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SPACE INNOVATION

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SatCom performances and constraints

New Space Economy

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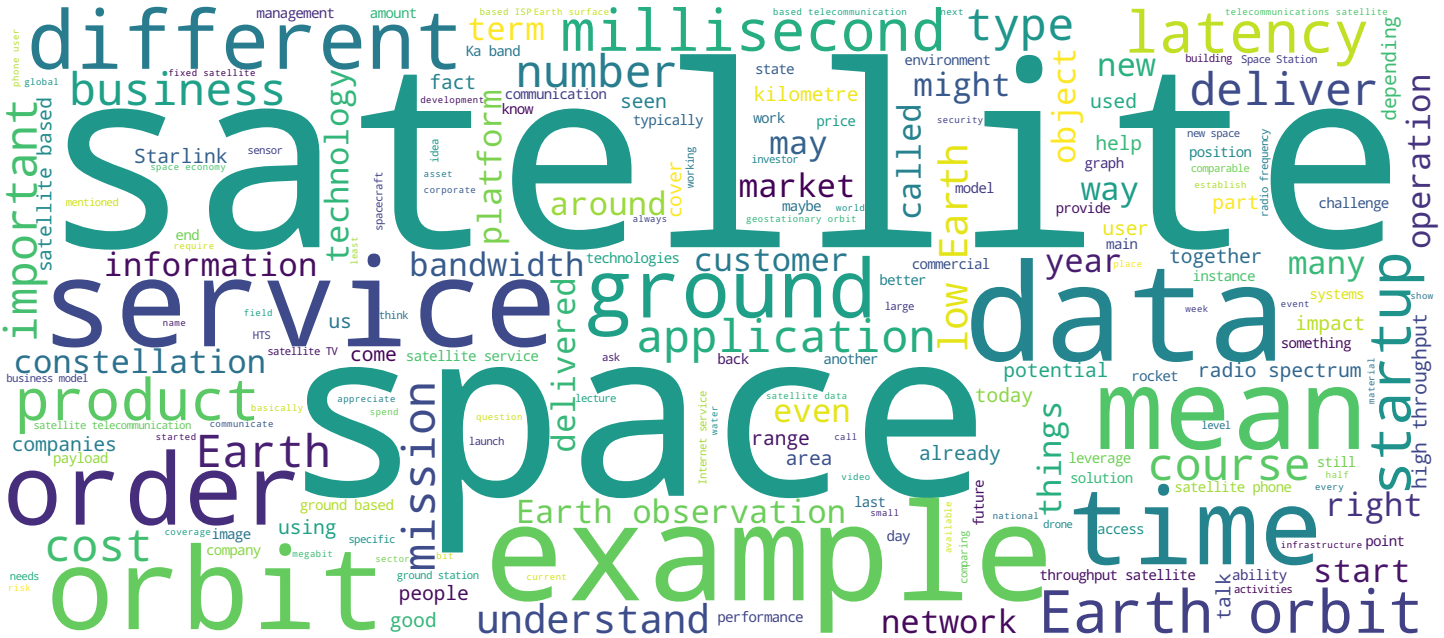

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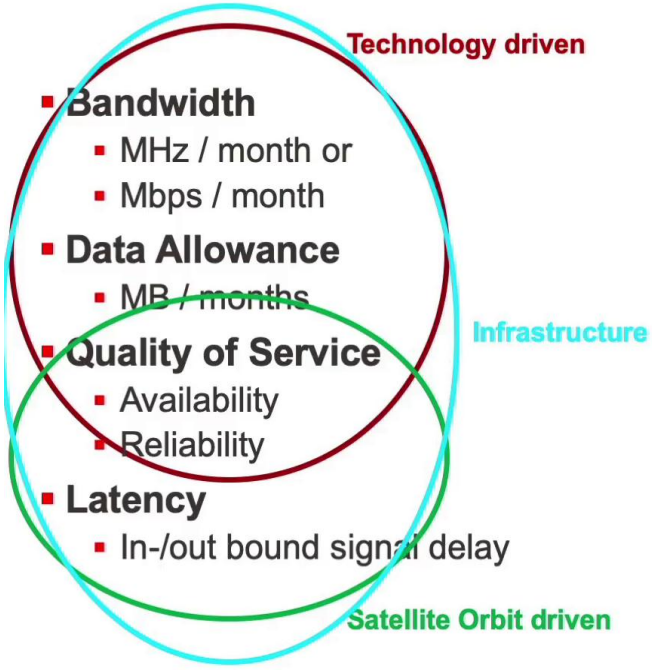
Video

