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From "Open Skies" to Traffic Jams in 12 GHz: A Short History of Satellite Radio Spectrum

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As an industry, communications satellites have traced a wobbly trajectory. Envisioned to bring revolutionary advances to telecommunications services in the U.S. Communications Satellite Act of 1962, the marketplace did open via Comsat, a public-private partnership. But the sluggish pace was revealed a decade later when progress increased substantially with the Open Skies policy. Free entry collapsed costs for wide area distribution of broadcasting services, launching the U.S. cable television industry (disrupting the TV broadcasting triopoly) in the 1980s and then direct-to-subscriber satellite TV (challenging the new incumbent cable operators) in the 1990s. In ensuing decades, however, fortunes reversed. Satellite phone and broadband service providers—Iridium, Teledesic, Motient, Intelsat and many others—financially crashed and burned. Yet another reversal may now be in evidence, however: satellites in service have increased more than three-fold in the past decade. Spasms of technological progress, including gains in small device electronics, are driving market change: "While some [satellites] are the size of a

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bus and weighing over 6,000 pounds, they can also be as small as a lunchbox," noted a 2018 Aspen Institute report. "Constellations can now be composed of hundreds or even thousands of satellites." The new mega-constellations are creating a crowded sky. With demand for orbital slots and complementary radio bands dramatically intensifying, new policy formulations are being floated. We outline possible innovations in spectrum property rights.

I. LAUNCHING SATELLITES

> "[S]atellites will enable one to call anywhere in the world for 10 cents . . . ."
> -- William H. Meckling[1]

> "Satellite technology was the ideal disruptive technology for its time. It solved most of the problems that tied us to the constricted telecom world of 1968. It is like a tall radio tower." -- Henry Goldberg[2]

Panic gripped the Western world following the 1957 Soviet Sputnik satellite launch, which allowed the space vehicle to orbit the earth, and was ominously visible in the night sky to astonished North Americans. As a modern marvel, the orb was not impressive: "pretty much the lamest excuse for a satellite ever launched—an aluminum-alloy sphere, twenty-three inches in diameter, weighing 184 pounds."[3] And, alas, "after that first victory, the Russians would never again lead in satellite technology."[4] But the technological breakthrough was proof of concept, the Cold War reigned, and the "space race" was a boon to modern commercial

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[1] William H. Meckling, *The Economic Importance of Space Technology,* RAND CORP., June 1962, at 2.

[2] Henry Goldberg, Communications Attorney, Panel Discussion at the Library of Congress: Papers of Clay T. (Tom) Whitehead (Jan. 11, 2013).

[3] JOHN BLOOM, ECCENTRIC ORBITS: THE IRIDIUM STORY 32 (2016).

[4] *Id.* at 39.

communications. U.S. policymakers reacted with measures designed to encourage promising civilian applications.

At Bell Labs, the possibilities were already being pondered. John Pierce sought to develop an idea for a "communications mirror in space."[5] Bouncing radio transmissions from earth to space, reflecting them back to an earth receiver, seemed ambitious but conceptually straightforward. This was initially not thought to replace existing terrestrial networks, but to extend signals to where there were none: "While orbital radio relays probably could not compete with microwave radio relay for communication over land, they might be useful in transoceanic communication."[6]

But how to organize the market? Should it be organized like the military branches' satellite programs? Or, should it be organized like the National Aeronautical and Space Administration's (NASA) commercial and civilian approaches? NASA, founded in 1958 to promote civilian satellite applications, was focused on scientific missions and space flight, including a manned mission to the moon. These activities were undertaken to, among other objectives, forge new science to support potential use in commercial networks. Perhaps unsurprisingly, however, "AT&T did much of the initial development work on communications satellites, and one early issue was whether to permit AT&T to obtain or retain a monopoly in this area."[7]

That policy adopted in the U.S. Communications Satellite Act of 1962 seemed to answer that question in Ma Bell's favor ("Ma Bell" being the popular nickname for American Telephone & Telegraph). The legislation announced a hybrid policy to enlist private investment guided by government control. While designed as "a set of special techniques intended to produce the results that a competitive market structure would have provided,"[8] it created an advantaged (and thus monopolistic) ownership structure for Comsat, a new private corporation—with heavy government oversight, including the appointment of three of its fifteen Directors—that was awarded the exclusive right to deliver international telephone traffic to and from the U.S. One half of its equity was apportioned to U.S. telecommunications carriers on pro rata shares of their domestic revenues, and the other half to stockholders buying shares. Effective corporate control was exercised by AT&T, given its 85% share of domestic phone industry revenues.[9] The company would operate as a common

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[5] COMSAT: United States, BUILDING THE WORLD (June 19, 2012), https://blogs.umb.edu/buildingtheworld/space/comsat-united-states/#page [https://perma.cc/B5GW-KW34].

