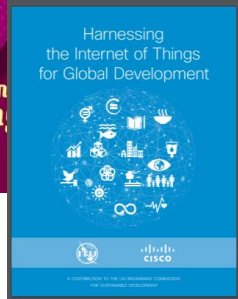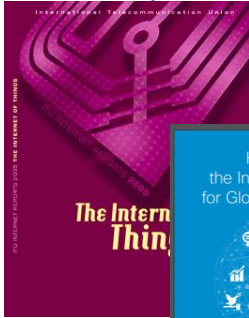# Internet of Things (IoT) & Development

Using IoT Technologies for Development

Agenda

- ITU's work on IoT

- Different "IoT" + M2M technologies

- Different IoT functions & functionalities – lots of different pieces of the puzzle!

- Smart cities

- Different examples – China, Brazil, India, Kenya.

- **Tension btwn consumer IoT, industrial IoT and IoT for health and development purposes.**

Internet of Things, 2005

- Overviewed concept & IoT technologies
- Chapters on enabling technologies and shaping the market
- Emerging challenges & implications for the developing world
- BUT little consideration at the time of data

www.itu.int/osg/spu/publications/internetofthings/
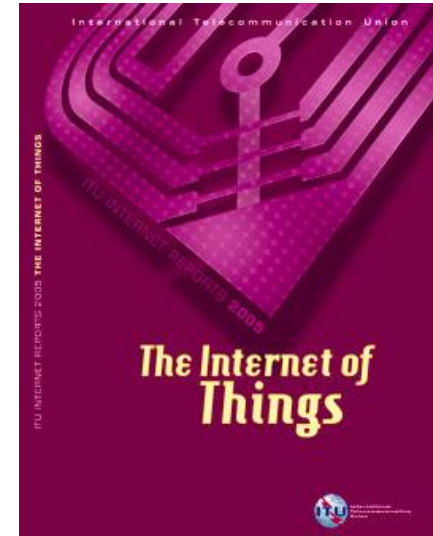
Harnessing IoT for Development
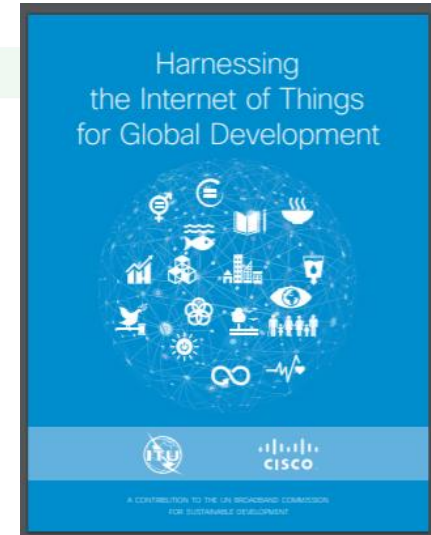
- Overviewed IoT & IoT technologies, sensors
- Listed examples & use cases (air quality, pollution, forestry cases, weather & climate, rare animals)
- Fascinating set of use cases – very diverse.
- Recommendations
- BUT relatively small-scale projects and still not much mention of data

http://www.broadbandcommission.org

Harnessing the Internet of Things for Global Development

What has Changed since 2015

Harnessing
the Internet of Things
for Global Development
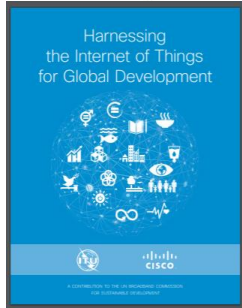
- IoT = subset of specific techs

- Set of technologies

- Focus on hardware

- Discrete use cases (river flow & temperature)

- Merged with 5G, big data & **satellite**

- Focus on data/trails

- Mixing + merging data (passenger temp + flight data)

IoT – A Misnomer?

- No single Internet – there may be many!

- May or may not be connected to the public Internet

- Things? People, animals, trees!

- Pushing intelligence out to the edges of the network, as opposed to centralizing it.

- Disparity between cutting-edge use cases (in towns) and 'development' use cases (sometimes in rural settings?).

- IoT combines/includes (M2M) and -> AI/big data

IoT, M2M & Big Data

The Internet of Everything and Everyone

Big Data

e.g.: Mobile money transactions

P2P

e.g.: Hand water pumps equipped to send text message reports of faulty pumps
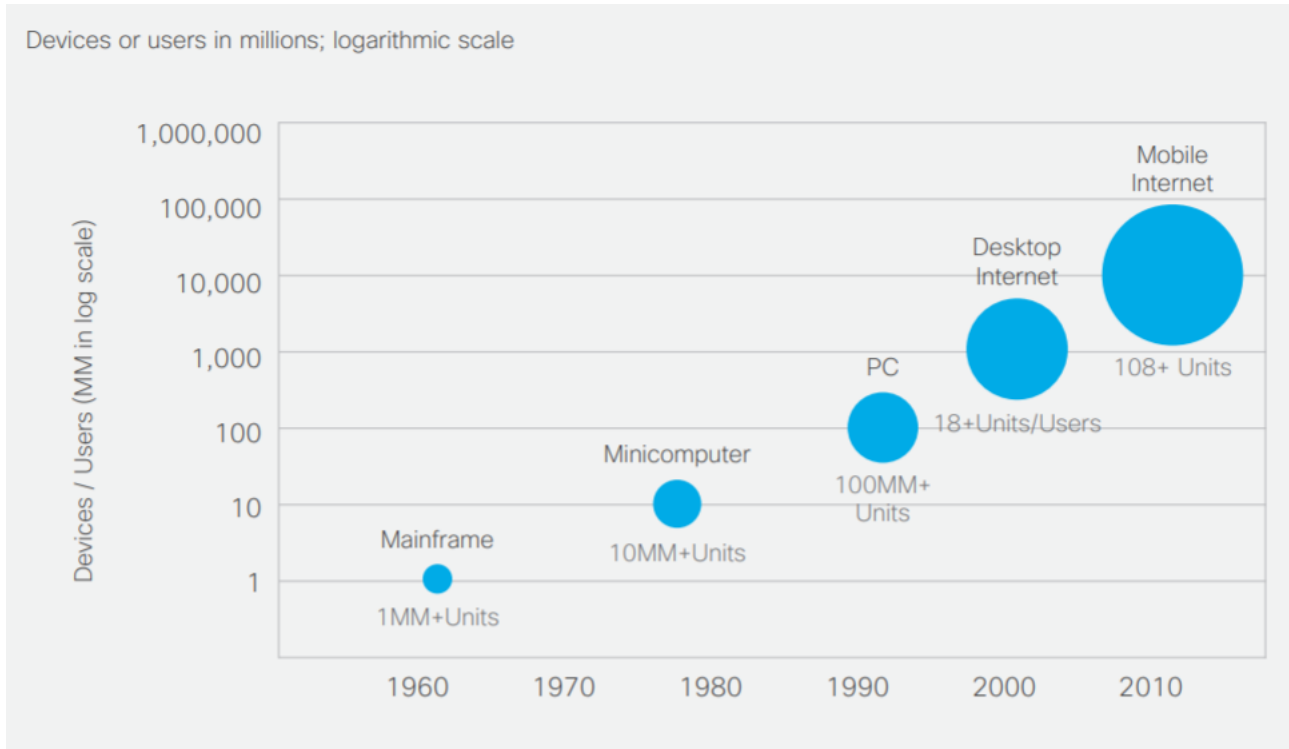
M2P

