cell & sat

HAPS & satellite integration in 4G/5G cellular networks

Didier Verhulst

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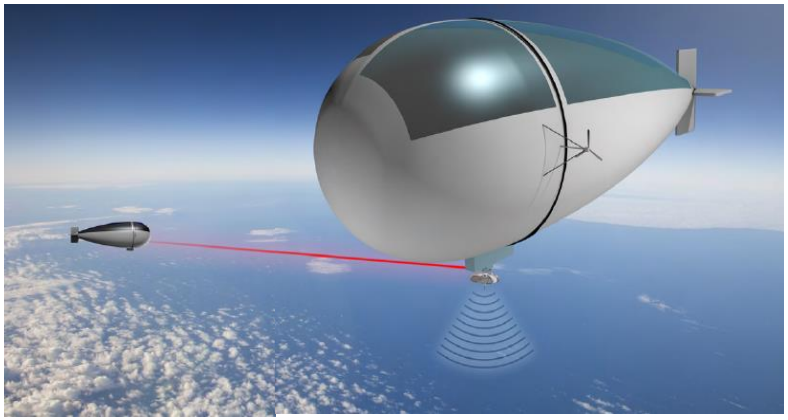
Cellular & (pseudo) Satellite technologies

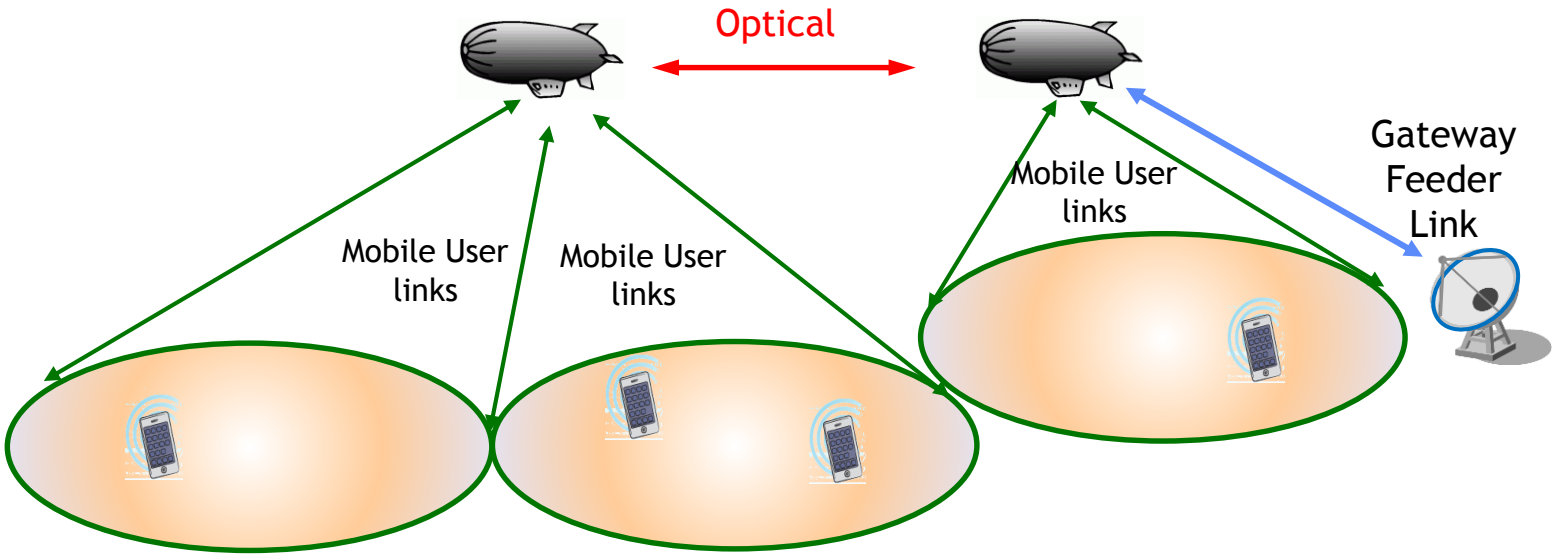
Cellular coverage from HAPS airship

- **Using a stationary HAPS like Stratobus**

ThalesAlenia Space
a Thales / Leonardo company



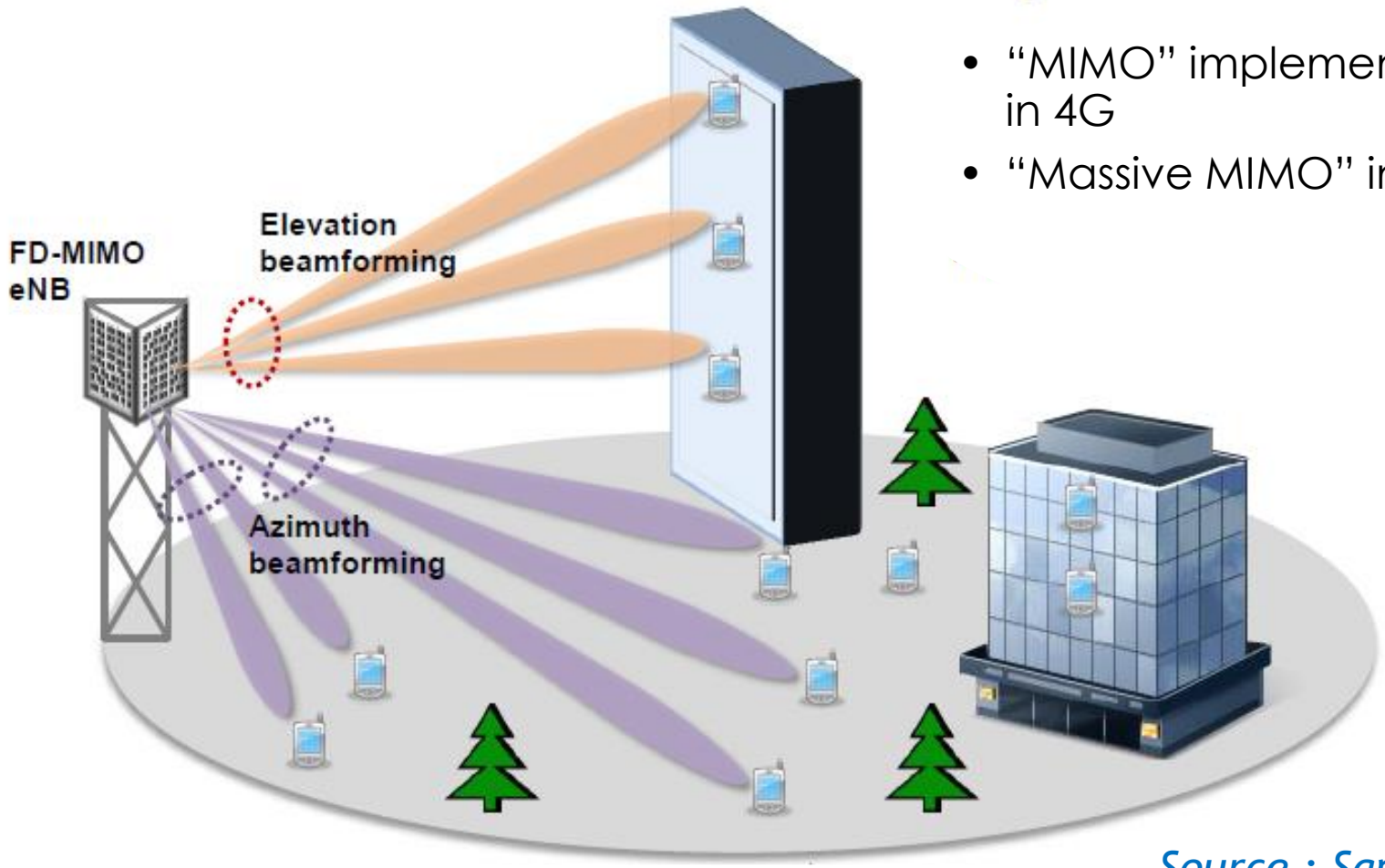
- **Serving mobile handsets directly**
  - 4G (and soon 5G) services
  - Using cellular frequencies (UHF, S band, etc.)