[6] *Id.* at 44.

[7] BRUCE M. OWEN, THE INTERNET CHALLENGE TO TELEVISION 145 (1999).

[8] Robert S. Magnant, *Satellite Communications: U.S. Policy Considerations,* 3 TELECOMM. POL'Y 297, 297 (1979).

[9] AT&T divested its nearly 3 million shares in Comsat in a 1973 public offering. *See Communications Satellite Corporation*, SEC News Digest 2 (June 18, 1973) (describing the sale of all COMSAT shares owned by American Telephone & Telegraph Co.); *see also AT&T Makes $71 Million*

carrier, with rates regulated by the Federal Communications Commission.[10] Indeed, the Act clarified that the FCC would exercise "a statutory role in the implementation of the national policy for satellite communications services."[11] It was seen as a "carrier's carrier," providing wholesale services—such as long distance calls, or transporting television and radio programming—for other providers, including terrestrial broadcasters and phone networks.

This seemed to combine modern regulation with modern technology, constituting a fitting example of the Kennedy Administration's "New Frontier." In signing the legislation on August 31, 1962, President John F. Kennedy said "[t]he ultimate result will be to encourage and facilitate world trade, education, entertainment and many kinds of professional, political and personal discourses which are essential to healthy human relationships and international understanding."[12]

Nonetheless, RAND Corporation economist Leland Johnson would write: "Comsat's status has long been a source of controversy."[13] It's mix of private ownership and public authority seemed to strain the monopoly rights it had been awarded, and the experiment in deviating from pure state ownership (as exercised in military ventures as well as in NASA's space exploration, not to mention in the nearly ubiquitous structures of non-U.S. terrestrial communications markets), prompted a range of opinion.

It was an interesting policy moment. The monopoly model was still in vogue. Both in the 1934 Communications Act approach to telecommunications as a regulated common carrier service, and in the Comsat exclusion, open competition was excluded by U.S. law.[14] But the very idea that a private carrier could provide the leadership in the technologically demanding space of Outer Space seemed to split the established policy perspective into warring halves. The 1968 Rostow

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on Sale of Comsat Stock, BROADCASTING 81 (June 18, 1973) (recounting how all of AT&T's holdings in Comsat was "virtually sold out"); *AT&T to Get Out of Comsat*, BROADCASTING 108 (Mar. 26, 1973) (announcing the sale). By 1977, less than one percent of the equity in Comsat was owned by telecommunications carriers. COMMUNICATIONS SATELLITE CORPORATION, COMSAT AT 15: ANSWERING THE NEED FOR BETTER COMMUNICATIONS 8 (1978) [hereinafter COMSAT REPORT] (reporting COMSAT's stock history).

[10] Federal law says that "all authorized users shall have nondiscriminatory access to the system," 57 Stat. 12, Section 102(c), with rates established by the FCC, 57 Stat. 12, Section 102(c).

[11] COMSAT REPORT, *supra* note 10, at 4.

[12] *Id.*

[13] LELAND L. JOHNSON, RAND CORP., ISSUES IN INTERNATIONAL COMMUNICATIONS: GOVERNMENT REGULATION OF COMSAT at iii (1987) [hereinafter Johnson Report]. This followed a much earlier observation in the Rostow Report: "Controversy over the role and future of Comsat has not abated since its creation in 1962." EUGENE V. ROSTOW, PRESIDENT'S TASK FORCE ON COMMUNICATIONS POLICY: FINAL REPORT 14 (1967) [hereinafter Rostow Report].

[14] Rostow Report, *supra* note 14, at 12 ("Comsat was given a monopoly position in the global system, the carriers were thereby precluded from direct participation in satellite ownership for international communications.").

Report, commissioned by Lyndon Johnson's Administration to provide expert advice on communications regulation, advanced conflicting views of competitive rivalry.

