5G & Non-Terrestrial Networks
IET London Local Network

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Thales Overview

Over 81,000 employees

68 Countries
Global presence

1 bn €
Self-funded R&D*

Sales in 2021
16.2 bn €

* Does not include externally financed R&D
Thales’s Mission

Sensing & data gathering

Data transmission & storage

Data processing & decision making

Digital Identity and Security

Defence and Security

Aerospace

Space

Ground Transportation

We help customers master decisive moments by providing the right information at the right moment.
Mobile comms through the decades

1980s
1G • analogue (primarily voice)

1990s
2G • digital (primarily voice + SMS)

2000s
3G • improved packet data services

2010s
4G • IP optimisation

2020s
5G • vertical markets

2030s
6G • research starting now!

massive consumer market expansion

massive business market expansion expected

1980s 1990s 2000s 2010s 2020s 2030s
5G vertical markets examples

- Automotive
- Media
- eHealth
- Agriculture
- Manufacturing
- Smart cities
- Energy
- Public safety
5G overview

10 Gbps bit rate

eMBB

1 million per km² density

mMTC

1 ms latency

URLLC

massive machine type communications

ultra-reliable low-latency communications

Vision presented by ITU in 2015

Followed by 3GPP standardisation

standardisation is key

not all aspects for given connection!
5G architecture & deployment

Radio Access Network
- gNodeB (base station)
  - Radio Unit
  - Distributed Unit
  - Central Unit

Core Network
- Data Networks (e.g. Internet)
- PSTN

Cloud Options:
- Cloud Option 1
- Cloud Option 2
- Cloud Option 3
Features and technologies

### New Radio (NR) Air Interface
- **scalable OFDM**
- **more flexible numerology**
- **flexible slot-based framework**
  - low latency, URLLC
- **advanced channel coding**
  - LDPC & polar
- **massive MIMO**
  - increased coverage & capacity
- **mmWave**
  - up to 100 GHz

### Networking
- **network function virtualisation (NFV)**
- **software defined networking (SDN)**
- **service based architecture**
- **HTTP/2 signalling**
  - REST API
- **network slicing**
- **Ethernet**
- **multi-access edge computing (MEC)**
- **private networks**
- **vehicle to everything (V2X)**
- **location services**
- **non-terrestrial networks**
- **enhanced security**

5G & Non-terrestrial Networks – IET London Local Network
20/09/2022

OPEN
5G public vs private networks in general

Public
- publicly accessible
- Mobile Network Operator (MNO)
- wide coverage: country, region, city
- public telephone number system

Private
- closed network (to public access)
- stand-alone or slice through MNO public network
- limited coverage: e.g. ports, factories, offices
- own telephone number system unless network integrated with MNO
## Spectrum is everything

### Ofcom shared access licences

- Low power (250 mW EIRP); multiple base stations within 50 m radius
- Medium power (5 W EIRP); single base station; rural areas
- Indoor/outdoor

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Bandwidths</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1781.7 to 1785 MHz paired with 1876.7 to 1880 MHz</td>
<td>2 x 3.3 MHz</td>
<td></td>
</tr>
<tr>
<td>2390 to 2400 MHz</td>
<td>10 MHz</td>
<td></td>
</tr>
<tr>
<td>3800 to 4200 MHz</td>
<td>10, 20, 30, 40, 50, 60, 80 and 100 MHz</td>
<td></td>
</tr>
<tr>
<td>24.25 to 26.5 GHz</td>
<td>50, 100 and 200 MHz</td>
<td>Indoor low power only</td>
</tr>
</tbody>
</table>
Non-Terrestrial Networks (NTN) drivers & systems

- **Increased coverage**
  - Rural users in developing countries
  - Mobile ‘not-spots’ with established users
  - Vertical markets

- **Promise of a single air interface for satellite systems**

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**Indirect Access** (Backhaul)

- Lower bit rates than terrestrial (e.g. 3 Mbps)

**Direct Access** (e.g. Transparent Mode)

- gNB (base station)
NTN and some potential use cases

- service ubiquity
- service continuity, e.g. mobile platforms
- multi-link networks
- network island connectivity
## 5G-NTN Platforms