EPFL

SatCom Performances and Constraints



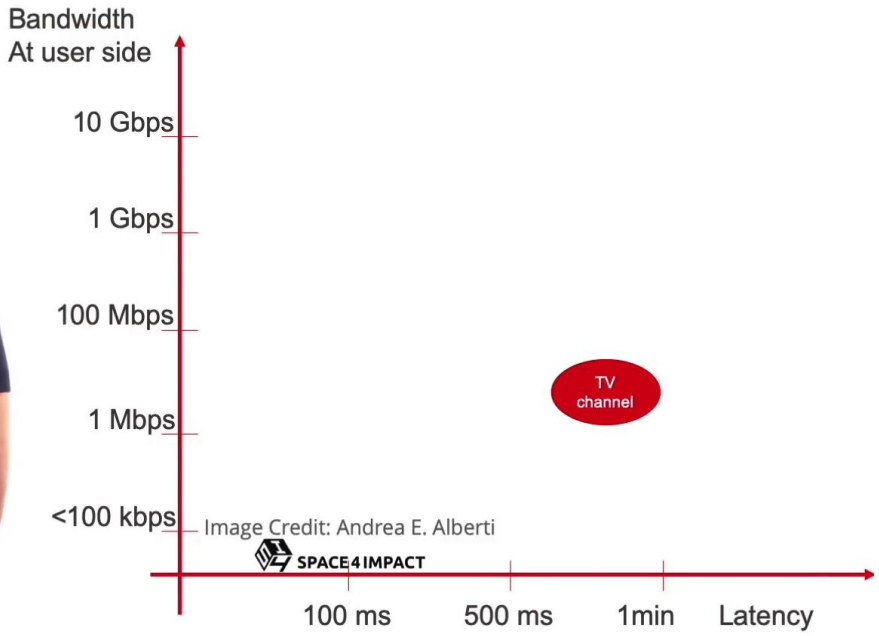
Now, throughout our discussion together, we have seen how much alike for our home appliances, our Internet connection at home, or our mobile iPhone subscription. We look at the performance of SatCom as an industrial vertical by measuring the bandwidth, that is, the speed of connection, the data allowance for each day or each month. We look at the availability and at the reliability of the service that we receive. Finally, we look at the latency that is, the delay between the outbound and the inbound signal. Now let's put together some numbers to understand what are the performances we are discussing about.

Notes

Summary

0m 05s

SatCom Performances and Constraints



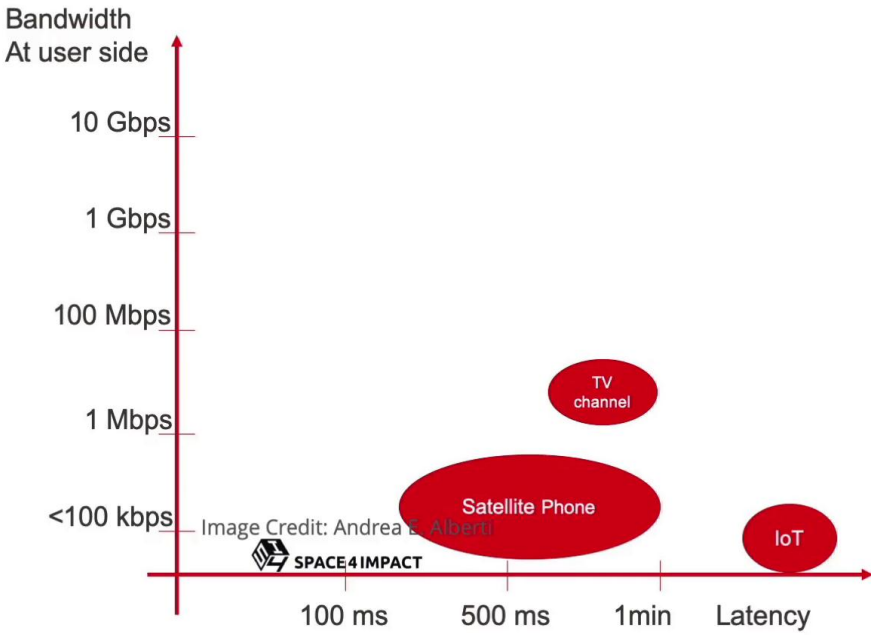
We look at the performances from the standpoint of the user, from the perception of the user. A single satellite TV channel delivers a bandwidth that is typically between 1.5 and 12 megabits per second, depending on the type of channel delivered. In this case, a single transponder from the geostationary satellite can cover a large portion of the Earth and can serve multiple users. In the case of satellite TV, we are talking about a minimum latency that spends between 600 to 800 milliseconds.

