Low power direct sensor-to-satellite IoT connectivity

Getting Above the Noise in Micropower Networks in Shared Access Spectrum

Steve Clarke, COO, Wyld Networks Ltd

Hybrid networks promise the world - combining terrestrial networks and utilising satellite for the uncovered 85% of the Earth's surface. But that 85% is remote - little infrastructure, no power, difficult access. Many applications, such as smart agriculture, maritime, resource and remote asset monitoring are cost-sensitive and demand ultra-low power.

This presentation will discuss the implementation using shared access spectrum, covering some of the challenges and solutions to implement a hybrid network in the ISM bands - from power usage, overcoming interference and antenna design through to roaming, quality of service and the capability gap between terrestrial and satellite communications.

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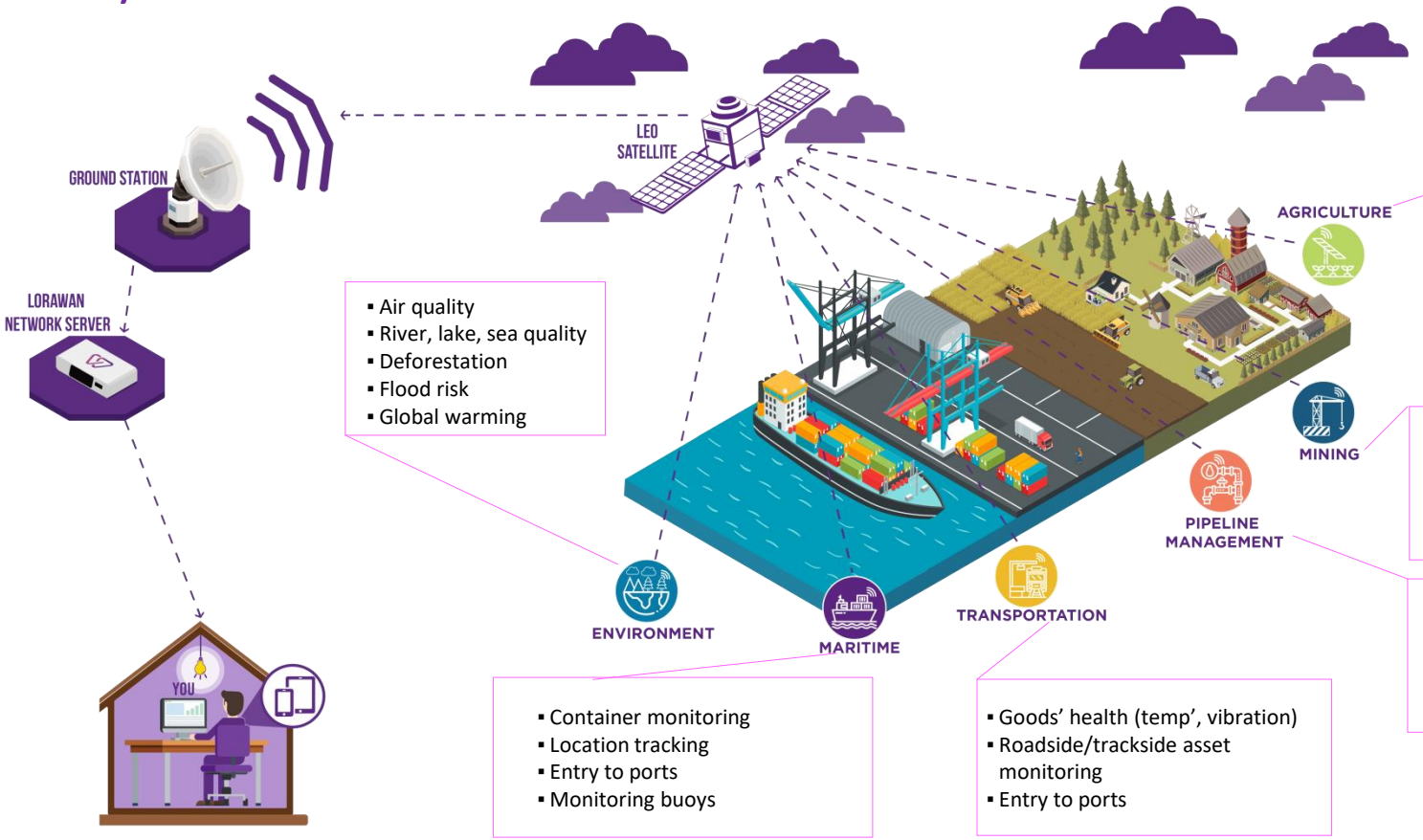
The Wyld Story

