Starlink Licensing for the Falkland Islands

A Security, Political and Technical Assessment

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Introduction

In general, satellite broadband services offer telecom operators a cost-effective alternative to extend network coverage into both underserved and un-served areas. This paper discusses the opportunities and challenges the community and Sure South Atlantic Limited ("Sure") are facing from a security, reliability, service delivery and strategic perspective focusing on the Falkland Islands as a service area.

The emergence of so-called mega constellations like Starlink, OneWeb and Kuiper, amongst others, has brought significant benefits to broadband consumers world-wide. Satellite broadband so far, was mainly limited to niche markets, given the technical complexity around terminal installation, distribution issues, support, and price. Starlink has provided a solution for end consumers which, so far, has not been offered by traditional GEO operators: easy self-installation, virtually plug and play with the equipment delivered to your doorstep.

There are some technical limitations around quality of service and security that exist and should be addressed.

About the Authors

TTP plc (ttp.com), a leading technology and product development services company based in the Cambridge (UK) technology cluster, has delivered cutting-edge innovations for over 35 years. Drawing on deep cross-sector expertise, including extensive work in aerospace, TTP partners with global industry leaders to accelerate science and technology-driven breakthroughs. In the space sector, the company specializes in 5G Non-Terrestrial Networks (NTNs), user terminals and antennas for satellite connectivity (including UAVs), satellite payload systems, aviation communications, and government and defence solutions. TTP's broad experience spans terrestrial and satellite communication technologies, ranging from system-level architecture to device design, across frequencies from VHF to V-band, and extending to land-based, aeronautical, and space-based platforms.

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Technical Limitations

This section examines the quality of service and committed bitrate which can be expected once Starlink take-up goes up and eventually is fully deployed.

Supply and Demand

According to FCC licenses Starlink and OneWeb operate the entire Ku band on the user and parts of the lower and upper Ka band on the feeder link.

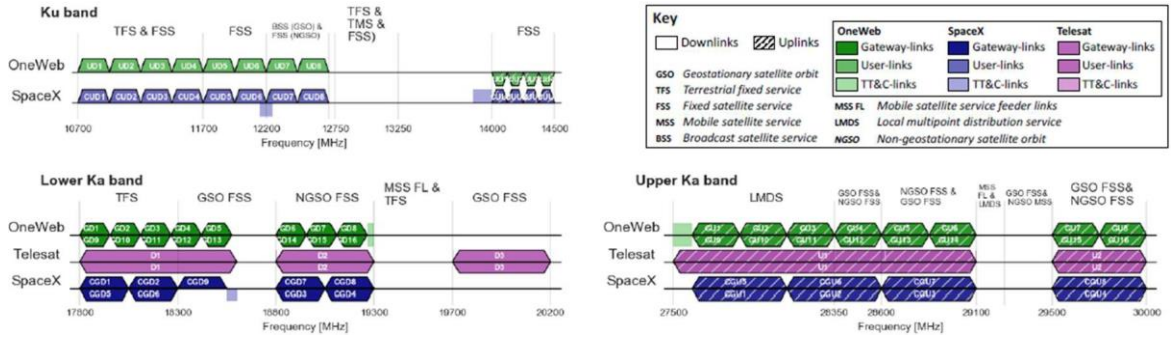
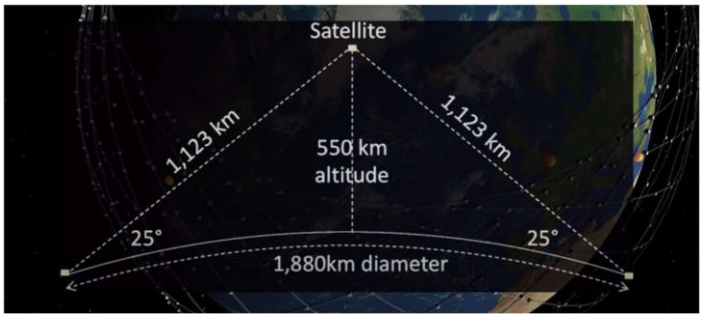


