



Future Hyper-Connected Cities & Communities



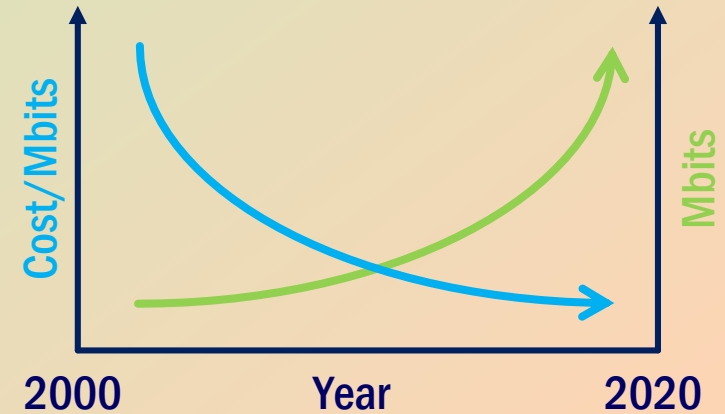
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The Mobile Revolution

As the result of the merger of the internet and wireless communication, mobile is the most rapidly adopted consumer technology in history.



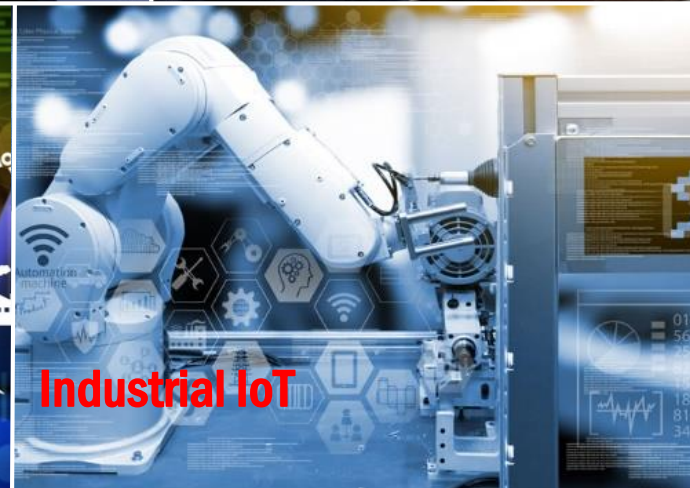
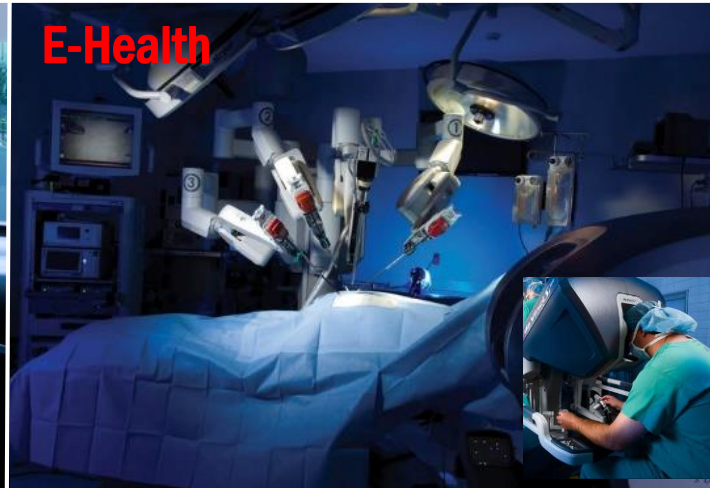
"We had no idea that this would turn into a global and public infrastructure"
Vinton Cerf, One of "the Fathers of the Internet"

"People want to talk to other people - not a house, or an office, or a car. Given a choice, people will demand the freedom to communicate wherever they are, unfettered by the infamous copper wire. It is that freedom we sought to vividly demonstrate in 1973"

Martin Cooper, "Father of the (Handheld) Cell Phone"