The Internet of Things

e.g.: Networked smoke and fire sensors to transmit warnings between homes in densely populated informal settlements

M2M

e.g.: Tracking mobile signals for population migration after epidemic outbreaks (e.g. Cholera/Haiti; Ebola/Liberia)

e.g.: Paper census records digitized and then analyzed

e.g.: Aggregate water pump flow and use data analyzed to inform new pump location decisions

e.g.: Aggregate data from fires in settlements is analyzed to inform urban planning decisions

Source: ITU/Cisco.

Successive cycles of computing

Devices or users in millions; logarithmic scale

Source: ITU/Cisco.

The cost is falling rapidly
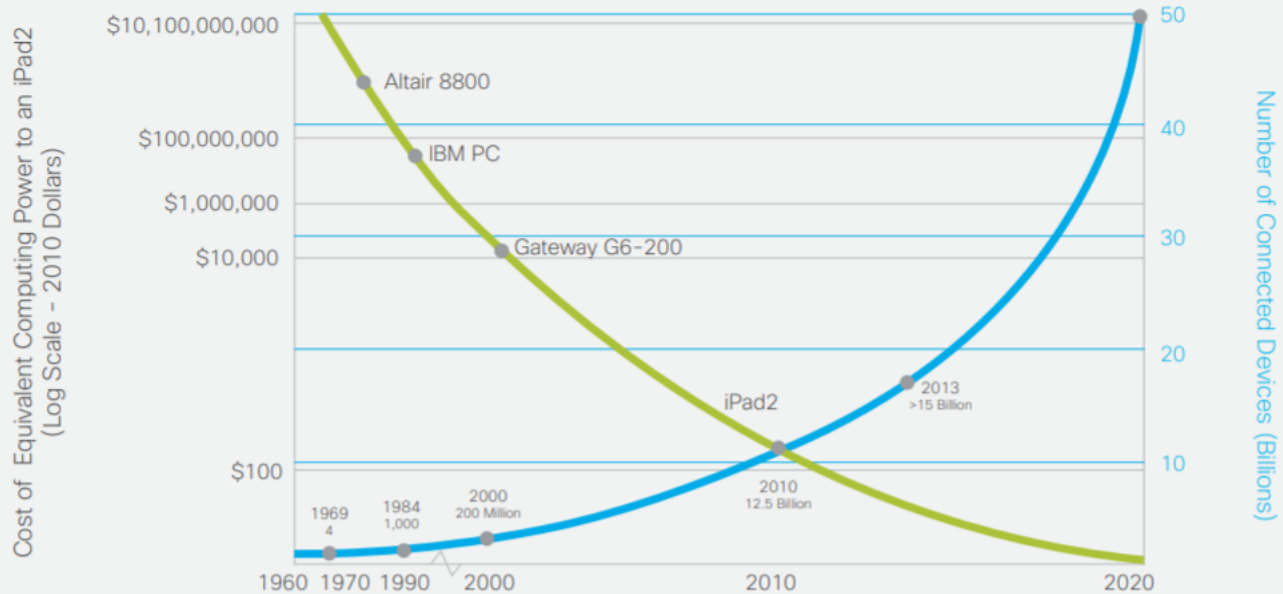
Source: ITU/Cisco, cost estimates from Mary Meeker.

Different Types of Sensors

Source: Harbor Insights.

Sensors or Functions
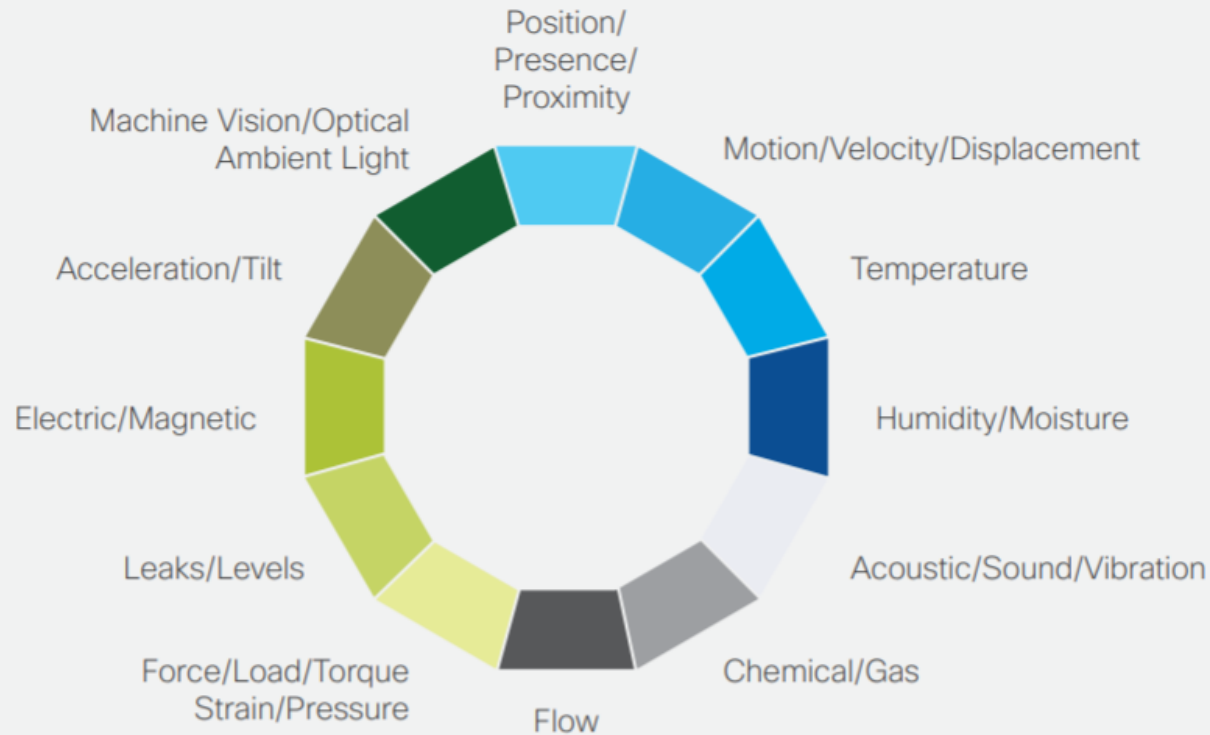
Functions	Sensors
Manufacturing	Asset management, smart sensors, diagnostics for industrial control, tank monitoring, data collection
Transport	Position, presence, proximity sensors, GPS
Water/utilities	Pressure, temperature, flow rate, electricity
Infrastructure	Force/load/torque/strain/pressure sensors
Healthcare	Smart body sensors, remote patient monitoring
Conservation	Acoustic, sound and vibration sensors
Homes	Temperature, energy, home monitoring, HVAC, lighting, solar energy, building alarms, security, fire, intrusion.