"4G/5G Base Station in the sky"

- **Unlike satellites, HAPS can communicate directly with standard broadband smartphones**
- **An airship HAPS like Stratobus will be capable to carry a complete set of 4G/5G base station components**
  - adapted from a terrestrial cellular COTS **baseband server**
  - adapted from a terrestrial cellular COTS **active array antenna**
  - with high power (5000 W) & weight (250 kg) (case of Stratobus)
- **With two main benefits:**
  - The system serves many cells from a **single control point:**
    - Implementing advanced interference mgt & performance optimization
  - From a 20 km altitude, the **service range can be quite large**, well beyond the usual terrestrial limits
    - Broadband coverage can reach at least **200 km** (in UHF): one HAPS replacing ~50 terrestrial base stations (w. typical 30 km rural coverage)
    - The range is further extended with IoT services (CatM1, Narrowband IoT)

4G / 5G (terrestrial beam) forming principles



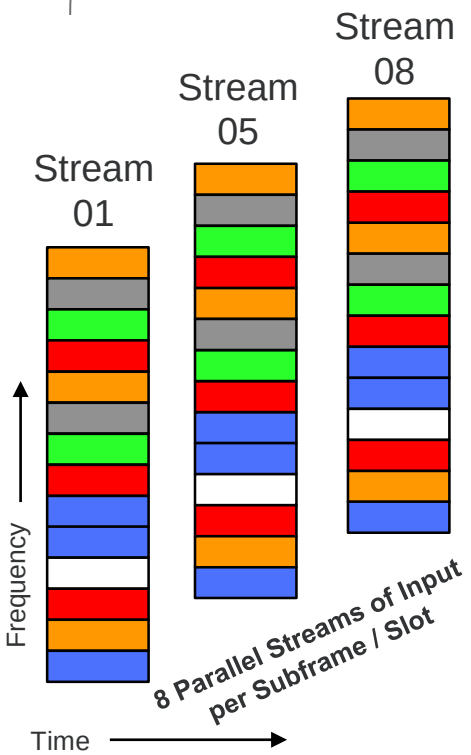
- "MIMO" implementation in 4G
- "Massive MIMO" in 5G

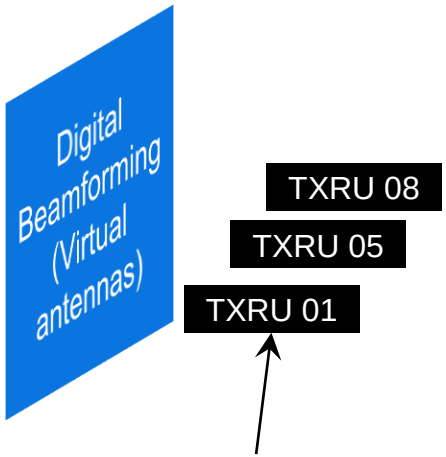
Source : Samsung

4G/5G baseband & active active antenna

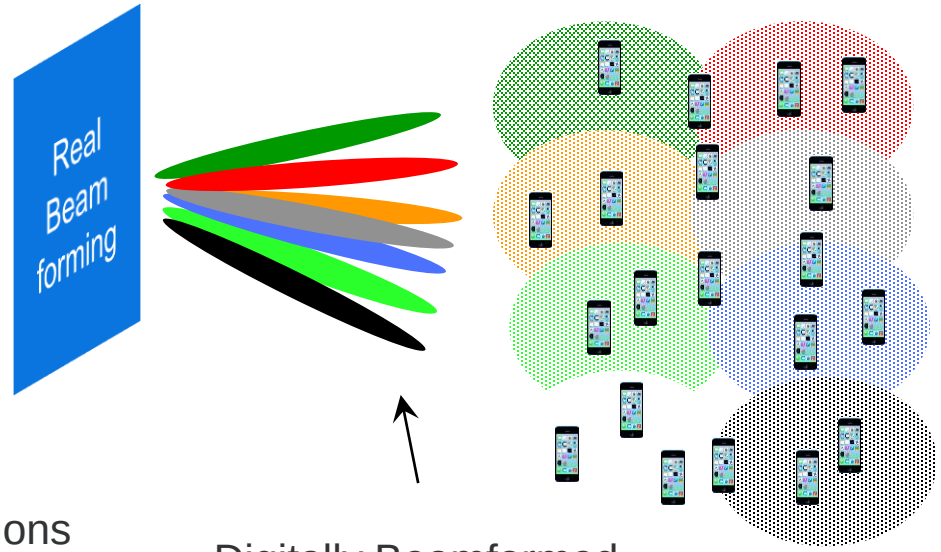
The baseband software performs beamforming assuming (virtual) static antennas

