



Queen Mary

University of London

Science and Engineering

Intelligent IoT for

Sustainable Development Goals:

Sensing with the communication network

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What are Sustainable Development Goals **SDG**?

The infographic features a large blue arrow pointing right with the year '2030' and a large black question mark overlaid on it. On the left, a semi-circular gauge chart shows progress: 15% in green, 48% in yellow, and 37% in red. A legend indicates 'On Track' with a green dot. Below the gauge, a circular icon of a factory is next to the text '99% OF THE WORLD'S URBAN POPULATION BREATHE POLLUTED AIR'. To the right, a line graph shows a fluctuating upward trend from 1925 to 2021. At the bottom right is the circular 'Sustainable Development Goals' logo with 17 icons.

On Track

**At least Slightly or Severely Off Track
Stagnation or Regression**

15% **48%** **37%**

99%
OF THE
WORLD'S URBAN
POPULATION BREATHE
POLLUTED AIR

**RISING GLOBAL TEMPERATURES
CONTINUE UNABATED, LEADING
TO MORE EXTREME WEATHER**

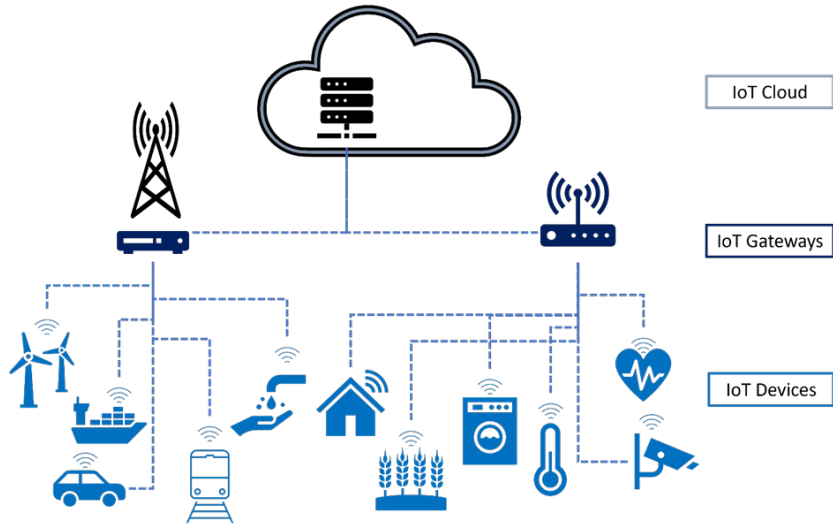
2030

**UN SDG summit
Sept 2023**

UN defined 17 SDG to be met by 2030

Can Digital Technology help?

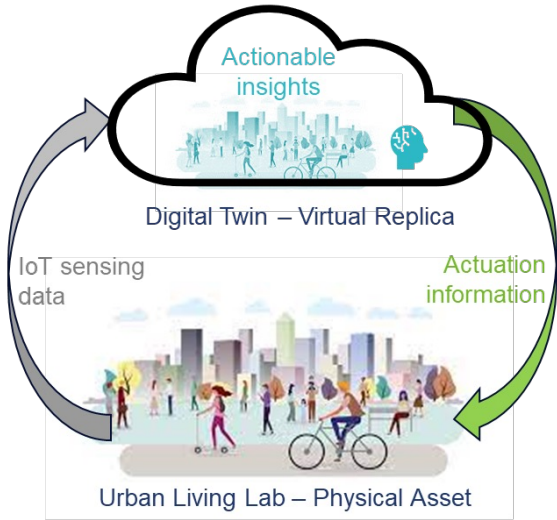
Internet of Things (IoT)



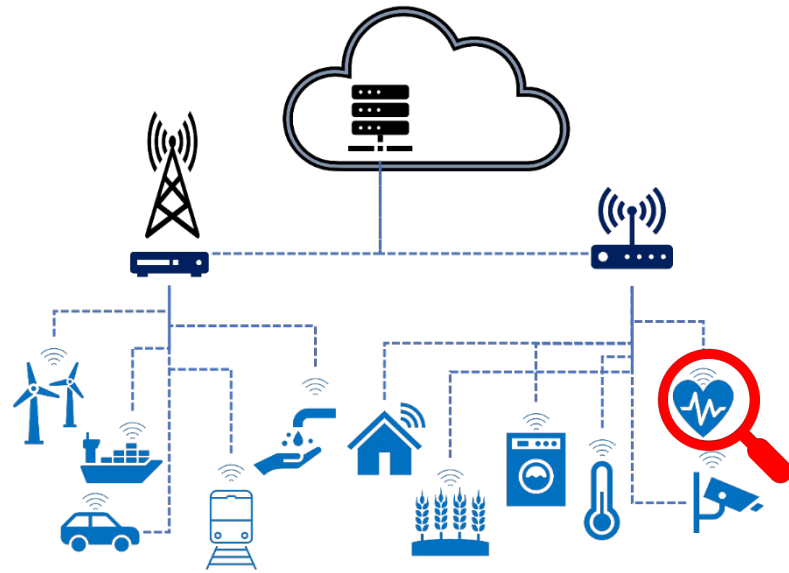
Artificial Intelligence (AI)



Digital Twin (DT)



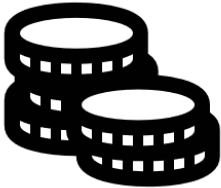
What is an **IoT** device?



A **sensor** connected over the **communication** network

Can IoT help?

Affordable



Real data anytime



Plug & Play



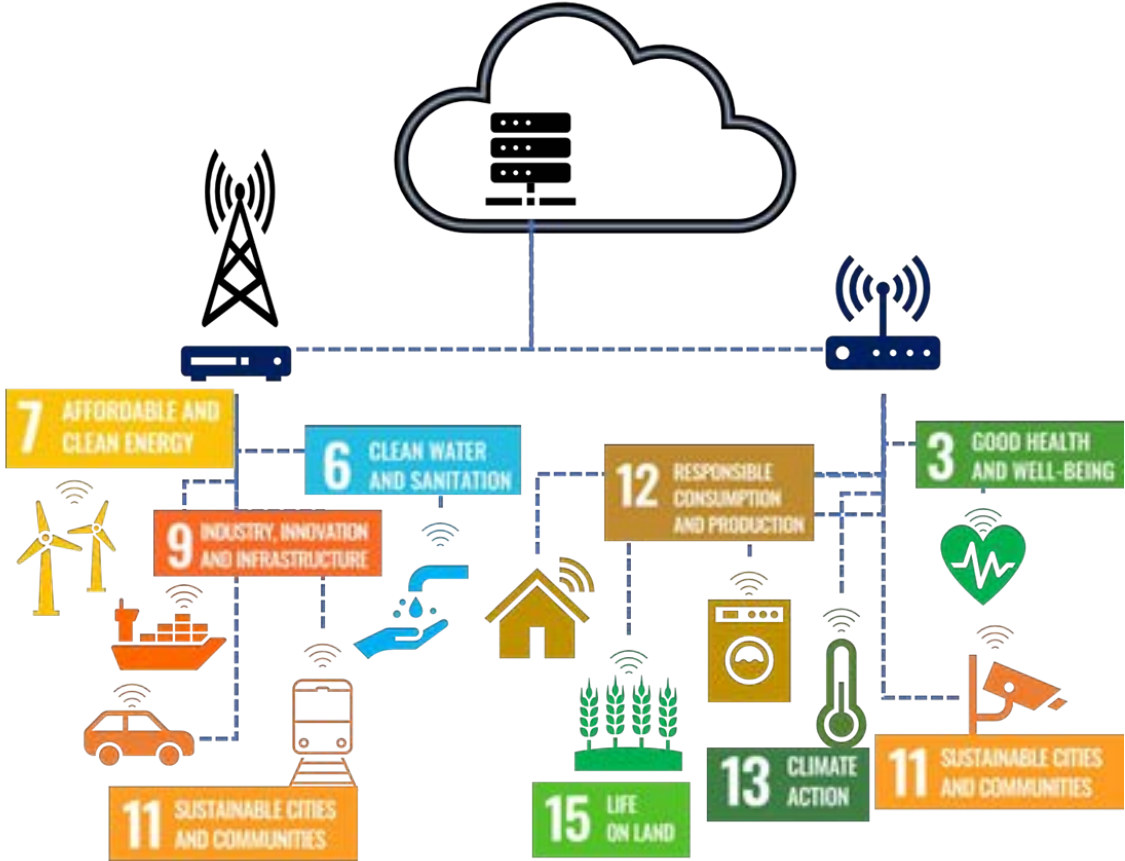
Real data anywhere



Internet is almost everywhere

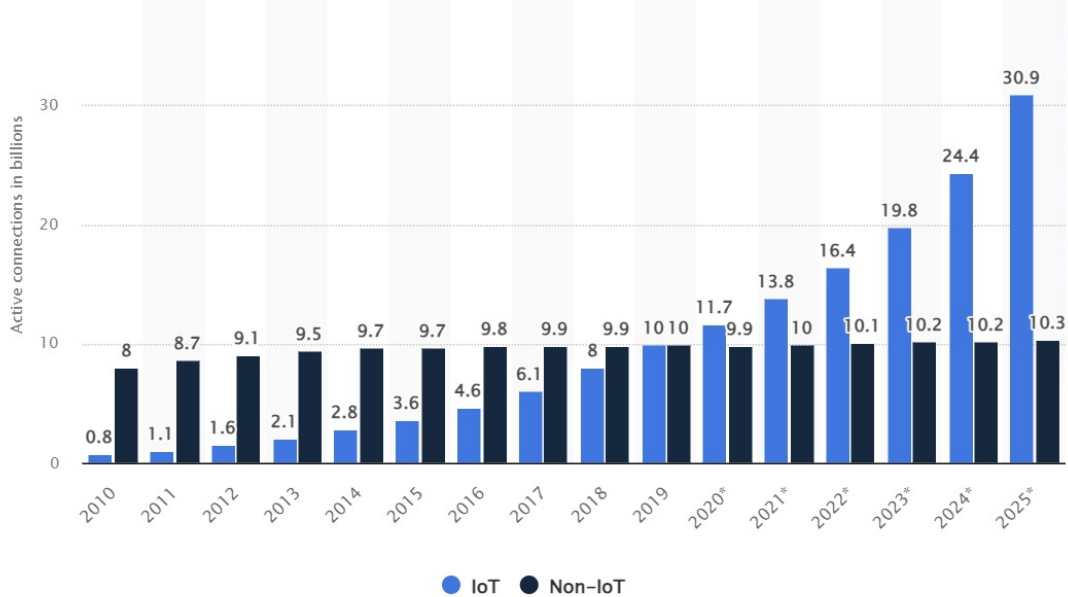


Affordable ubiquitous real time info!



