RTT TECHNOLOGY TOPIC
September 2023

High Altitude Platforms

Over the course of this year (January to November 2023) we have been making our way through the eleven chapters of our new book, 5G and Satellite RF and Optical Integration, highlighting industry announcements that help to consolidate the narrative of an emerging market for 5G services from space coupled to increasing use of optical free space technology for inter satellite, inter constellation and earth to space/ space to earth links.
As a reminder,
Chapter 1 covers 5G radio spectrum including RF C Band, RF link budgets and active and passive device efficiency.
Topics addressed in the rest of the book include
Chapter 2 Optical C Band link budgets and active and passive device efficiency
Chapter 3 RF over Fiber- link budgets and network architectures
Chapter 4 Space RF Link Budgets
Chapter 5 Optical Inter Satellite Links (OISL)
Chapter 6 Deep Space and Near Space technologies
Chapter 7 Ground Station and Earth Station Hardware and Software
Chapter 8 Low Altitude Platforms
Chapter 9 High Altitude Platforms
Chapter 10 RF and Optical Technology Enablers
Chapter 11 Technology Economics of RF and Fiber for terrestrial and space networks.

For more information and to order go to
https://uk.artechhouse.com/5G-and-Satellite-RF-and-Optical-Integration-P2194.aspx
Hard and soft copies of the two previous books in the Series can be ordered here
https://uk.artechhouse.com/5G-and-Satellite-Spectrum-Standards-and-Scale-P1935.aspx
https://uk.artechhouse.com/5G-Spectrum-and-Standards-P1805.aspx

If you are interested in writing a book for Artech House or have research work you would like included in future 5G and 6G satellite RF and optical titles then email geoff@rttonline.com who will put you in touch with the Artech commissioning team.

Our next LEO, MEO and GSO workshop presented in association with the Continuing Education Institute in Sweden will be held in Barcelona from 11th to 15th December - details via the link.

https://www.cei.se/course-820-leo-meo-and-gso-system-and-service-integration-group.html

If you would like an in house presentation of this course then CEI would be happy to arrange this for you. The workshop includes background on 6G, satellite and space RF and optical technologies. Contact CEI Europe

High Altitude Platforms (Chapter 9)
In last month's (August) Technology Topic we looked at the challenges and opportunities of connecting aircraft and other manned and unmanned aircraft flying between the ground and 12 kilometers using 5G radio and network technology. The opportunities include market volume enabled by global standards, potential spectrum availability across the FR1 and FR2 bands and the radio performance (RF efficiency) realized from forty years of engineering investment. The challenges are mainly to do with aviation industry concerns about the effect of 5G radio signals on existing and future aircraft radio and radar systems including radio altimeters in C band and airport

radar systems at S band. At cruising altitude for passenger aircraft, line of sight radio or optical links to LEO and or MEO and or GSO using proprietary protocols provide an alternative connectivity option which includes the longer term opportunity to scale to multi gigabit optical data links integrated into an aircraft's optical data bus. Optical links from optical ground stations are also an option for connecting and directing piloted and unpiloted aircraft in future air traffic management systems.

High altitude platforms (HAPS) are normally deployed in the stratosphere between 17 and 22 kilometres. This is above the height at which civil aircraft fly and generally above cloud level though night/noctilucent clouds can occasionally be found as high as 85 kilometers. One high altitude platform (HAP) can provide coverage typically over a 140 kilometer diameter cell. If equipped with spot beam antennas this can be divided into sub cells of a similar size to terrestrial cellular systems, for example a 2 kilometer diameter cell.

HAPS are of the order of ten to one hundred times lower than LEO satellites. This means HAPS have an RF link budget (spreading loss) advantage over LEOS of between 20 and 40 dB and a latency advantage of several milliseconds. (Less than one millisecond for a 20 km flight path compared to 4 milliseconds for a 700 kilometer LEO link). The maximum path length to the edge of a 140 kilometer diameter cell is 73 kilometres. The longer path length incurs 33 dB of additional radio path loss compared to a line of sight path from a terrestrial base station one kilometre away. Similar constraints apply to LEO systems operating at low elevation.

Nearly **A**lways **N**early **O**verhead is almost always the best link both in terms of atmospheric loss and line of sight gain (minimal obstruction from buildings, hills or foliage). The only advantage of lower elevation (apart from the need for fewer HAPS or LEO satellites for global coverage) is when you need to get signals into buildings. The best answer for that is usually a terrestrial mobile network or a dish on the roof pointing upwards (fixed rather than mobile service).