Different IoT technologies

		NEED OF MOBILITY →	
		FIXED	**MOBILE**
GEOGRAPHICAL SPREAD →	**DISPERSED**	**Applications** Smart Grid, Smart Meters, Smart City Remote Monitoring **Technology** PSTN Broadband 2G/3G/4G Power Line Communication	**Applications** Car Automation eHealth Logistics Portable Consumer electronics **Technology** 2G/3G/4G Satellite
	CONCENTRATED	**Applications** Smart Home Factory Automation eHealth **Technology** Wireless Personal Area Network Wired Network Indoor Electrical Wiring	**Applications** On Site Logistics **Technology** Wi-Fi WPAN

Different IoT technologies (log'ic scale dist.)
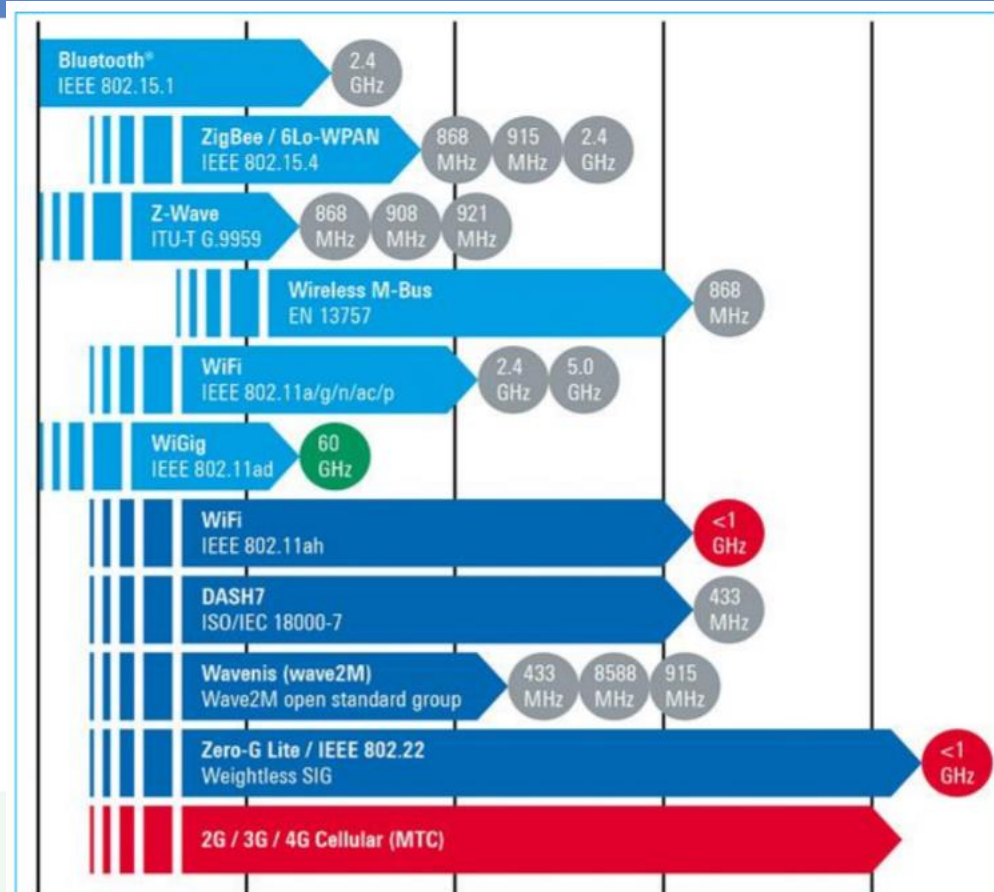
Different bandwidth needs

- **Very low Bandwidth** <1kbps (monthly usage 10KB to 1 MB) e.g. remote sensors

- **Low bandwidth** 1-50 kbps (monthly usage 1-10MB) e.g. utility, health, security monitoring

- **Medium bandwidth** 50 kbps to a few MB (monthly usage 10MB to 300MB) e.g. retail, ticketing, inventory control, gaming, digital pictures

- **High bandwidth** (monthly usage >300MB to 90GB) e.g. digital signage, video surveillance.

Different pieces of the puzzle

The way IoT is used

Applications

SDG 3: Good health & wellbeing

3 GOOD HEALTH AND WELL-BEING

1

Data-management including data-protection and quality regulations, standards and governance mechanisms

→ collectively ensure the safe and ethical collection, use and sharing of digital health data.

2

Medical-device regulations

→ approval and use of safe, cost-effective and high-quality – but also highly diverse – digital health solutions.

3

Regulations governing the delivery of medical care

→ enables medical practices to be supported and enhanced by digital health solutions.

Tracking beds, patients, security, cold storage, supply chain, remote diagnosis, tele medicine and imagery, smartphones becoming medical devices – BUT data!! & scale.

https://broadbandcommission.org/Documents/publications/DigitalHealthReport2018.pdf

Fitness & Wellness Apps

- No. of steps (location & mobility).
- **Wristbands** for hormones (one example of 'femtech').
- **Smartphones** are now used to test for UTI, diabetes & kidney disease.
- **FitBits** can monitor quality of sleep
- **Apple Watch** can monitor irregular heartbeats and atrial fibrillation.
- **Alexa** can now listen for agonal breathing, precursor to heart attacks.

- BUT data & confidentiality
- Consumer versus medical.
- First prosecution using heart rate & webcam to convict a murderer in US

Sources: Various.

Cold supply chains in Tanzania, certification in Uganda

Vaccines have to be kept within 2-8C to be effective. With the approval of the Ministry of Health, a project with Nexleaf (funded by Google) installed temperature sensors in fridges and supply trucks for vaccines in Tanzania to ensure safe & certified delivery of vaccines to rural areas.

In Uganda, the mTrac SMS system is used to monitor medicines & prevent stock-outs. In Ghana, the company mPedigree uses stickers on packaging to track & certify drugs' origin & authenticity.

Source: Nexleaf.

Eye tests via mobile in Kenya, India & Botswana

Smartphones have been used to screen and test eyes of >250,000 people in Kenya, Botswana and India, paid for by partner charities and governments, of comparable efficiency to medical tests – BUT complementary to medical analysis.