Notes

Summary

0m 57s

SatCom Performances and Constraints



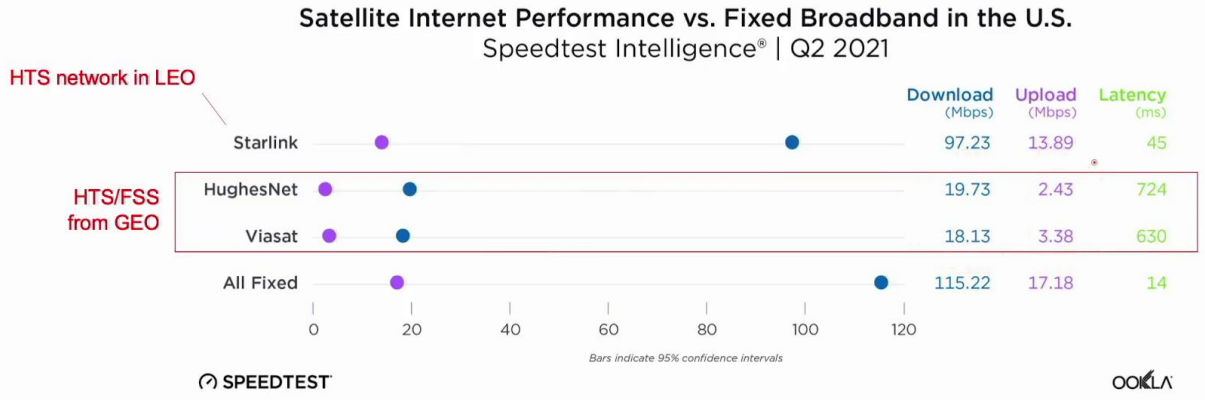
In the case of satellite phones, a latency below half a second would be required to have an optimal conversation with our counterparts. Nevertheless, even though that the satellite infrastructure deployed is much closer to the Earth, operating in low Earth orbit or in medium Earth orbit, with theoretical very low latencies, the satellite phone users can appreciate latencies that are spanning between 200 to 300 millisecond for the fastest services to about one second. What about the bandwidth that is delivered? Well, for simple satellite phone users, a bandwidth of about 2.4 kilobit per second is delivered, and this can go up to 700 kilobit per second for each user, depending on the price and on the technology of the service offered. A brief moment on satellite-based Internet of Things, for which a dedicated lecture will be delivered to you, a very simple message. The trick is not to seek for the lowest latencies or the highest data rate. What we seek with satellite-based IoT is to deliver connectivity to remote assets by ensuring the transfer of very small packets of data on a delay that could range up to several minutes. What we care is to reach our asset, to monitor, and to command it, even though with a time leg.

Notes

Summary

1m 43s

SatCom Performances and Constraints



https://www.speedtest.net/insights/blog/starlink-hughesnet-viasat-performance-q2-2021/

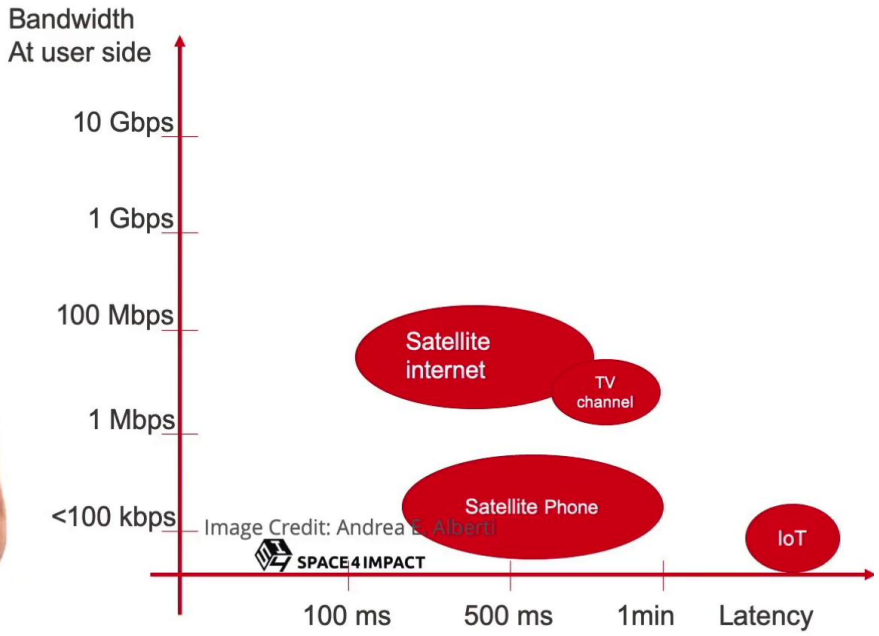
Now, before completing our little graph together, let's talk about Internet services offered through satellites. Satellite Internet services can greatly span in terms of delivered bandwidth, in terms of data allowance and of latency. This graph is comparing some of the measured performances as perceived at the user side, as delivered from the largest satellite Internet providers, and is comparing it to fixed ground Internet providers. Let's look at the latency. The latency of ground-based applications is about 14 milliseconds, according to this Infograph, Starlink is delivering 45 milliseconds of latency. It's a blink of an eye, is unperceptable, at least for the human senses. Internet based on geostationary satellites experience instead a latency that is well above half a millisecond. Let's look now at the bandwidth. Again, Starlink is able to deliver download and upload performances that are much comparable to ground-based ISPs. But the services delivered through geostationary-based satellites are not magnitudes away, are just factors.

