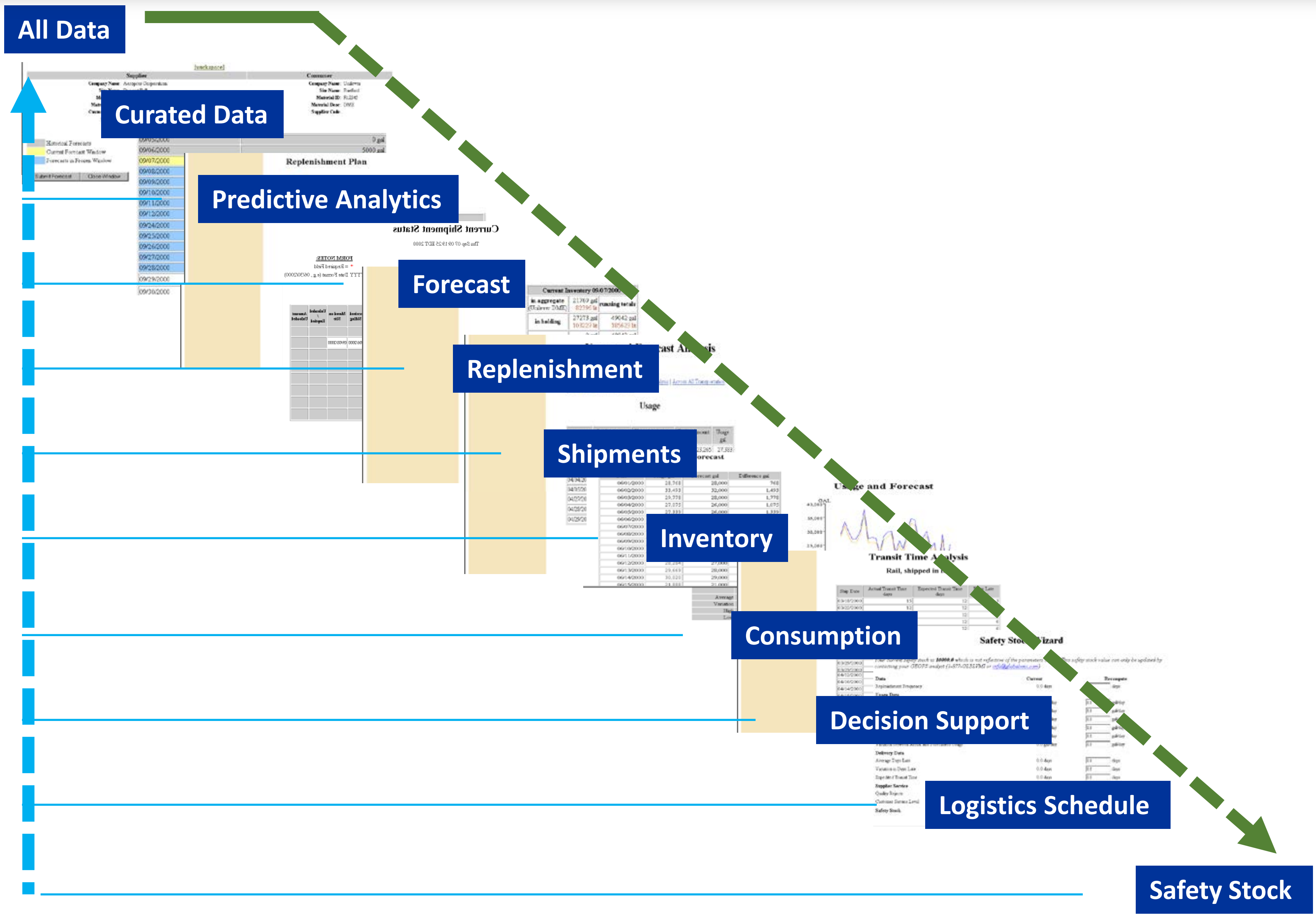