In Kenya, Leap's mobile-learning solution delivers interactive training to Community Health Workers (CHWs) through SMS text messages and voice recordings to rural clinics.

https://www.bbc.com/news/av/technology-46780899/ces-2019-eyeque-s-glasses-test-your-ca

Healthcare status via mobile in China (AliPay)

Ant Financial's mobile payment brand Alipay plotted an expansion of a feature to monitor users' health. A red code means 14 days of quarantine & follow updates on DingTalk, a communication app from Ant Financial parent Alibaba. Yellow means stay indoors for a week, green = no restrictions.

GUIDANCE/ADVICE OR OBLIGATION?
DATA OR PUNISHMENT?
EMERGENCY OR NORMALITY?

Source: Mobile World Live.

Korea Telecom KT had a similar initiative

SDGs 6, 7, 11 and 12

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

According to the SDGs report 2019, over half the world's population has been living in cities since 2007 and that share is projected to rise to 60 % by 2030. There is a need to develop national urban plans to help cities grow in a more sustainable and inclusive manner.

Smart Water using NB-IoT in China

700K water meters with a 12-year life cycle, measuring flow, pressure vibration, temperature = fault rate.

$4.6 per meter per year
$1,600 per site

Source: Huawei.
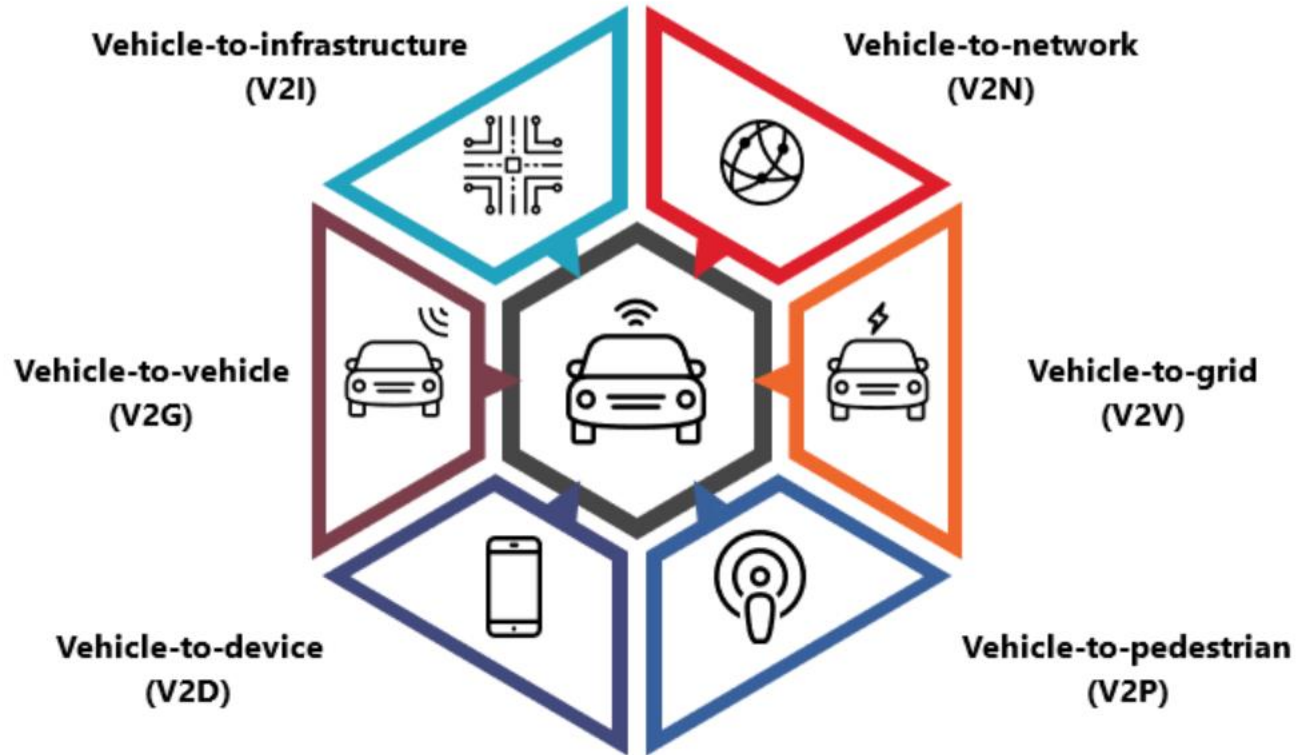
Smart Water Pumps in Kenya

> 300 smart hand pumps in Kenya across 3 counties, supplying >60,000 rural people. Only 3% of smart hand pumps are estimated out of action, compared with 1/3 of normal pumps across Africa.
The smart hand pumps enable a 72-hour guaranteed repair service or refunds are made, but most are repaired within 48 hours.

Source: Oxford University, https://esrc.ukri.org/news-events-and-publications/impact-case-studies/secur water-supply-with-smart-hand-pumps/.

V2X Technologies

Vehicle-to-infrastructure (V2I)

Vehicle-to-network (V2N)

Vehicle-to-vehicle (V2G)

Vehicle-to-grid (V2V)

Vehicle-to-device (V2D)

Vehicle-to-pedestrian (V2P)

https://www.accesspartnership.com/tapping-into-the-connected-cars-market-

# Vehicle Tracking in Brazil – SIMRAV

ANATEL responsible for defining BW of GSM signal, DENATRAN for hardware. Plans with different coverage ranges created by the cell operators. As it depends on GSM and GPS signals, functionality is linked to the quality and range of these signals. Rural areas without infrastructure may not have coverage. BUT there were big privacy concerns – Courts called to decide – optional at best.

Integrated System for Automatically Monitoring and Registering Vehicles (SIMRAV)
https://ihsmarkit.com/research-analysis/brazil-still-hoping-to-fight-vehicle-theft-with-

Collision & Pedestrian Avoidance
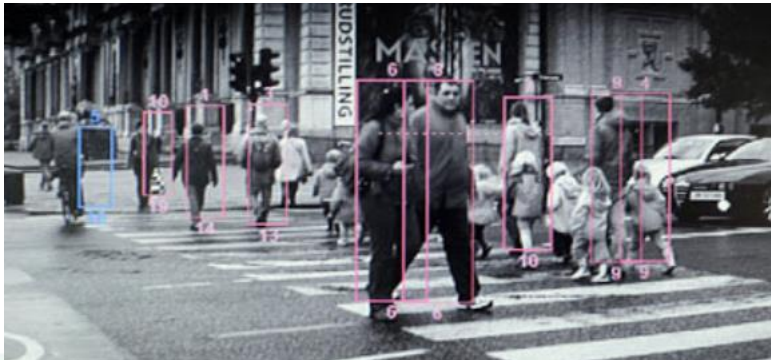
HARMAN showcased a vehicle-to-pedestrian technology based on 5G. It forewarns drivers and pedestrians of impending dangers using vehicle-to-everything (V2X) technology. Verizon is using 5G ultra-wideband (UWB) network and 5G Edge with HERE location and data technology for vehicle & pedestrian safety, collision avoidance, location identification & navigation for ridesharing.

https://ihsmarkit.com/research-analysis/connected-car-highlights-from-ces-2020.html?ite=985773&ito=1274&itq=9c137fd9-7b10-4763-baca-a4fa713d631d&itx%5Bidio%5D=32533571

Smart Parking using NB-IoT in China

China Mobile & DTMobile have 2 smart parking pilots using NB-IoT connectivity in Yunnan and Southeast Guizhou. Based on LTE networks, NB-IoT is suitable for smart parking as it has support for a long battery life and offers improved coverage which allows sensors to be placed in any location.