go Global, go Wyld

- Founded in 2016 with an objective of enabling affordable low power IoT connectivity using LEO Satellites
- Hybrid Solution - Objects can seamlessly connect to **Both** existing terrestrial LPWAN networks and LEO satellites
- Exclusivity in building Eutelsat's LoRa satellite connectivity infrastructure
- 30 launch partners in many sectors including agriculture & environment, oil & gas and maritime

eutelsat SEMTECH NASDAQ OMX FIRSTNORTH tern

Wyld’s sensor-to-satellite markets and use cases



- Air quality
- River, lake, sea quality
- Deforestation
- Flood risk
- Global warming

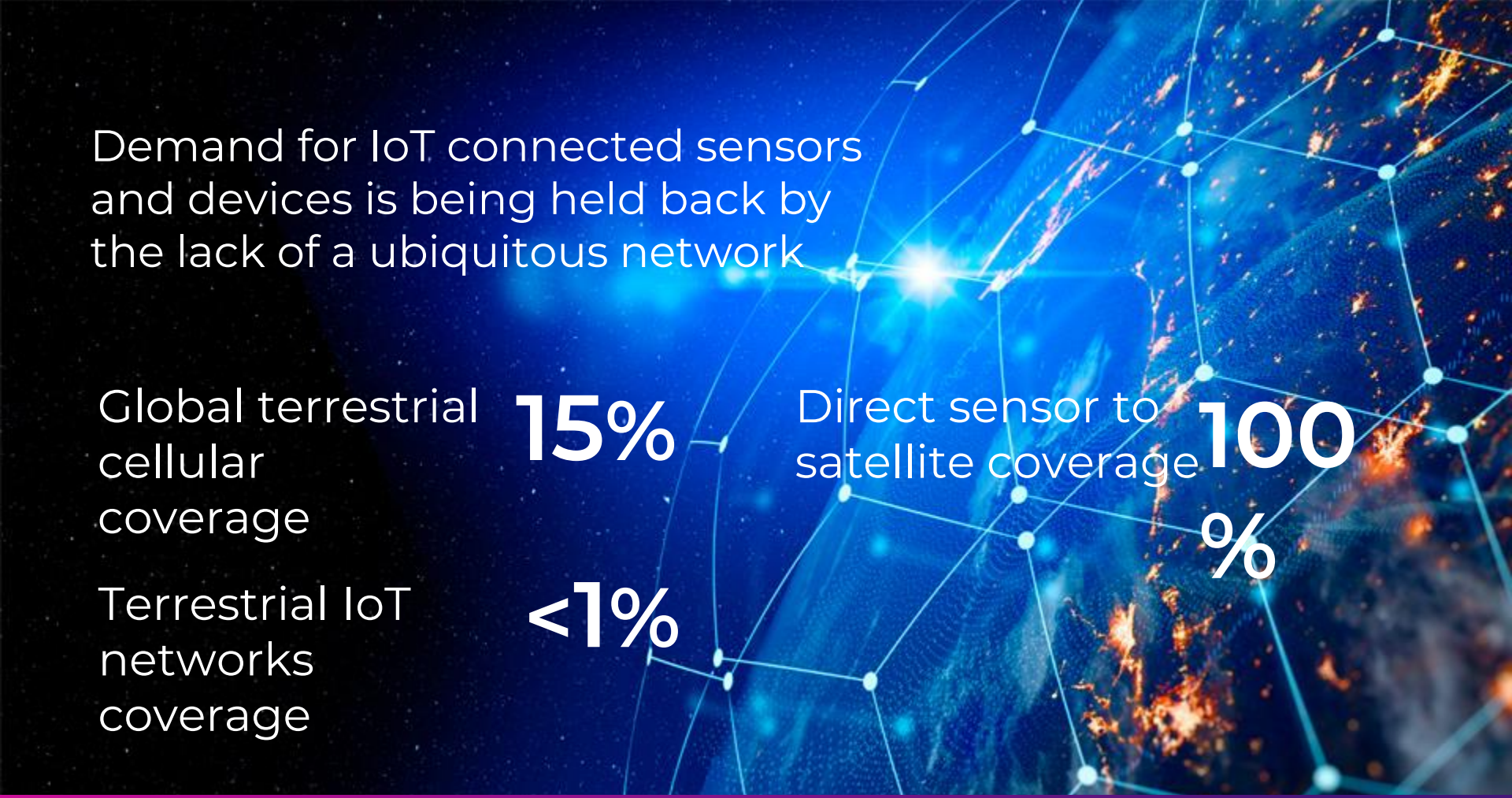
- Soil Moisture
- Pollination health
- Asset management
- Carbon capture
- Soil health
- Livestock monitoring