First, it seemed to welcome such: "[t]he main concern of policy in this field should be to improve the effectiveness of regulation where regulation is necessary, to remove unnecessary restraints on private initiative, and to provide as free a field as possible for the imagination and enterprise of innovators."[15] On the other hand, in specific situations, not so much: "[d]irect and open competition between cable and satellite entities might theoretically produce optimal development of rival technologies, but establishing such an environment in practice in a regulated industry of so few firms would be very difficult . . . ."[16] But, on the third hand: "[i]n the view of some observers, the rivalry of the cable companies and Comsat has produced more rapid innovation and rate reduction than might otherwise have obtained."[17] Leaving the authors of the report to ask: "[o]n what ground should public policy continue to prevent the carriers from using satellite technology to compete with Comsat?"[18]

That question was about to be answered in a decidedly competitive way.

II. OPEN SKIES

> We looked at the feasibility of creating a competitive COMSAT business, and we concluded it was feasible. And from that came the Open Skies policy… It meant how in the "F" were we going to get competition in the telecommunications business? -- Tom Whitehead[19]

The monopoly era in satellite communications veered into a perfect storm. The "natural monopoly" argument for only one efficient provider was challenged by the changing economics of communications networks. The AT&T system, while innovative compared to the state PTTs (state-owned Post, Telephone and Telegraph monopolies) around the rest of the world, was increasingly in conflict with competitive forces. Rival suppliers, in wired and wireless modes, sought to enter various service markets. Repeatedly, AT&T sought and gained regulatory support to resist such forays.

If AT&T were advantaged by economies of scale, indeed were it a natural monopoly, why were such barriers required? The immediate answer, that particular markets might be relatively profitable and hence ripe for "cherry picking" (or "cream

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[15] *Id.* at 14.
[16] *Id.* at 21.
[17] *Id.* at 22.
[18] *Id.* at 23.
[19] Interview by John Eger with Tom Whitehead, Former Dir., Off. of Telecomm. Pol'y, 3-4 (July 14-16, 2008) [hereinafter Whitehead Interview].

skimming"), was compelling to AT&T executives and, too often, regulators.[20] But it failed to acknowledge that the existing regulatory regime already employed various pricing schemes to avert such entry, and sponsored widespread cross-subsidy schemes to support "one system." Innovative rivalry was still seen to outperform the incumbent monopolists. Why not unleash such forces to see how far they might disrupt the "natural monopoly" assumption—rarely tested on existing data, and unable to be gauged on emerging markets not yet observed. In any event, the contours of the monopoly were ill-defined, at best, opportunistically defined by captured regulators, at worst. Better approaches were sought.

The question of monopoly was coming to be treated as a variable, not a constant. Before the massive antitrust suit against AT&T was filed in 1974, Tom Whitehead, telecommunications policy advisor in the Nixon White House, became the first public official to endorse the idea.[21] Whitehead struck out to first liberalize space, in a policy adopted by the FCC in January 1972: Open Skies. Open Skies was undertaken with an eye not just on satellites, but on Ma Bell:

> Question: At this point when you were preparing the Open Skies Policy, were you already thinking about the AT&T monopoly?
> Tom Whitehead: Oh, yeah… That was the primary focus, absolutely.[22]

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[20] AT&T had advanced this argument early on, moving toward its famous policy campaign to establish U.S. communications via "one policy, one system, [and] universal service." MILTON L. MUELLER, JR., UNIVERSAL SERVICE: COMPETITION, INTERCONNECTION, AND MONOPOLY IN THE MAKING OF THE AMERICAN TELEPHONE SYSTEM 4 (1997). The brainchild of AT&T's acclaimed president, Theodore Vail, the policy dates back over a century. RICHARD G. TOMLINSON, TELE-REVOLUTION: TELEPHONE COMPETITION AT THE SPEED OF LIGHT 5 n.2 (2000):

> In the 1910 AT&T Annual Report Vail both discussed the benefits of regulation and wrote of the necessity for being protected from competition. "If there is to be state control and regulation, there should also be state protection—protection to a corporation striving to serve the whole community… from aggressive competition which covers only that part which is profitable." This argument against 'cream-skimming' would later be routinely raised by telephone companies facing potential competition.