6G Use Cases

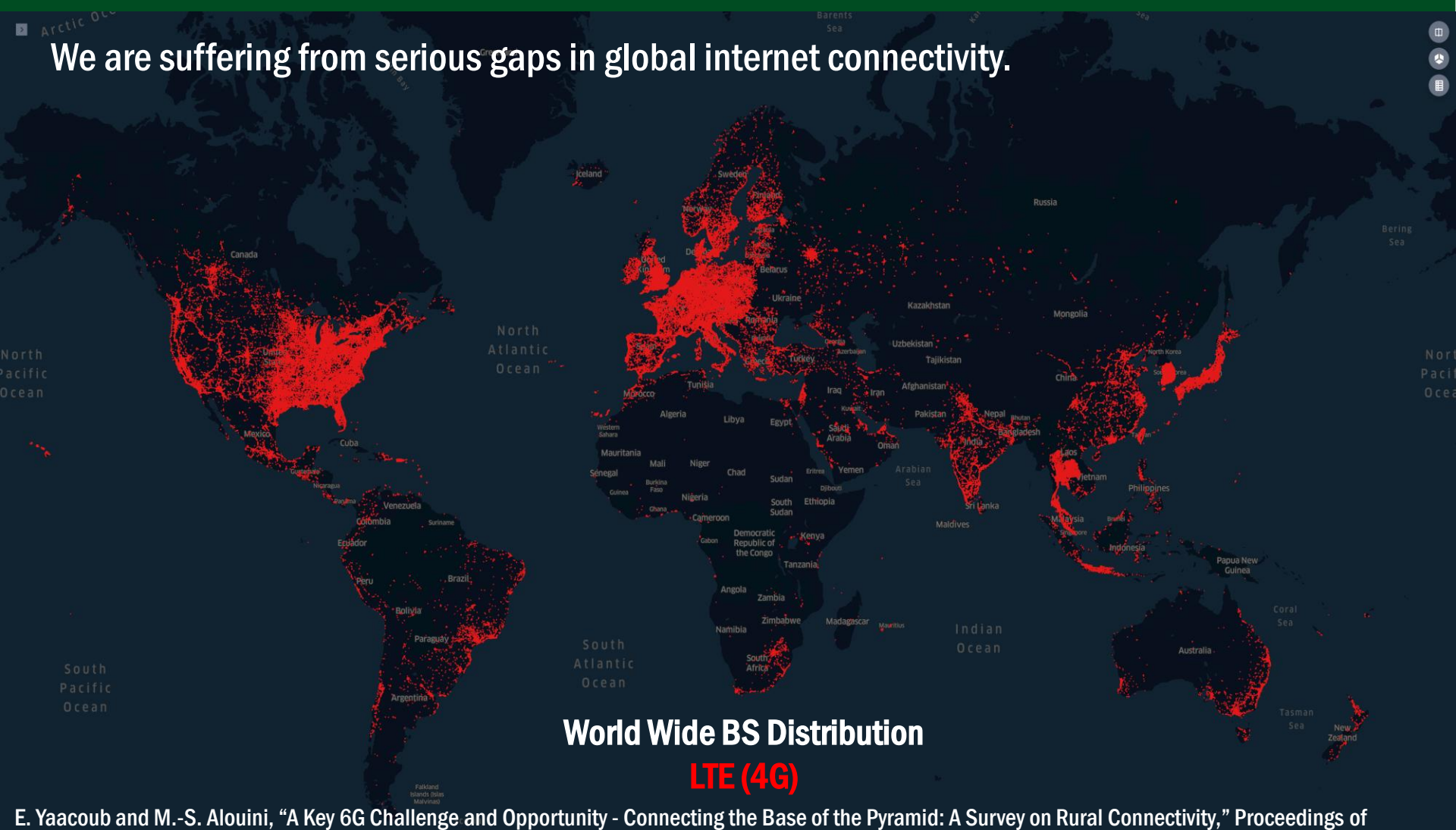


Some Trends/Projections

- **8.5 billions by 2030 & 11 billions by 2100**
- **As of 2018, 55% of the world's population lives in urban areas => expected to increase to 68% by 2050**
- **By 2030, the world is projected to have 43 megacities with more than 10 million inhabitants**

The Connectivity Divide

We are suffering from serious gaps in global internet connectivity.



