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Liftoff: Unleashing Innovation in Satellite Communications Technologies

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Thank you, Chairwoman Rodgers, Ranking Member Pallone, Subcommittee Chairman Latta, Ranking Member Matsui, and Members of the Subcommittee. I am Whitney Q. Lohmeyer, and I am an engineering professor, technical and regulatory consultant, and strategic advisor in the satellite communications industry. I hope that sharing my experiences through the lens of these three roles will help the Committee ensure that U.S. spectrum licensing and management policies are clearly defined, provide regulatory certainty, promote innovation while protecting incumbent networks, encourage competition and investment, maintain American leadership in this sector, and safeguard the security of the American people.

I joined this industry in 2011, as a National Science Foundation (NSF) Graduate Research Fellow at the Massachusetts Institute of Technology (MIT) in the Department of Aeronautics and Astronautics under Prof. Kerri Cahoy. We partnered with multiple geostationary (GEO or GSO) satellite communications companies for my PhD research, and one day, the Chief Scientist of Inmarsat asked our team, "What would it take to transmit data from someone's cell phone to one of our GEO satellites?" Back then, a bulky power supply multiple times the size of a cell phone was required to ensure the signal could travel 35,678 km above the Earth. There also wasn't a way for cellular and satellite systems to communicate. With industry's recent focus on NGSO systems, which generally orbit at less than 2,000 km, and the Third Generation Partnership Project's (3GPP) inclusion of non-terrestrial networks into today's cellular standards, the technologies required to connect a cell phone to a satellite that in 2011 were only available in the future now exist.

Announcements of partnerships like Starlink and T-Mobile to expand coverage in rural areas, the birth of direct-to-device companies like Lynk and Skylo, and the launch of more than 4,300 Starlink and OneWeb NGSO satellites, make it is clear we are in a moment of unprecedented growth. It is encouraging to see the Committee's attention on our complicated and dynamic industry this early in the process, as the lives of Americans depend on satellite technology and services.