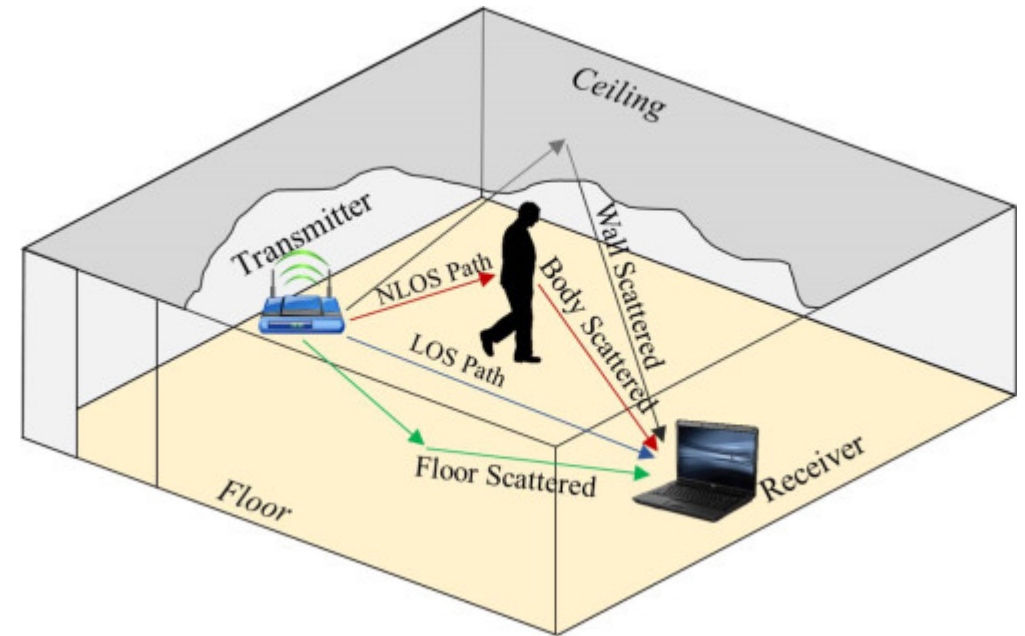
How many IoT devices are needed to inform SDGs?

3 times more connected things than connected people!!!



<https://www.statista.com/statistics/1101442/iot-number-of-connected-devices-worldwide/>

Deploying brand-new sensor infrastructure is **prohibitively expensive**. How about using an existing pervasive communications network and transform it into **the world's largest distributed radar network!**



H. Farhana et. Al "Device free human gesture recognition using Wi-Fi CSI: A survey", Engineering Applications of Artificial Intelligence, 2020

Can the **communication network sense**?

Communication

Sensing

SETTING SIGHTS ON
GENERATIONAL LEAP

1-10 Gbps

6G

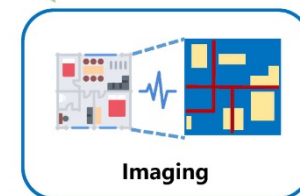
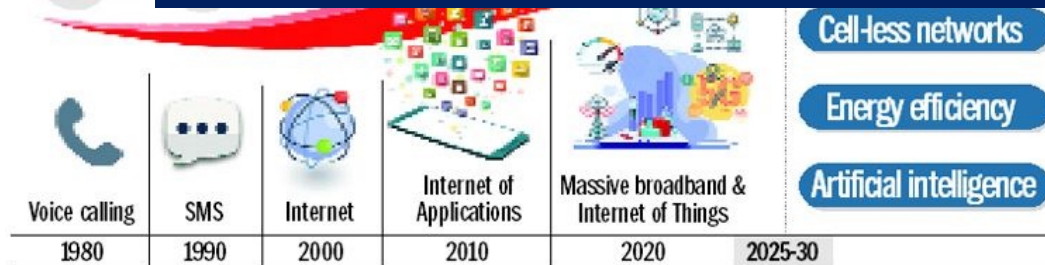


Integrated Sensing and Communication (ISAC)
Sensing and communication functions co-exist with the same hardware and spectrum to utilize resources efficiently.

2.4 Kbps

1G

Monitoring



High-speed data rate and low latency

Support device-free target sensing

Y. He et.al. "SenCom: Integrated Sensing and Communication with Practical WiFi"

Use Case: Intelligent Transportation Systems

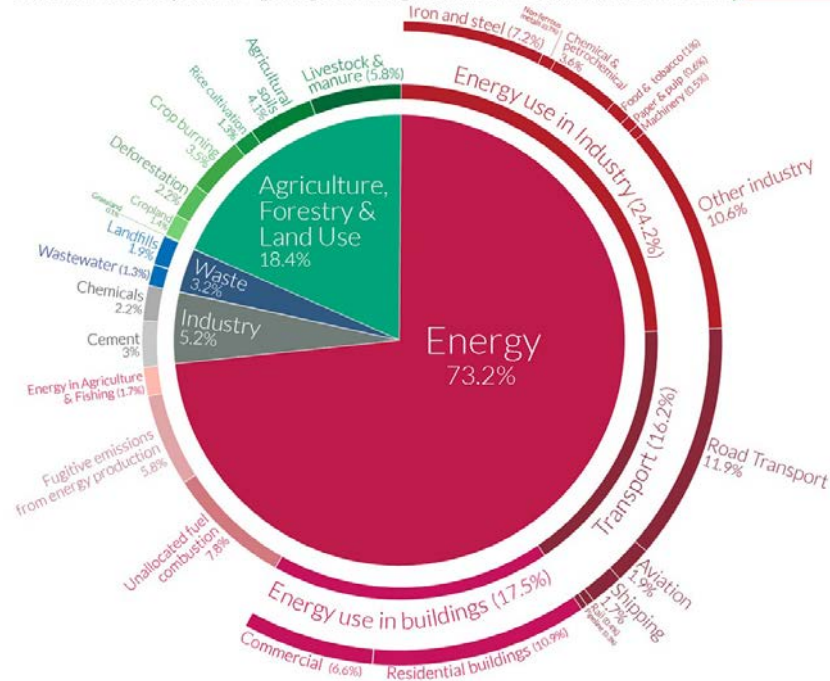


Intelligent Transportation Systems **ITS**

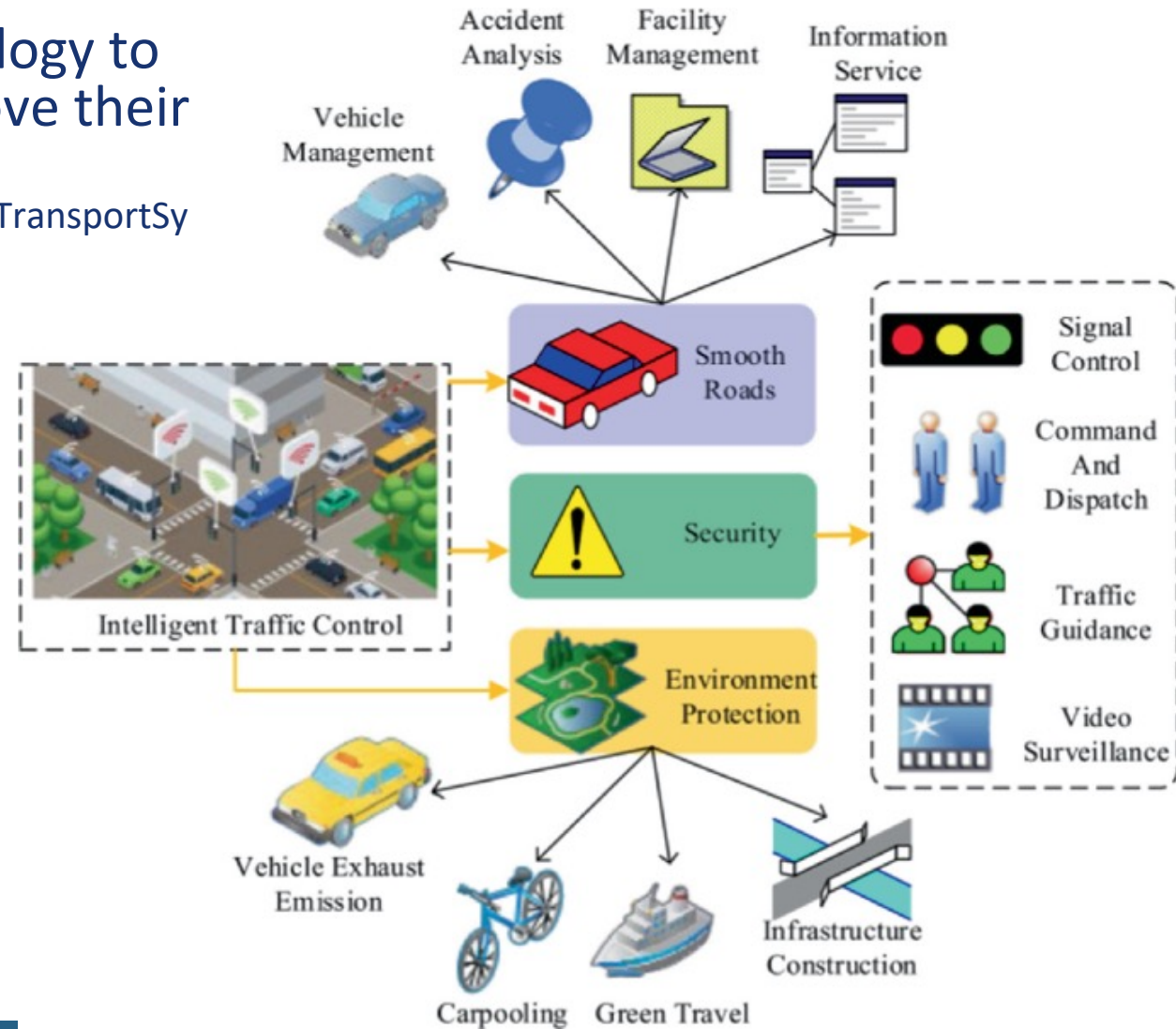
“Add **information** and **communications** technology to transport infrastructures and vehicles to improve their **safety, reliability, efficiency and quality.**”

<https://www.etsi.org/images/files/ETSITechnologyLeaflets/IntelligentTransportSystems.pdf>

Global greenhouse gas emissions by sector 
This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.



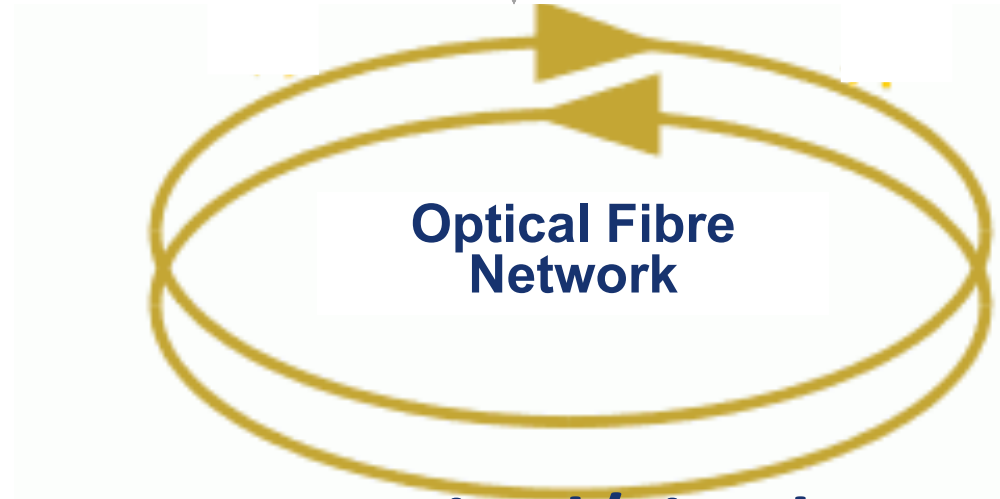
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).
Licensed under CC-BY by the author Hannah Ritchie (2020).