Notes

Summary

3m 34s

SatCom Performances and Constraints



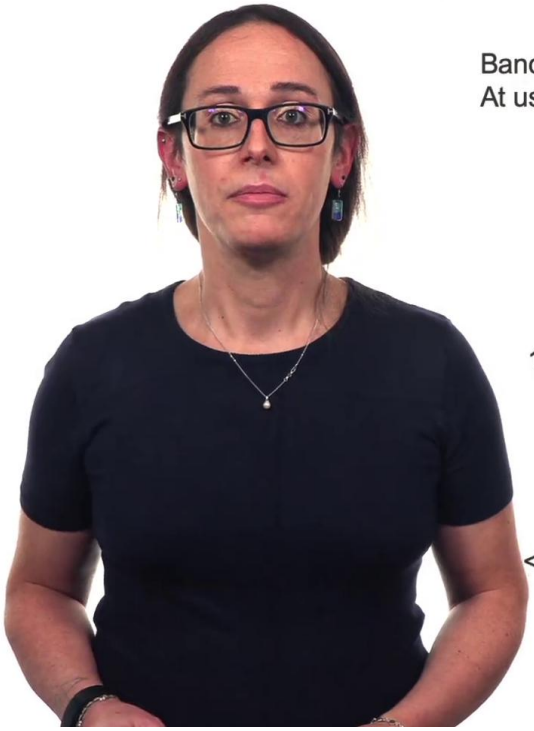
Let's complete now together our little graph. We have seen that Starlink offers today, as we speak, services that are comparable to ground-based ISPs with latencies lower than 100 milliseconds, and download bandwidth that ranges between 50 and 100 megabit per second. And the price? It is comparable to what a normal ground-based ISP would ask us. Nevertheless, let's not forget that their constellation is still in ramp-up, and Starlink is still approving each and any of the users.