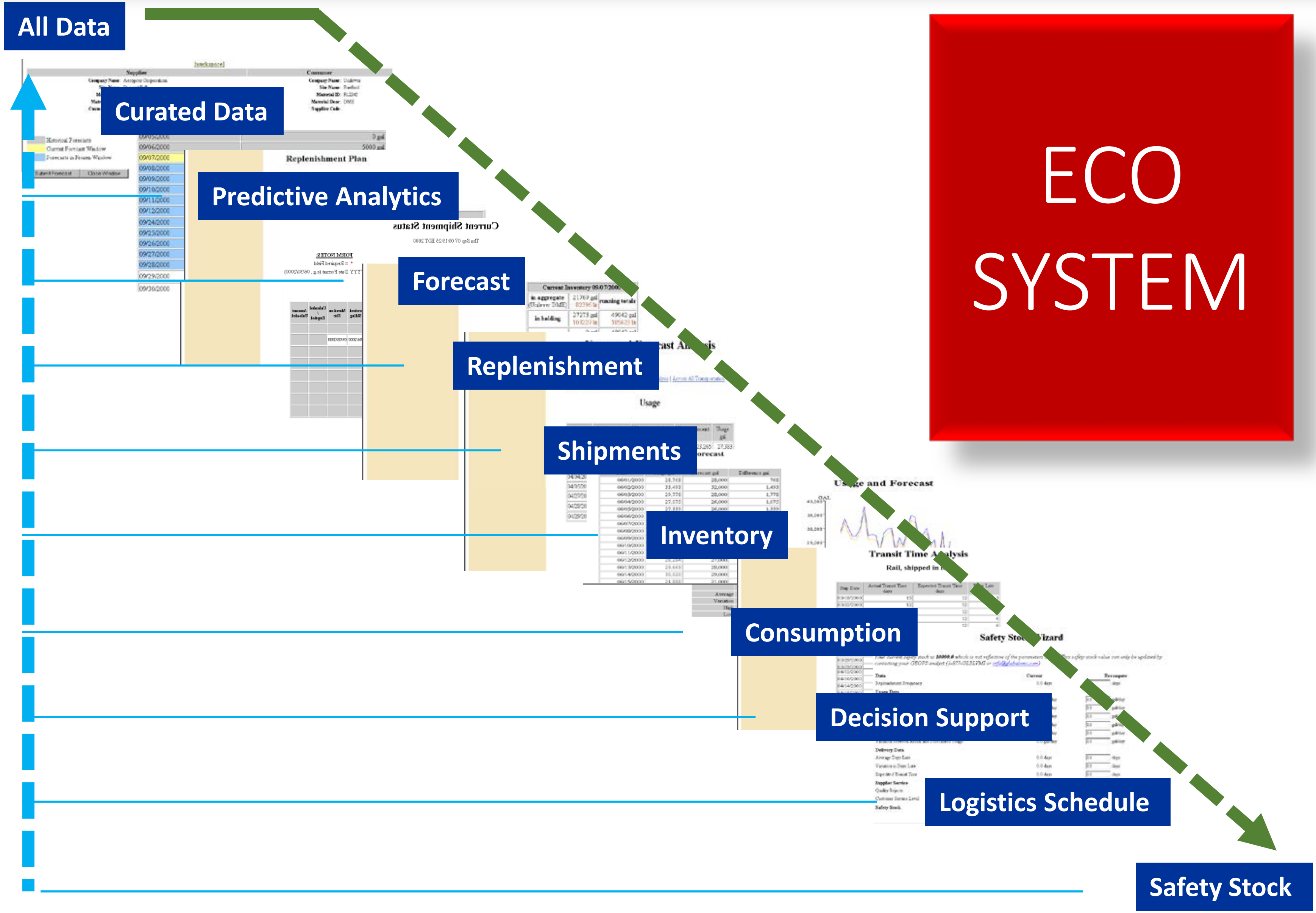
MONEY