Source: China Mobile.

Payment via the Cloud
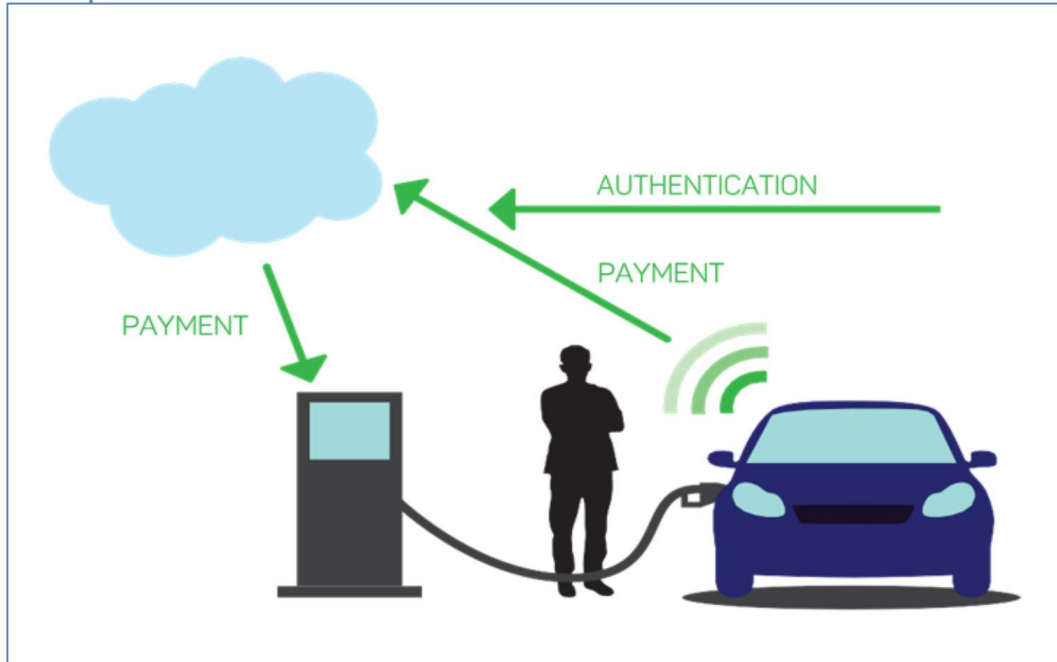
Application software such as Apple Pay, Google Pay and Samsung Pay, with Near Field Communication (NFC) or Bluetooth Low Energy (BLE) peripheral hardware. Techniques such as Host Card Emulation (HCE) & QR codes allow mobiles to be used as payment devices. For road tolls, parking, car taxation, servicing, drive-thru, car rental, insurance.

Source: https://www.mobilepaymentstoday.com/articles/how-connected-cars-are-driving-connected-payments/

Cybersecurity of Internet-connected cars

In US, GM, Toyota, and Ford, circa half the US auto market—and were due to sell mainly Internet-connected cars by end 2019. By 2022, 2/3 of new cars in US are predicted to have online connections to the cars' safety-critical system, putting them at risk of deadly hacks – security concerns about hacking, especially fleet-wide.

https://ihsmarkit.com/research-analysis/two-us-senators-question-cybersecurity-vulnerabilities-of-
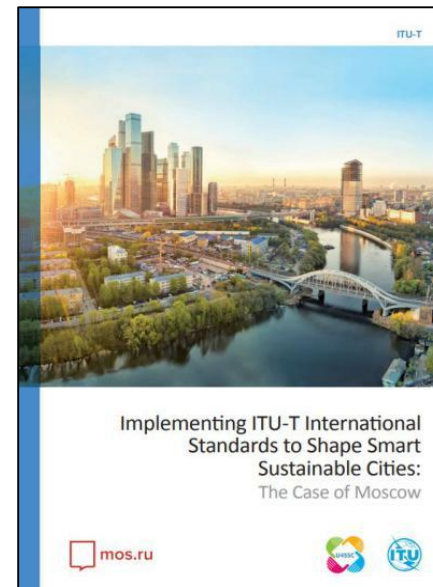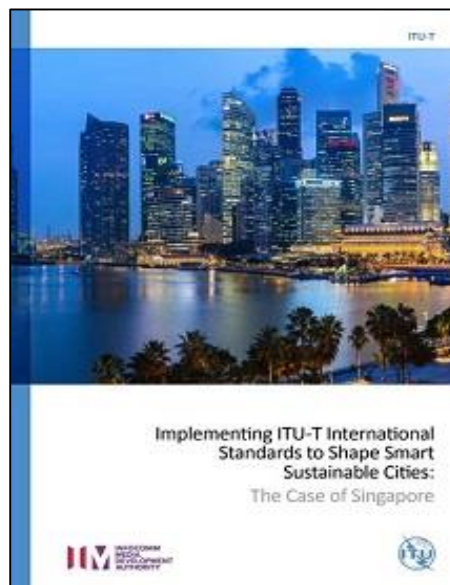
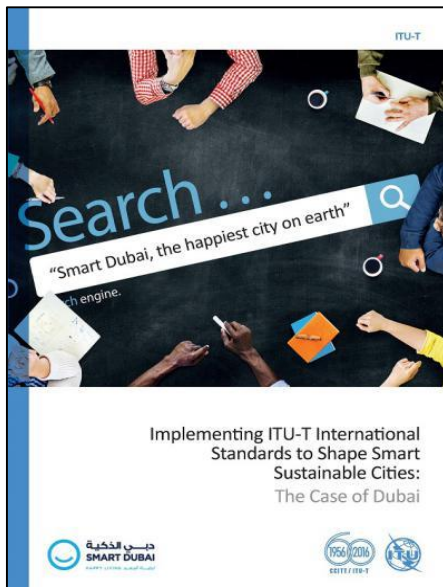# ITU's Smart Sustainable Cities Initiative (SSC)

ITU has a Smart Sustainable Cities Initiative to manage urban complexities, reduce urban expenditure, increase energy efficiency & improve the quality of life for urban residents.

Smart Sustainable Cities

Source: https://www.itu.int/en/ITU-T/ssc/Pages/default.aspx.

KPIs for Smart Sustainable Cities

ITU has developed a set of
Key Performance Indicators
(KPIs) to monitor energy
efficiency of ICT equipment
and devices, so cities, firms
and people can make
informed choices.