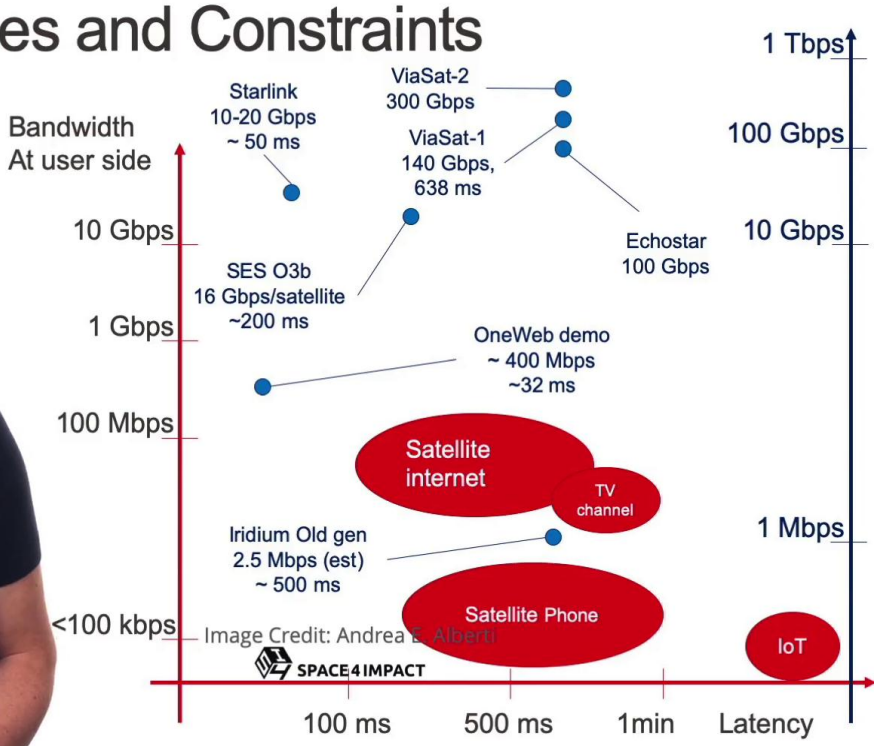
Notes

Summary

5m 27s

SatCom Performances and Constraints





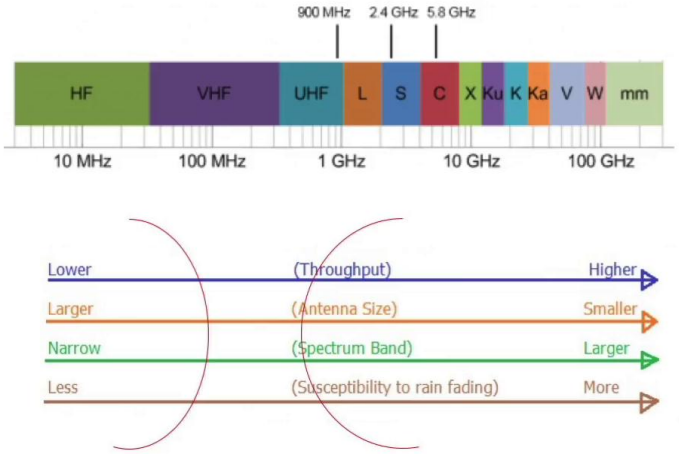
High throughput satellite or HTS, for example, those controlled by ViaSat or Yuxnet, deliver bandwidth that are ranging between 11 to 20 megabits per second, with latencies that range between 600 to 800 milliseconds. Now let's switch perspective, from a user standpoint to a provider standpoint. The situation is highly dependent on our choices: technology, orbit, and the complexity of the infrastructure that we choose. Since 2011, high throughput satellites or HTS are able to deliver as much as 20 times the throughputs of old style fixed satellite services. For example, Hughes EchoStar XVII delivers 100 gigabit per second. ViaSat-1 delivered 140 gigabit per second based on 60 Ka bands channels, and yes, up to 300 gigabit per second. The impact of this, this means that the satellite providers are able to deliver viable solution for back hole for satellite or radio TV, for mobile services, for Internet based on satellite with a significant drop in terms of cost per bit. Now, when we look at the Starlink satellites, we see that they deliver significantly less bandwidth at individual level than that of an HTS, but they leverage on a complex network in order to ensure that their customers are served in a global manner. Now, let's try to understand together how the radio frequencies are managed.

Notes

Summary

6m 09s

SatCom Performances and Constraints: Radio Spectrum



Mobile Satellite Service (MSS)
IoT
Satellite Phones

Fixed Satellite Service (FSS)
High Throughput Satellites (HTS)
Satellite TV
Starlink