**World Wide BS Distribution
LTE (4G)**

E. Yaacoub and M.-S. Alouini, "A Key 6G Challenge and Opportunity - Connecting the Base of the Pyramid: A Survey on Rural Connectivity," Proceedings of IEEE, April 2020. Available on arxiv.



Connecting the Base of the Pyramid



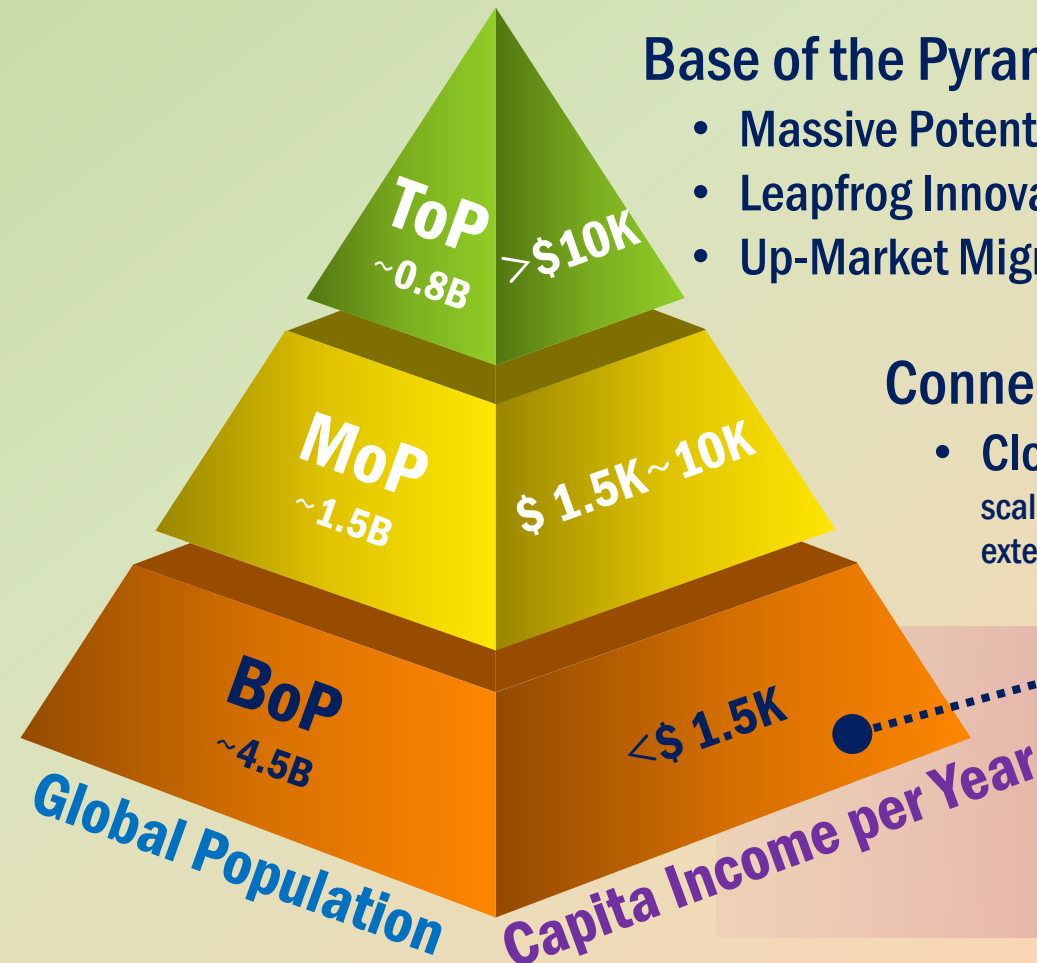
Base of the Pyramid Model

Base of the Pyramid (BoP) as Leverage Point

- Massive Potential Market – Creating new markets from unserved needs
- Leapfrog Innovation – Incubating new distributed & disruptive technologies
- Up-Market Migration – Potential for growth through reverse innovation