Analytics Layer
Machine Learning, Data Science Algorithms
Cloud Storage and Mobility Layer
Network & Transportation Layer
Security and Context Layer
Perception Layer
Sensors, Actuators, Beacons

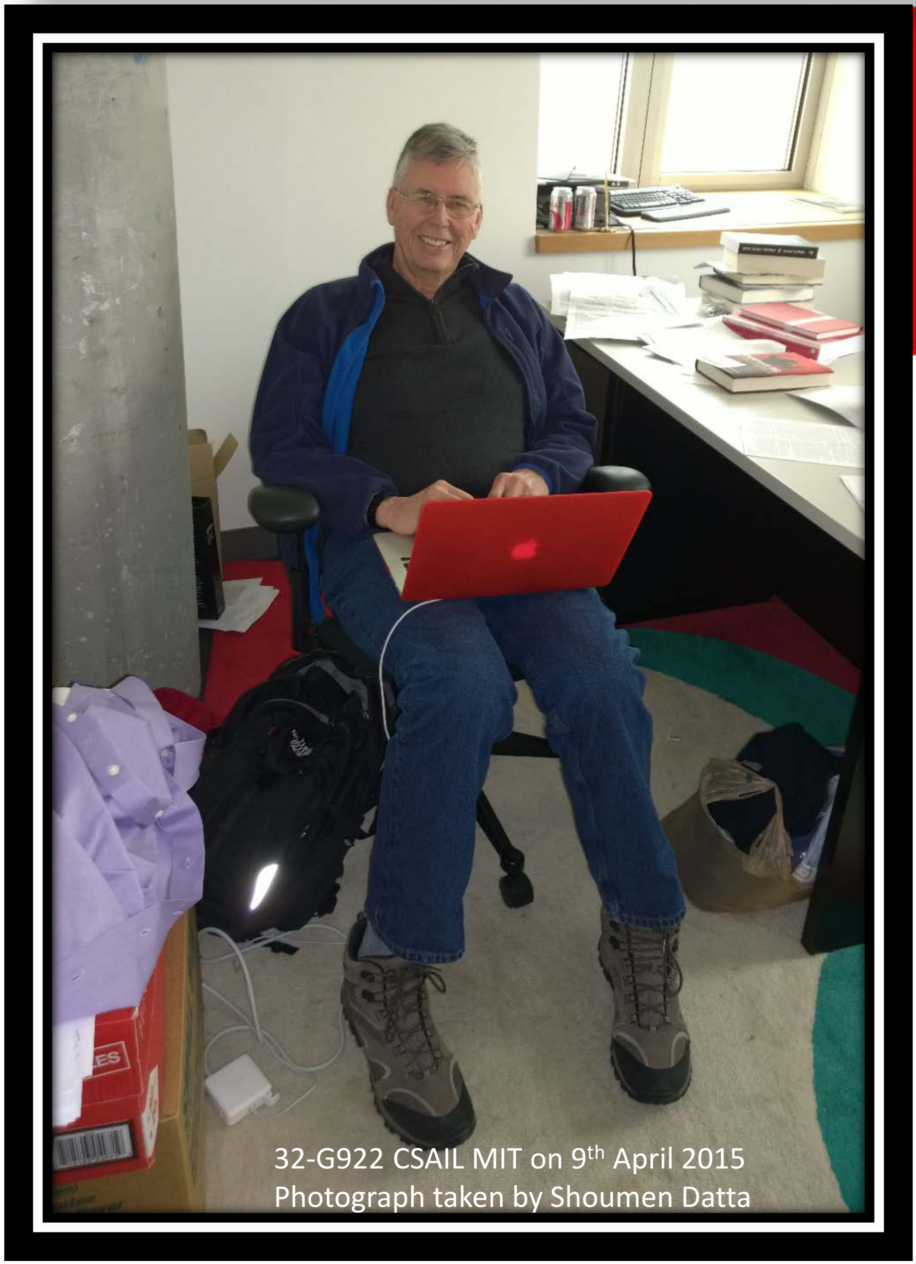
Do you control and command all the nodes to drive convergence and fuel intelligence?