ITU case studies on Standards for SSC

Implementing ITU-T International Standards to Shape Smart Sustainable Cities: The Case of Dubai

Implementing ITU-T International Standards to Shape Smart Sustainable Cities: The Case of Singapore

Implementing ITU-T International Standards to Shape Smart Sustainable Cities: The Case of Moscow

Source: https://www.itu.int/en/ITU-T/ssc/Pages/default.aspx.

ITU reports on Smart Sustainable Cities

Source: https://www.itu.int/en/ITU-T/ssc/Pages/default.aspx.

SDGs 2 and 12

SDG 2: End hunger

SDG 12: Ensure sustainable consumption and production patterns

Agriculture & crop yields are now vulnerable to climate change

FAO – as much as 1/3 of food produced for human consumption each year is lost or wasted, most of it in developed countries.

Agricultural Sensors using cellular gateways

Cellular gateways are devices powered by integrated batteries that interface with 3P sensors to transmit data over cellular networks. This overcomes 2 big barriers to farm connectivity - lack of power & lack of wired/wireless Internet in the field. Cellular gateways transmit sensor readings as decryptable text messages to a cloud server, accessible via an online login.
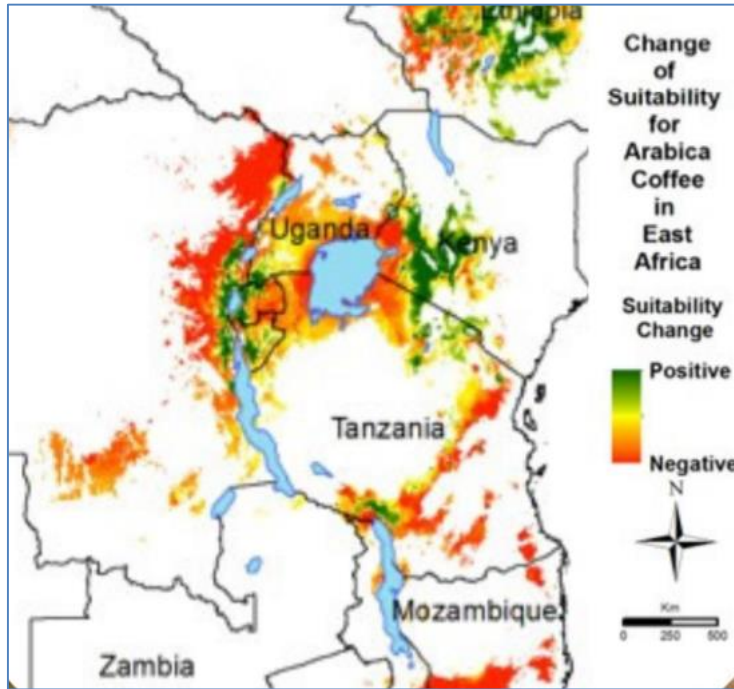
https://www.iotworldtoday.com/2018/01/18/case-study-harvesting-data-through-cellular-gateways/

Agricultural Sensors

Functions	Sensors
Camera	leaf health, lighting brightness, chlorophyll measurement and ripeness level. Also used for measuring leaf area index (LAI) and measuring soil organic and carbon make-up.
GPS	Location for crop mapping, disease/pest location alerts, solar radiation predictions and fertilizing.
Microphone	Predictive maintenance of machinery.
Accelerometer, gyrometer	Force/load/torque/strain/pressure sensors, angle index, rollover alarm
Sensors	Temperature, pressure, sound

https://www.mouser.ch/applications/smart-agriculture-sensors/

RFID Pig Farming in PNG – FAO & ITU

In Papua New Guinea, FAO and ITU have designed a livestock-tracking blockchain system for smallholder pig farmers. Using radio-frequency identification (RFID) tags and a smartphone app, farmers can keep digital records of how they raised their pigs – proving the pigs received a diet of sweet potatoes, for example, or whether they have been vaccinated.

http://www.fao.org/in-action/pig-farmers-in-papua-new-guinea/en/

Climate-Smart Agriculture – World Bank

Change of Suitability for Arabica Coffee in East Africa

Suitability Change

Positive

Negative

N

Km
0   250   500

Suitability maps from the International Institute of Tropical Agriculture (IITA) show areas suitable for Arabica coffee will drastically decrease as average global temperatures rise.

Shade trees (like banana) can add +50% income for producers, absorb carbon in the soils and reduce local temperatures & drought problems. Intercropping changes the micro-climate locally.

https://www.greengrowthknowledge.org/case-studies/climate-smart-agriculture-successes-africa
https://www.greengrowthknowledge.org/sites/default/files/downloads/best-

SDGs 13 and 14

SDG 13: Take urgent action to combat climate change and its impacts

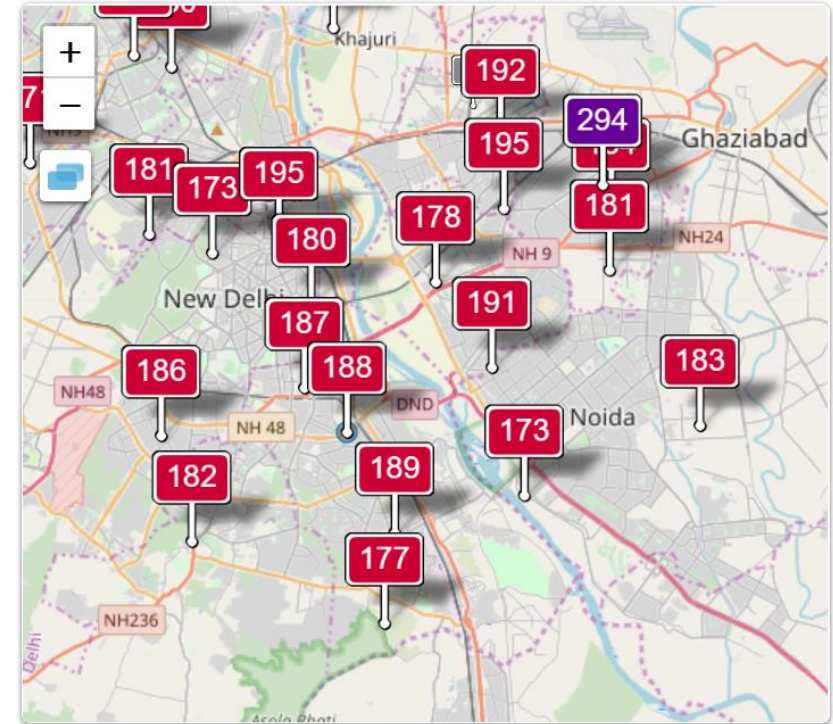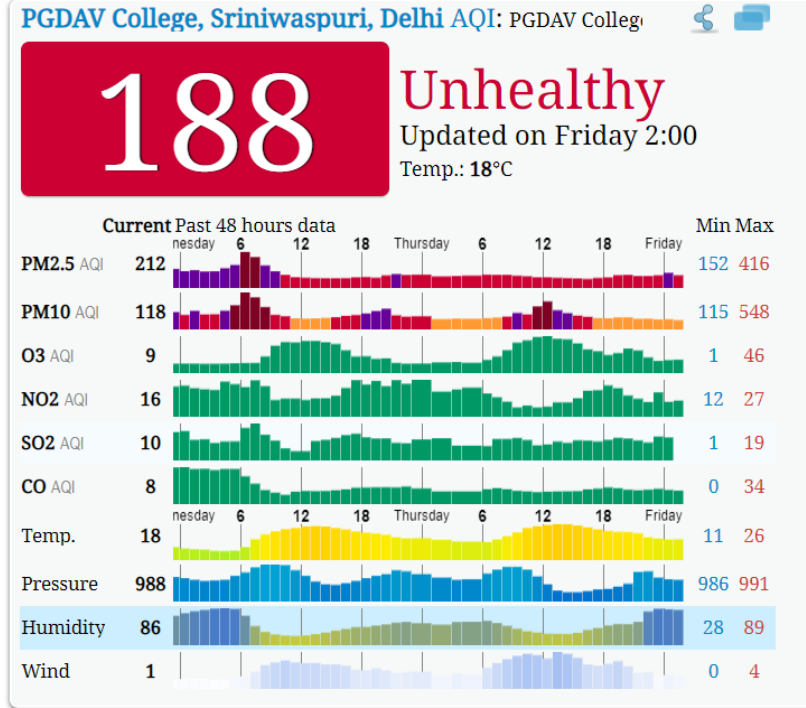**SDG 14: Conserve & sustainably use the oceans, seas & marine resources for sustainable development**