The active antenna provides coherent aperture and flexible 3D antenna virtualization





Each TXRU carries different linear combinations of PRBs from all streams



Digitally Beamformed 3D Radiation

Proposed HAPS coverage in S band (~2.1 GHz)

- **The system carries an active array S-band antenna on board**
  - flat panel antenna

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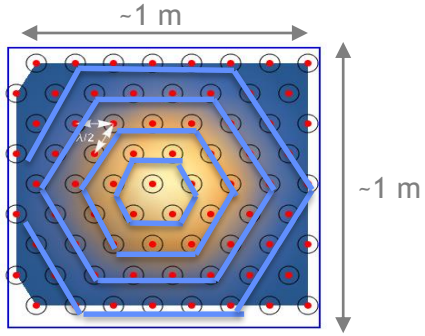
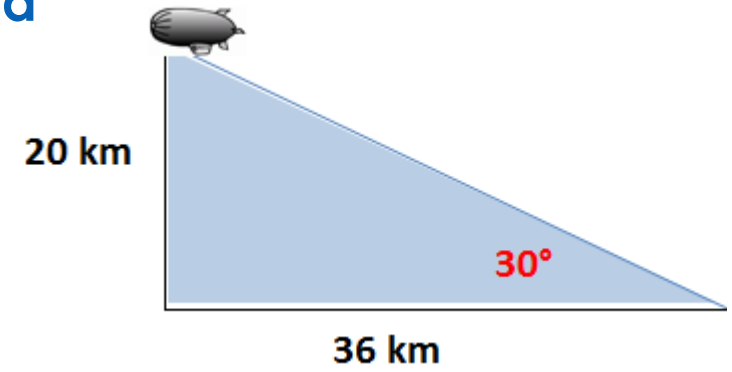
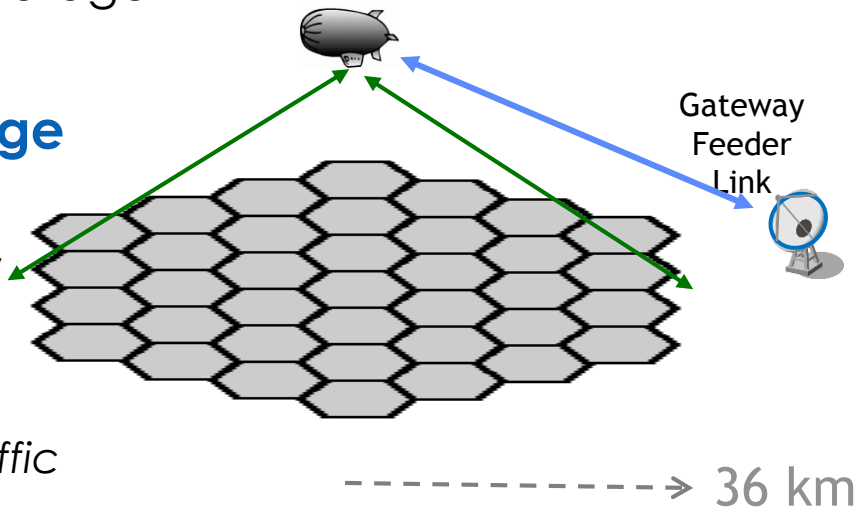
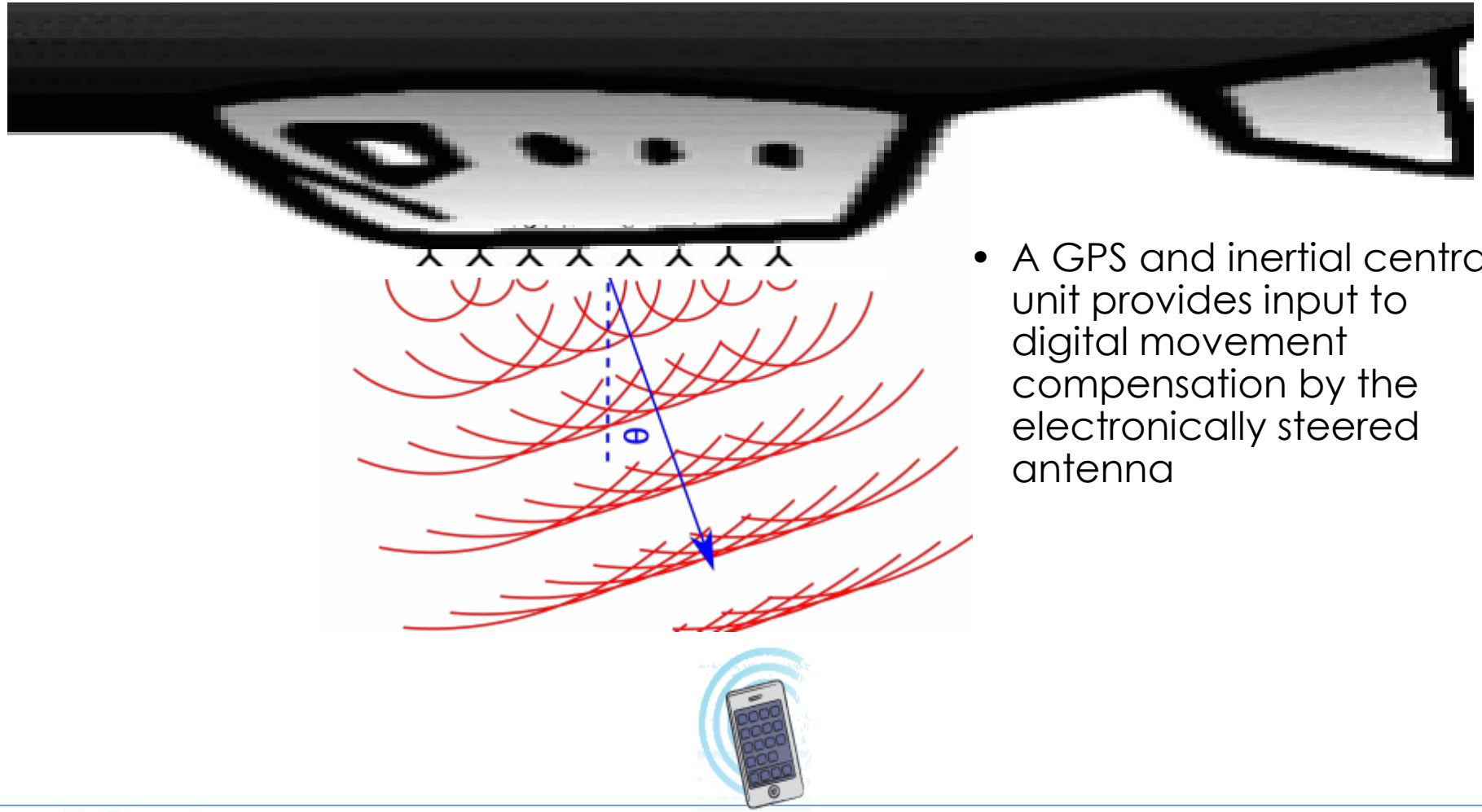