Do you control and command all the nodes to drive convergence and fuel intelligence?



Innovation in Curation Algorithms



How to extract ambient intelligence?

Postgres

Introduced the object-relational model, effectively merging DB with abstract complex data types eg CAD, geospatial, so-called big data

www.csail.mit.edu/node/2459

Michael Stonebraker
Turing Award 2015

Challenges in Data Curation

- Noise obscures signal
- Data acquired is a blend of noise with signal
- Signal volatility introduces noise which is often proportional to signal

→ How do we correct/reduce the error due to this "noisy channel" factor?

→ Can novel algorithms reduce/deconstruct data to subtract "noise" and reconstruct the signal?

→ What about the application of the principles of (Shannon, Kalman-Bucy) error correcting algorithms?

☑ https://en.wikipedia.org/wiki/Kalman_filter
☑ http://news.mit.edu/2010/explained-shannon-0115
☑ http://www.cs.cmu.edu/~guyb/realworld/errorcorrecting.html
☑ http://www.cs.cmu.edu/~aarti/Class/10704/lec16-shannonnoisythrm.pdf

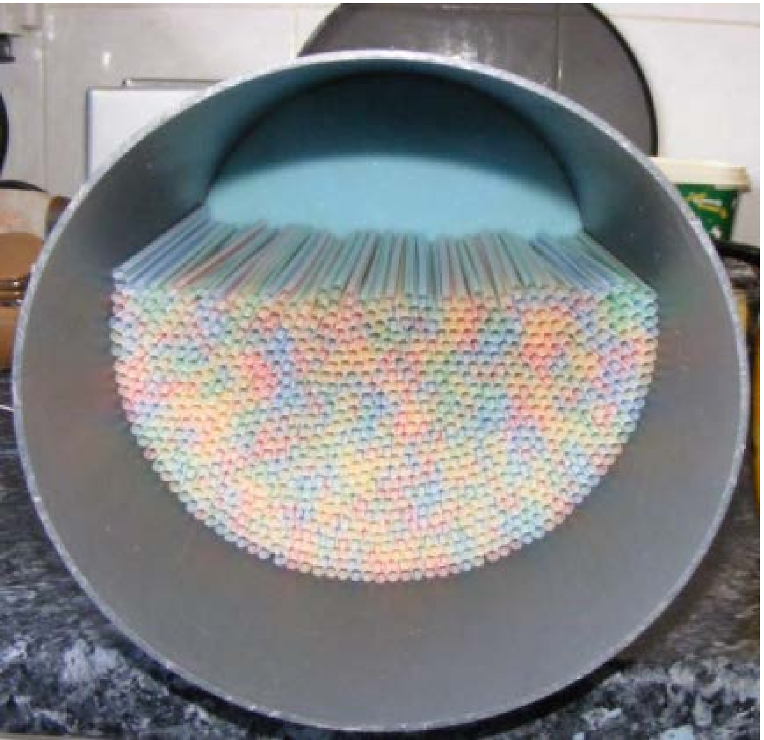
Data Curation Concepts from Laminar Flow