Connectivity as Key Enabler

- **Cloud-based platform** - A potential solution for BoP scaling challenge (overcome high costs associated with the extended distribution)



- **A huge market of creative and resilient consumers and producers**
- **Largely excluded from formal markets**
- **Growing fast but underutilized productive sector**

Smart Cities to Smart Living

Smart Grid
Smart Transportation
Environmental Protection
Water Distribution
Smart Healthcare

SMART CITY
BUILDING TOMORROW'S CITIES



SMART EVERYWHERE
Equal and Eco-Friendly
Quality of Life

Smart Village
Smart Home
Virtual Education
Remote Healthcare
Nature Friendly

SMART LIVING



High Data Rate ●

URLLC ●



High Speed
Backhaul



[1] E. Yaacoub and M.-S. Alouini, "Efficient Fronthaul and Backhaul Connectivity for IoT Traffic in Rural Areas," Under review for IEEE IoT magazine and available on TechRxiv (Powered by IEEE)



Network in a Box





Network in a Box & Pop-up Networks



**Disaster
Emergency**



**Concert
Sport Event**



**Military
Mission**



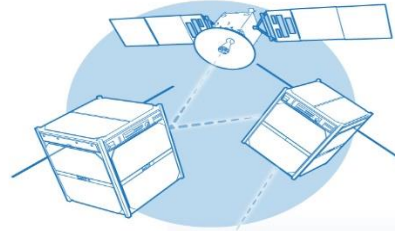
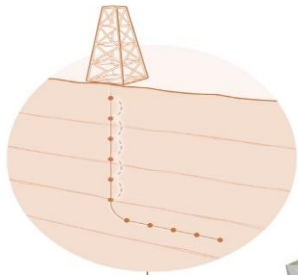
**Scientific
Mission**