ITS: Sensors and Communication Networks

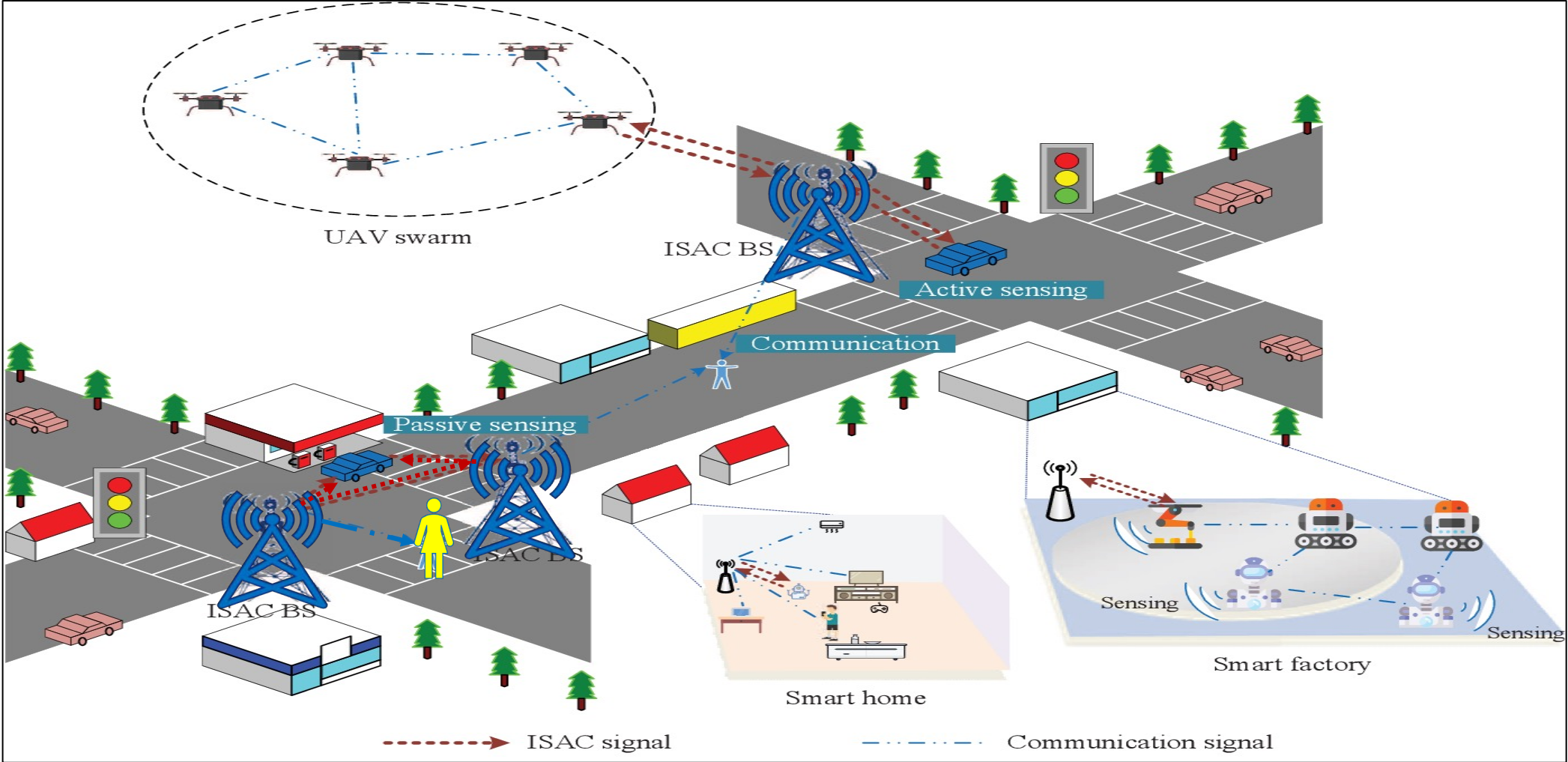


Wireless



Wired/Fixed

ISAC for Intelligent Transportation Systems

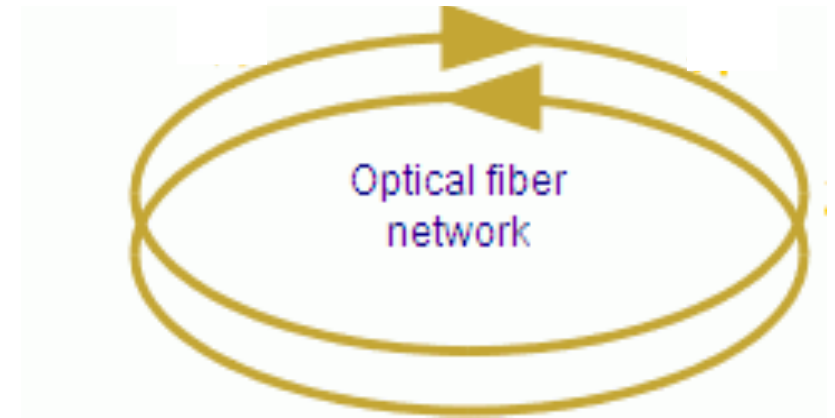


Wireless

Z. Wei et. al “Integrated Sensing and Communication Signals Toward 5G-A and 6G: A Survey”, IEEE Internet of Things Journal, 2023

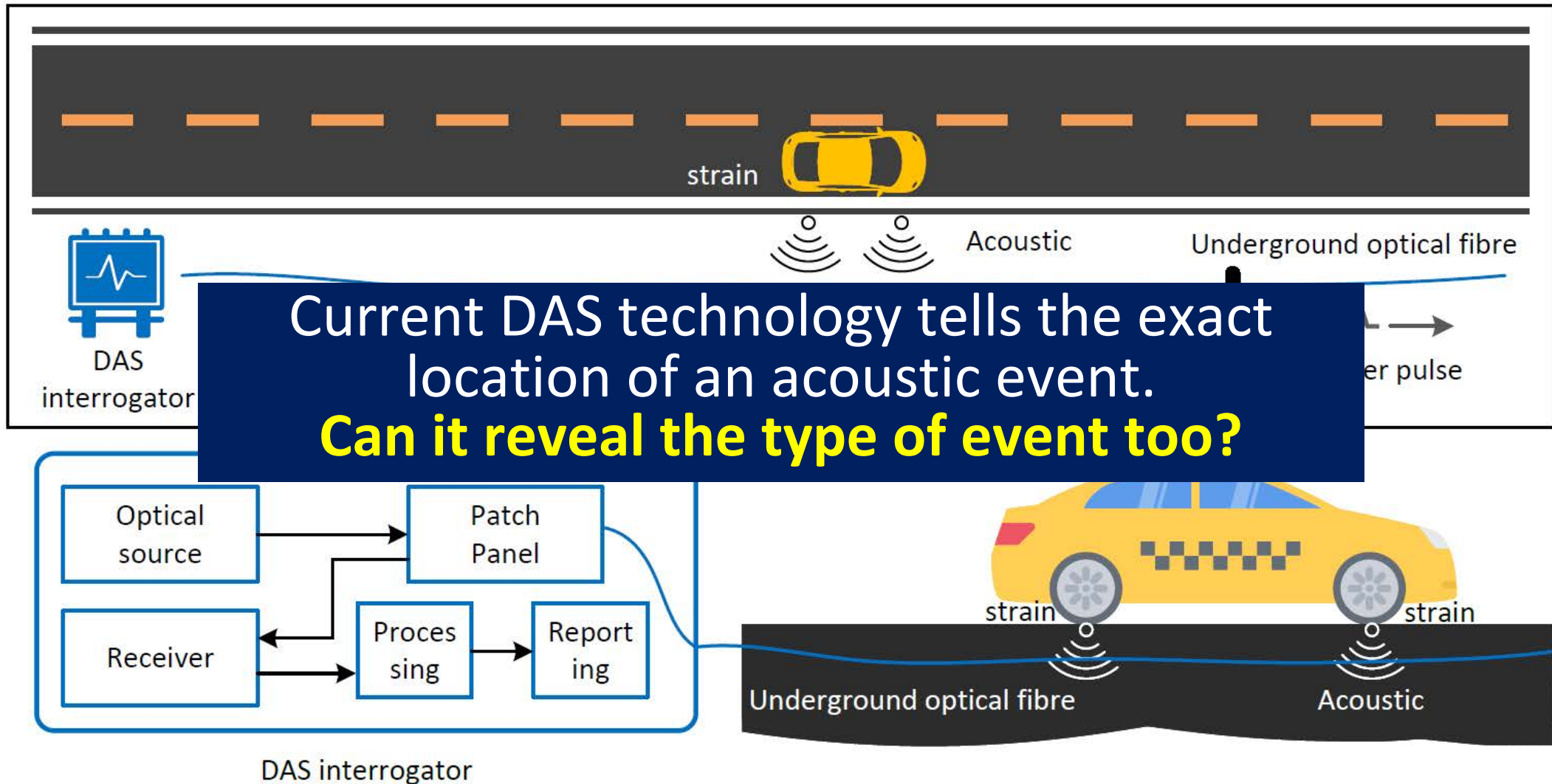
DAS for Intelligent Transportation Systems

Fibre-based Distributed Acoustic Sensor Systems



Wired/Optical Fibre

How does DAS work?



Why DAS for ITS?

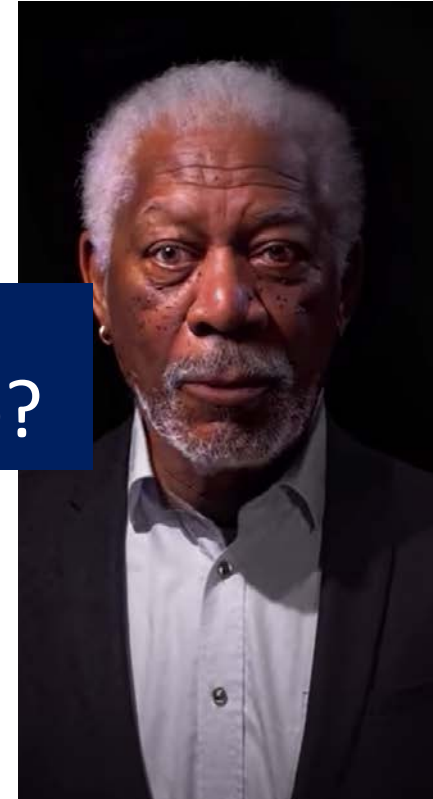
Unused (dark) fibre is almost everywhere



Resilient to adverse weather and visibility conditions

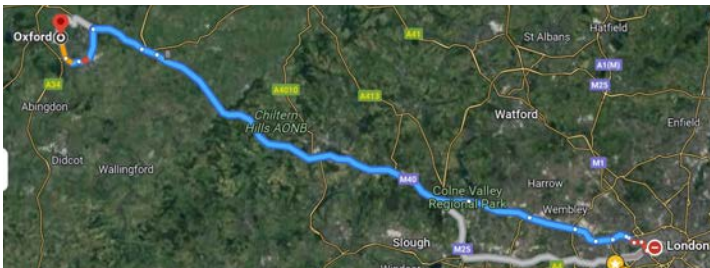


Almost impossible to fake!