- Remote asset management
- Safety monitoring
- Strata movement
- Dust & noise monitoring

- Leak detection
- Crack detection
- Valve monitoring
- Pressure & flow monitoring

- Container monitoring
- Location tracking
- Entry to ports
- Monitoring buoys

- Goods’ health (temp’, vibration)
- Roadside/trackside asset monitoring
- Entry to ports


Demand for IoT connected sensors and devices is being held back by the lack of a ubiquitous network
Global terrestrial cellular coverage
15%
Terrestrial IoT networks coverage
<1%
Direct sensor to satellite coverage
100 %

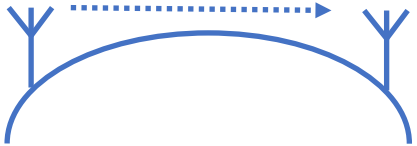
For ***Range***, Height is Everything

Physical factors that affect the range include:

- Obstacles
  - Hills
  - Buildings
  - Trees
  - Water
- Curvature of the Earth

Antenna Height	Range
1m	3.6km
10m	10km
100m	36km

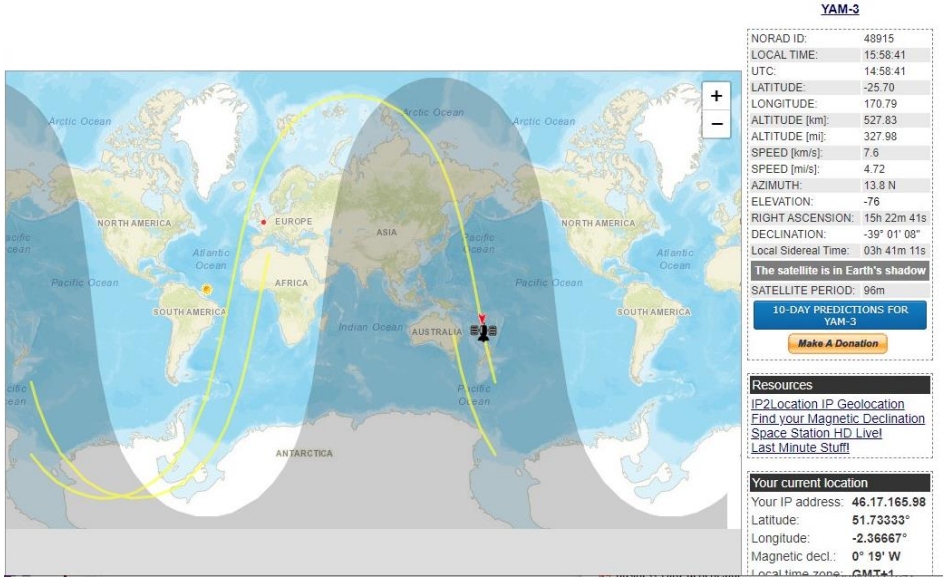
Line of Sight range, sending antenna at ground level