- **Implementing dynamic beam forming**
  - to improve throughput and minimize outage
  - to compensate HAPS mobility
- **To provide "medium density" coverage**
  - to a distance of 30 to 60 km
    - Higher range means reduced capacity
  - System capacity is under evaluation
    - *accounting for 5G Massive MIMO*
    - *with dynamic adaptation to various traffic profiles*



HAPS movement compensation

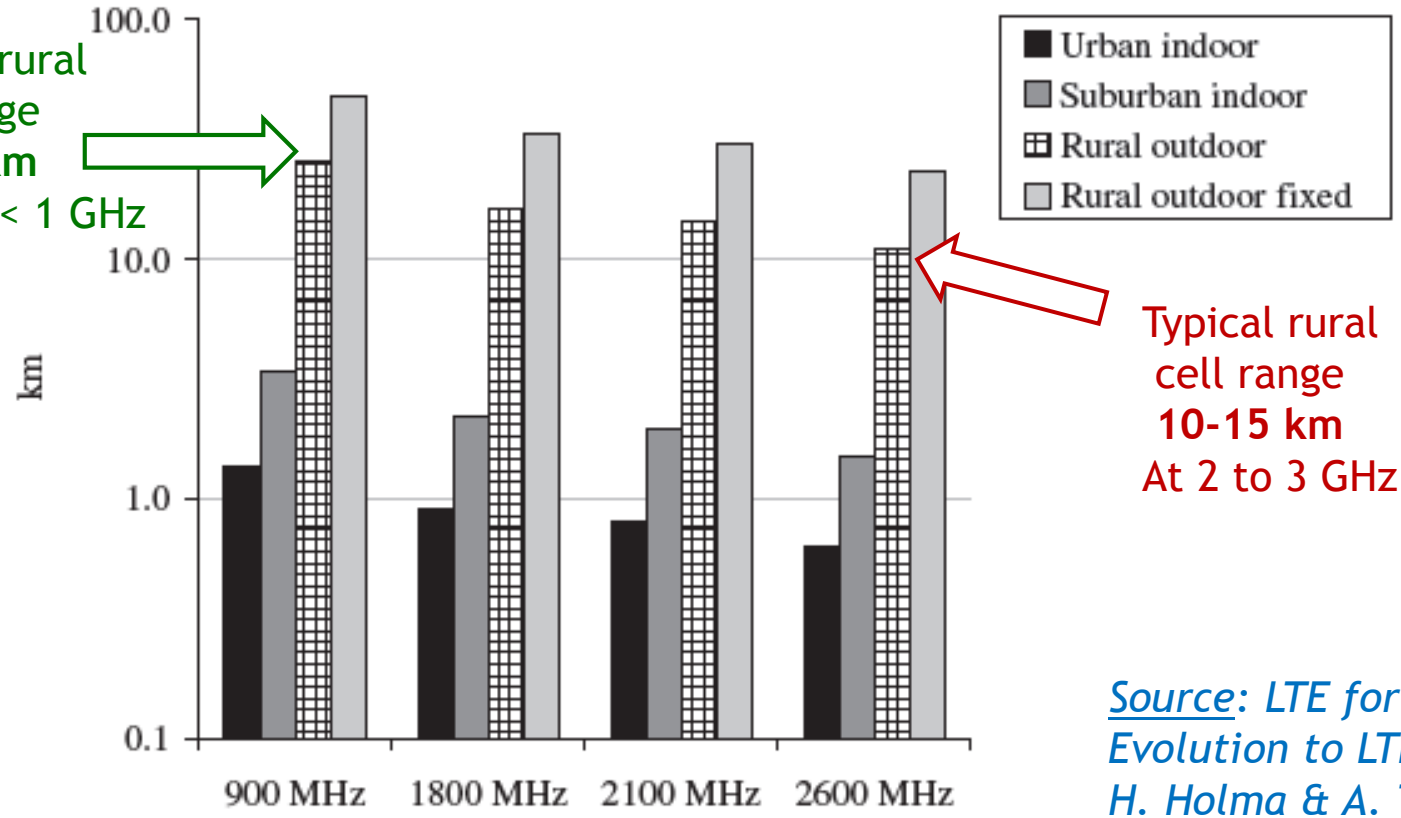


- A GPS and inertial central unit provides input to digital movement compensation by the electronically steered antenna