The protectionist gambit succeeded first with state franchise monopolies for telephone service, then in the structure of the 1934 Communications Act, which established new parameters for federal regulation under the Federal Communications Commission. While promoting "common carrier" rules to enforce non-discriminatory pricing that would ostensibly promote efficiency, the crafting and enforcement of the rules generally had the reverse effect, employing AT&T's proffered subterfuges to escape competition. Even when regulators began to split ways with AT&T philosophically, decades later, the system retained a protectionist tilt. "Through the 1970s, AT&T came up with one scheme after another to nullify the effect of the FCC's orders and destroy the companies battening on them." TIM WU, THE MASTER SWITCH: THE RISE AND FALL OF INFORMATION EMPIRES 192 (2010).

[21] *Id.* at 187.

[22] Whitehead Interview, *supra* note 20, at 5.

New thinking was prompting regulatory change. "Whitehead and others believed that the telephone system no longer needed to be a monopoly . . . ."[23] In point of fact, the Comsat-AT&T alliance had been subject to FCC common carrier mandates and was yet pointedly not achieving the textbook outcomes envisioned. RAND economist Leland Johnson's study of the situation found that while regulators responded to "Comsat's market power" by granting the FCC power to impose "rate-of-return regulation," covering capital costs, operating costs and a fair rate of profit, the system had "not led to satisfactory results."[24] Comsat was earning far above the risk-adjusted rate-of-return, as the Commission was virtually powerless to police such a complicated structure. The initial rate proceeding, commencing in 1965, was "appallingly long and complex"—a decision was not reached until 11 years had passed. But that was too hasty; an appeal to a federal court froze the matter still longer. Actual regulations were decided *in 1978*.

These rules were yet ineffective in constraining profits to competitive levels, as Comsat's returns were far above the 12.48% per annum formally allowed. In addition, "perverse incentives" pervaded Comsat's operations. The system was too dependent on high-cost technologies, because they were easily billed to customers under regulatory rules, and—despite being rewarded with higher profits (by regulatory design) to achieve efficiencies—charged rates twice those of its smaller competitors. These outcomes were a product of the political construction of both the Comsat enterprise and its regulatory institutions.

In Washington, D.C., the old saw is that nothing succeeds like failure. But inefficiencies and failed competition may, over time, incentivize alternatives.[25] Observed failures, particularly from growing opportunity costs associated with the suppression of increasingly promising technologies, motivated a response. It seemed straightforward that parties that were "financially and technically well qualified [be allowed] to enter an established multibillion dollar domestic telecommunications industry," when that industry suffered "regulatory ills, such as a lack of incentive to innovate."[26] The existing structure was inimical to the stated goals of "the Comsat Act, such as obtaining the benefits of satellite technology in terms of quality services

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[23] WU, *supra* note 21, at 192; *Id.* at 187 ("Clay Whitehead, Nixon's telecommunications czar, became in 1974, the first government official to call openly for an end to the Bell monopoly."); *Id.* ("The antitrust laws… should be enforced to ensure that regulatory mechanisms cannot become a haven for escape from competition").

[24] Johnson Report, *supra* note 14, at vi (1987).

[25] Gary S. Becker, *A Theory of Competition Among Pressure Groups for Political Influence,* 98 Q. J. ECON. 371 (1983) (discussing a classic treatment of this idea).

[26] Robert S. Magnant, *Satellite Communications*, *US Policy Considerations*, TELECOMM. POL'Y. 297, 299 (1979) ("under this policy of multiple entry, anyone financially and technically qualified could enter an established multibillion dollar domestic telecommunications industry…attempt to cure some of industry's regulatory ills, such as a lack of incentive to innovate").

and reduced costs [which] were definitely impeded by the carriers" who (in the Comsat structure) were given deep influence and deference.[27]

Tom Whitehead, shortly after earning a PhD in Management at MIT, became a Nixon White House advisor at age 30. He was given a portfolio for technology agencies (including the NSF, NASA, and the FCC), and soon became a change agent[28] by promoting a new version of President Eisenhower's old "Open Skies" initiative.[29] The idea was to relax barriers barring non-Comsat satellites from supplying domestic U.S. telecommunications services. The reform was "somewhat grudgingly adopted" by the Federal Communications Commission in 1972.[30] The upshot (with apologies) was that numerous competitors to Comsat were soon launched, including satellites owned by "RCA, Western Union, the American Satellite Corporation, Satellite Business Systems, Hughes, and Comsat General."[31]