Table 1 Frequency band allocations of Starlink, OneWeb and Telesat (Original FCC licenses)

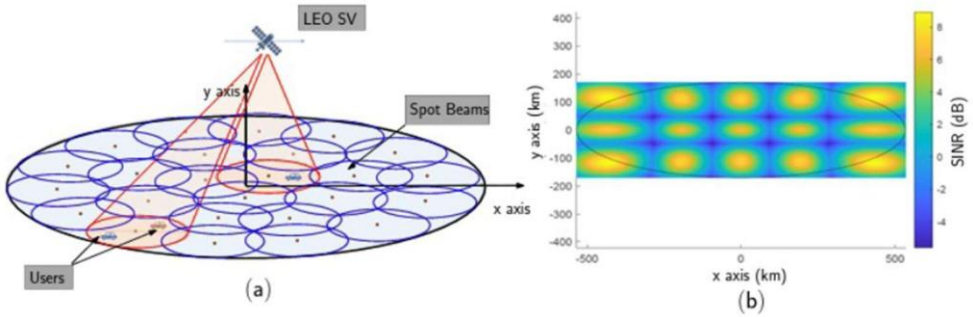
Based on a channelization of 250MHz of specified bandwidth per beam and assuming an average spectral efficiency of 3.5 bit per second per hertz (16 and 32 APSK) a throughput of 800Mbps per beam is achievable. At present the SNR (Signal Noise Ratio) parameter on the UT-1 terminal is 11 to 12.5 dB, which corresponds to 16 to 32 APSK (Amplitude and Phase-Shift Keying) and a maximum of 3.5 bit/s/Hz.

From a coverage point of view, Starlink uses a 15mile/24km hexagons per cell which implies a coverage of 380km2 per cell.



Given the altitude of each Starlink satellite of up to 450 - 550kms and assuming 45-degree look-angle from satellite level, the total maximum surface area that can cover is about 2,500km^2.

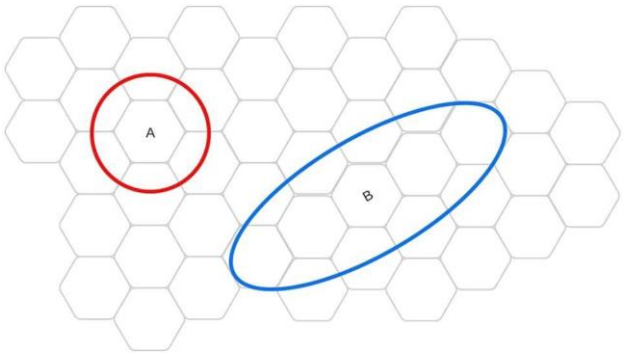
The illustration below shows a high-level visualization of how the beam configuration of Starlink satellites works.



Each spacecraft employes 2,000 MHz of spectrum for the user link split into eight channels of 250 MHz per beam as per frequency plan.

Each satellite has three downlink antennas and one uplink antenna, and each antenna can generate eight beams for each polarisation. The total number of beams is 24 for the downlink and 8 for the uplink (or 48 down and 16 up for both polarisations).

Currently Starlink satellites operate about 16 beams on the forward and 8 beams on the return, which yields a total throughput of about 24Gbps per satellite which has been widely communicated by SpaceX but must be seen as an upper boundary. While this may be available on a satellite level, current terminals can only operate in one polarisation which implies only 8 active user beams on board or half the announced capacity. However, assuming sufficient angular separation of the satellites several satellites can serve the same cell. In this case power needs to be reduced by 3dB (virtually half) to avoid adjacent spot beam interference. Additionally, there is a difference between cell size and operational beam. Whereas the throughput per beam may achieve some 800Mbps, this beam may be shared across 4 or 5 cells if the satellite is positioned at a low look angle.