Great, but....
Can it reveal the **type of event** too?

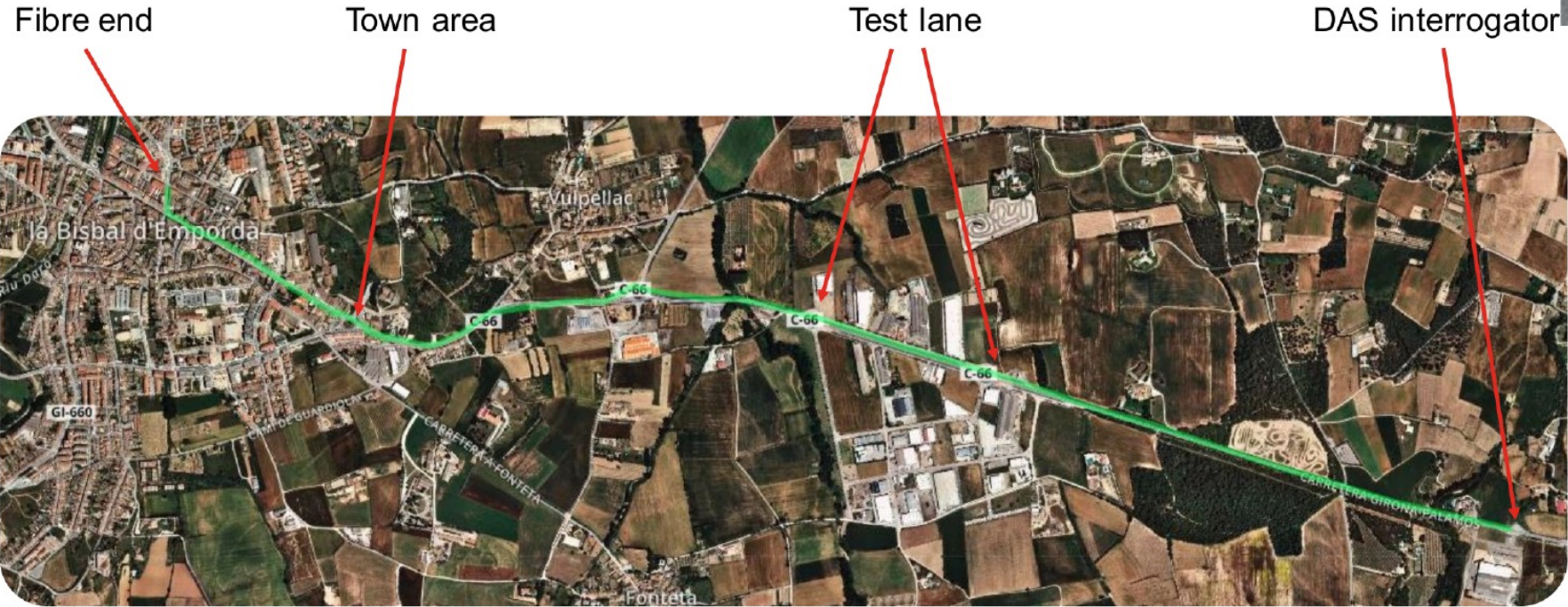
2 DAS interrogators needed instead of 1000 cameras



Does not capture personal data



How much can be sensed with DAS?



Car 1: Jeep Compass

Car 2: Renault Clio

Car 3: Toyota CHR (Hybrid)

Car 4: Fiat diablo

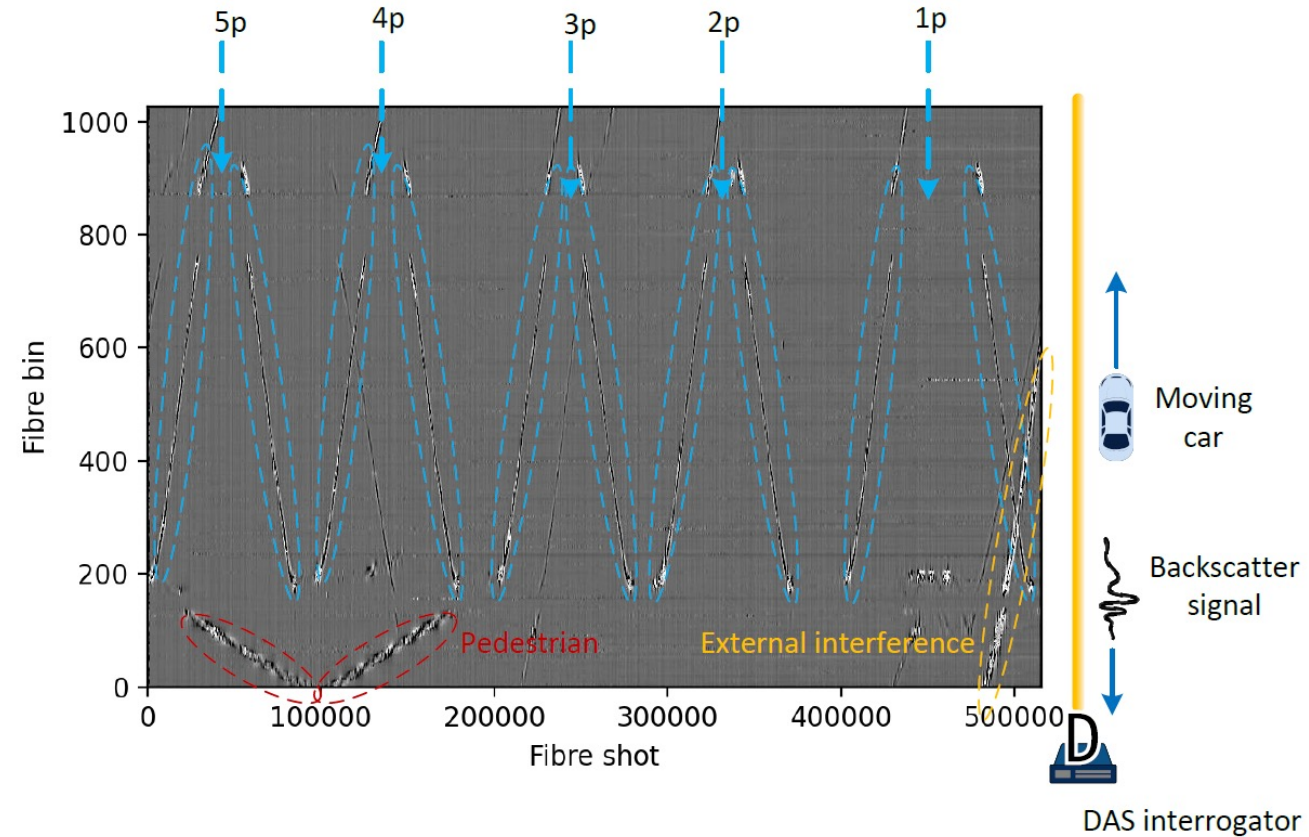
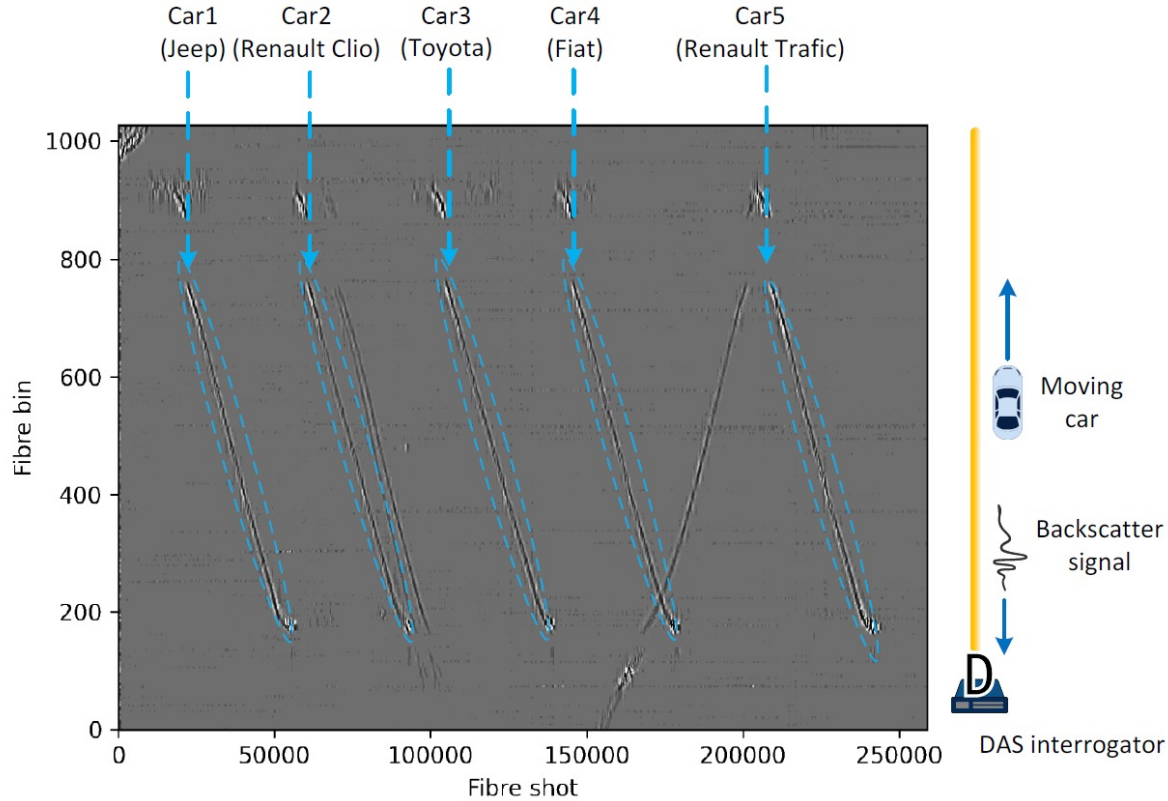
Car 5: Renault traffic



What does **DAS data** look like?

Chia-Yen Chiang

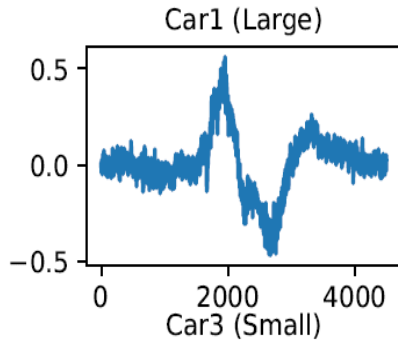
Dr. Ruikang Zhong



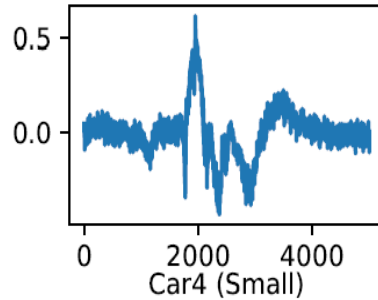
What does a **DAS** signal look like?