WMO maintains the Global Observatory System (GOS)
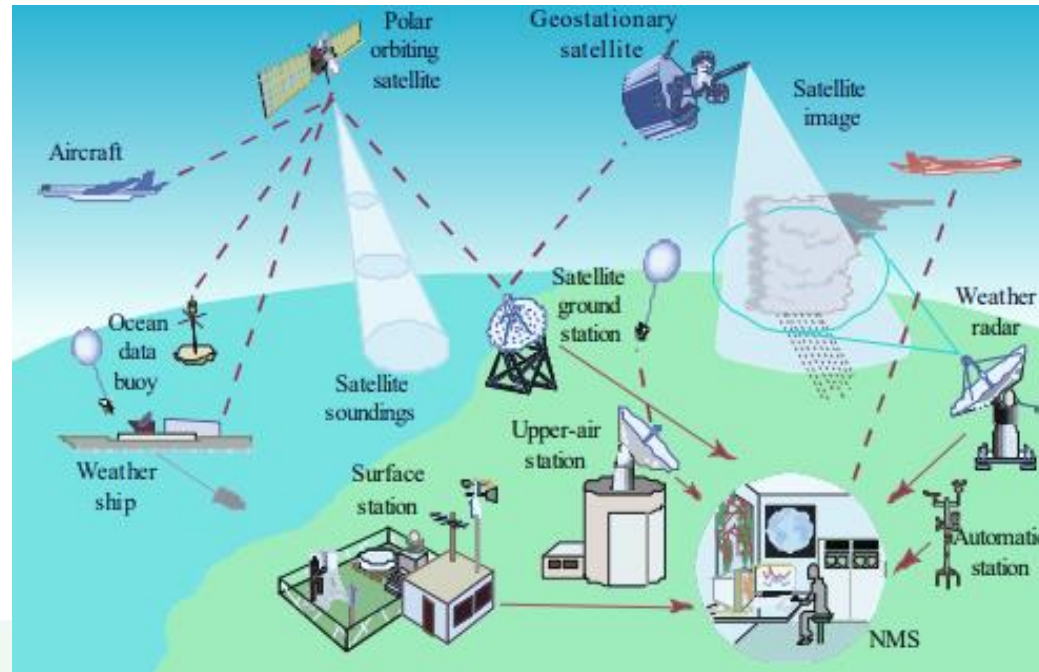
Sensors for Air Quality Index

House air quality in India & Indonesia

An estimated 3 billion people may still cook over open fires. Wrist bands are being used to monitor indoors air quality in India and Bangladesh, where there are indoor cooking fires.

Sensors are being used to monitor carbon monoxide in Indonesia.

BUT monitoring & measurement or redesign of kitchen, ventilation and cleaner cooking stoves?

Climate – Ocean Currents
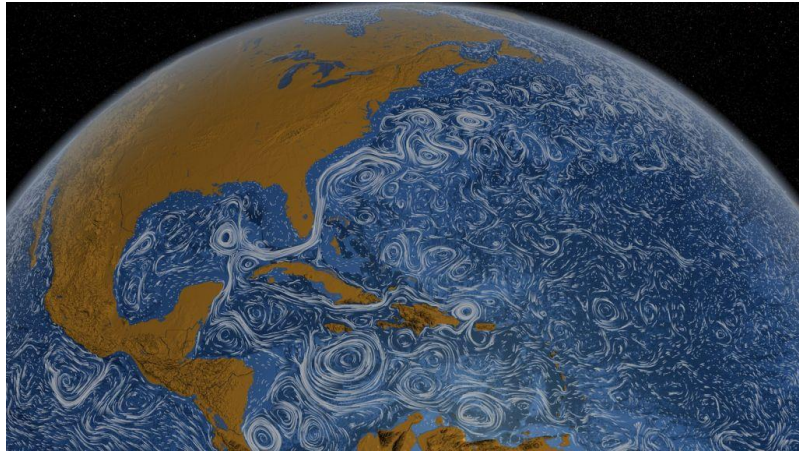
Argo Mission

- A scientific project that uses thousands of autonomous, missile-shaped floats to gather information about ocean temperature, salinity & currents.

- Currents are speeding up +5%/decade

- Wind speed +1.9% per decade

Shijian Hu, Institute of Oceanology in Qingdao, China, & Janet Sprintall, Scripps Institution of Oceanography, UCSD, 'Science Advances', 6 Feb 2020

https://www.livescience.com/ocean-currents-speeding-up.html?utm_source=Selligent&utm_medium=email&utm_campaign=9160&utm_content=LVS_newsletter+&utm_term=3282665&m_i=RD%2BcR1HwW48zBGkIVOsSR9tTa_okJ6fMM6TiFghN1dK7I58T42mmQWFV4bvudsZ9a4sSNr4WEwofYuPjw4vxe9IEXhd0fABSukuoZkRRRG

Climate – Great Barrier Reef

In Australia, a project by the University of Melbourne has installed IoT sensors on the Great Barrier Reef to monitor local temperature, UV levels and the health and vitality of the Great Barrier reef .