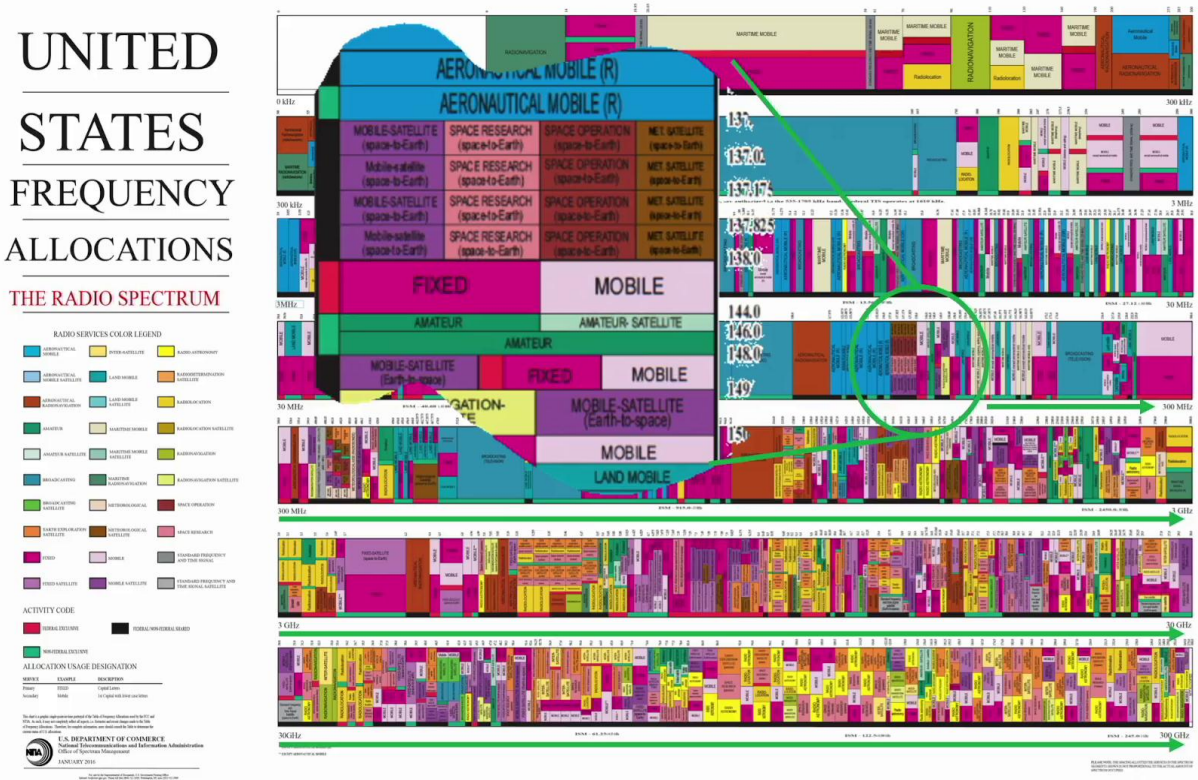
"Frequency Band Comparison" by Treinkvist licensed under CC BY-SA 4.0
Advantages and disadvantages L,S,C,X,Ku,K,Ka Frequency Bands (rfwireless-world.com)

As we speak, most of the telecommunications satellites deployed nowadays are transmitting radio signals. Depending on the region of the spectrum where we are operating, that is, depending on the wavelength or on the frequency of the signal that we choose, and depending on the specific technology that we adopt, the throughput varies. In this representation, the radio spectrum seems split in a clear and simple manner. In truth, the management of the electromagnetic spectrum in the radio frequency is an extremely complex matter and is subject to national and international regulations.

Notes

Summary

8m 15s



http://www.visualcapitalist.com/wp-content/uploads/2018/07/us-frequency-allocations.jpg

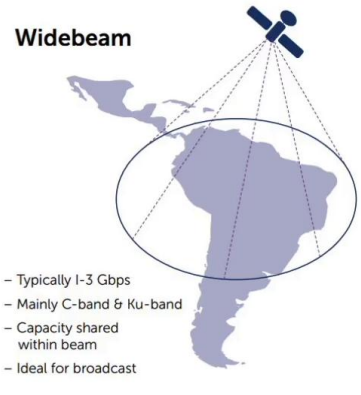
Here we see the radio frequency spectrum as it is allocated for the US. I perfectly know what you are thinking. Hey dude, this graph is not readable. I agree, it is pretty complex and pretty busy. It is complex and busy because it covers a number of services both for space and ground that leverage on the electromagnetic spectrum in radio frequency. As we take a closer look to this graph, we can appreciate that the complexity of it is because the radio spectrum is serving a whole amount of different services. Not only space services like, for example, telecommunication based on satellites, but also amateur radio, mobile phones, aeronautical services, maritime services, governance, security, and defence services. Each of the services are regulated and licensed from national and international bodies with all the due and needed security. The radio spectrum research for satellites, for telecommunications satellites, is represented in violet in this graph and starts at about 137 megahertz and ranges up to about 300 gigahertz. Why this whole range? The higher the frequency of operation in telecommunication, the higher the communication throughput, in other words, more bandwidth, more data.