<table>
<thead>
<tr>
<th>Platform</th>
<th>Altitude (km)</th>
<th>Bent pipe Round-trip Delay(^1) (ms)</th>
<th>Max Tangential Velocity</th>
<th>Number for global coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerial Vehicle (UAV, HAPS)</td>
<td>~ 8 to 50</td>
<td>~ 3</td>
<td>15 m/s</td>
<td>N/A (localised only)</td>
</tr>
<tr>
<td>Low Earth Orbit (LEO) satellites</td>
<td>~ 600 to 1500</td>
<td>~ 28 to 50</td>
<td>7 km/s</td>
<td>hundreds to thousands</td>
</tr>
<tr>
<td>Medium Earth Orbit (MEO) satellites</td>
<td>~ 10000</td>
<td>~190</td>
<td>5 km/s</td>
<td>tens</td>
</tr>
<tr>
<td>Geostationary Earth Orbit (GEO) satellites</td>
<td>35786</td>
<td>~ 540</td>
<td>0 km/s</td>
<td>~four (polar regions not covered)</td>
</tr>
</tbody>
</table>

Note 1: Low elevation UE and gateway scenario
5G main components and interfaces
Direct Access NTN architectures (1)

### Transparent Mode

> ‘bent pipe’

### Radio Unit on satellite

> Good cost vs performance

> High-performance feeder link
Direct Access NTN Architectures (2)

- **Distributed Unit and Radio Unit on satellite**
  - Latency reduction at lower layers

- **Full gNB (base station) on satellite**
  - Latency reduction for gNB
## New systems potentially suitable for backhaul

<table>
<thead>
<tr>
<th>System</th>
<th>Satellite Type</th>
<th>Cost</th>
<th>Satellites Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O3b mPower</strong></td>
<td>SES</td>
<td>~40 sats</td>
<td>~40 sats target</td>
</tr>
<tr>
<td></td>
<td>MEO</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OneWeb</strong></td>
<td>LEO</td>
<td>~$5 billion</td>
<td>~700 sats target</td>
</tr>
<tr>
<td></td>
<td>UK Government, Bharti Global</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Starlink</strong></td>
<td>SpaceX</td>
<td>~$10 billion</td>
<td>~12,000 sats target?</td>
</tr>
<tr>
<td></td>
<td>LEO</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Kuiper</strong></td>
<td>Amazon</td>
<td>~$10 billion</td>
<td>~3300 sats target</td>
</tr>
<tr>
<td></td>
<td>LEO</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lightspeed</strong></td>
<td>Telesat</td>
<td>~$5 billion</td>
<td>~300 sats target</td>
</tr>
<tr>
<td></td>
<td>LEO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Near-term direct access systems (not all 5G-NTN standard)

<table>
<thead>
<tr>
<th>SpaceMobile</th>
<th>Lynk</th>
<th>Omnispace</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST</td>
<td>Lynk Global</td>
<td>Omnispace &amp; Lockheed Martin</td>
</tr>
<tr>
<td>LEO</td>
<td>LEO</td>
<td>LEO &amp; MEO</td>
</tr>
<tr>
<td>~$2 billion cost?</td>
<td>~$? million</td>
<td>claims low cost</td>
</tr>
<tr>
<td>~170 sats target</td>
<td>~5,000 sats target</td>
<td>~200 sats target</td>
</tr>
<tr>
<td>Vodafone, Rakuten, AT&amp;T</td>
<td>Aliv, Telecel Centrafrique, Unitel, Telikom, bmobile</td>
<td>5G-NTN stds</td>
</tr>
</tbody>
</table>
3GPP Releases

<table>
<thead>
<tr>
<th>Release</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Freeze</td>
<td>22/03/2019</td>
<td>03/07/2020</td>
<td>18/03/2022</td>
<td>15/12/2023</td>
</tr>
<tr>
<td>End Date (Protocol stable)</td>
<td>07/06/2019</td>
<td>03/07/2020</td>
<td>10/06/2022</td>
<td>03/2024</td>
</tr>
</tbody>
</table>

NTN introduced

Source: [https://www.3gpp.org/specifications/67-releases](https://www.3gpp.org/specifications/67-releases) (retrieved 18/09/2022)
July 2022: Ericsson, Qualcomm and Thales take 5G into space

Ericsson
5G virtual RAN stack modified for LEOs

Qualcomm
5G smartphones for NTN access

Thales
5G radio satellite payload for LEOs

testing and validation of 5G NTN

smartphone-use-case focused direct access
Conclusions

**5G expected to be transformative**

New applications & vertical markets

**5G-NTN takes transformation further**

Alternative backhaul solutions
Followed by direct access

- **Interoperable**
  - Prior to 5G

- **Integrated**
  - 5G & 5G Advanced

- **Unified**
  - 6G

Non-terrestrial Networks

Terrestrial Networks

Thales engaged in 6G research

5G expected to be transformative

5G-NTN takes transformation further