Prices for long-distance transport of communications signals, both voice and long-distance (data services were not yet so important a part of the picture), plummeted. The rivalry "made distribution of television programs to [TV] stations and to cable [TV] systems much less expensive," wrote Owen & Wildman.[32] "Previously, television distribution had relied on costly microwave interconnections supplied by AT&T . . . ."[33] The radical downshift in the pricing structure opened whole new industries: cable TV networks could now be distributed to thousands of local cable TV systems, efficiently delivering new programs to subscribers. This cost-push effect stimulated demand for additional content by viewers and its complement—liberalization of rules protecting incumbent terrestrial television stations from competition. "In 1976 the FCC quickly deregulated private 'receive-only' satellite antennas,"[34] a reform notable in pointing out that such receiver dishes (not emitting any radio traffic and, hence, entirely non-interfering) were banned to begin with.

[27] *Id.* at 300.

[28] Dennis Hevesi, *Clay T. Whitehead, Guide of Policy that Helped Cable TV, is Dead at 69*, NY TIMES (July 31, 2008) https://www.nytimes.com/2008/07/31/washington/31whitehead.html [https://perma.cc/23H2-M6X7] ("Clay T. Whitehead, the official in the Nixon administration who laid the groundwork for Open Skies, the policy that led to the creation of the domestic satellite system that brought cable television and lower-cost long-distance telephone service into millions of American homes").

[29] Clyde E. Rankin, *Utilization of the Geostationary Orbit—A Need for Allocation?*, 13 COLUM. J. TRANSNAT'L L. 98, 99 (1974) (discussing the Outer Space Treaty of 1967 and assuring "outer space is free for the exploration and use by all States without discrimination of any kind").

[30] BRUCE M. OWEN, THE INTERNET CHALLENGE TO TELEVISION 146 (1999) ("[T]he FCC somewhat grudgingly adopted this policy in 1972.").

[31] ITHIEL DE SOLA POOL, ON FREE SPEECH IN AN ELECTRONIC AGE: TECHNOLOGIES OF FREEDOM 44 (1983); *see also id.* at 242 (noting AT&T was excluded to guarantee "business in the formative years to a group of oligopolists").

[32] BRUCE M. OWEN & STEVEN S. WILDMAN, VIDEO ECONOMICS 20 (1992).

[33] *Id.*

[34] *Id.*

The economic effects were pronounced. Brian Lamb, founder of one of the first basic cable TV networks, C-SPAN, in 1979, noted that the new competition lowered video transport costs by over 95 percent.[35] While cable TV systems had retransmitted local broadcast TV signals in some markets since 1948, they had never produced much original programming.[36] Yet Open Skies—and the almost immediate FCC (and federal court-led) deregulation of new programming choice—let a thousand networks bloom. "[E]liminating controls on programming in a late-1970s deregulation by the FCC [led] to a boom in 1978-81 (when national satellite video networks increased from eight to thirty-eight) . . . ."[37] In other words, deregulating transmission opportunities fueled an expansion of video content—which, in turn, triggered more build-out of distribution facilities: a virtuous circle. This eventually delivered the fantastically more capacious Internet distribution of today's world.

Indeed, satellite television made an important contribution to this competitive reformulation of the marketplace in the 1990s. Using signals allocated at 12.2 GHz to 12.7 GHz, two systems—Hughes' DirecTV (launched 1994), and EchoStar's DISH (1996)—created systems serving the entire continental U.S. with digital video packages distinctly larger (more channels) than offered by most cable systems.[38]

The "Death Star" was at first mocked by cable industry interests, who ran TV commercials claiming that the technology did not work, but quickly established itself as a competitive threat.[39] This was surprising, in that industry experts touted direct broadcast satellite (DBS) as a filler in remote areas not wired for cable.[40] But urban and suburban submarkets soon proved vulnerable to attack by the larger, digital video packages, and by 2004 cable TV subscribership held a (shrinking) lead over DBS of less than three-to-one (see *infra* Figure 1). A decade later, that margin had been reduced to less than 3-to-2. This success in the U.S. was mirrored, or exceeded, in the rest of the world. By 2008, "75% of global revenues from satellite services, totaling US $94.2 BN and 228 million subscribers worldwide. . . " were accounted for by satellite television.[41]

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[35] THOMAS HAZLETT, THE POLITICAL SPECTRUM: THE TUMULTUOUS LIBERATION OF WIRELESS TECHNOLOGY, FROM HERBERT HOOVER TO THE SMARTPHONE 18 (2017) ("Brian Lamb, founder of C-SPAN, the first basic cable TV network, testifies that the market for new national TV programming opened because the new competition lowered video distribution costs by more than 95 percent.").