Car type

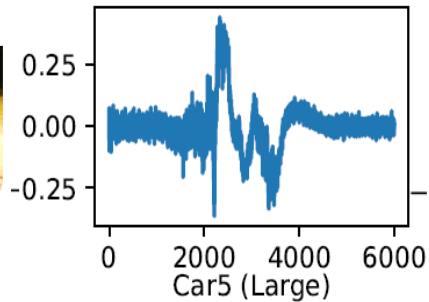
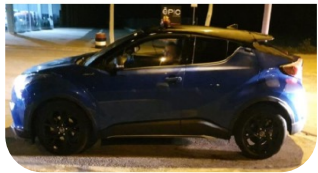
Car 1: Jeep Compass



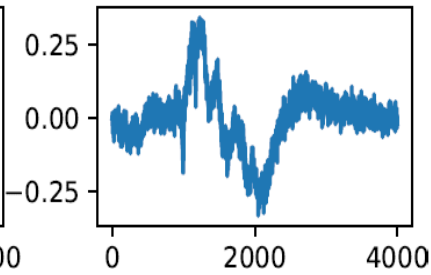
Car2 (Small)



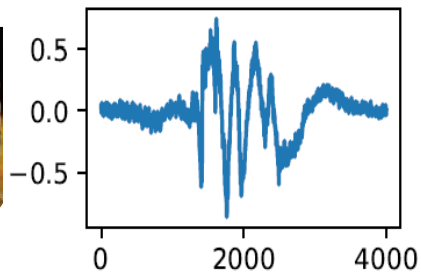
Car 3: Toyota CHR (Hybrid)



Car4 (Small)



Car 5: Renault traffic



Car 2: Renault Clio

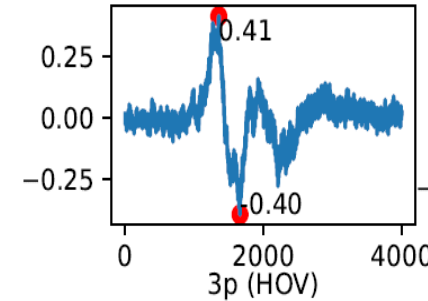


Car 4: Fiat diablo

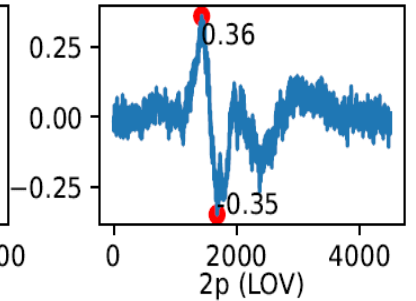


Car occupancy

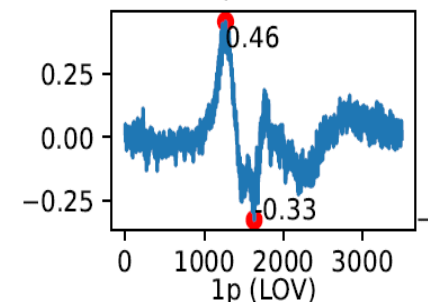
5p (HOV)



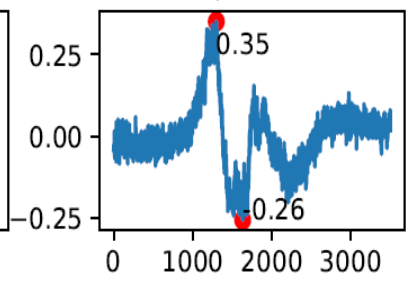
4p (HOV)



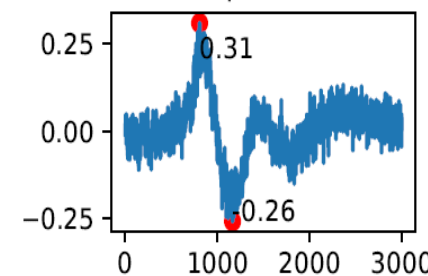
3p (HOV)



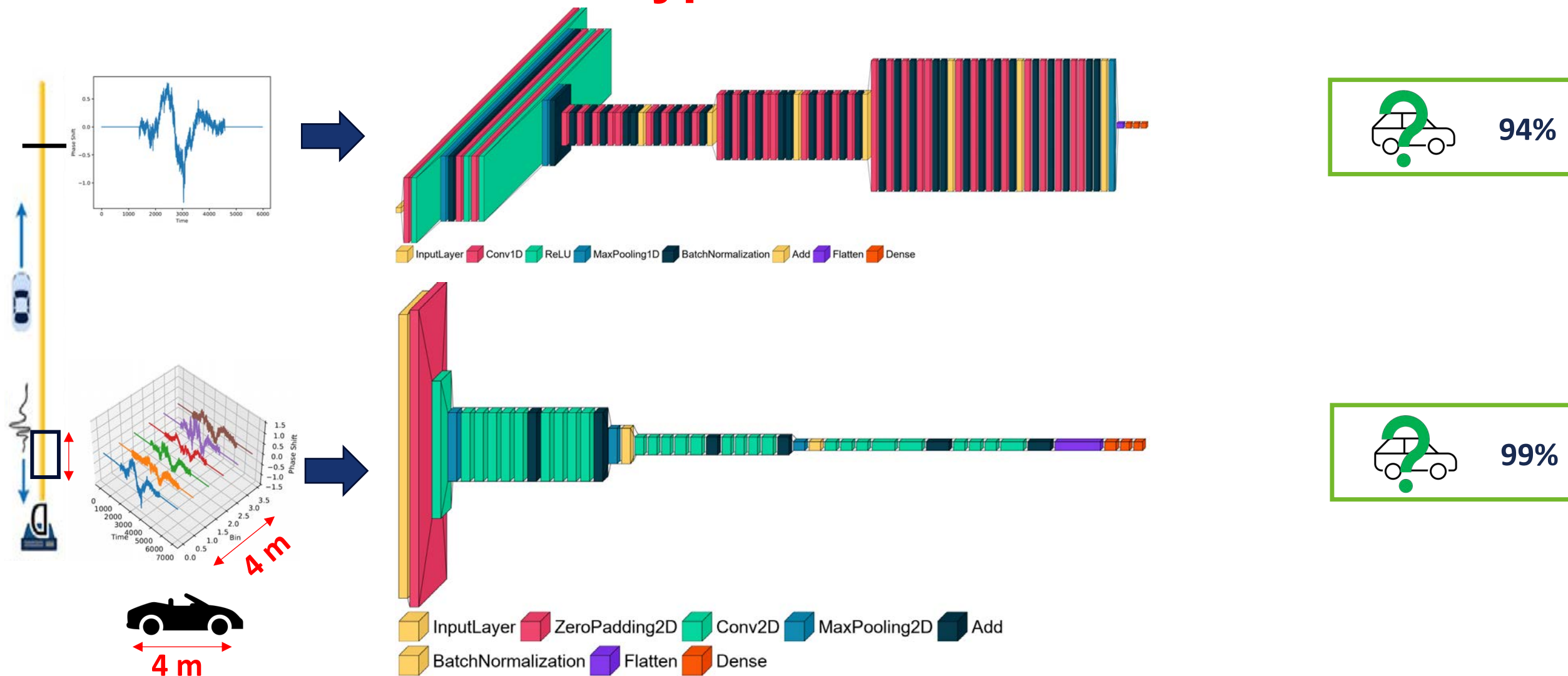
2p (LOV)



1p (LOV)



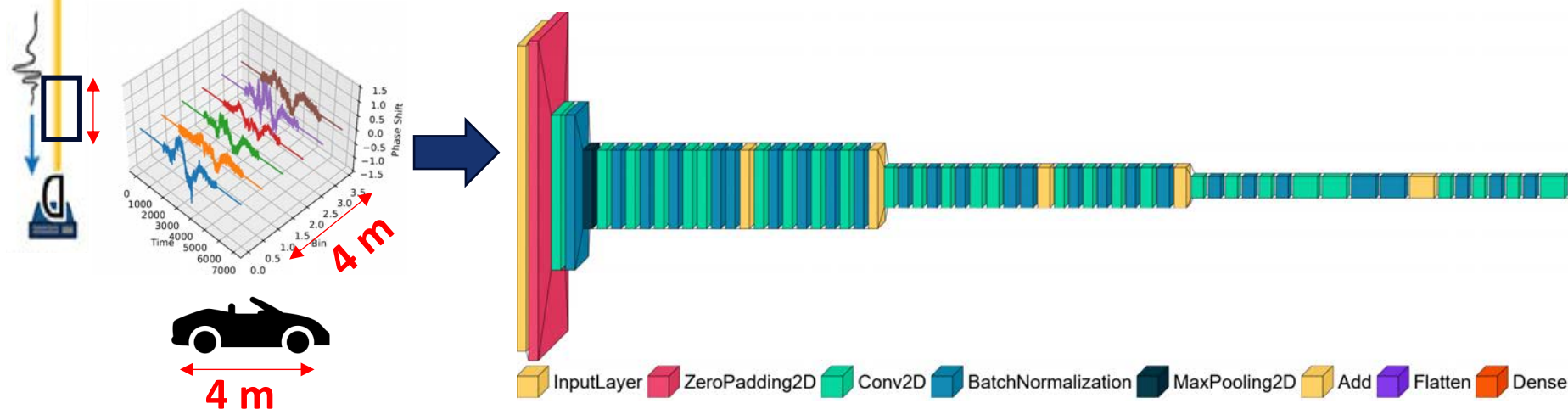
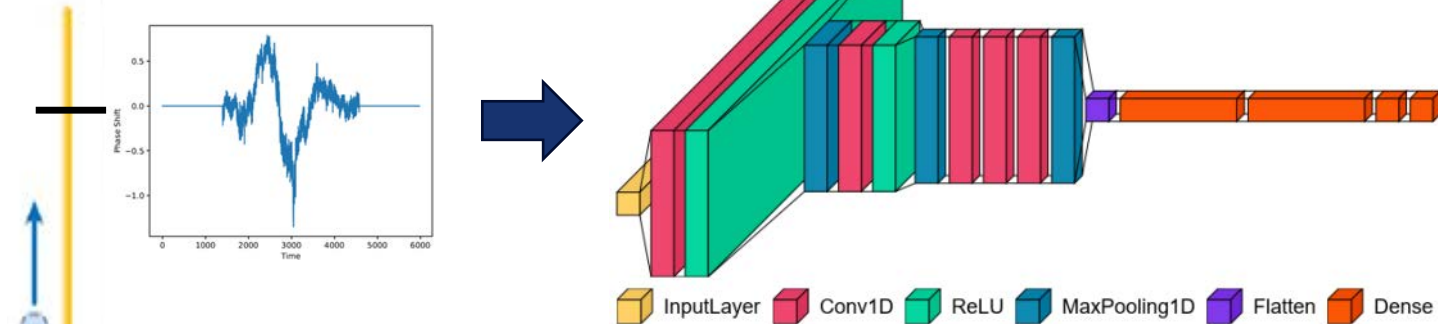
Can AI tell what is the **type/size of a car**?