Satellite Solves the Height Problem
. . . and others too

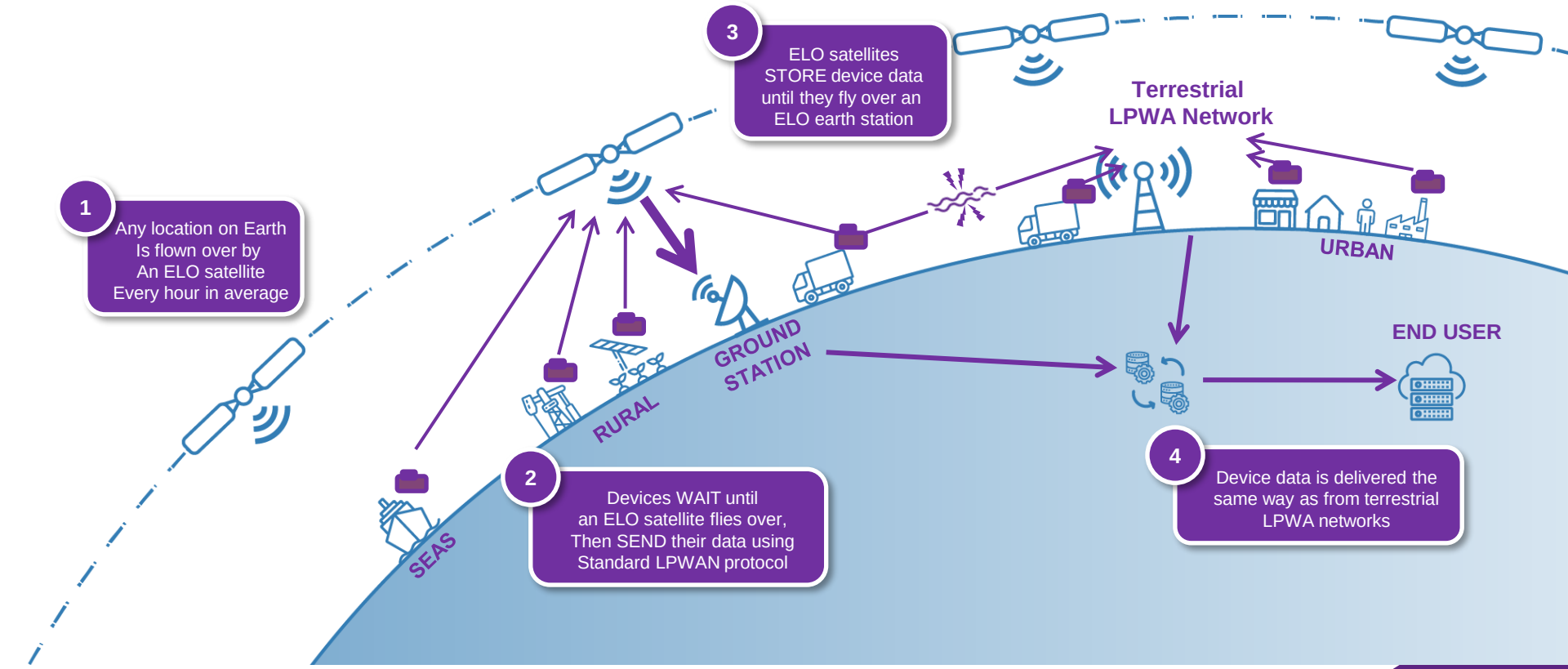
- Plenty of height
  - Low Earth Orbit 200 - 1600 km
  - Geostationary Orbit 36,000 km
- One (LEO) satellite covers whole earth surface
- Almost zero infrastructure