Technically, all the user terminals inside the contour of the spot beam have enough link budget to communicate with the satellite, so the beam that has been "spread" over five cells to be able to service user terminals in any of them. The resource scheduler can, however, decide what cells inside the beam's field of regard (FOR) it will allow service to, and deny access to the rest, thus limiting the damage to CIR by over-spreading of the beam. In the example above our 800 Mbps beam would be shared between 5 cells and could only allocate 160 Mbps per cell on average.

In summary, the amount of capacity per cell is not unlimited given spectrum constraints. For this reason, Starlink had to introduce subscriber limitations per cell in order to maintain an acceptable degree of service like for instance around London and the Southeast of the UK.

More recently, Starlink also announced a new pricing model for its Starlink Global Mobile Priority. In addition to a monthly service access fee, it introduced a download volume-based data plan where customers are charged per GB consumed. Once the data plan is depleted, access speeds will be throttled down to 1Mbps or 512kbps.

Quality of Service Considerations

The Falkland Islands' population is about 3,500 with Stanley hosting about 3,000 inhabitants and the remaining 500 inhabitants are spread out over the rest of the country (Camp and MPC). Currently most households are being served by ADSL in Stanley and rural 4G both providing 15Mbps of access speed and prices range between 15GBP to 350GBP per month depending on data quota.

Stanley covers a surface area of about 2.5 km2 only, which means only one cell would cover all of Stanley and its surrounding area.

For consumer broadband quality of service provided to remotes is largely driven by three main aspects:

1. Average committed bitrate (CBR)
2. Contention ratio, an indicator for network sharing, and
3. Access speed for simultaneous users

For Starlink, assuming an overall bandwidth limitation of 800Mbps per beam, and a further reduction to 80% to allow network load balancing, the resulting service once fully deployed would have to be significantly contended. As per sensitivity analysis below, assuming an uptake of 1,200 households in Stanley, contention ratios would need to be as high as thirteen times to provide an average access speed of 8Mbps per household.

Achievable broadband speeds during peak times are significantly reduced. Assuming a contention ratio of 25 times implies that only 4% of users are online at the same time on average. During peak times, which typically occur between 8 to 10pm, 20 to 30% of households can be online simultaneously watching news or a video stream. Access speeds would be heavily reduced to single digit Mbps as demonstrated in the following table.

Criteria	Quantity	Unit
Total Supply Starlink	800	Mbps
Average traffic load (80%)	640	Mbps
Amount of Remotes Stanley	1,200	Units
Implied average QoS	666.7	kbps
Contention Ratio	3.3x	Shared
Implied Average Access Speeds (30% Online)	1.8	Mbps

More enterprise data services like corporate networks require contention ratios to be much lower in the range of 1 to 5 times. At this level achievable access speed would be as low as 2.7 to 4.0Mbps per remote site.[1]

At the telco level, uncontended service at high availability rates is standard practice, assuming some 1,000 sites across Stanley implies an access speed of less than 1 Mbps.

Sensitivity Analysis on Implied Access Speeds (Mbps)

Amount of Remotes vs Contention Ratio

		Remotes		
		800	**1,000**	**1,200**
Telco	**1.0x**	0.8	0.6	**0.5**
Corporate	**5.0x**	4.0	3.2	**2.7**
Consumer	**25.0x**	20.0	16.0	**13.3**

c

[1] A remote site is an office or building or household

Micro Outages

Another effect to consider is that LEO constellations still experience some micro-outages where data are actually lost and cannot be recovered as it is not a buffering problem. Whereas this issue is not a major problem for standard consumer broadband customers, it does not meet quality criteria of standard telecoms grade solutions or secure networks.

Several satellite operators, MNOs, cloud operators and telcos have tested Starlink and measured minor outages of a few seconds every 2-3 minutes. This can be acceptable for consumer broadband but does not meet telco-grade service offerings for mobile network operators, let alone secure, reliable networks.

It is our view that with a larger number of satellites, the increasing adoption of inter-satellite laser links (ISL) and as satellites themselves become more capable providing more power, larger aperture enabling smaller beams, these problems will be overcome within the next 5 years. The yet to be successfully tested Starship V3 launch vehicle could launch hundred next generation Starlink satellites capable of transmitting 1Tbps of capacity each. Assuming a constellation of 7,500 Starlink satellites it would take 75 successful Starship launches dedicated to Starlink only for the constellation which will take time, bearing in mind that other missions like going to Mars will need to be accommodated as well.