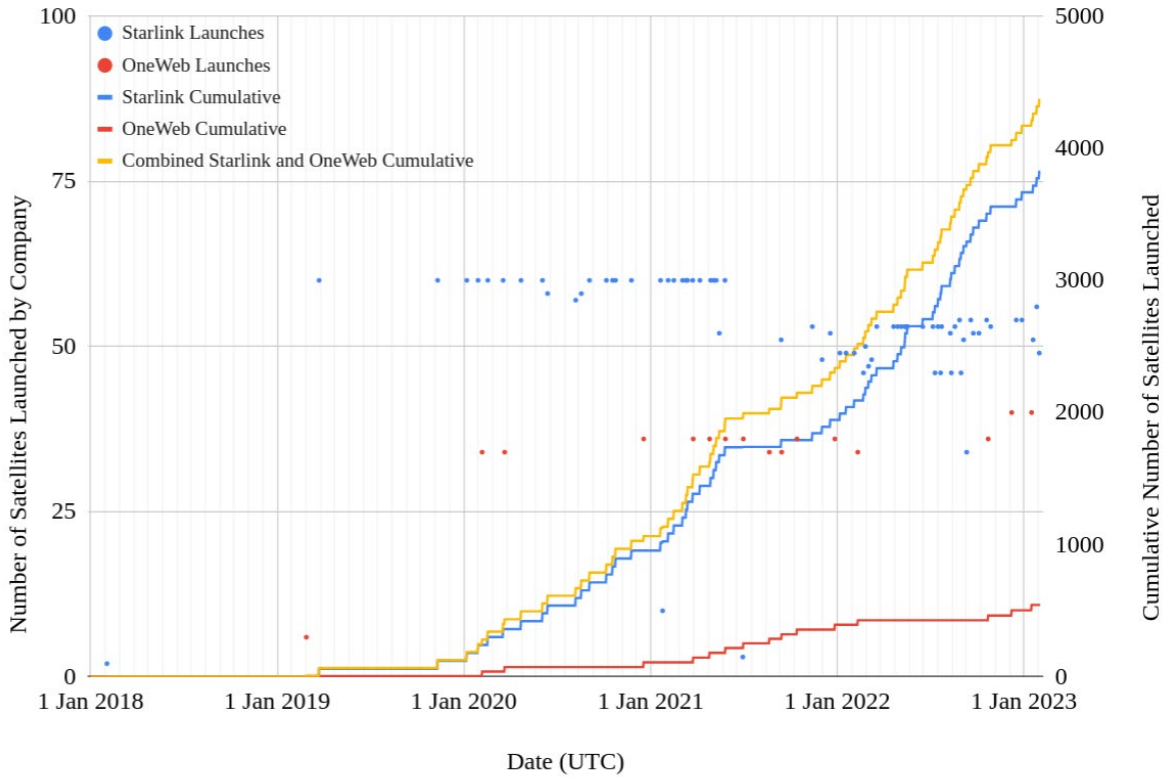

Figure 1. Number of OneWeb and Starlink Satellites Launched on a Per Company and Cumulative Basis

While at MIT, I met Greg Wyler, the founder of the O3b satellite communications network. His mission was to connect schools and healthcare centers in rural areas throughout the world with satellite broadband, and he hired me as one of the first employees on his latest project, which would become OneWeb. As a Satellite Communications and Regulatory Engineer, I worked closely with Qualcomm on the integration of their chipsets into the OneWeb user terminal, which is the hardware that is located on a customer's premise (e.g., the roof of a home or on a farm), and connects a user's device (e.g., cell phone or computer) to a satellite.

In 2015, I served on the U.S. Delegation to the International Telecommunication Union's (ITU) World Radio Conference (WRC-2015) and to Working Party 4A: Efficient Orbit/Spectrum Utilization. During the WRC-15 cycle, agenda items related to satellite broadband and rural connectivity were less of a focus for the United States. After the WRC, I traveled to Shanghai to coordinate our NGSO Fixed Satellite Service (FSS) network with Chinese operators. I represented OneWeb at the FCC on NGSO FSS

matters and I was a member of the team that drafted and submitted OneWeb's U.S. Market Access application to the FCC in 2016.

Two years later, I accepted an academic position as Engineering Faculty at Olin College,[1] an impact-driven undergraduate institution at which faculty and students work closely on today's most challenging technology and policy issues. There, I direct the Olin Satellite + Spectrum Technology & Policy (OSSTP) Research Group,[2] which consists of a diverse set of twenty-five researchers[3] – more than 50% of whom identify as female or under-represented minorities.

In addition to my role in academia, I have advised more than thirty entities (satellite companies, academic institutions, and investors) on technical and regulatory strategy, as well as the valuation of spectrum. I have drafted and shepherded, or am currently shepherding, the submission of eight full commercial Part 25 FCC applications to the International Bureau and more than ten Experimental License applications to the FCC's Office of Engineering & Technology.

FCC NGSO Processing Round Approach

The submission of OneWeb's 2016 U.S. Market Access application initiated the first of four NGSO FSS Processing Rounds to date. When the FCC adopted its Processing Round regime in 2003, it did so with the aim of authorizing systems efficiently. It was unlikely that the Commission anticipated the launch and operation of more than one constellation, yet now the Commission has received submissions from more than twenty distinct applicants for a total of more than 70,000 satellites.[4] While this is a clear indication that the U.S. market is one that many want to serve, issues of the Processing Round frameworks incentivize systems to file prematurely and over file due to the nature of modifications.

[1] *See* Olin College of Engineering, https://www.olin.edu/
[2] *See* Olin Satellite + Spectrum Technology & Policy (OSSTP) Group, https://www.osstp.org/
[3] *See* OSSTP Team, https://www.osstp.org/our-team
[4] *See* A. Kriezis and W. Q. Lohmeyer, U.S. Market Access Authorization Timeline Analysis for Megaconstellation Networks, OSSTP (Apr, 2022), https://www.osstp.org/fcc-analysis

The ITU accepts modifications to existing filings as long as the proposed changes do not increase the interference environment of the system. To ensure flexibility and a decrease in the interference environment, operators include all potential combinations of orbits they might deploy in their applications. This has resulted in applications of tens of thousands of satellites per network, making it challenging to assess the actual likelihood for interference between NGSOs and into other systems.