Can AI tell how many people are in this car

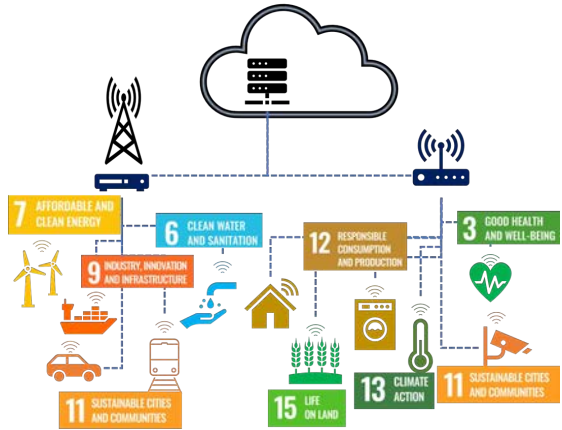


?



At what cost can IoT help? IoT technical challenges

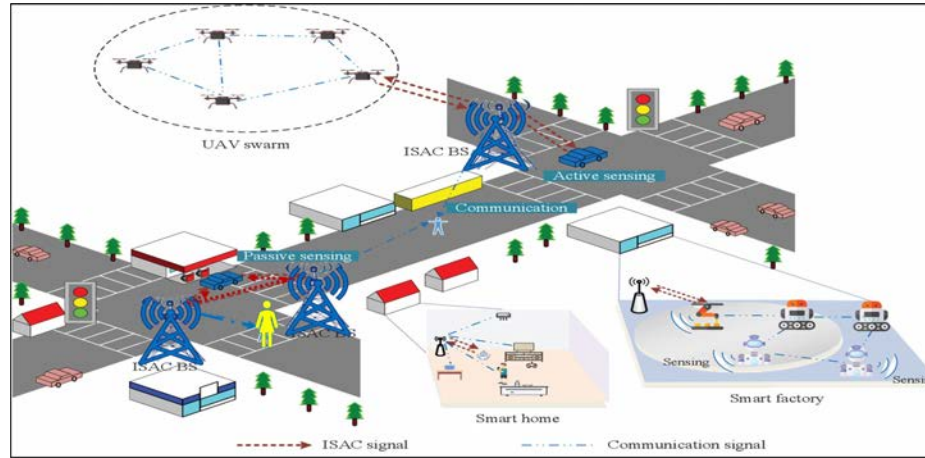
IoT for SDG



Connectivity



Com. Net. for Sensing



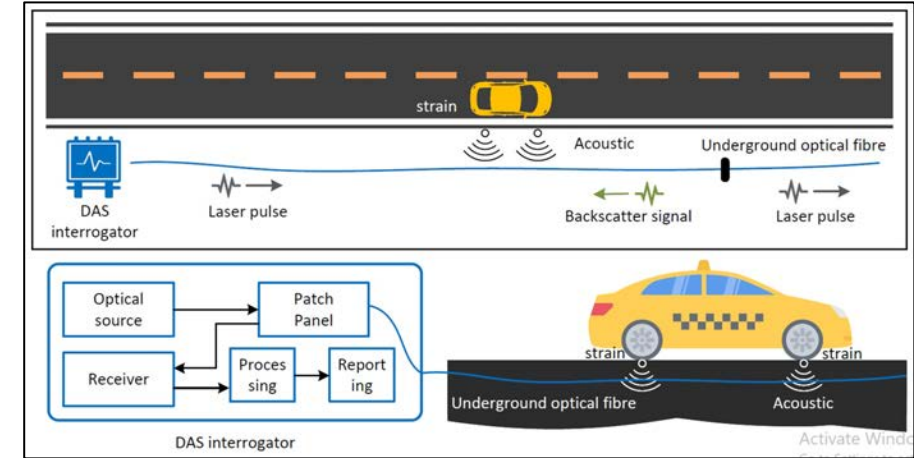
Constraint devices



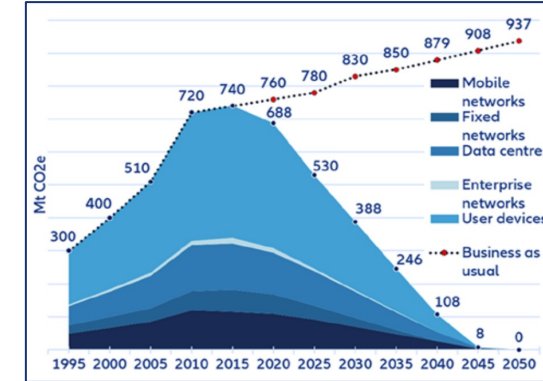
Data torrent



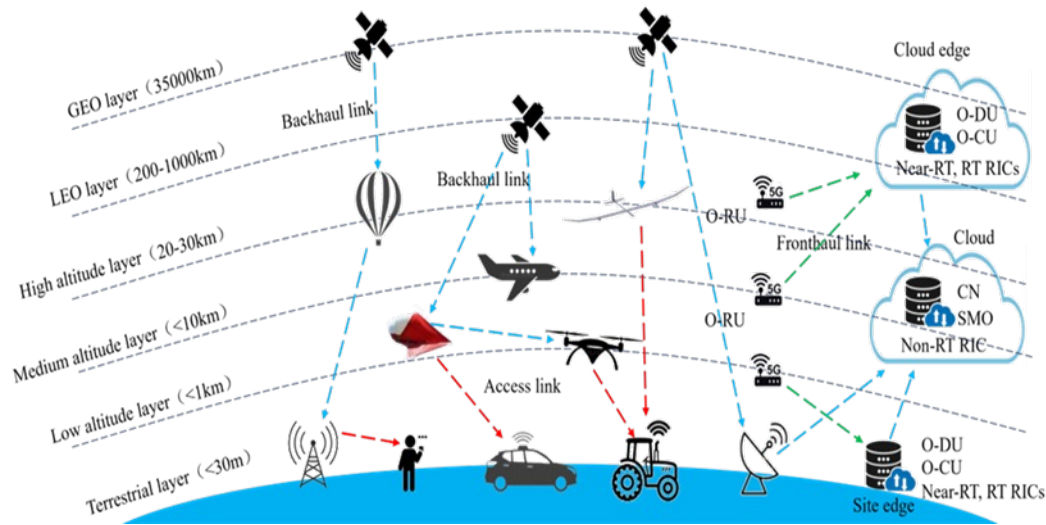
DAS for ITS



CO2 footprint

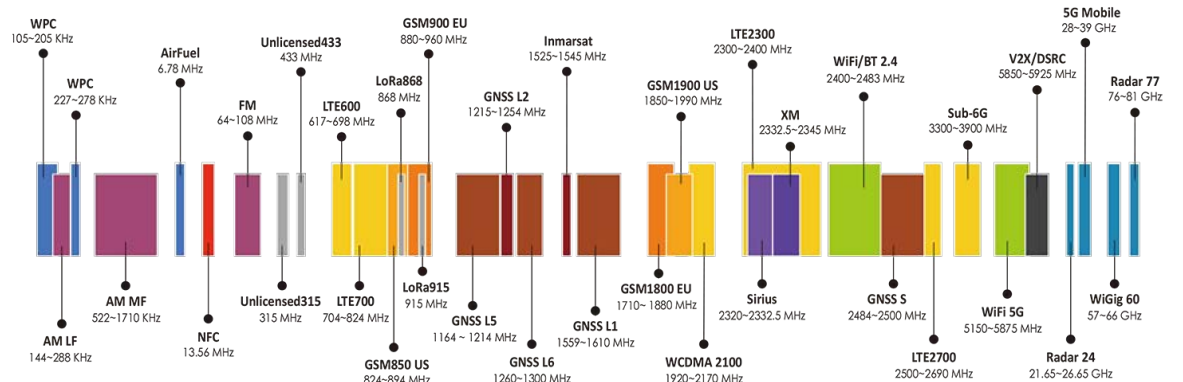


IoT connectivity – which one?