Conclusion on Technical Limitations

- There is a supply limitation of about 640Mbps for Stanley per satellite.
- Starlink service, once fully deployed, will experience significant QoS issues:
    - Access speeds for consumers may be less than 2Mbps during peak times.
    - Telecom grade professional data services are not shared at all, would be less than 1Mbps as they require high reliability.
- Micro-outages
    - They do exist, usually for a few seconds.
    - Also apply to other LEO constellations.
    - This problem may be overcome with the next generation of Starlink satellites.

Routing Security

Providing broadband services to a community is more than just about buying another subscription for a household. It has serious, short- and long-term implications for the well-being, economic prosperity, and the digital inclusion of the entire community. Therefore, telecommunication and satellite networks have always been considered as strategic assets which need to be protected and regulated for a good reason to ensure the safety, sovereignty, and wellbeing of nations.

This has been demonstrated by a series of secure communication initiatives like lawful intercept requirements. As a result, hostile nations are often excluded from the provision of broadband networks and critical network infrastructure. Examples include the exclusion of high-risk vendors (such as Huawei) from providing 5G network buildout in the UK.

More critical scenarios include the approach of the U.S. Department of Defense (DoD) to procurement of satellite capacity from commercial suppliers. Any satellite solutions must solely terminate on US soil to prevent any enemy interference. Only as a secondary solution, operations out of allied territories are deemed acceptable.

During several crisis in the Middle East, direct satellite links from US East coast to Afghanistan or Iraq were sold at a premium given the limited number of solutions available to the market.

Starlink Routing Configuration around Falkland Islands

Actual traffic measurements of Starlink satellites flying over the Falkland Islands conducted by an international satellite operator on a given day indicated that about 50% of traffic was routed via Chile, and 20% of traffic landed in Argentina.

Figure 1 Starlink Gateway locations in Chile and Argentina

Current official gateway locations include Falda del Carman (ARG) and Punta Arenas (Chile).

According to a map on "Unofficial Starlink Global Gateways & POPs", a Google maps platform where independent gateway operators can submit their gateways, additional gateways sites in Argentina include La Plata, Campana, Rio Negro, Salta, and Chivilcoy. Gateway locations like Rio Negro to be built out by Telespazio in collaboration with Altec, are close enough to serve the Falkland Islands.

Taking a close look at Argentinian gateway locations, it is most likely that some traffic is already being routed through Argentina directly.