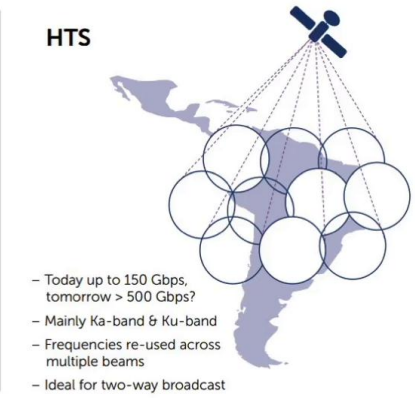
Notes

Summary

9m 07s

SatCom Performances and Constraints: Radio Spectrum Utilization





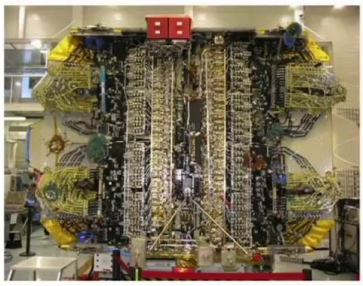
https://www.intelsat.com/wp-content/uploads/2020/08/Intelsat-Technologies-in-Space-Report.pdf

The management and the regulation of the radio spectrum, as we saw it, is extremely complex. The ability to deliver bandwidth through the radio spectrum is also reaching a plateau. The technologies, in fact, are starting to implement incremental improvements. One of the greatest advancement that we had in satellite telecommunication was to switch from a single wide beam broadcasting as delivered from fixed satellite services to multiple beams as delivered through high throughput satellites. In this way, we can leverage on the fact that we can deliver the same frequencies to multiple areas, and like that, we can replicate the throughput.

Notes

Summary

11m 10s



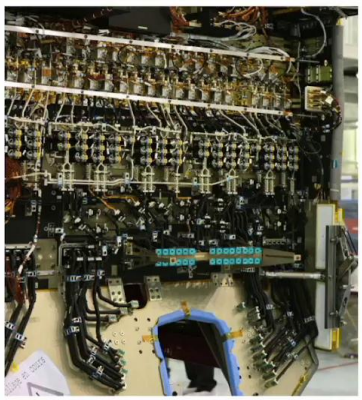


Image credits Airbus, ESA, NASA/JAXA

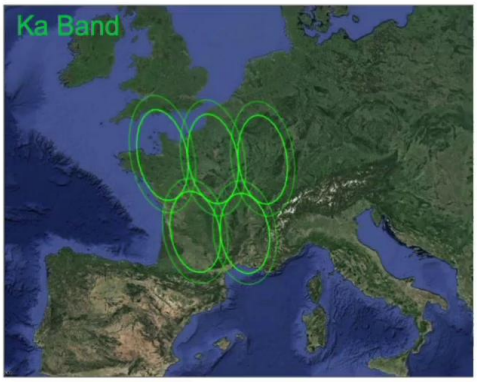
What does this mean? Each telecommunications satellite is equipped with multiple transponders. Each is able to manage a sub-portion of the spectrum, either in reception, either in transmission. From a technology standpoint, this means that to achieve high throughput satellites, we need two things. We need to multiplicate the amount of transponders able to communicate from ground to satellite and from satellite to ground. We need new innovative antenna technologies in order to manage multiple beams on multiple sub-portions of the Earth.

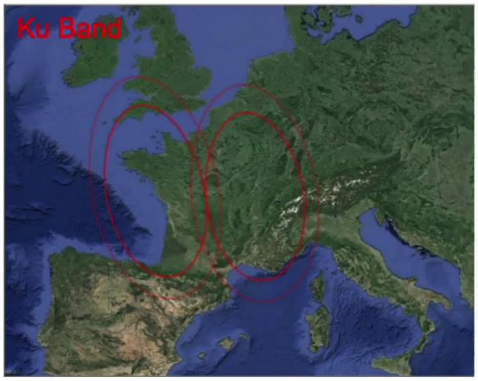
Notes

Summary

12m 05s

SatCom technology inherent performance drivers





Avanti Communications+Arthur D. Little “High Throughput Satellites”

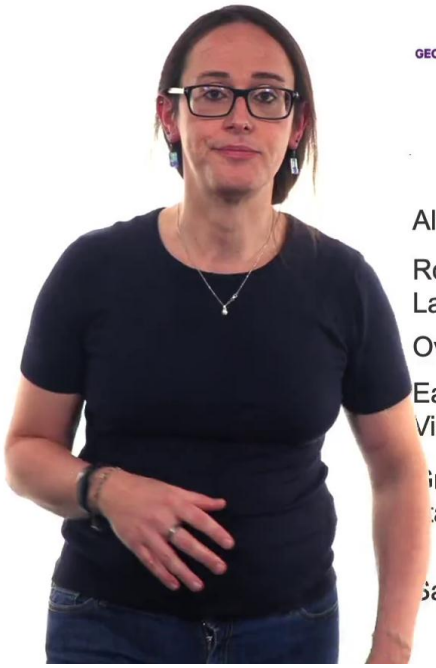
We mentioned before how, depending on the position of the satellite with respect to the Earth, we might have a smaller visibility or a larger visibility of the Earth's surface for optimal satellite-based telecommunication. In truth, not only the satellite position is affecting our ability to cover the Earth's surface, but also the technology that we are using in order to deliver the services. In this example, we are comparing the footprint of two high frequency radio bands: the Ku band in red and the Ka band. The Ka band is delivering a higher bandwidth because it's operating at higher frequency than the Ku. In turn, we can appreciate from this graph that the Ku band with two beams is able to cover the same area on the Earth than five beams in the Ka band. Therefore, in order to deliver broadcasting services, Internet services, TV services to ground, we have to ask ourselves, what is the ideal bandwidth that we require in order to deliver the service? What is the coverage that we might need in order to deliver it?