Frequency Allocation

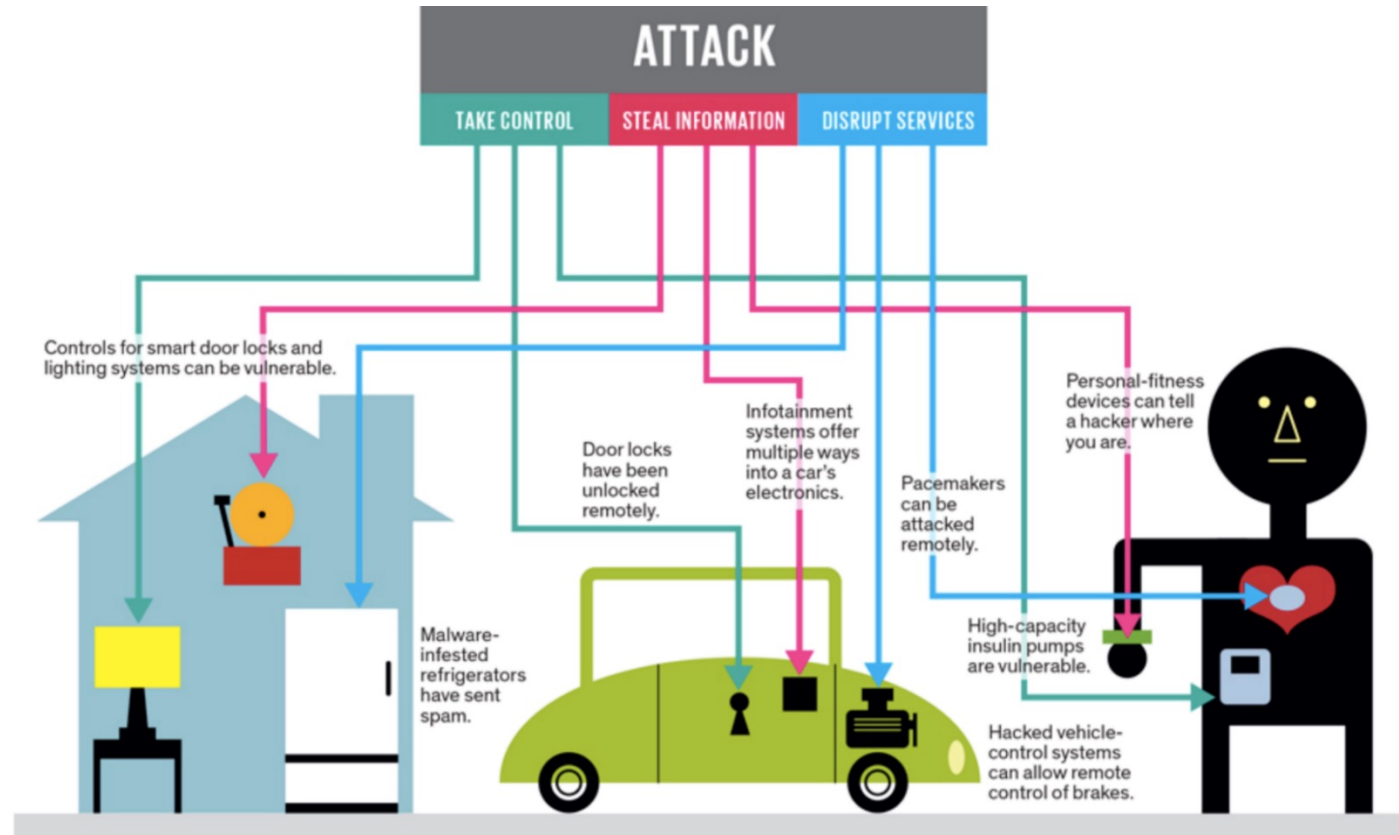
Application



https://www.inpaqgp.com/rw_0af18ff39d1c8594f84424c61a5ad7b6

Constraint devices – security risk

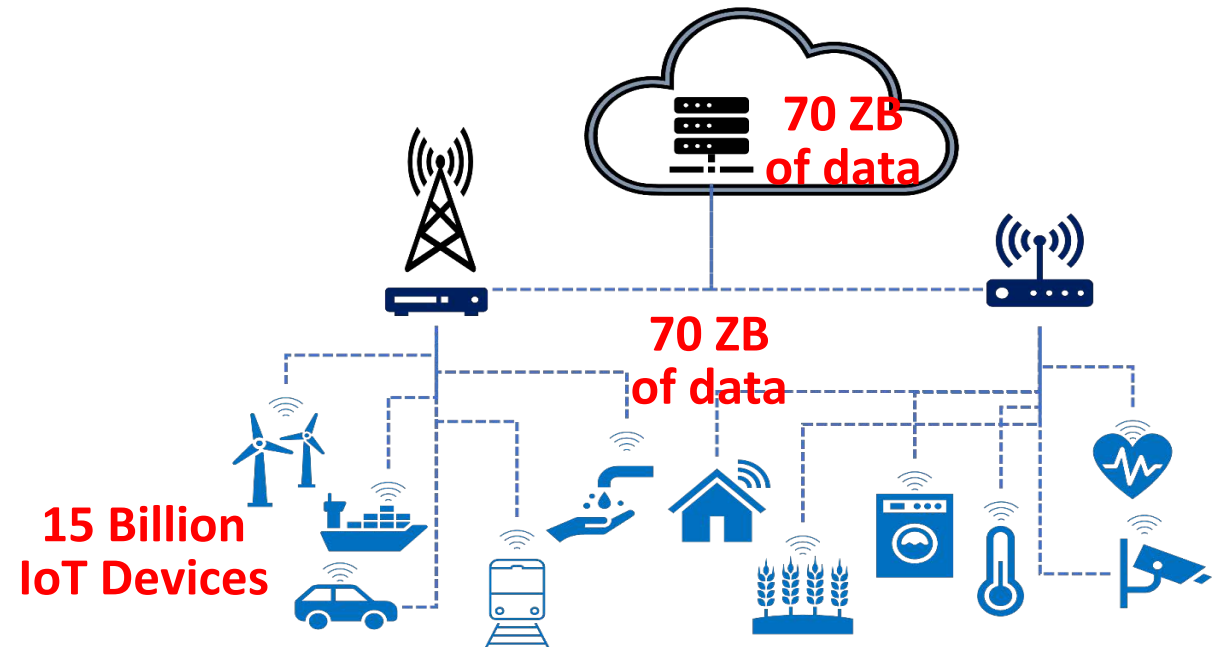
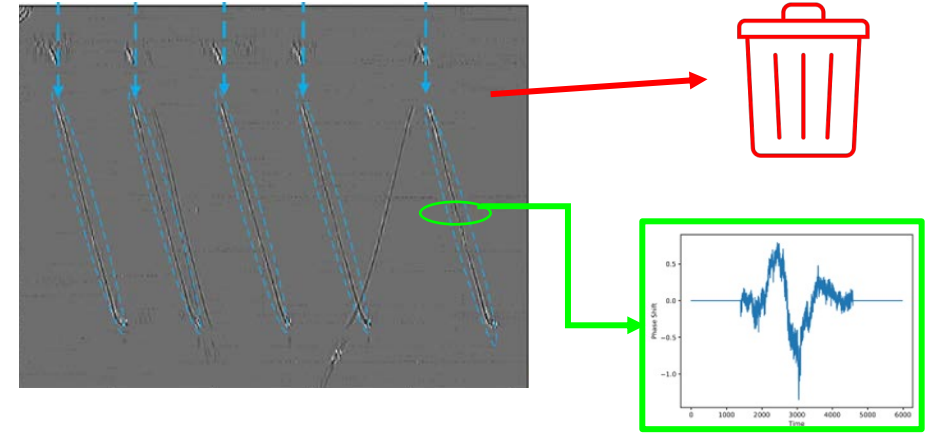
- Lightweight devices
- Remote locations
- Energy constraints
- Security risks
- Vital role of IoT devices
- Access to personal data



<https://www.pubnub.com/blog/10-challenges-securing-iot-communications-iot-security/>

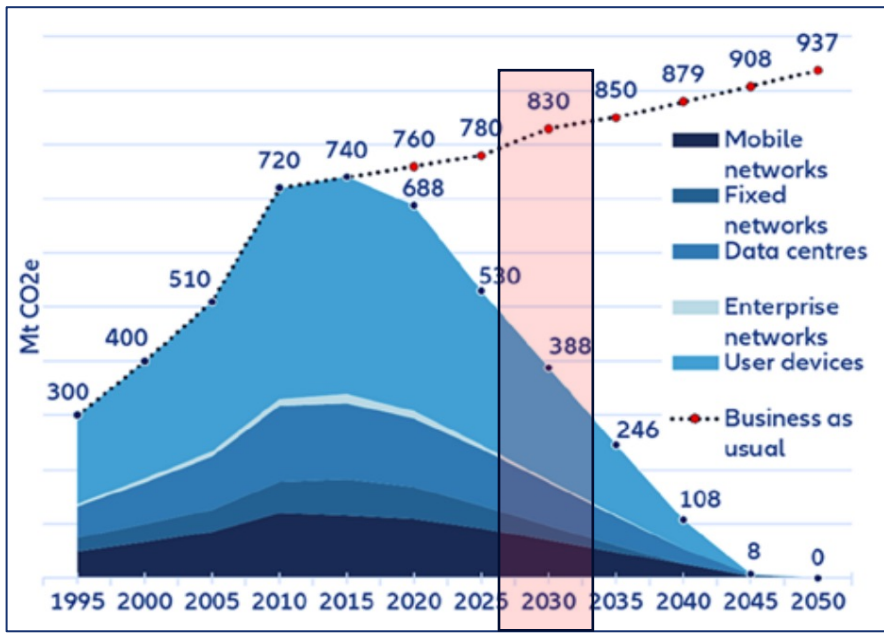
Data torrent – a lot is garbage

- 70 000 000 000 000 000 000 000 Bytes
- More than 50,000 times the size of Google + Amazon + Microsoft + Facebook
- Do we need ALL of it to inform SDG?

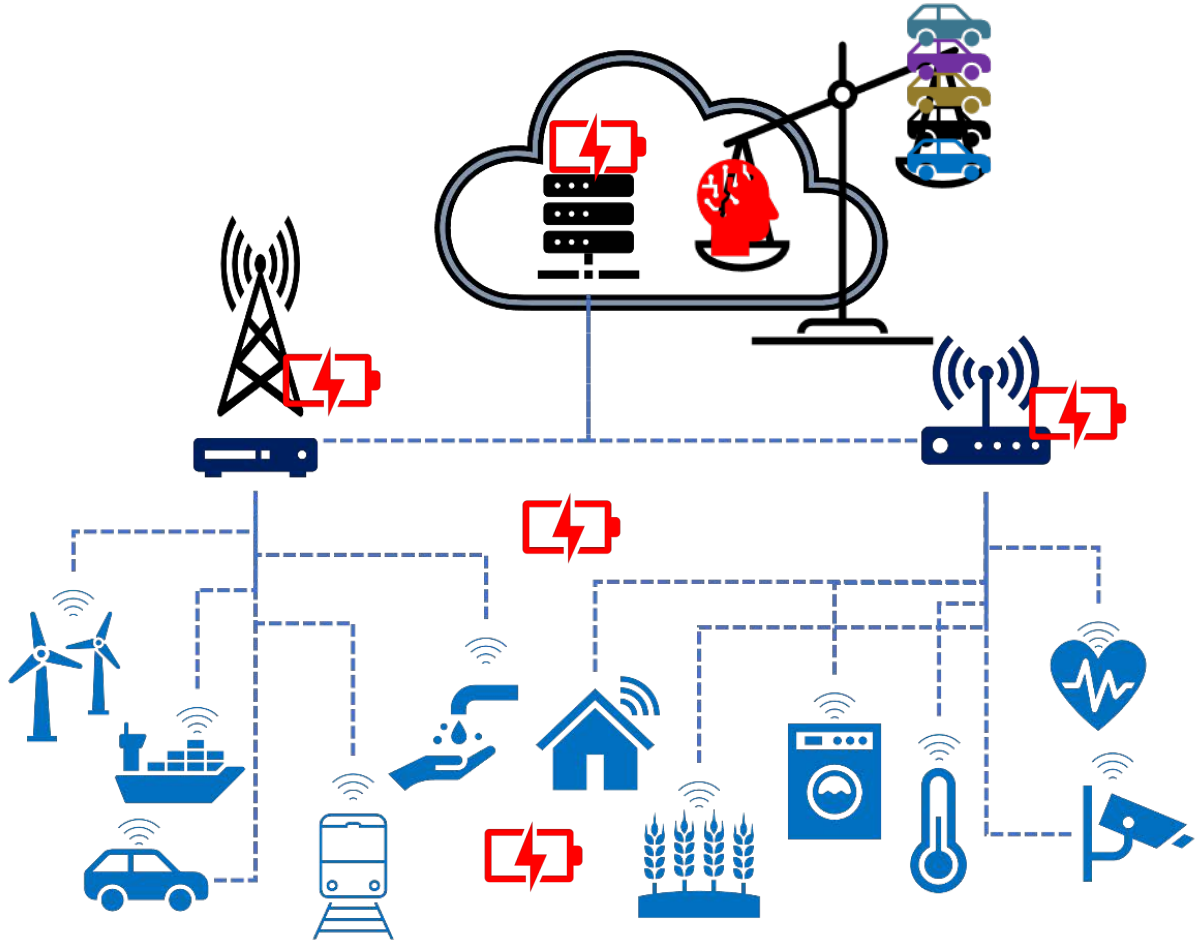


Energy consumption– carbon footprint

Global **ICT sector** emits as much **greenhouse gases** as **the aviation sector**



Allianz SE, Jul 04, 2023
https://www.allianz.com/en/economic_research/publications/specials_fmo/decarbonizing-information-technologies.html



Promising directions

**IoT connectivity
cost energy**



**AI for Energy Efficient
connectivity**

Gain of 27.75%



Yuqin Liu

**AI training causes
CO2**



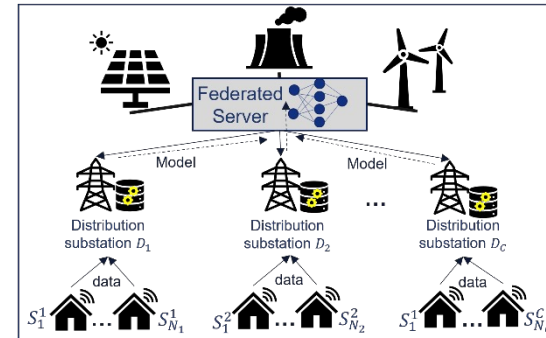
**Universal model training
for stress detection**

95% Accuracy



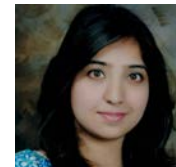
Moudy Alshareef

**Data transfer is
costly and risky**



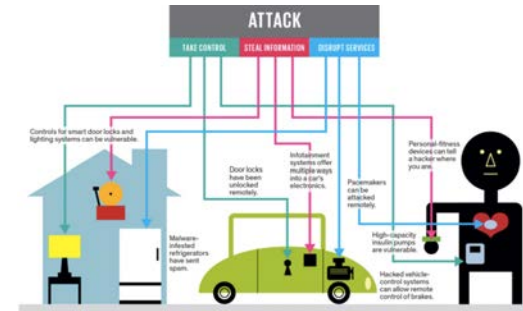
**Federated learning for
energy theft detection**

74% Accuracy



Zunaira Nadeem

**IoT security of
constraint devices**



**Artificial Immune
System for Malware
attack detection**

85% Accuracy



Dr. Hadeel Alrubayyi

Other non-technical challenges...