In April of 2022, Argyris Kriezis -- then an Olin College senior and Olin Satellite + Spectrum Technology & Policy (OSSTP) Researcher, now AeroAstro PhD Candidate at Stanford and NSF SpectrumX Research Fellow – and I published an analysis of the NGSO FSS Processing Rounds applications, summarizing their system parameters and the time it took to receive an FCC authorization. On average, it took the Commission 2.0 years (ranging from 1.0 - 3.8 years) in the first Round and 2.9 years (ranging from 1.3 - 4.1 years) in the second Round.[5] Of the applicants in these two Rounds, OneWeb, Starlink, and Kepler have started launching their systems.

Less than one-third of applications in the third Round (May 2020: Ku-/Ka-band) have received a First Action, and all of the fourth Round (November 2021: V-band) applicants are still under review. Part of this delay could stem from applicants filing prematurely. When Processing Rounds are initiated, applicants have a brief window to file. If this period occurs before an applicant has secured a satellite manufacturer or reached Critical Design Review (CDR), then they will likely not be able to submit full orbital debris and interference showings, causing additional delays in the licensing process.

Furthermore, half of these Processing Rounds took place during the COVID-19 pandemic when the FCC was significantly understaffed. Despite working with limited engineering and legal resources, members of the International Bureau had the herculean task of authorizing the most dynamic and complex satellite systems in history, handling contentious modification requests while simultaneously issuing

[5] *See id.*

Proposed Rulemakings on Orbital Debris Mitigation[6] and NGSO Sharing and Licensing policies[7]. They were understandably overloaded; however, delays are compounding.

The Role of OSSTP and SpectrumX in the Advancement of Satellite Spectrum Policy

Since its founding in 2019, OSSTP researchers have worked with satellite industry mentors to apply data analytics and modeling tools to develop technology and influence policy. The ultimate goal of our Group is to aid in the creation of a safe and sustainable space environment in which many spectrum-users coexist for years to come, all while educating the next generation of policy makers and technologists through apprenticeship-styled learning experiences. OSSTP has written software to analyze aspects of every satellite application, NGSO or GSO, available in the FCC's filing database, and has validated the interference compliance and orbital debris mitigation strategies of a subset of these networks. We have also dedicated ourselves to building accessible educational materials for K-12 and undergraduate students with the aim of igniting their curiosity in space and satellite communications.

OSSTP is funded by the National Science Foundation[8] and the Amateur Radio Digital Communications (ARDC)[9]. SpectrumX, initiated by a five-year $25M NSF Center Grant, brings together radio spectrum stakeholders from twenty-seven universities, a federal research facility, and corporate partners to conduct strategic spectrum research and workforce development projects.[10] The SpectrumX

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[6] *See Mitigation of Orbital Debris in the New Space Age*, IB Docket Nos. 18-313, 02-54, Notice of Proposed Rulemaking, 33 FCC Rcd 11352 (2018). *See also Orbital Debris in the New Space Age*, IB Docket No. 18-313, Report and Order and Further Notice of Proposed Rulemaking.

[7] *See Revising Spectrum Sharing Rules for Non-Geostationary Orbit, Fixed-Satellite Service Systems, Systems; Revision of Section 25.261 of the Commission's Rules to Increase Certainty in Spectrum Sharing Obligations Among Non-Geostationary Orbit Fixed-Satellite Service Systems,* Order and Notice of Proposed Rulemaking, FCC 21-123 (2021)

[8] *See* National Science Foundation (NSF) Award Number 2132700 - Spectrum Innovation Initiative Center: SpectrumX - An NSF Spectrum Innovation Center; *See* NSF Award 2037732 - Spectrum Innovation Initiative Planning: Olin Satellite Innovation Initiative Center (OSIIC); *see also* NSF Award 1936665 - Collaborative Research: Cubesat Ideas Lab: Space Weather Atmospheric Reconfigurable Multiscale Experiment (SWARM-Ex)

[9] *See* Amateur Radio Digital Communications (ARDC), https://www.ardc.net/

[10] *See* SpectrumX, https://www.spectrumx.org/

vision is to become a trusted resource within the spectrum ecosystem, offering innovative policy and technical contributions through inclusive education and research activities.

Congressional engagement with SpectrumX members on pressing policy decisions and support of undergraduate STEM research programs like OSSTP is imperative for maintaining and improving U.S leadership in technology and public policy.