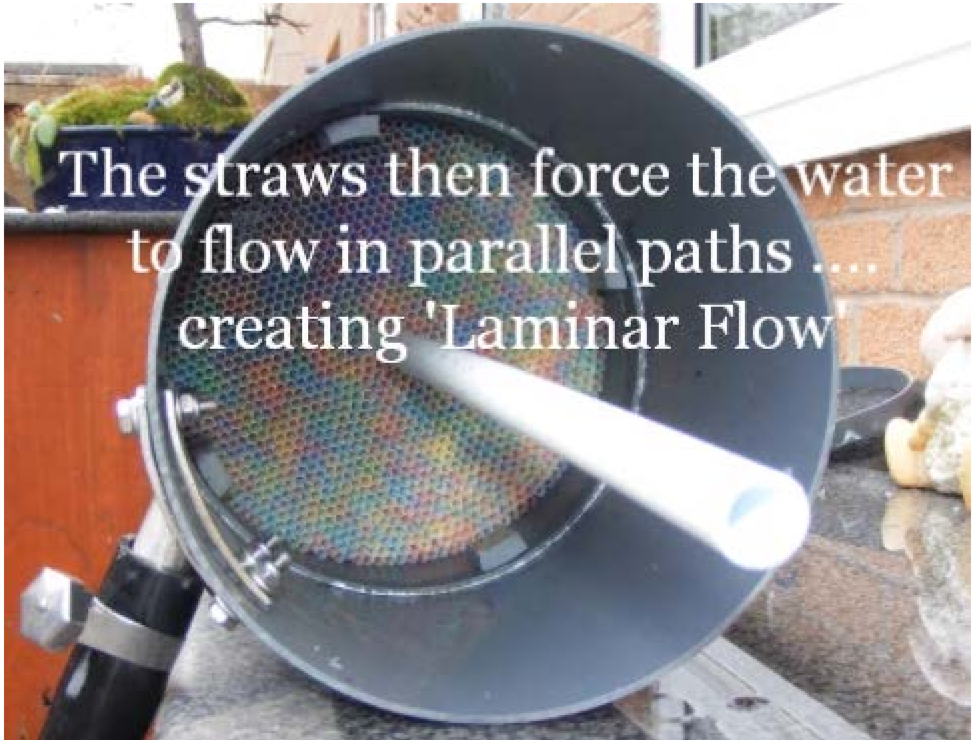
Smart City data is not an unique issue in this context. This is applicable across all data domains.

This a data curation problem. We are observing related signal/noise issues in big data analytics.

Are there any concepts related to data curation which may be triggered by laminar flow?

http://bit.ly/LAMINAR-FLOW-DATA-CURATION-CONCEPT





Why you need to collaborate, build ecosystems and pursue open connectivity

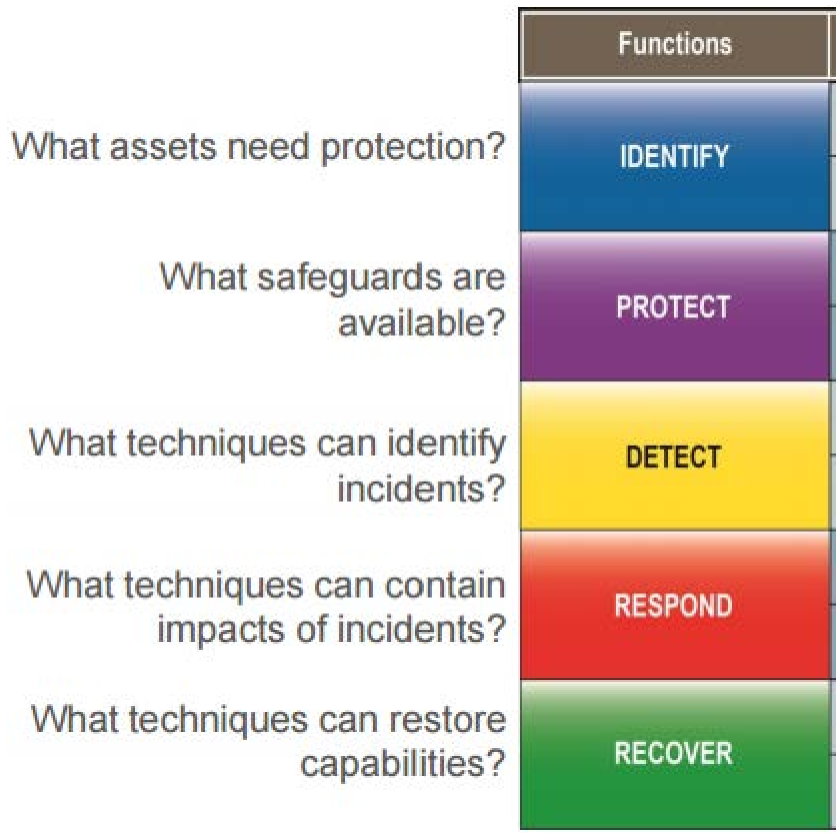
PLATFORMS

The Holy Grail is about ambient intelligence from data.