Conflicting SDGs



Diverting the attention from key issues



'Fake' sustainability

- **Covid** resulted in the best recorded **air quality** versus economy, increased poverty, unwell-being, etc.
- **Fuel poverty** resulted in **reduced CO2** due to heating but poor health, increased in hospitalized children with respiratory diseases, reinforced inequality, etc.



SDG solutions need regulation.

Artistic urban intervention by *nkkn*

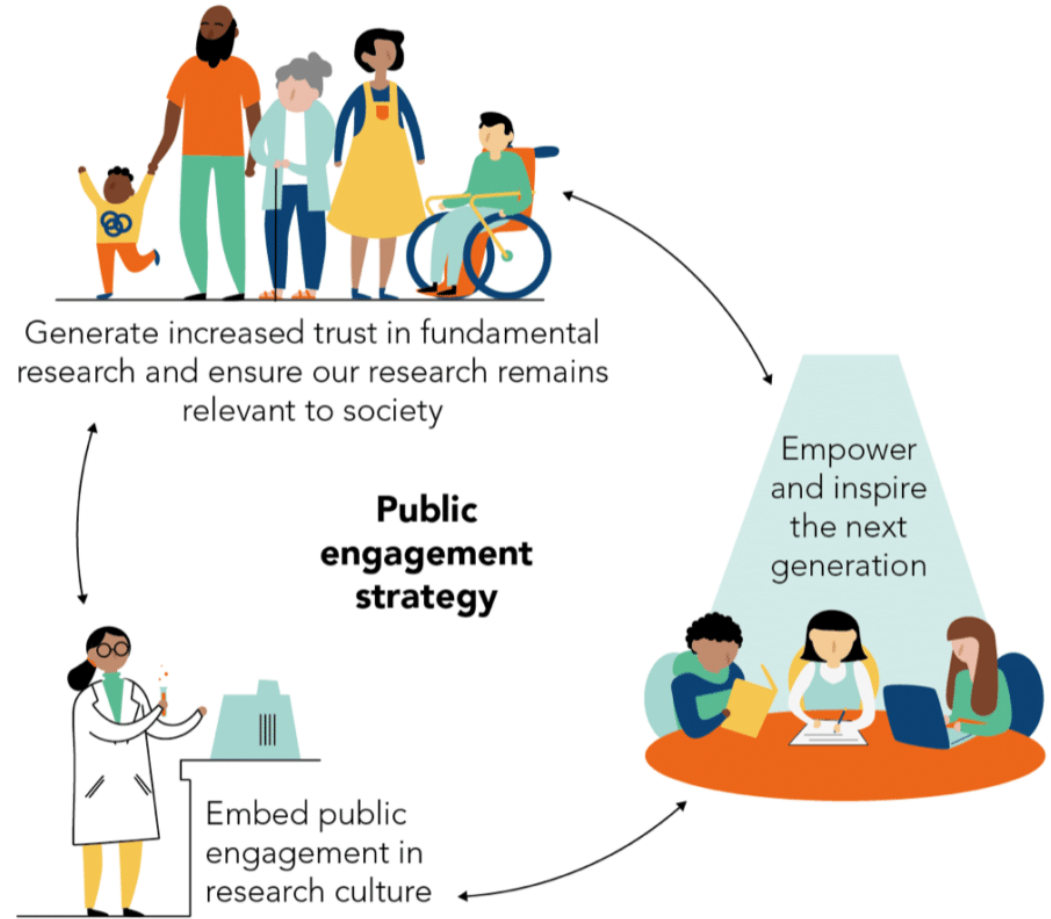


<https://vimeo.com/841194185/e363ff32e0>



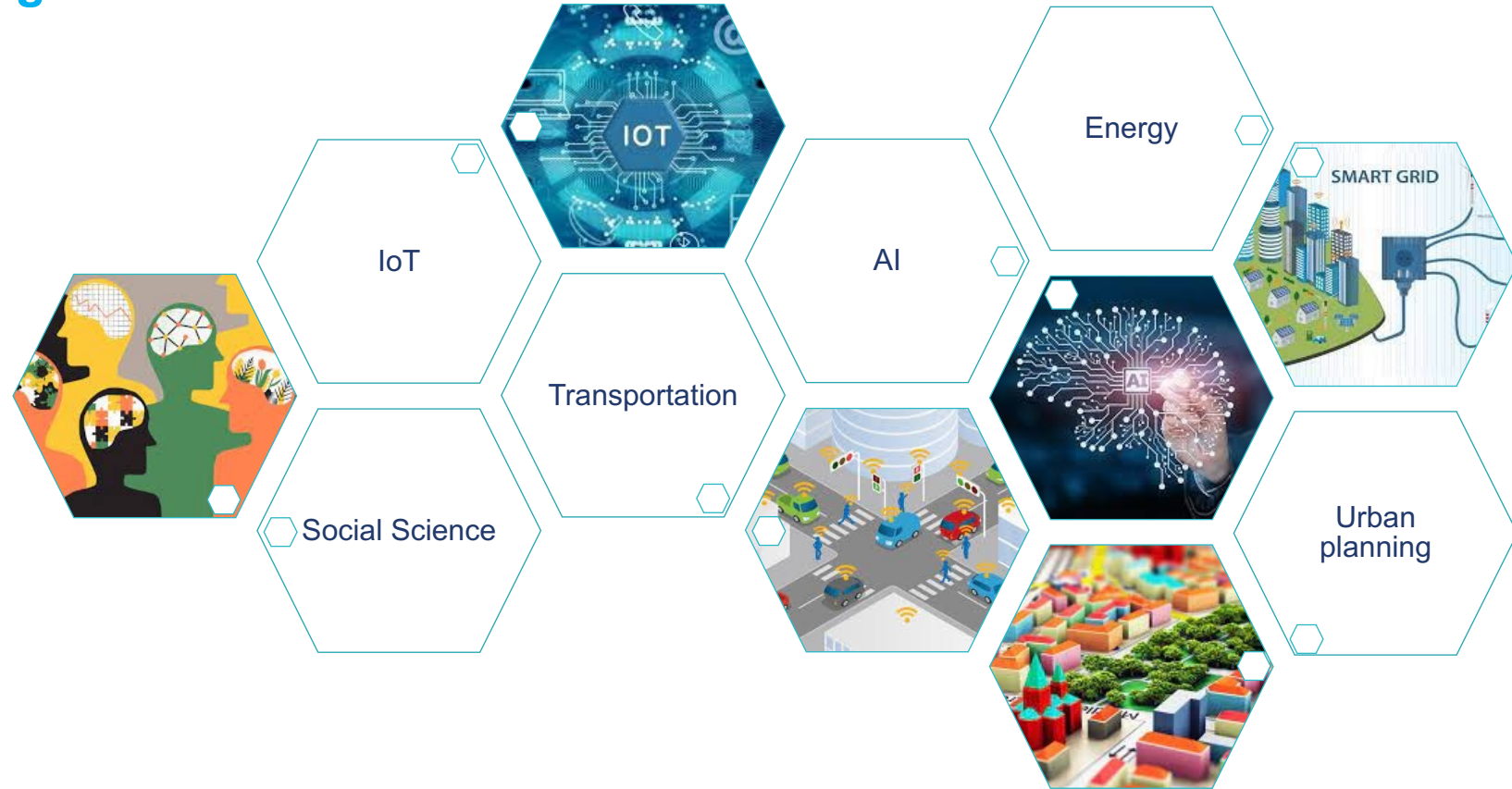
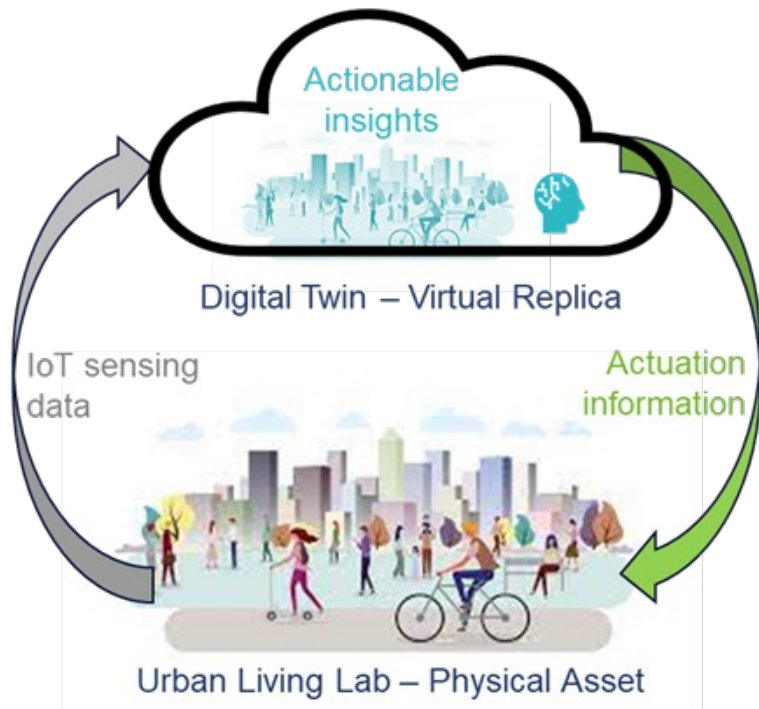
Public resistance to SDG initiatives

Solutions that are **not accepted** by the public are **useless**



DT4SDG – cost effective anticipatory SDG solutions

<https://www.qmul.ac.uk/dtsdg/>



led by **social science**, shaped by **domain experts**, and enabled by **technology innovation**



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Visit: <https://www.qmul.ac.uk/dtsdg/>