Climate Monitoring Using Internet of X-Things

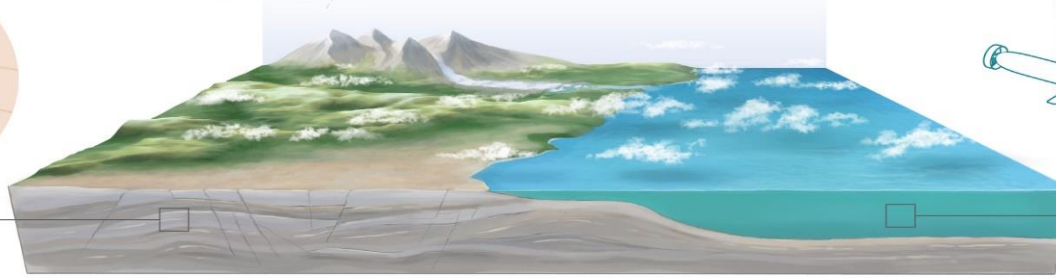
Internet of Underground Things

Changes in soil
Seismic activity
Gas leakage



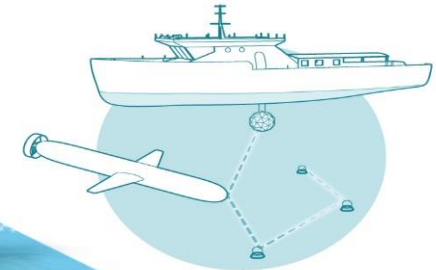
Internet of Space Things

Cloud cover
Sun radiation
Ocean and land surface monitoring



Internet of Underwater Things

Ocean Salinity
Acidity
Temperature

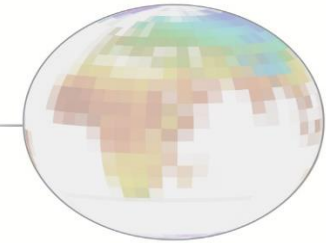


Global network of internet of X-things collects climate data



IoUGT
IoUT
IoST

Data analysis and global climate modeling



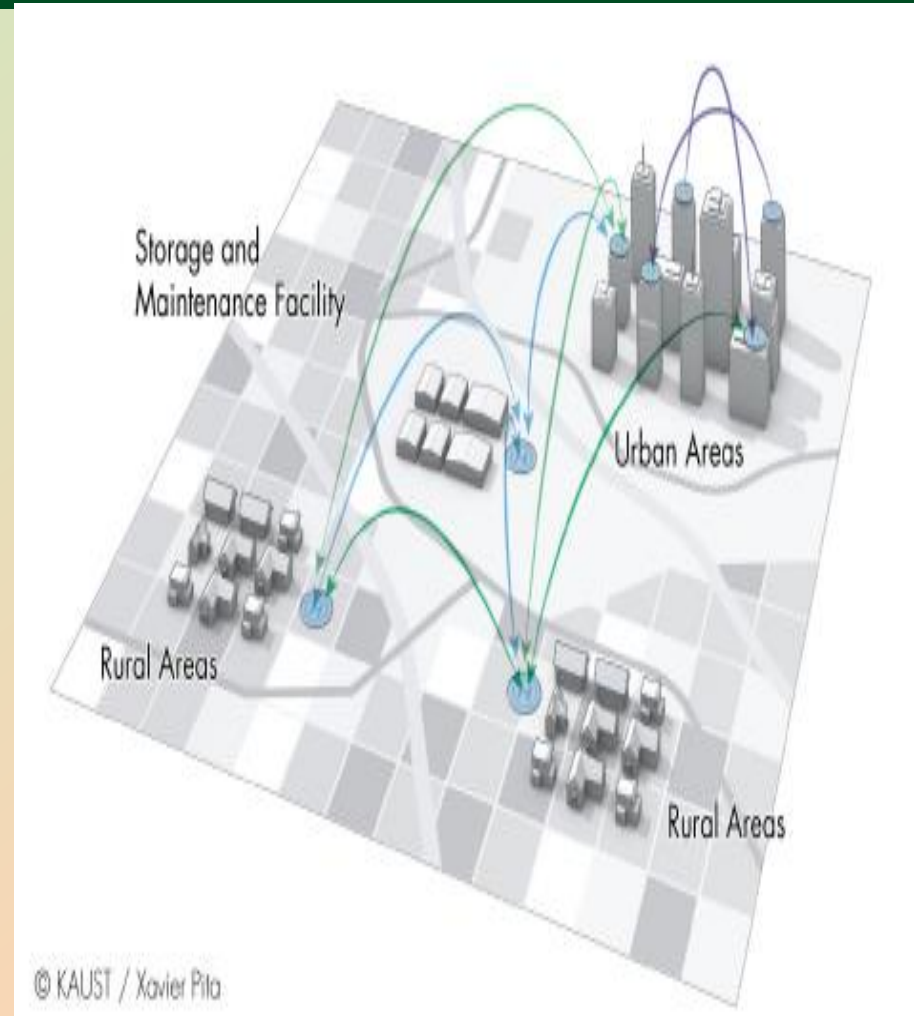
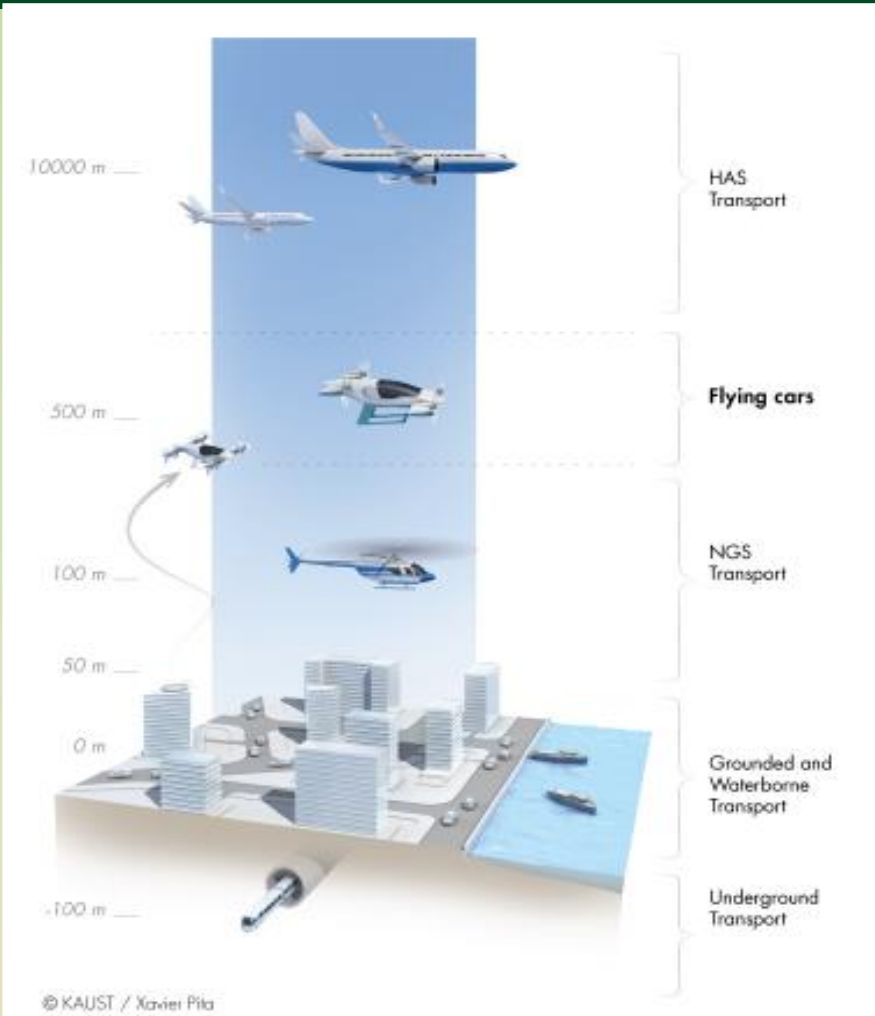
[1] N. Saeed, A. Celik, T. Al-Naffouri, and M. -S. Alouini, "Underwater optical wireless communications, networking, and localization: A survey", Elsevier Adhoc Networks, 2019.

[2] N. Saeed, T. Al-Naffouri, and M. -S. Alouini, "Towards the Internet of underground things: A systematic survey", IEEE Communications Surveys and Tutorials, 2019.

[3] N. Saeed, A. Elzanaty, H. Almorad, H. Dahrouj, T. Y. Al-Naffouri, M-S. Alouini, "CubeSat communications: Recent advances and future challenges", IEEE Com Surveys and Tutorials 2020



Connection with Emerging and Future Transportation Systems



[1] G. Pan and M. – S. Alouini, "Flying car transportation systems: Advances, techniques, and challenges", Under Review.
 [2] N. Saeed, T. Y. Al-Naffouri, M -S. Alouini, "Wireless communications for flying cars", Under Review.

Nikola Tesla

(10 July 1856 – 7 January 1943)

“When wireless is perfectly applied, the whole earth will be converted into a huge brain, which in fact it is, all things being particles of a real and rhythmic whole. We shall be able to communicate with one another instantly, irrespective of distance.”

Nikola Tesla (1925)



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Thank You
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