Mandatory Shotclocks on FCC Satellite Applications

In November 2022, Argyris Kriezis and I, along with Olin College junior and OSSTP Researcher Kaitlyn Fleming, submitted a Petition for Rulemaking to the FCC requesting the consideration of a one-year shotclock on NGSO applications.[11] Clearly defined, mandatory shotclocks would offer regulatory certainty and technical and financial clarity, given the milestone and surety bond requirements codified in 25.164[12] and 25.165[13] of the Commission's Rules, respectively.

The FCC's milestones require the launch and operation of half of an applicants authorized network within six years of a license grant and their full network within nine years. These requirements importantly promote the buildout of systems while aim to prevent spectrum warehousing. The Commission's bond regulations require NGSO applicants post a $5M escalating surety bond thirty days after grant. As noted in our Petition, the size of this $5M bond may seem minimal compared to the billions of dollars of investments some broadband networks require. However, securing the funds, scheduling the payment, and potentially having the bond linger for up to five years can be taxing for NGSO startups. Having a mandated shotclock would provide a clear projection of surety bond payments.

In addition to the bond requirements, there are also application and operating fees. Under Chairwoman Rosenworcel, the Commission has considered the affordability of the licensing process and

[11] *See* Whitney Q. Lohmeyer et al., Petition for Rulemaking, Revising License Determination Rules for NGSO License Applications (filed Nov. 10, 2022), available at https://www.fcc.gov/ecfs/document/1110237682587/1.
[12] *See* 47 C.F.R. § 25.164 (2021)
[13] *See* 47 C.F.R. § 25.165 (2021)

deserves credit for decreasing NGSO FSS application fees from nearly half a million dollars ($471,575) to $15,050. Unfortunately, this decrease took place after the last processing round, and some participants haven't received reimbursements for the ~$450,000 required at filing over a year later.

With increasingly long authorization processing time, applicants, particularly startups, are struggling with the resulting regulatory uncertainty that impacts their financial and technical system buildout. A mandatory shotclock would give certainty to the schedule of fees and project timeline to meet bond and milestone requirements. Additionally, applicants could seek waivers for circumstances when a one-year shotclock is not appropriate for their system, as efficiency in processing must give way to the need to ensure interference-free communications services. Lastly, if Congress mandates shotclocks, it is imperative that it equips the Commission with the necessary technical and legal expertise and resources to avoid the risk of an unfunded mandate.

Redefining Satellite Communications to Include Services Beyond FSS and MSS

It is also important for Congress to understand that commercial NGSO applicants include services beyond the FSS and Mobile Satellite Service (MSS). The Earth Exploration Satellite Service (EESS) is critical for emergency response during natural disasters like wildfires and hurricanes and could be deployed for precision agriculture. The EESS consists of companies like Planet,[14] which provides daily satellite data to help us understand the physical world and take action, as well as Tomorrow.io,[15] which plans to expand its weather forecasting platform via its Weather Monitoring Constellation to reach customers beyond the U.S. Air Force, JetBlue, Ford, Uber and National Grid.

More recently, our industry has grown to include the rise of companies like Xona Space Systems,[16] a talented group of entrepreneurs and engineers out of Stanford University, answering the call of the White House in addressing our nation's need for the next generation of precise and protected

[14] *See* Planet, https://www.planet.com/
[15] *See* Tomorrow.io, https://www.tomorrow.io/
[16] *See* Xona Space Systems, https://www.xonaspace.com/

Global Navigation Satellite Services (GNSS). Noting that these GNSS services could be used to further the development of autonomous vehicles and farming equipment.[17] In keeping with the whole of the government emphasis on space situational awareness,[18] startup True Anomaly[19] exemplifies how the In-space Servicing, Assembly, and Manufacturing (ISAM) market is designing systems to perform rendezvous proximity operations (RPO).

These talented teams of entrepreneurs and veterans are just a few of the players that rely on satellite communications spectrum in orbit to provide crucial services that contribute to the leadership and security of our nation, and they therefore must have a seat at the table when we consider the regulations that govern satellite communications systems.