4G terrestrial low density rural coverage

➢ Typical LTE cell range for 1 Mbps downlink

Typical rural cell range **~30 km** At freq < 1 GHz

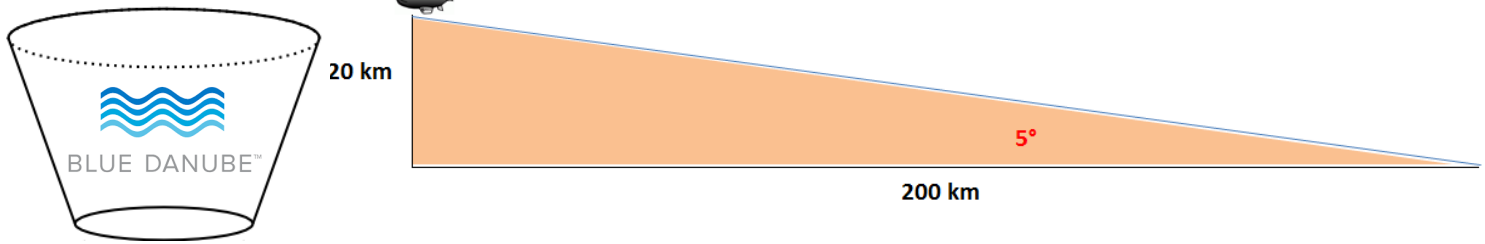


Typical rural cell range **10-15 km** At 2 to 3 GHz (S band)

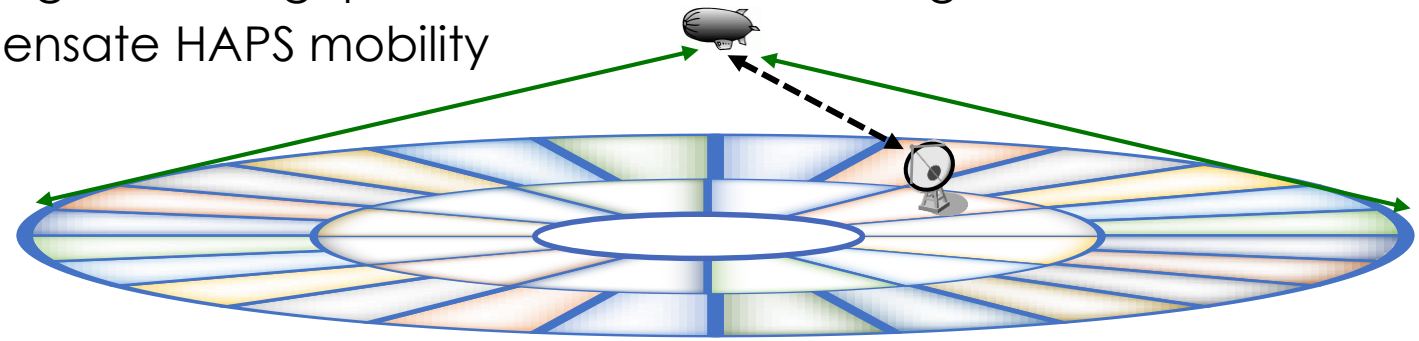
Source: LTE for UMTS Evolution to LTE Advanced H. Holma & A. Toskala, Nokia

Proposed HAPS coverage in UHF band (~700 MHz)

- **The system can carry an active array UHF-band antenna**
  - of conical shape



- **The system can implement dynamic beam forming**
  - to improve range & throughput and to minimize outage
  - and to compensate HAPS mobility

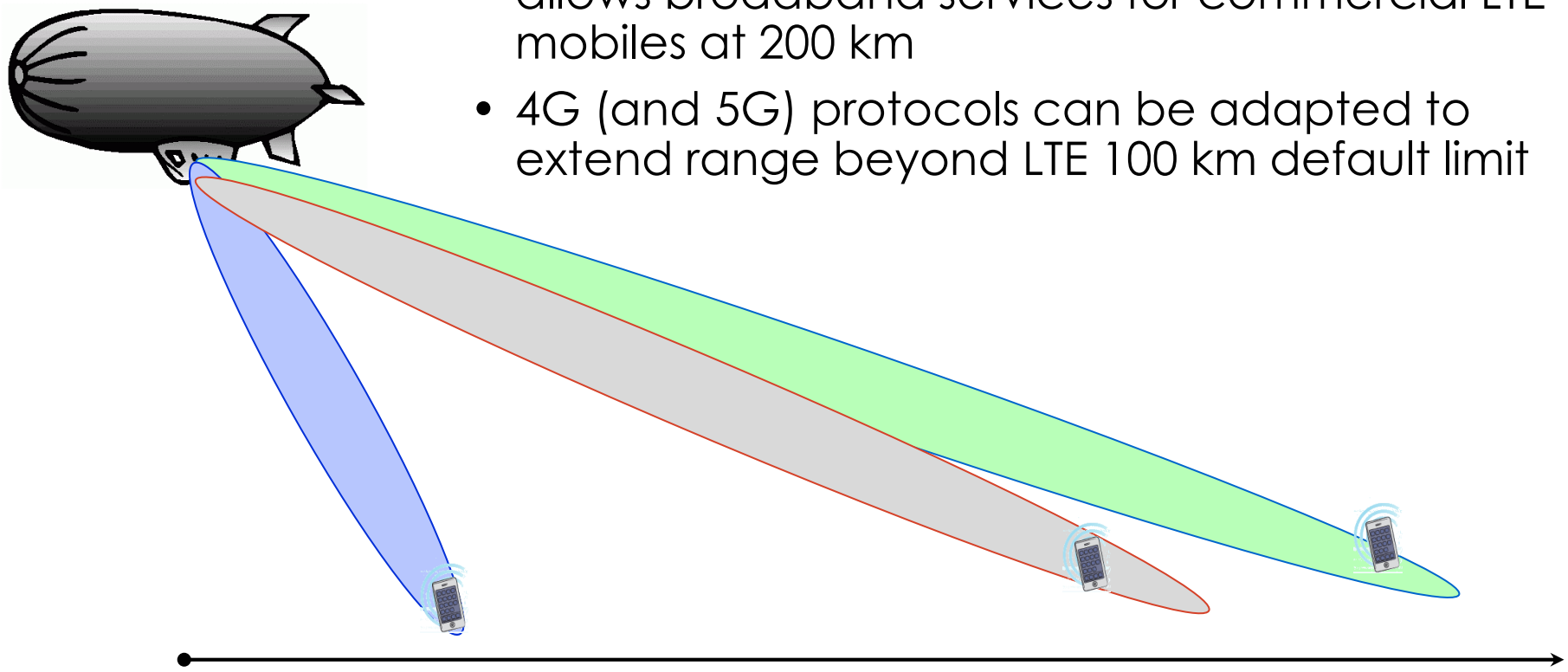


- **to provide "low density" wide coverage**
  - 3Mbps broadband services up to a distance of 200 km
  - wider coverage for low bit rate IoT services