[36] The Cable History Timeline, The Cable Center, 1 (2014), https://syndeoinstitute.org/wp-content/uploads/2022/10/CableTimelineFall2015.pdf [https://perma.cc/S4PV-725V].

[37] THOMAS HAZLETT & MATTHEW L. SPITZER, PUBLIC POLICY TOWARD CABLE TELEVISION: THE ECONOMICS OF RATE CONTROLS 95 (1997).

[38] Patrick R. Parsons, BLUE SKIES: A HISTORY OF CABLE TELEVISION 608-609 (2008).

[39] STEPHEN KEATING, CUTTHROAT: HIGH STAKES AND KILLER MOVES ON THE ELECTRONIC FRONTIER 121-129 (1999). *See also* HAZLETT, *supra* note 36 (2017).

[40] Parsons, *supra* note 39, at 610.

[41] Alina Orlova, Roberto Nogueira & Paula Chimenti, *The Present and Future of the Space Sector: A Business Ecosystem Approach*, 52 SPACE POL. 1, 2 (2020).

The competitive success in broadcast video subscription services is today fading (see *infra* Figure 1). With the rise of video delivery via "over the top" broadband services, both cable and satellite TV subscriptions are in decline.[42] Cable operators retain, however, a broadband pipe to seamlessly shift to delivery of third-party content. Satellite services are shifting to better engage this transition. As of 2018, about 8.4 million U.S. households (almost all in rural areas) paid for satellite-delivered broadband connections, or about six percent of America.[43] New mega-constellations of low-earth orbit satellites aim for this ratio (see *infra* Part V).

The Federal Communications Commission has certified that such services can effectively compete with terrestrial networks. In 2018, the so-called CAF-II (the second phase distributing subsidies for the Connect America Fund) "reverse auction" was held by the Commission.[44] The process allocated subsidies to telecommunications carriers that agreed to supply about 700,000 unserved locations with broadband service at a quality sufficient to meet federal standards. Satellite broadband provider, Viasat, won funding to connect about 190,000 locations, the most of any of the 103 carriers selected. The per-location payments were, however, adjusted downwards to reflect the lower speeds and high latency associated with satellite service relative to DSL, cable, fiber or fixed wireless connections.[45]

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[42] F. Andrew Hanssen & Thomas W. Hazlett, *Internet Streaming Overcomes Paramount: The 1948 Paramount antitrust ruling stifled American video entertainment*, 44 REGULATION (Winter 2021/2022): 12-16 ("The unleashing of 'over-the-top' (OTT) video streamed via broadband internet to home flat screens, tablets, and smartphones helped fuel this boom. In 2010, the total production of Netflix, Apple TV, HBO Max, Disney+, CBS All Access, Peacock, and Hulu, was 13 hours—*for the year*. In 2020, it was 2,136 [14].").

[43] *See* Sascha Segan, *The Satellite Divide: Which Americans Rely on Satellite Internet?*, PCMAG (Dec. 9, 2019), https://www.pcmag.com/news/the-satellite-divide-which-americans-rely-on-satellite-internet [https://perma.cc/EA29-VKXP] (explaining that 8.4 million households, or approximately 6 percent of Americans, rely on satellite internet).

[44] *See* CAF Phase II Auction, Universal Service Administrative Company, https://www.usac.org/high-cost/funds/caf-phase-ii-auction/ [https://perma.cc/YR23-GQBS] (last visited Apr. 11, 2023) (explaining the CAF reverse auction).

[45] *See* Victor Glass & Timothy Tardiff, *The Federal Communications Commission's Rural Infrastructure Auction: What Is Hidden in the Weeds*, 43 TELECOMM. POL'Y 101821, 101832 tbl. 6, 101829 9 tbl. 5 (2019) (indicating that Viasat had won funding to provide service for 190,595 unserved locations and that satellite services with lower speeds and higher latencies than the Gigabit speed/latency combination received a weighted reduction in the amount of support available to that service in that bidding round).