Security

CYBERSECURITY

Intruder detection, repulsion, prevention in real-time



www.nist.gov/cyberframework/upload/cybersecurity_framework_bsi_2015-04-08.pdf

Assessing and Minimizing Inherent Risks

Function Unique Identifier	Function	Category Unique Identifier	Category
ID	Identify	ID.AM	Asset Management
		ID.BE	Business Environment
		ID.GV	Governance
		ID.RA	Risk Assessment
		ID.RM	Risk Management Strategy
PR	Protect	PR.AC	Access Control
		PR.AT	Awareness and Training
		PR.DS	Data Security
		PR.IP	Information Protection Processes and Procedures
		PR.MA	Maintenance
		PR.PT	Protective Technology
DE	Detect	DE.AE	Anomalies and Events
		DE.CM	Security Continuous Monitoring
		DE.DP	Detection Processes
RS	Respond	RS.RP	Response Planning
		RS.CO	Communications
		RS.AN	Analysis
		RS.MI	Mitigation
		RS.IM	Improvements
RC	Recover	RC.RP	Recovery Planning
		RC.IM	Improvements
		RC.CO	Communications

Inventory is difficult

Assessing and Minimizing Inherent Risks

Function Unique Identifier	Function	Category Unique Identifier	Category
ID	Identify	ID.AM	Asset Management
		ID.BE	Business Environment
		ID.GV	Governance
		ID.RA	Risk Assessment
		ID.RM	Risk Management Strategy
PR	Protect	PR.AC	Access Control
		PR.AT	Awareness and Training
		PR.DS	Data Security
		PR.IP	Information Protection Processes
		PR.MA	Maintenance
		PR.PT	Protective Technology
DE	Detect	DE.AE	Anomalies and Events
		DE.CM	Security Continuous Monitoring
		DE.DP	Detection Processes
RS	Respond	RS.RP	Response Planning
		RS.CO	Communications
		RS.AN	Analysis
		RS.MI	Mitigation
		RS.IM	Improvements
RC	Recover	RC.RP	Recovery Planning
		RC.IM	Improvements
		RC.CO	Communications