Single ground station to serve all users



A Low Earth Orbit (LEO) satellite orbit tracker

courtesy of NY2O.com


1
Any location on Earth
Is flown over by
An ELO satellite
Every hour in average
2
Devices WAIT until
an ELO satellite flies over,
Then SEND their data using
Standard LPWAN protocol
3
ELO satellites
STORE device data
until they fly over an
ELO earth station
4
Device data is delivered the
same way as from terrestrial
LPWA networks
Terrestrial
LPWA Network
GROUND
STATION
RURAL
URBAN
SEAS
END USER

And it causes its own set of problems . . .

Geostationary

- Transmission range 36,000km
  - needs special antennae
  - needs to be accurately pointed
- Big satellites, expensive launches
- Shortage of orbital slots around world
- Number of users per satellite
- Won’t work indoors

Low Earth Orbit

- Transmission range 500-1000km
  - simpler antennae
  - but satellite moving ~ 7.5km/s
  - small transmission window < 3 min
- Latency
  - waiting for the satellite
  - waiting for download to earthstation
- Fewer (but still a larger number) of users per satellite and still won’t work indoors

Application Characteristics

Target Cost / Performance Target

- < $30 USD hardware costs
  - including sensor, antenna, case
- 2 x AA batteries / > 2year life
  - wake only when necessary
- Easy to install
- Secure
- 10s – 100s bytes, several times / day
- Low data tariff
  ~ 1 cent / message

-----> A challenge for satellite broadband, 5G/6G etc
- hardware cost / complexity
- antennae
- power consumption
- L band and S spectrum licensing cost

Can We Make ISM Band Work?

Good

- Free to use – no spectrum licensing
- Cheap equipment
- Near-worldwide coverage at:
  - *470-510 MHz for China*
  - 863-876 MHz + 902-928MHz RoW
- Some very good technologies which will work at low power

Bad

- Shared spectrum
  - interference
  - limited spectrum available
- 2.4 Ghz band too noisy
- No return path
- Difficult to cover worldwide given range of frequencies
  - But OK outside of China
- Capacity
- Link Budget . . .

Noise is the Enemy

It’s not so much the range loss:

- at 900 MHz, free path loss is around 145-152 dB for LEO applications

So we want a link budget of >160 dB:

- at 100mW (20dBm) ERP we need sensitivity >- 140dBm*

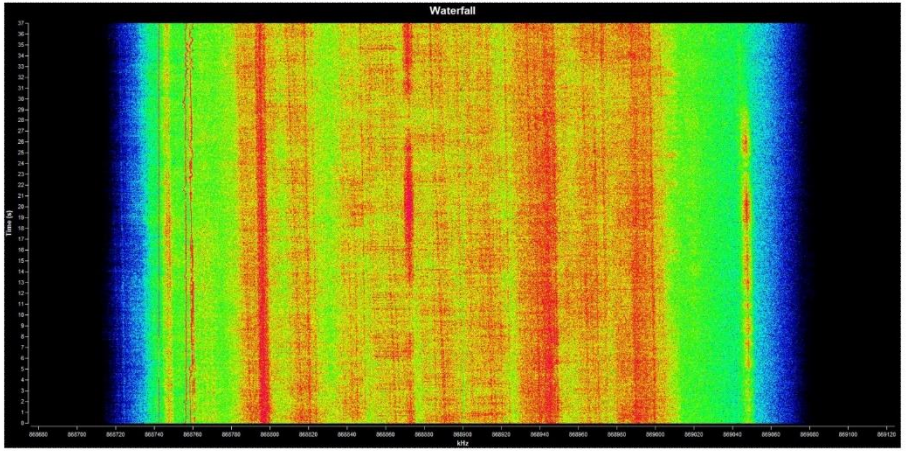
With minimal antenna gain, several narrow band and spread spectrum technologies offer this:

- LoRa®-CSS at high spreading factors works, but has inefficient spectrum usage
- LoRa®-LR-FHSS offers much better spectrum efficiency – i.e. more users

The problem is the *noise from existing users*

Spectrum occupancy mid-868 band, Dubai Noise floor is around -126dBm

Courtesy Eutelsat



868.74 MHz 868.9 MHz 869.05

** To put in context, this is a power level of 10 x 10^{-18}W or 10 ato watts*

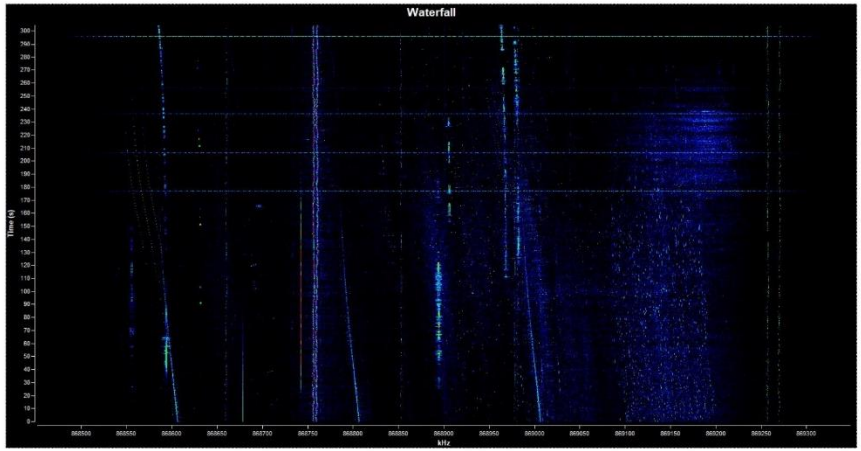
Pick Your Frequency Carefully

Spectrum occupancy mid-868 band, Paris Noise floor is around -148dBm

Courtesy Eutelsat

Spectrum occupancy varies according to location, selectivity of antennae, time of day . . . .

Band usage needs to be dynamic – and the receiver needs to set up for optimum time and frequency of transmission.



868.5 MHz 868.85 MHz 869.2

Antenna Considerations

- Good antenna performance is essential in satellite devices
- Satellite may come in at a low elevation:
  - the satellite track for a the closest pass may be many 100s km away
  - satellite may never pass overhead
- Antennae may perform better if their gain is higher at the lower elevations, where the path length is greater:
  - this also suits hybrid terrestrial operation
- As with all radio products, consider where it will be mounted:
  - careful antenna choice may allow mounting on or close to a ground plane
  - don’t skip the antenna matching
- Cost and power precludes tracking antennae

What If I Can't See the Sky?

You can't keep shouting louder:

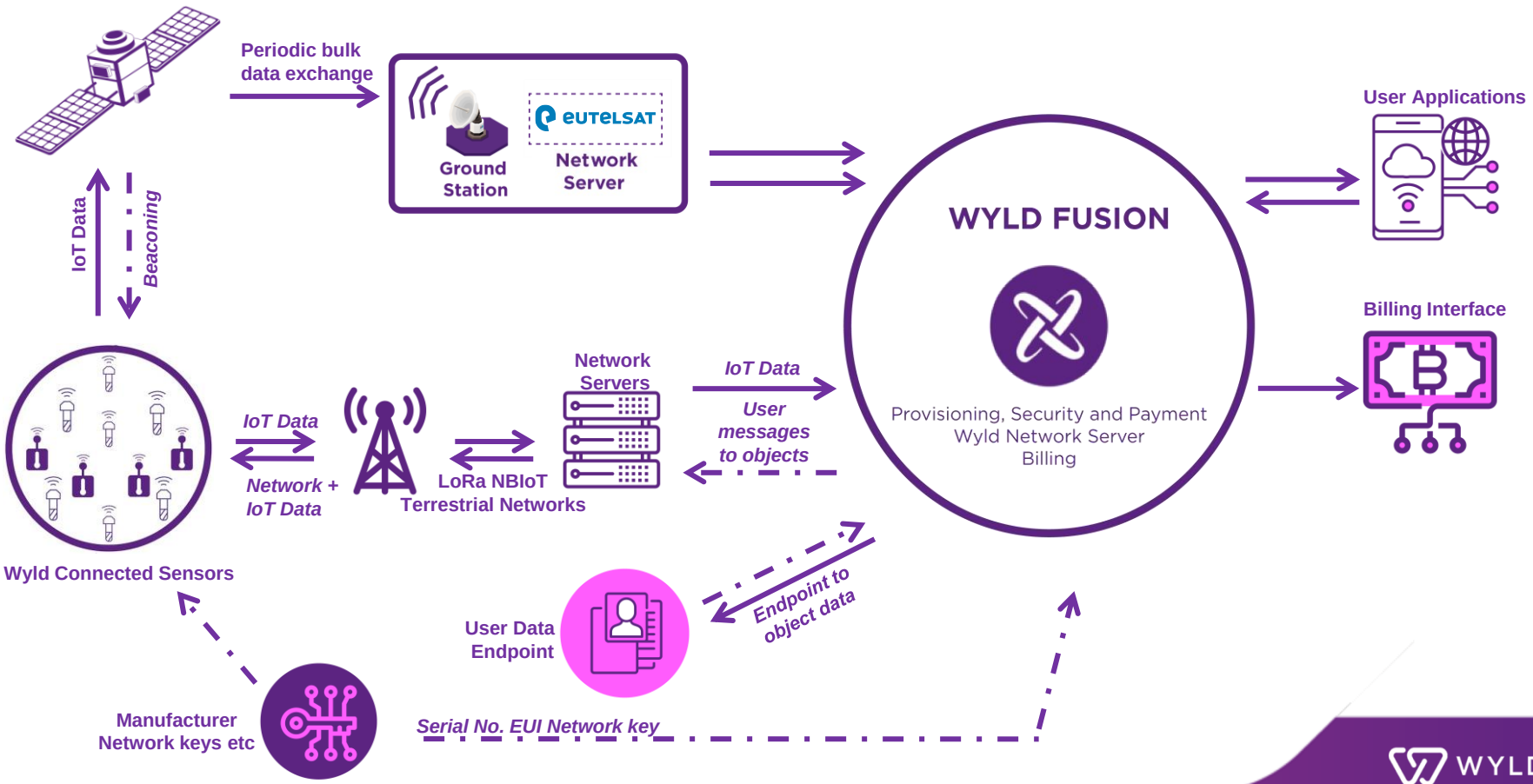
- The link budget is such that there is insufficient margin indoors, or even where there may be obstacles for Line-of-Sight such as in forests at low (satellite) elevations
- Imperfect equipment mounting may mean only some passes get good unobstructed passes
- Allow devices with poor location reach nodes with good coverage using radio hoping and meshing e.g. with Wyld TRIoT® and Wyld Mesh®
- Improves link reliability

How Do I Increase Capacity?

Hybrid networking and roaming:

- Prioritise traffic over terrestrial links
  - high data rate
  - higher capacity
  - possibility of 2-way communications
  - lower data costs
- Devices automatically switch over when they detect a known terrestrial network
- Use same radio devices (where network is compatible)
- Use same antenna, albeit with poorer terrestrial performance:
  - optimise for satellite reception
  - use separate terrestrial antenna at limit of range

Satellite/Terrestrial Data System



Thank you

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