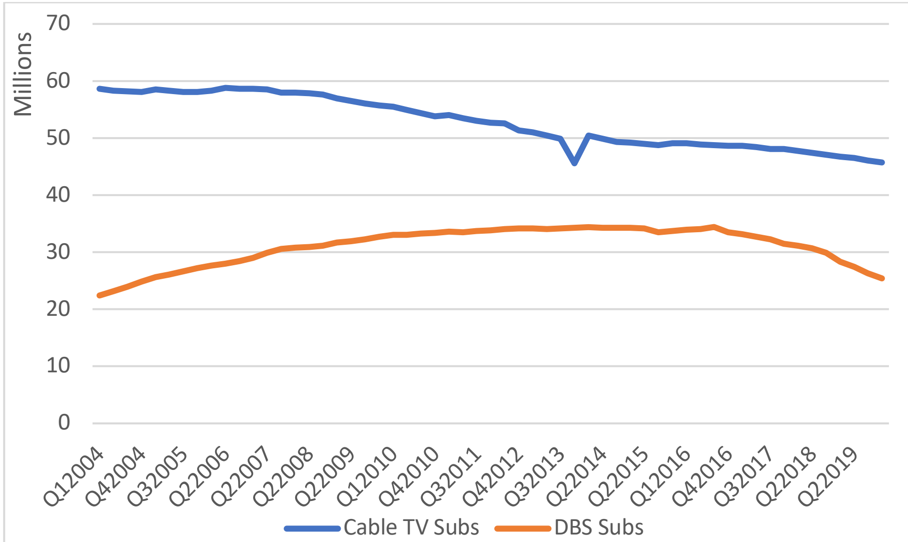

FIG. 1. U.S. CABLE TV AND SATELLITE TV (DBS) SUBSCRIBERS (QUARTERLY 2004-2019)[46]

But the Open Skies policy impacted the satellite marketplace far beyond the success of satellite television in the 1990s. Its free entry rules permitted a prolonged period of financial terror in telecommunications (voice and broadband) services. It is not ironic that a pro-competitive policy would produce both gains and excessive experimentation; the one reliable aspect of the monopoly period was that over-investment in new services was suppressed. Beginning in the late 1990s, multiple satellite ventures launched, burned through financial resources, and then were either ended (as was Teledesic, a joint venture funded by billionaires Bill Gates and Craig McCaw) or reorganized under the bankruptcy laws.[47] The latter exit was more frequent, and it has endowed the current marketplace with a large number of operating systems that survived by extinguishing creditor obligations of substantial size. These networks include Iridium (bankrupted in 1999), Ligado (2012) and Intelsat (2020) (see Table 1).

Yet the well-populated financial graveyard for billion-dollar satellite investments has seemingly failed to extinguish the urge to splurge on new communications technologies in space. In 2014, a headline announcing the formation of SpaceX's new venture for a global orbiting broadband network, asked: *Satellite internet is a space business widow-maker—so why does Elon Musk want*

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[46] Leichtman Research Group, Inc., https://leichtmanresearch.com/research/ [https://perma.cc/K2BJ-KHCF].

[47] Sharon Pian Chan, *The Birth and Demise of an Idea: Teledesic's 'Internet in the sky,'* SEATTLE TIMES (Oct 7, 2002), https://archive.seattletimes.com/archive/?date=20021007&slug=teledesic070 [https://perma.cc/E7YF-BPPZ] (Teledesic raised $900 million in cash but reported assets of just under $300 million in June 2000).

in?[48] In fact, dramatic advances in computational software, electronics and miniaturization had introduced game-changing options for competitors. The most fundamental advances drove down costs and increased the functionality of low earth-orbit satellites. By placing satellites at 400 to 800 miles above the surface of the earth, the substantial latency experienced with geosynchronous orbits (about one-half second, with signals traveling to and from a satellite perched at over 22,000 miles in the sky) is largely eliminated. "Mega-constellations" also allow for far more data to be transmitted facilitated by the use of tiny ("pico") satellites that are light, easily launched, and scalable with changing demands. The development of "CubeSats," with the first experiments launched by academic researchers in 2003,[49] has allowed these small devices (10 cm X 10 cm X 10 cm, and weighing only about one kg) to achieve economies via standardization, and yet perform impressive network functions when combined in modular configurations. The lack of entry barriers, combined with emerging cost efficiencies in the construction of satellite systems, further intensified rivalry.

