RTT TECHNOLOGY TOPIC
June 2023

Deep Space Near Space

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 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 Munich from 20th to 24th November- details via the link.

www.cei.se/leo-meo-and-gso-system-and-service-integration

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 standards and spectrum and 6G, satellite and space RF and optical technologies.

Deep Space Near Space (Chapter 6)

Last month's (May) Technology Topic looked at optical transceivers and optical link budgets.
In this month's (June) Technology Topic, Deep Space Near Space, we study the technologies used in radio and optical telescopes and their potential application in 5G and 6G satellite and space communication systems.

The ITU defines deep space as anything beyond two million kilometers. The James Webb Space Telescope (JWST) at the L2 Lagrange Point is 1.5 million kilometers from Earth but its 28 Gigabyte

data files are sent back twice a day to the Deep Space Network so there is some flexibility in this definition. The Moon is 405,696 kilometres from earth so is defined as Near Space.

The Near Space Network used to be called the Near Earth Network but has been renamed as part of the NASA Program to encourage the private sector to provide near earth and lunar and Lagrange Point connectivity including rocket launch telemetry and telecommand and control. Commercial Ground Stations already provide over 50% of the bandwidth dedicated to these services, a continuation of a policy underway for a number of years. Tenders from NASA include the replacement of existing networks and the development and funding of commercial space stations to replace the International Space Station (ISS). Ongoing study work includes the deployment of integrated RF and optical communications and next generation timing and location and positioning and ranging space based systems from a broad cross section of the US and European space supply chain. US Space Defence also has an increasing focus on the Lagrange points for space surveillance, space asset protection and related activities.

The obvious difference between a Deep Space and Near Space link budget is that we need more gain in a Deep Space Budget because we have further to go. The less obvious difference is that for instruments in space like the JWST we need gain and bandwidth primarily in one direction, the downlink. We need to get 50 gigabytes a day back to earth but we don't need to send much in the other direction though what we do send (telecommand and control) is crucially important. The Near Earth Network link budget by comparison is sometimes but not always more symmetric. On the one hand there is a need to bring near space imaging bandwidth back to earth. This includes pictures of space from near space from Hubble but also pictures of earth from near space which is potentially petabytes of bandwidth that we need to handle. Multi spectral and hyper spectral imaging, RF trilateration and Synthetic Aperture Radar all add to this space downlink load. In the other direction, the Near Earth Network Uplink is not just doing telemetry and telecommand but also shipping radio and TV and telephone calls and the internet into near space (GSO, MEO and LEO) and across and down again.

The Near Space Network is an aggregation of all the technologies needed to support direct- to-Earth and relay services including antennas, ground stations and terrestrial inter connectivity. Services include data and voice communication, telemetry, command and control, tracking and ranging for all objects either in space in LEO, GSO, HEO or lunar orbit or objects travelling to and from those objects. The LEO orbits include polar, mid latitude and equatorial. Polar Orbits are also important for aviation and other sub orbital services and require substantial ground station assets in the Arctic and Antarctic Sub Continent. Satellites in Near Space used for earth imaging and other earth facing applications such as Wide Field of View missile detection are also supported from the NSN.

In Chapter 6 of the book we study in detail the technologies and techniques used in Deep Space and Near Space optical and RF communication. As with optical space links good mechanical design, the science of minimising vibration and jitter, has a surprisingly large impact on the link budget. Many of the techniques used to stabilize ground based radio and optical telescopes can be elegantly repurposed to minimize vibration and jitter in RF and optical deep space and near space communication.

Other factors are equally important. In terrestrial copper networks, the term 'last mile' was often used to describe the losses introduced by the final bit of twisted pair from a street cabinet fed by fiber. The 'last mile' in the journey from deep space and near space to Earth is also where most of the link budget loss is incurred. In the other direction, from Earth to space, most of the damage gets done in the first few meters when scintillation or smoke or rain or hail or snow causes wave front distortion and beam pointing loss.

Fortuitously these atmospheric aberrations can be measured and modelled and mitigated. For optical systems, dark path and dry path routing also means that atmospheric losses for optical links

can be minimised. Radio links into space also work better from mountain tops particularly if background radio noise is low. Keeping radio and optical receivers cool also helps. These factors together provide us with the launch point for our next Technology Chapter (and Chapter by Chapter review), Ground Station and Earth Station hardware and software and the challenges of supporting LEO, MEO and GSO systems.

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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