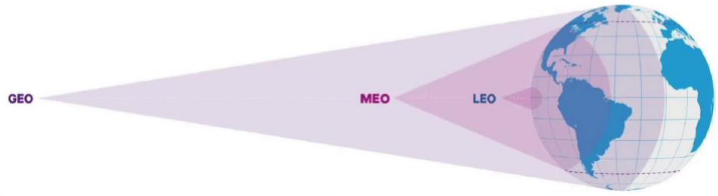
Notes

Summary

12m 56s

SatCom Performances and Constraints: Orbit





	GEO	MEO	LEO
Altitude	~36000 km	2000-20000 km	350-2000 km
Round trip Latency	250 ms	13 ms - 130 ms	3-13 ms
Overpass	24 h / 24 h	20-40 min / few h	2-10 min/ 90 min
Earth Visibility	large	mid	small
Ground stations	Few, stationary	mid	Several, fast and accurate tracking
Satellites	Fewer but costlier	mid	Constellation required

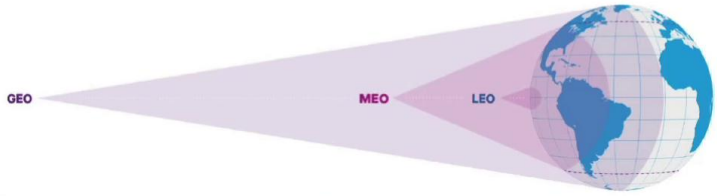
We mentioned in our time together that the orbit is a fundamental ingredient in the recipe to deliver satellite -based telecommunication services. Now, let me introduce to you some of the key aspects that each orbit delivers. We will look at it by analysing two extreme cases: the geostationary orbit and the low Earth orbit. The geostationary orbit is a very peculiar one because the satellites in this orbit will look as static from a ground observer. This means that we are able to establish a link 24 hours a day. The ground stations can be approximately fixed, and therefore, they can be rather large in order to upload more information and to deliver higher quality of service. In turn, a satellite in GEO, suffers a larger latency inherent to the fact that a radio beam must run for 36,000 kilometres from the ground to the satellite to the ground. This latency is typically about 250 millisecond. Now, let's look at the case of a low Earth orbit. The low Earth orbit comprehends an amount of orbits that can span from about 400 kilometres from ground level up to 2,000 kilometres from ground level. If we calculate the inherent latency, we span from about three millisecond to about 12 millisecond.

Notes

Summary

14m 32s

SatCom Performances and Constraints: Orbit



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Satellites	Fewer but costlier	mid	Constellation required

A satellite in low Earth orbit cannot be in a static position with respect to the Earth. This means that an observer from the ground will see the satellite raising and then lowering its attitude with respect to the ground. This translates in a link time that spends between two minutes and 10 minutes depending on the type of orbit. What this means for the ground applications? This means that the ground stations that need to communicate with the satellite must be dynamic or need to deploy technologies that are able to shape the antenna like beam forming technologies as applied by Starlink in order to track a satellite during the period of coverage.

Notes

Summary

16m 37s

SatCom – Recap

- Concepts
  - Definition of Space Assets
  - Space Economy Enablers
  - Space Policy
  - Space Supply Chain
- Satcom business models
  - “Satellite TV” Business Model
  - “Satellite phone” Business Model
  - “Satellite Internet” Business Model(s)
- Satcom performance and constraints
  - Bandwidth and Latency
  - Radio Spectrum and Spectrum Utilization
  - Orbit

If we are trying to improve our business by leveraging on satellite-based telecommunications services, we might be teased by high performances, high bandwidth, low latency. But maybe we want to ask ourselves, what really our needs are most of the times, and what are the consequences, and what will happen in the remaining cases? In our next module together, we we will explore the impact and evolution of the satellite telecommunications market. I thank you and appreciate our time together. See you next time. Ciao.

Notes

Summary

17m 38s