RTT TECHNOLOGY TOPIC
July 2023

Ground Station and Earth Station Hardware and Software

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 hopefully help to consolidate the underlying 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

Ground Stations and Earth Stations (Chapter 7)

Last month's (June) Technology Topic, Deep Space Near Space looked at the technologies used in radio and optical telescopes and their potential application in 5G and satellite communication systems. This month (July 2023) we look at the technologies used in Ground Stations and Earth Stations.

The terms ground station and earth station are used interchangeably but there are differences. A Ground Station can for instance be a long wave or short wave transmitter or transceiver using the ionosphere as a wave guide or an over the horizon radar system. An Earth Station implies that it is connecting with space. The new high count LEO constellations and MEO constellations have also introduced the term Earth Stations in Motion (ESIM).

On a global basis, Starlink have filed an expected requirement for several hundred earth stations and several million earth stations in motion. Amazon Web Services have similar filings to support their ambitions to add value to images and data from space and cross subsidised universal connectivity.

Gateways are also used to integrate multi orbit connectivity offers such as the GSO/MEO maritime service offers from SES O3B and GSO/HEO and potentially S band LEO from Inmarsat/Viasat. Intelsat as another example have added Starlink transceivers to their service offer which in turn opens up opportunities to co-share earth station sites.

Earth stations (defined as structures sending and receiving bits to and from space) work best on remote mountains in dry areas but that is not always convenient particularly if large amounts of fiber bandwidth need to be provisioned. Earth stations supporting RF uplinks and downlinks also work best in areas of low RF noise which is usually away from towns and cities. Being a safe distance away from microwave landing systems and other radar sources is also a good idea. Low elevation is needed in order to track LEOS and MEOS as they travel from horizon to horizon. This is technically inconvenient for a number of reasons. At lower elevations there will be more speading loss, propagation loss through the atmosphere will be higher and more variable and a bigger rain fade margin will be needed. Buiding blocking, foliage, and other things that get in the way will also be a problem at lower elevations. Adding more satellites to a LEO constellation means that more satellites are overhead more of the time and removes elevation loss from the link budget equation though co sharing with GSO has to be managed.

There are many ongoing commercial innovations in the ground station sector including Ground Stations as a Service (GSaaS) which include players such as AWS (Amazon Web Services) and Spire Global.

At a technical level the open question is the rate of adoption of optical ground stations and optical earth stations in motion. This is determined by the rate of deployment of Optical Satellite Links which allow for dark path and dry path (and ideally, dust free) routing for example to enable long distance low latency backhaul via LEO optical networks. Adoption rate will also be dictated by the bandwidth demands of optical imaging from space including space facing and earth facing imaging, RF signal analysis and Synthetic Aperture radar, all of which are growing at an exponential rate. End to end Quantum encryption would also add value to the optical offer.

An ever increasing appetite for interconnectivity on cruise ships may also hasten maritime OGS. An estimated 300 hundred cruise ships and 30 million cruise passengers per year will eat their way through a lot of food and a lot of internet bandwidth. (Rather more than 03B's ten terabit RF network can manage). Maritime defence, destroyers and aircraft carriers will also need maritime OGS to be compliant with future global situational awareness systems that will be largely optically based. RF on its own would struggle to meet this demand growth and interference levels including space to earth and earth to space interference would be challenging.

RF however will not disappear and lower bands in the RF spectrum will always be needed for all weather inter connectivity. There are also many opportunities for RF quiet path routing that are yet to be explored and Ka and higher frequency (V band and above) links will work nicely into ground stations located on high mountains in dry and cold places co located with optical transceivers. 6G studies are looking at RF frequencies up to 950 GHz and potential 3 THz in the longer term at which point the 'radio beam' is beginning to behave in a similar way to light.

The missing piece in this puzzle is the space between space and the ground which brings us to our next two Technology Chapters, Low Altitude Platforms (August) and High Altitude Platforms (September).

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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