Range 200 km

4G/5G link budget adaptation & extended range

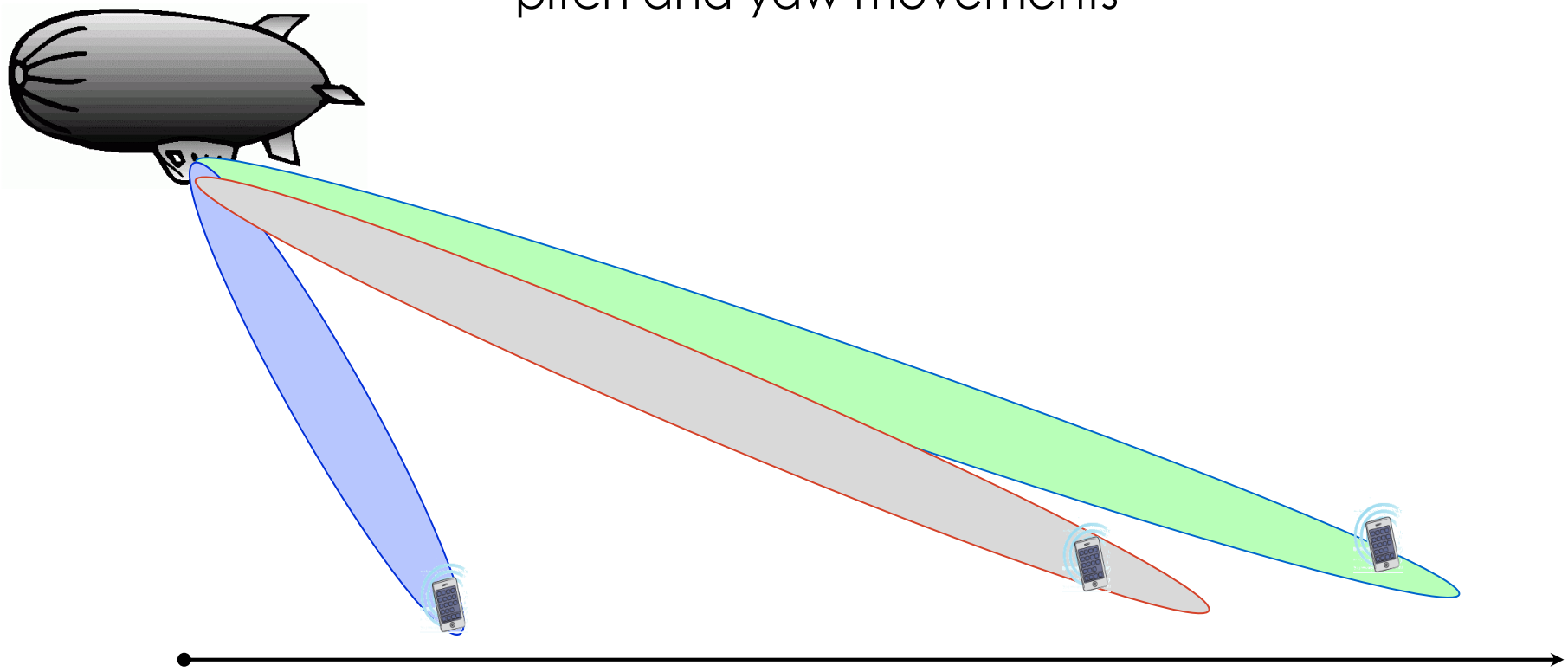
- The high gain of the active array antenna allows broadband services for commercial LTE mobiles at 200 km
- 4G (and 5G) protocols can be adapted to extend range beyond LTE 100 km default limit



Extended range up to 200 km

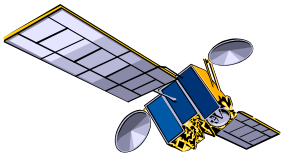
HAPS movement compensation

- The active array will also compensate HAPS roll, pitch and yaw movements



Extended range

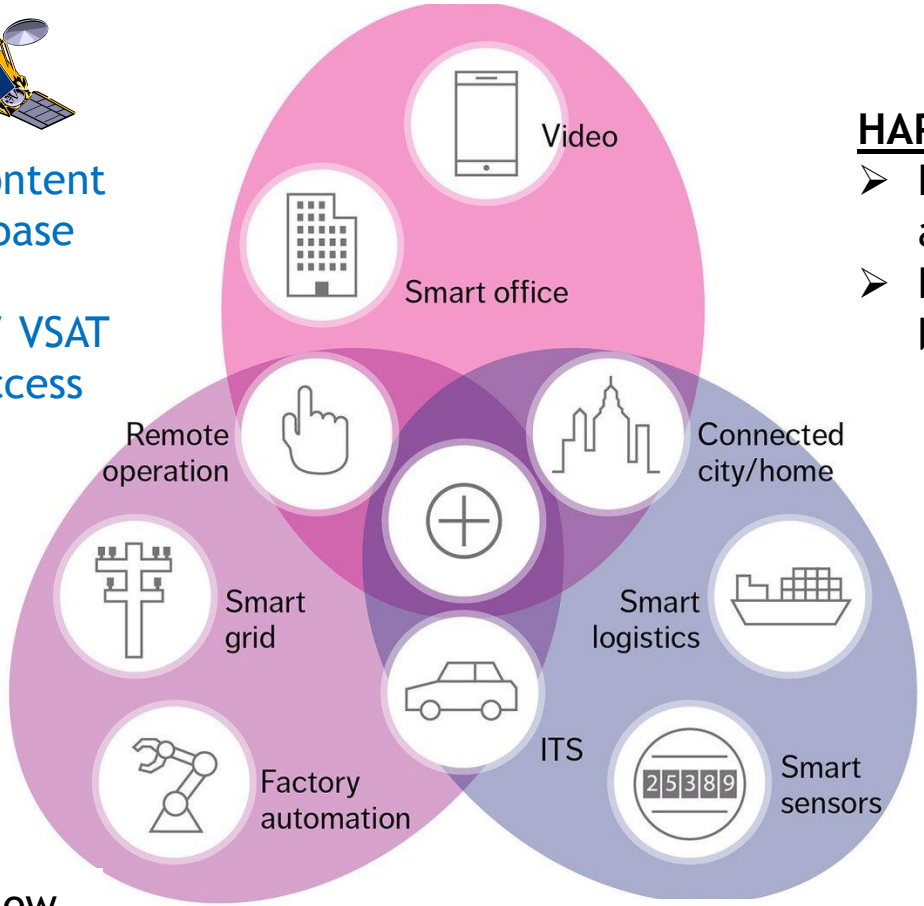
Satellite and HAPS contribution to 5G



Satellite:

- Backhauling and content distribution to 5G base stations,
- Continental VHTS / VSAT fixed broadband access

eMBB (enhanced Mobile Broadband)



HAPS:

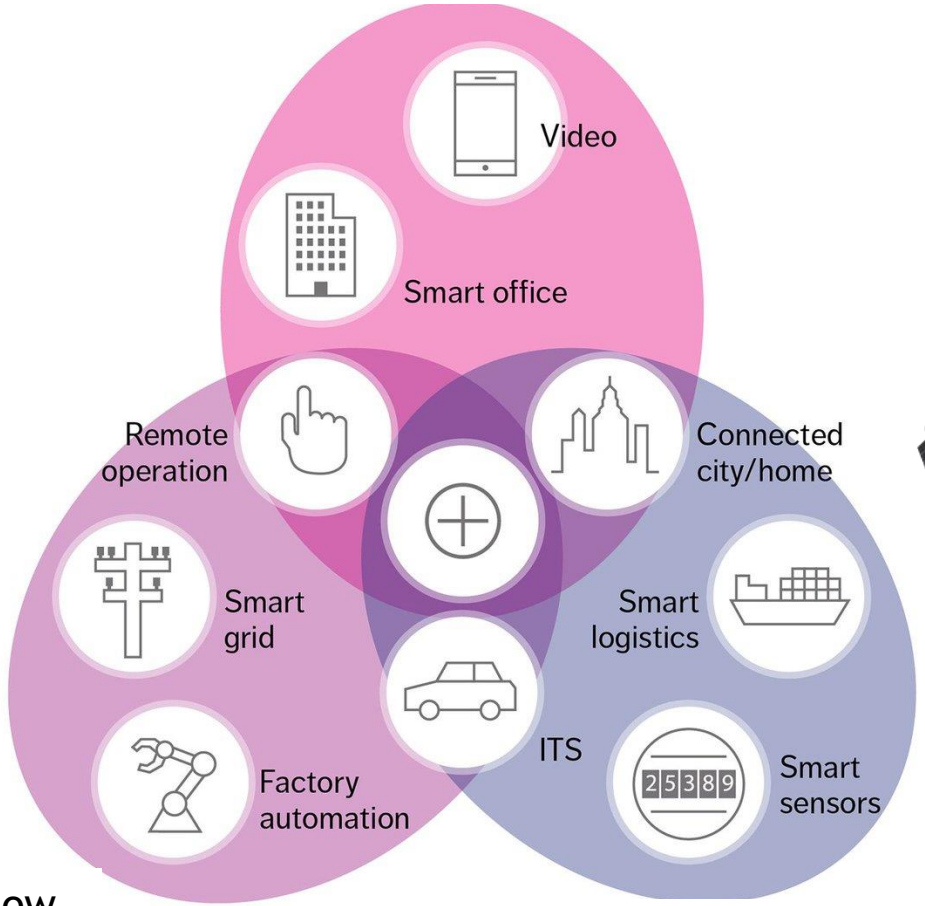
- Direct broadband access to smartphones
- Local high capacity broadband access

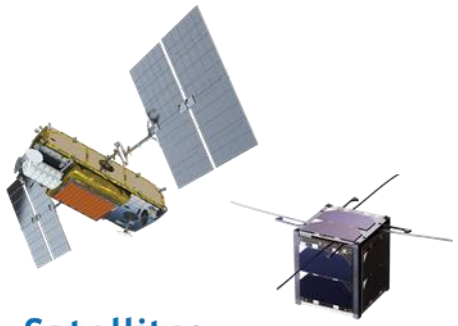
URLLC (Ultra Reliable Low Latency Communications)

mMTC (massive Machine Type Communications)

Satellite and HAPS contribution to 5G

eMBB (enhanced Mobile Broadband)





Satellite:

- Worldwide IoT constellation

HAPS:

- Regional cellular IoT coverage

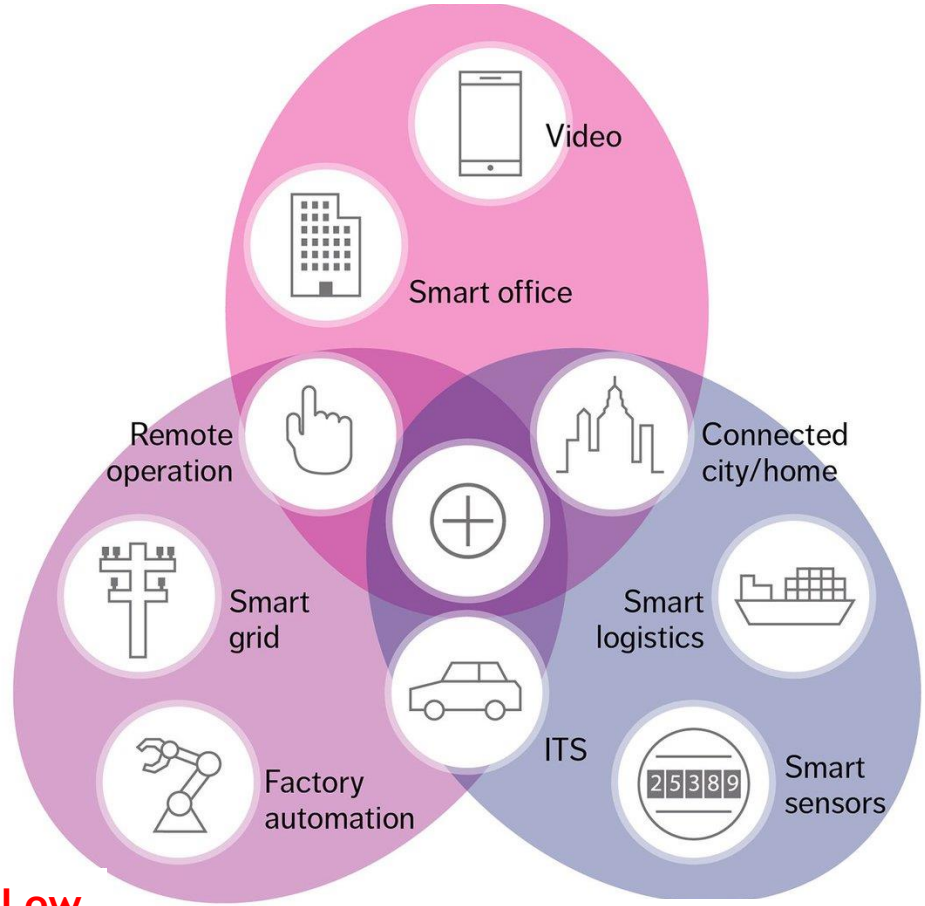
URLLC (Ultra Reliable Low Latency Communications)