If Ku and Ka band frequencies (and or higher frequencies) are being used, there will be additional path loss if the radio signal goes through clouds and rain. The fade margin increases with rain rate and elevation and can be of the order of 10 to 12 dB. Lower radio frequencies such as S band remain largely unaffected. Path loss and blocking loss will be minimised if HAPS platforms are **N**early **A**lways **N**early **O**verhead though this implies a high density of HAPS platforms and negates the economic benefit of illuminating larger cells (See the argument above). There is therefore a compromise point between network density and throughput which is essentially the same as capacity versus coverage.

At WRC-03 it was agreed that spectrum would be made available for high altitude platform stations (HAPS) supporting IMT base stations (HIBS), initially within a 60 MHz pass band between 2010 and 2170 MHz split into three sub bands 2010 to 2025 MHz (15 MHz), 2110 to 2170 MHz (60 MHz) and/or 2110 to 2160 MHz (50 MHz). This is close to 5G Band NR1 (2210 to 2710 MHZ) and adjacent to Inmarsat's S Band European Aviation Network (EAN) spectrum in Europe which uses 2.17 to 2.2 GHz for space to earth and 1.98 to 2.01 GHz for Earth to space (mobile uplink). Mobile transmit is at 1885 to 1980 MHz which overlaps with Band N1 mobile transmit. This is important as it means that the pass band is within the standard Band N1 duplex transmit (TX) and receive (RX) switch path in a 5G smart phone. Adjacency to the Band 1 pass band together with Globalstar's Band 53 allocation was almost certainly a factor in Apple's decision to invest in the Globalstar constellation as the basis for the iPhone 14 satellite connectivity service offer.

After WRC-03 not a lot happened on **HIBS** until WRC19 when it was agreed that a number of bands up to 2.7 GHz Band 7 be considered at **WRC-23**, the **694 to 960 MHz Sub 1 GHz bands** (5G FR1 Low Band NR n5, 8,20,28,71, 81, 82 and 83), L Band **1720-1885 MHz** (5G FR1 Mid Band n1, n2, n3) and **2500 MHz to 2690 MHz** (5G FR1 Mid Band n7). This in turn was almost certainly a factor in Softbank's acquisition of the Google Loon HAPS patents.

Delegates at WRC-19 also agreed that *'allocations to the fixed service in the frequency bands **31-31.3 GHz**, **38-39.5 GHz** will be identified for worldwide use by HAPS'* and that *'existing worldwide identifications for HAPS in the bands **47.2-47.5** GHz and **47.9-48.2 GHz** are available for worldwide use.'*

As with terrestrial 5G, future WRC meetings can be expected to address the use of higher RF frequencies for HAPS including V Band (40 to 75 GHz) and W Band (75-110 GHz). Within the V and W Bands there are three bands allocated for fixed but potentially mobile services, two 5-GHz bands at 71-76 GHz and 81-86 GHz and a3 GHz band at 92-95 GHz. These are known collectively as E Band from the waveguide naming regime for 60 to 90 GHz.

The final question to answer is RF or optical and the answer is both. For inter HAPS links it is hard to see why you would not use optical as the preferred option. Equally if a global HAPS network of balloons or airships was deployed making their way steadily round the equator then there would always be a HAPS that could dark path route down to an Australian, European or US/Latin American optical ground station. 5G terrestrial networks however are still essentially RF with some optical transport though as you can tell, we are suggesting that this ratio will change over time and the ratio of RF and optical in HAPS would sensibly change at the same or similar rate.

In the end it comes down to the relative effectiveness and efficiency of RF and optical technology enablers. This brings us to the subject of our next Technology Topic (October) summarizing Chapter 10 (RF and Optical Technology Enablers).

Ends

RTT Technology Topics reflect areas of research that we are presently working on. We aim to introduce new terminology and new ideas to help inform present and future technology, engineering, market and business decisions.

The first technology topic (on GPRS design) was produced in August 1998. 25 years on there are over 270 technology topics **archived on the RTT web site**.

Do pass these Technology Topics and related links on to your colleagues, encourage them to join our **Subscriber List** and respond with comments.

Contact RTT

RTT, and **Niche Markets Asia** are presently working on research and forecasting projects in the mobile broadband, public safety radio, satellite and broadcasting industry and related copper, cable and fibre delivery options.

If you would like more information on this work then please contact **geoff@rttonline.com**
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