Presentation by Marimuthu Swami Palaniswami, University of Melbourne, to IoT Week 2017, CICG Geneva.
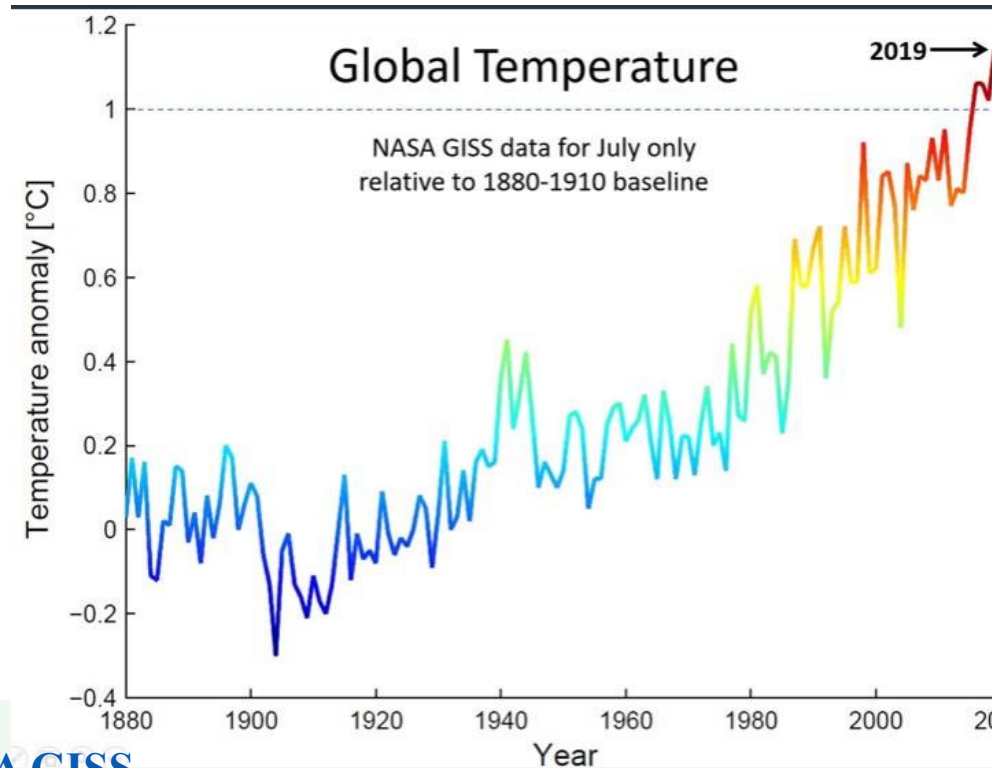
Satellites monitor sea level & ocean temp.
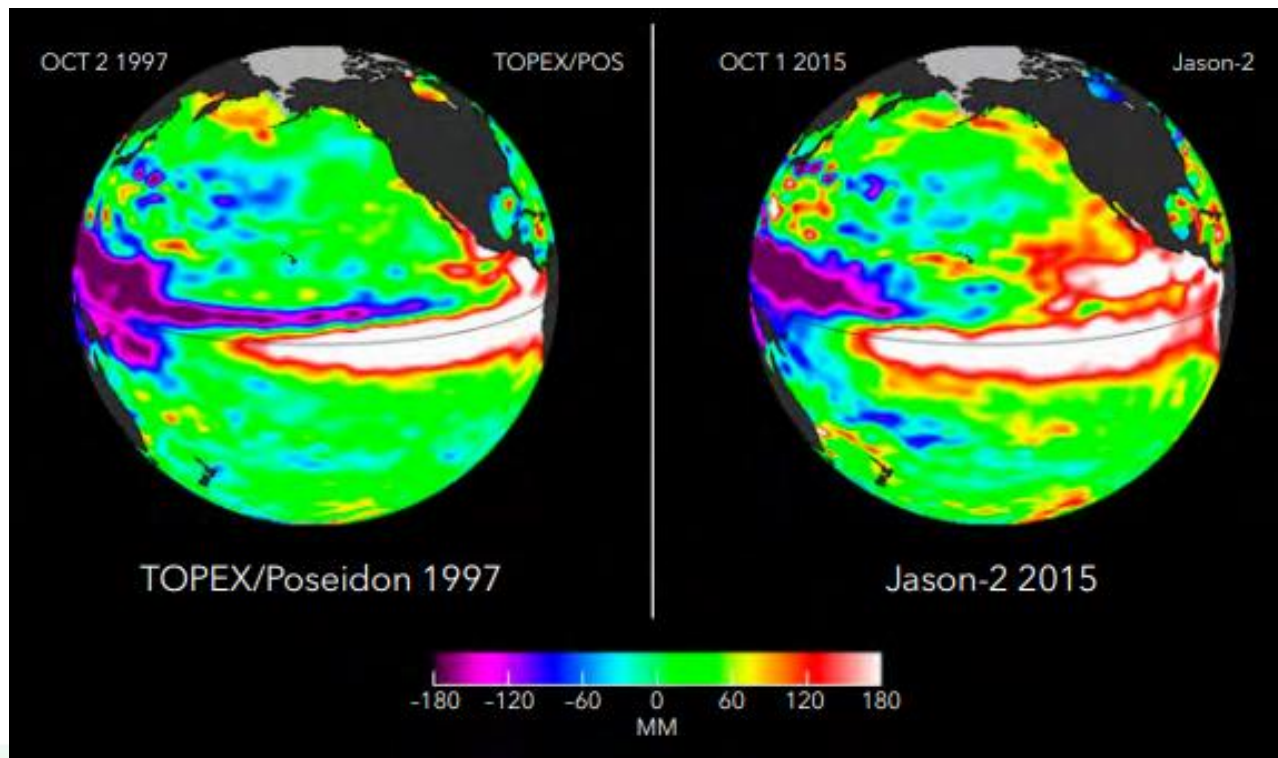
Sources: TOPEX/Poseidon, Jason-2.

Contributing to a warming world…

Source: NASA GISS.

UN Intergovernmental Panel IPCC

Established by UNEP and WMO in 1988, the UN Intergovernmental Panel on Climate Change provides research and advice on the current state of knowledge of climate change; the social and economic impact of climate change, and potential response strategies.
http://www.ipcc.ch/about/

Global Warming of 1.5° C
Oct 2018

Climate Change & Land
August 2019

Mountain Rescue – What3words

What3words

- Divides world into 3x3 m2 squares

- Each with a unique locator

- Used recently to rescue tourists caught in a storm on Ben Nevis Scotland.

- Mobile phone + an app?

https://www.bbc.com/news/uk-scotland-highlands-islands-51447226

Conclusions

- Internet of Things -> Internet of Everything?

- Data – trails, data implications, prosecutions, legal evidence?

- Cybersecurity – hacking of car fleets

- BUT Measurement is NOT action to address a problem

- Attention moving from 'making it happen' to the ***consequences*** of having made it happen!