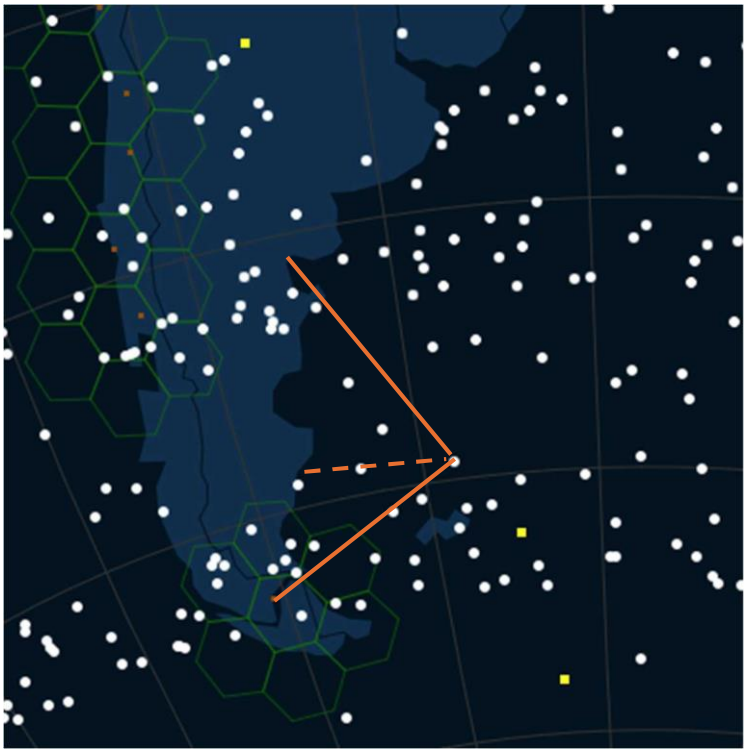


Figure 2 Current Starlink Configuration around Argentina and Falkland Islands

As an example, any satellite over the North of the Falklands could potentially terminate in Argentina rather than in Chile, Punta Arenas. The dotted line in Figure 2 indicates potential future gateway locations closer to the Falklands. It is reasonable to assume that a sizeable amount would be routed through Argentina.

Additionally, one of the five main Starlink POPs in South America is hosted in Argentina. Therefore, it can be assumed that most of the traffic generated in the Falkland Islands will be routed through Argentina irrespectively of whether it is landed in Argentina directly or routed via Chile.

Finally, it is important to note that lawful intercept of Starlink users in the Falkland Islands would not be possible if traffic was to terminate in Argentina. The Falkland Islands Government would never know what type of traffic or data is transmitted or received from Starlink terminals when traffic is being terminated outside its territory unless there are agreements on lawful intercept in place. However, this may be difficult to achieve with the current Argentinian government. In any case, lawful intercept should be an explicit licensing requirement in case the FIG would like to proceed with the licensing of Starlink.

Figure 3 The five main Starlink POPs across South America

Possible Argentinian Response

If a populist government under Milei or future administrations were to escalate the political situation it has three options:

1. Direct Technical intervention at gateway and POP level

   Based on the lawful intercept requirements an Argentinian government could easily identify and intercept gateway locations serving the Falkland Islands. It could either intervene at the physical level directly, or more likely simply instruct the gateway provider to stop the service. It is unclear to which extent Starlink could route the entire traffic via Chile, but this may not be possible due to gateway beams,

switching limitations and the altitude of used satellites at that time. The same is true for an intervention at POP level.

2. Launch Cyberattacks via Starlink terminals.

   The Falkland Islands have experienced several cyber-attacks from Argentina in the past. It is conceivable, that the established satellite infrastructure routed via Argentina would sustain similar attacks with security implications for the community. Whereas professional telecommunications companies are equipped to deal with this to a certain extent, this cannot be expected from a private household or small businesses. Most likely, a private household or small business would not even realise that they are being attacked until it is too late.

3. Political interference

   Another alternative would be for the Argentinian government to use its good relationship with Elon Musk and the White House to stop providing services for the Falkland Islands altogether. If political and economic capital can be gained, or in exchange for an Argentinian SpaceX procurement for ARSat to support for the Argentinian space programme for instance, this would be difficult to refuse.

Reliability and Politics

There is significant anecdotal evidence of how Starlink specifically has been used in the past to exert pressure on governments and for political gain. At the beginning of the Ukraine-Russian war during 2023, the Starlink service was put into question whether it should be provided and according to unconfirmed reports even US 4-star General had to intervene personally and urge Elon Musk not to switch off the Starlink service. Noticeably in recent, largely US-imposed peace negotiations, a Starlink switch-off is constantly being touted as a way to exert pressure onto the Ukrainian government to agree to a truce.

Some other, lesser-known examples include several developing countries across Africa. To continue receiving development aid from the US, they may need to license and allow operations of Starlink. Officially it can be communicated as a wonderful way to enable digital inclusion in developing countries, however, it prevents countries developing their own satellite and space ecosystem as existing markets for local service providers and telecoms operators are being undermined.

In summary, Starlink is being and will continue to be used to pressure governments to sign deals, allow licensing access of Starlink or both as it has been demonstrated in Ukraine.