The Allocation of Spectrum to Support Satellite Communications: Launch and Telemetry

As we buildout constellations of thousands of satellites to provide affordable broadband to our rural populations, and as we offer other services like EESS, GNSS and ISAM, demand for launch has

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[17] *See* U.S. Department of Homeland Security in partnership with the National Coordination Office for Space-Based Positioning, Navigation and Timing, *Homeland Security Infrastructure Protection Plan: Critical Infrastructure Security and Resilience*, Washington, DC: Department of Homeland Security, 2014 *available at* https://www.gps.gov/multimedia/presentations/2014/11/ICG/dhs.pdf; *See* The White House, *National Space Policy of the United States Of America*, Washington, DC, 2020, *available at* https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf; *See* the Department of Transportation, *Complementary PNT and GPS Backup Technologies Demonstration Report*, Cambridge, MA: U.S. Department of Transportation, 2021, *available at* https://www.transportation.gov/administrations/assistant-secretary-research-and-technology/complementary-pnt-and-gps-backup; *see also* Cybersecurity and Infrastructure Security Agency, *Report on Positioning, Navigation, and Timing (PNT) Backup and Complementary Capabilities to Global Positioning System (GPS)*, Washington, DC: U.S. Department of Homeland Security, 2020, *available at* https://www.cisa.gov/publication/pnt-backup-report

[18] *See* Notice, FCC, FCC Opens Proceeding On Servicing, Assembly and Manufacturing In Space (Aug 8, 2022), https://www.fcc.gov/document/fcc-opens-proceeding-servicing-assembly-manufacturing-space-0; *See In-space Servicing Assembly and Manufacturing and National Strategy,* Office of the President of the United State (April 2022), https://www.whitehouse.gov/wp-content/uploads/2022/04/04-2022-ISAM-National-Strategy-Final.pdf; *see also Notice of In-space Authorization and Supervision Policy Listening Sessions; Request for Comments,* National Space Council, Executive Office of the President (EOP), (Pub. Oct. 17, 2022), https://www.federalregister.gov/documents/2022/10/17/2022-22413/notice-of-in-space-authorization-and-supervision-policy-listening-sessions-request-for-comments ("National Space Council Listening Session").

[19] *See* True Anomaly, https://www.trueanomaly.space/

soared to an all-time high. Our launch industry has answered the call of this market dynamic by strengthening the reusability of their vehicles and establishing an impressive launch cadence. Now, it is critical that these vehicles are able to obtain FCC authorization and coordinate the use of shared frequencies near-automatically. A secondary allocation for commercial space launches and commercial reentries could offer more regulatory certainty, promote innovation and competition, and aid in streamlining the authorization process for launch vehicle suppliers.

The satellite industry is experiencing a similar, and concerning, lack of allocation for satellite telemetry (space-to-Earth) particularly in the S-band that is forcing filers to potentially operate and deploy aspects of their network outside of the United States. Considering 2200 - 2290 MHz, which is utilized internationally for telemetry, and is one of the three bands targeted for commercial launch and commercial reentry, would proactively address our nation's urgent lack of S-band spectrum for telemetry.

Conclusion

In closing, I applaud the bipartisan FCC, under Chairwoman Rosenworcel, for proposing to create the Space Bureau and for hiring more personnel to focus efforts on rapidly addressing licensing applications and issues facing the satellite industry.[20] The submission and grant of an FCC license application is a significant and meaningful milestone for companies that potential investors value. The increasingly long wait-times for NGSO FSS authorizations and the lack of clarity in the licensing process is concerning to our vibrant investor community and is causing the talented ecosystem of entrepreneurs that our nation has intentionally grown and attracted to consider filing off-shores through overseas administrations. The Committee's and Commission's continued focus on the satellite communications industry can counter this risk and maintain U.S. leadership in this sector.

I hope Congress will ensure the FCC has adequate resources including funding to expeditiously establish and support this new Bureau. The wave of investment and energy in these satellite constellations

[20] *See* Press Release, FCC, Chairwoman Rosenworcel Proposes Space Bureau (Nov 3, 2022), https://www.fcc.gov/document/chairwoman-rosenworcel-proposes-space-bureau

is awe-inspiring, and we must ensure the FCC is not a bottleneck for U.S. approval in this historic period. Thank you again to the committee for focusing on satellite policy – I look forward to your questions and appreciate the opportunity to share my experience.