ID.GV-3

ID.GV-1

Personal and organizational data is co-mingled

ID.GV-1: Organizational information security policy is established

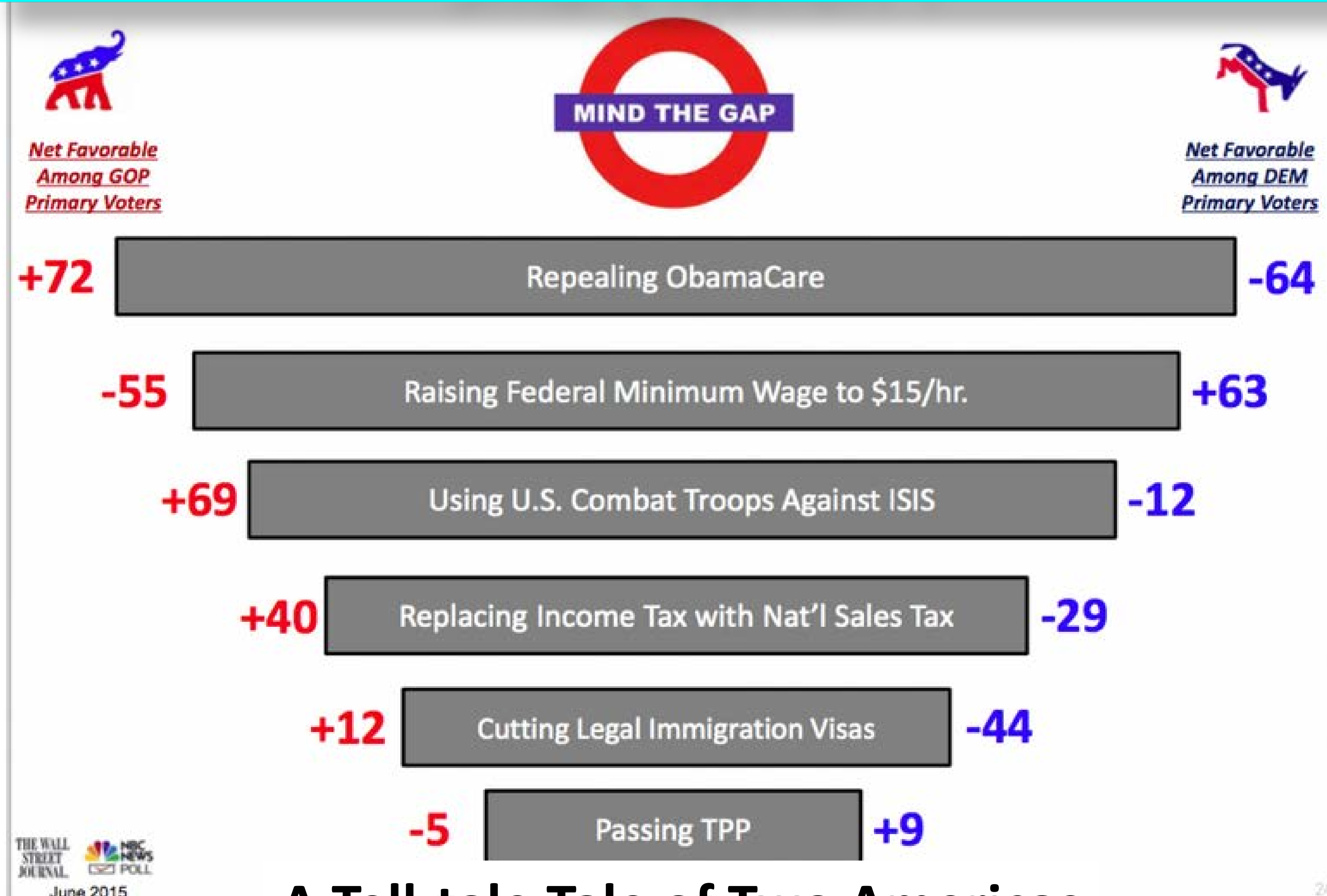
ID.GV-2: Information security roles & responsibilities are coordinated and aligned with internal roles and external partners