Conclusion on Routing Security

- Starlink routes traffic through Argentina
- Technically, there is a significant risk that:
  - traffic could be intercepted, i.e. deliberate alteration, deletion or insertion of data, including PII data.
  - opens Falklands infrastructure to cyber-attacks, such as DDOS and malware attacks -including ransomware.
- No lawful intercept possible to monitor traffic.
- Political risk is high.
  - Musk-Milei relationship poses a risk to Falkland Islands
  - This would be amplified in case Argentina procures SpaceX products including launches or satellites for ARSat for instance.
  - Evidence suggests that Starlink has been and will continue to be used to exert political pressure.

OneWeb vs Starlink, and future lookout

While SpaceX (Starlink) continues to address the satellite internet market, it is important to

(a) consider the other players, in particular OneWeb and Amazon, and

(b) the future lookout of Starlink.

The table below compares key criteria of Starlink and OneWeb. Initially Starlink and Eutelsat OneWeb served different market segments. Whereas Starlink focuses on residential and small businesses in rural areas, offering a range of speed options and a DIY installation. Eutelsat OneWeb, on the other hand, targets businesses and specialized sectors with customized solutions and professional support.

Whereas OneWeb was originally designed around professional data solutions, Starlink initially targeted consumer broadband further opening up a market which was not well served by traditional satellite operators.

The table below compares key features.

Criteria	OneWeb	Starlink
Altitude	1,200kms	450 – 550kms
Type of orbits	Polar	Several, avoiding polar regions
Frequency band	Ku	Ku
Bandwith per beam	250MHz	250MHz
Route to Market	MNOs, telcos	Direct
Support for Open standards	Gen 1 is proprietary (LTE modified)	Proprietary

Finally, Starlink has emerged as an opportunistic model rather than a core priority or Space X. The main purpose remains to colonise Mars and to use any additional cash flow to finance this mission including Starlink:

- SpaceX is heavily subsidized by US taxpayers. It received $886M in FCC rural broadband subsidies.
- SpaceX benefits from NASA & DoD contracts that indirectly support Starlink's infrastructure.
- Starlink uses SpaceX launch cost advantages

Alternative Multi-orbit Options

In order to provide a reliable, secure network a multi-orbit approach including GEO and LEO is recommended.

A combination of classic GEO connectivity, amplified by alternative professional LEO constellations like OneWeb would provide the best of both worlds.

Viasat estimates that only 10% of global IP traffic is actually latency sensitive, as about 58% is accounted for by Video streaming. Therefore, using a classic GEO solution is still appropriate in most instances and if secure LEO solutions are available, they should be added.

Additionally, 5G backhaul solutions enabling shared access platforms feeding local towers could provide a seamless end user experience at superior quality of service whilst enabling lawful intercept.

Overall Conclusions and Recommendations

As Starlink routes traffic through Argentina there is a significant technical risk as traffic could be intercepted and it opens Falklands infrastructure to cyber-attacks including DDOS attacks.

Furthermore, unless there are agreements in place there is no lawful intercept possible to monitor traffic in particular in case the traffic lands in Argentina. Lawful intercept should be a licensing requirement for Starlink imposed by the FIG.

In general, political risk would be high as the Musk-Milei relationship poses a risk to Falkland Islands. This would be amplified in case Argentina procures SpaceX products including launches or satellites for ARSat for instance.

Anecdotal evidence suggests that Starlink has been and will continue to be used to exert political pressure.

From a purely technical standpoint there is a supply constraint of about 800Mbps per user beam per satellite which effectively will be reduced to 640Mbps to allow for traffic load. Once Starlink service is fully deployed, we will experience significant QoS issues:

- Access speeds for consumers may be as low as 1 to 5 Mbps during peak times.
- Telecom grade professional data services are not shared at all, would be less than 1Mbps as they require high reliability and lower network sharing.

Another problem is micro-outages which may be acceptable for consumer broadband but are not acceptable for professional services. This also applies to other LEO constellations, and we believe this problem may be overcome with the next generation of Starlink satellites with more extensive inter-satellite links and smaller beams per cell.

Sources and References

Live Starlink Satellite and Coverage Map at www.Satellitemap.space

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Sure Telecom

Viasat Starlink