mMTC (massive Machine Type Communications)

Satellite and HAPS contribution to 5G

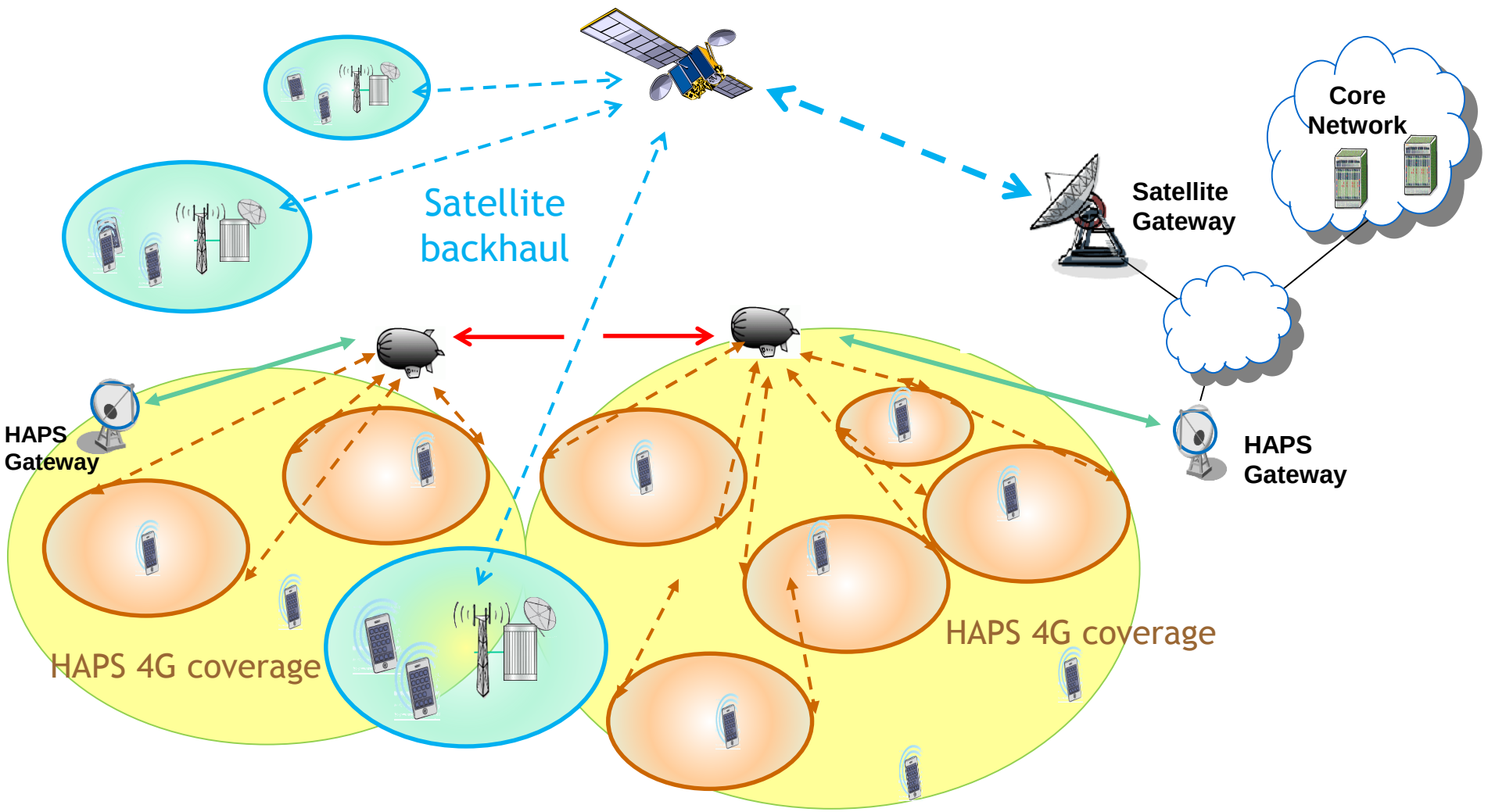
HAPS:

- Mission critical and low latency services



URLLC (Ultra Reliable Low Latency Communications)

Broadband cellular coverage : using Satellite & HAPS



Satellite & HAPS complementarity

- **HAPS** (airship, solar planes, loons) **will be natural complement to GEO, MEO,** (V)**LEO satellites**
  - "Pseudo" satellites with reduced CAPEX and (relatively) easy to deploy
  - They can provide local fixed & mobile capacity
  - They can support low latency services (much better than LEO's)
- **HAPS can also be seen as extension to terrestrial networks**
  - They can support "base station in the sky" providing spot capacity and offering wide cellular coverage in low density areas
  - They can share frequency spectrum with terrestrial cellular networks
    - *Provided regulatory clearance … and with interference control mechanisms*
  - They should become integral components of 5G "Non Terrestrial Networks"
- **HAPS payload design will benefit from large scale technology development in 5G terrestrial networks**
- **The HAPS remaining challenges are many economical: Total Cost of Ownership** (CAPEX + OPEX) **vs satellite & vs terrestrial**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