ID.GV-3: Legal and regulatory requirements regarding cybersecurity,

Personalization - Your Smart City -

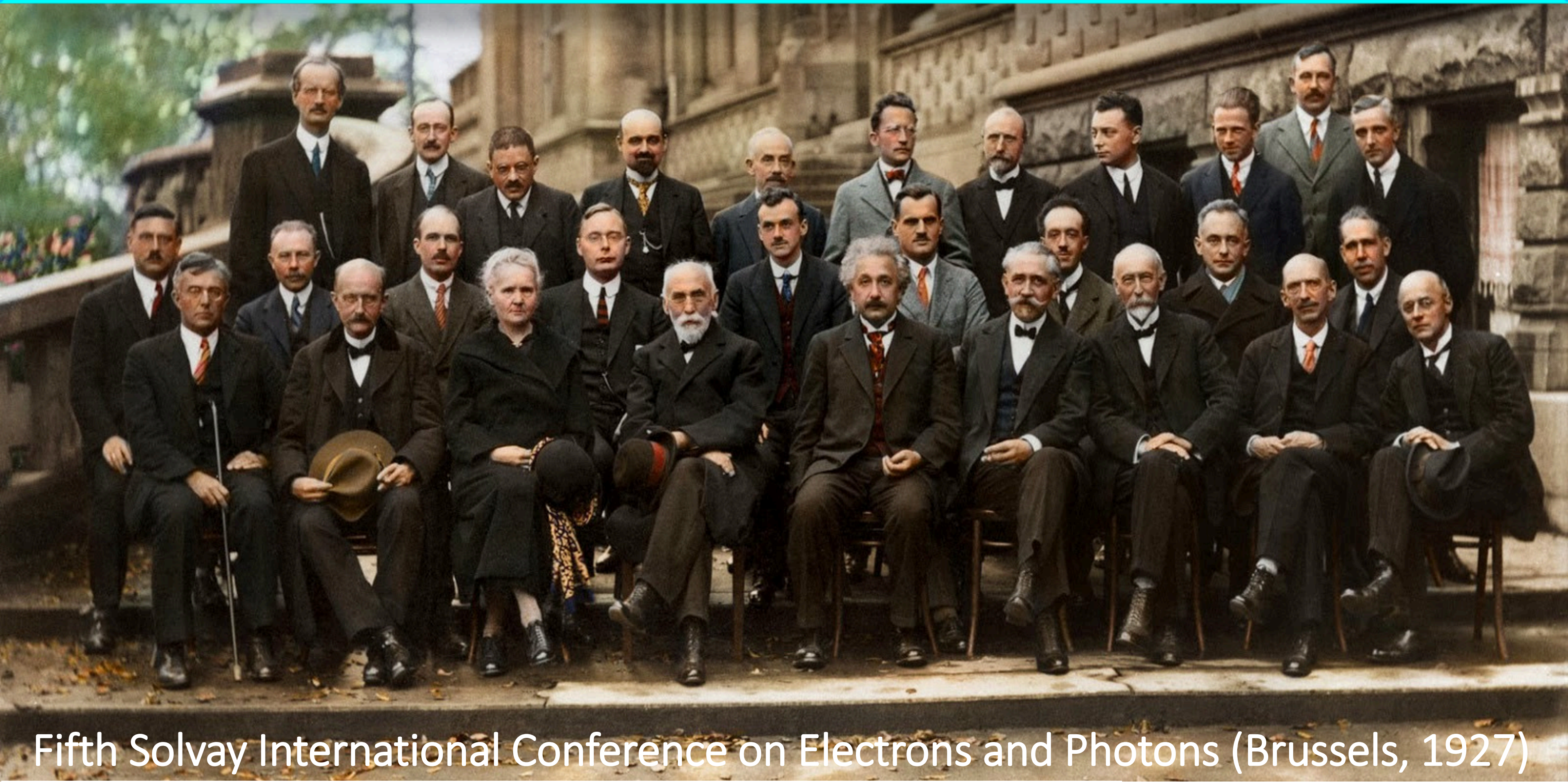
What is important to you?

Smart Nation ?



A Tell-tale Tale of Two Americas

Smart Citizens ?



Back: Auguste Piccard, Émile Henriot, Paul Ehrenfest, Édouard Herzen, Théophile de Donder, Erwin Schrödinger, JE Verschaffelt, Wolfgang Pauli, Werner Heisenberg, Ralph Fowler, Léon Brillouin.

Middle: Peter Debye, Martin Knudsen, William Lawrence Bragg, Hendrik Anthony Kramers, Paul Dirac, Arthur Compton, Louis de Broglie, Max Born, Niels Bohr.

Front: Irving Langmuir, Max Planck, Marie Curie, Hendrik Lorentz, Albert Einstein, Paul Langevin, Charles-Eugène Guye, CTR Wilson, Owen Richardson.

http://bit.ly/1927-SOLVAY-BRUSSELS

Is this your Smart City ?

Think different

Apple Developers Conference ● Santa Clara Convention Ctr ● March 2014

Elusive Euphoria for the New Utopia?

Irrational Exuberance?

Thank you

I have created nothing new

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