A major confluence threatening initial investments in voice networks in space was the parallel success on the ground. Notably, "[m]ajor companies like Teledesic, Iridium, and Globalstar invested tens of billions of dollars into their voice-centric systems that were ultimately undercut by broadly available terrestrial cellular service."[50] The boom-bust was seen in the enthusiastic funding for satellite in the 1990s (driven by low-risk premia in the dot.com expansion, and enticed by evident success in satellite TV services).

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[48] *See* Tim Fernholz, *Satellite Internet Is a Space Business Widow-Maker—So Why Does Elon Musk Want In?*, QUARTZ (Nov. 19, 2014), https://qz.com/294888/satellite-internet-is-a-space-business-widow-maker-so-why-does-elon-musk-want-in [https://perma.cc/V864-759M] (describing the business case for SpaceX satellite internet).

[49] *See* Armen Toorian, Ken Diaz & Simon Lee, *The CubeSat Approach to Space Access*, IEEE AEROSPACE CONFERENCE 4 (2008) (explaining the 2003 launch of CubeSats).

[50] DOUG BRAKE, SPECTRUM POLICY AND THE FUTURE OF SATELLITES 7 (2019).

TABLE 1. MAJOR COMMUNICATIONS SATELLITE BANKRUPTCIES IN U.S.

Year	*Exit/Bankruptcy*	*Approximate Dollar Losses*	*Operating in 2023?*
1999	Iridium (Motorola)[51]	$5 billion	Yes (Iridium)
2002	Globalstar[52]	$3.34 billion	Yes
1999	ICO[53]	$1.1 billion	Yes (Pendrell)
2000	ORBCOMM[54]	$800 million	Yes
2002	Motient[55]	$500 million	Yes (part of SiriusXM)
2010	TerreStar[56]	$1 billion	Yes (part of DISH)

[51] *See* Douglas A. McIntyre, *The 10 Biggest Tech Failures of the Last Decade: Failure to Launch—Iridium*, TIME (May 14, 2009), https://content.time.com/time/specials/packages/article/0,28804,1898610_1898625_1898640,00.html [https://perma.cc/DPR2-DHQD] (Iridium).

[52] *See* Company News; *Globalstar Files for Bankruptcy Protection*, N.Y. TIMES (Feb. 16, 2002), https://www.nytimes.com/2002/02/16/business/company-news-globalstar-files-for-bankruptcy-protection.html [https://perma.cc/9W9V-7GPF] (noting that Globalstar filed for bankruptcy and its Chapter 11 papers listed $3.34 billion in debts); Globalstar, https://www.globalstar.com/en-us/ [https://perma.cc/2P3G-BTD5] (last visited Mar. 26, 2023); Bloomberg News, *Company News; Globalstar Files for Bankruptcy Protection*, N.Y. TIMES (Feb. 16, 2002), https://www.nytimes.com/2002/02/16/business/company-news-globalstar-files-for-bankruptcy-protection.html [https://perma.cc/9W9V-7GPF] (noting Globalstar's Chapter 11 papers listed $3.34 billion in debts); GLOBALSTAR, https://www.globalstar.com/en-us/ [https://perma.cc/2P3G-BTD5].

[53] *See* Elizabeth Douglass, *Satellite-Telephone Firm ICO Files for Bankruptcy Protection*, L.A. TIMES (Aug. 28, 1999), https://www.latimes.com/archives/la-xpm-1999-aug-28-fi-4388-story.html [https://perma.cc/EP8U-89FD] (explaining that ICO had sought Chapter 11 bankruptcy protection and that its petition listed $1.1 billion in debt); *ICO Global Communications Name Change to Pendrell Corporation Becomes Effective Today*, BUS. WIRE (July 21, 2011), https://www.businesswire.com/news/home/20110721005155/en/ICO-Global-Communications-Name-Change-to-Pendrell-Corporation-Becomes-Effective-Today [https://perma.cc/HU9X-MCNJ] (noting that ICO Global Communications changed its name to Pendrell Corporation); PENDRELL, https://pendrell.com/ [https://perma.cc/844A-HGPP] (last visited Mar. 26, 2023).

[54] *See* Theresa Foley, *Bidders Plot Comeback for a Satellite Network*, N.Y. TIMES (Apr. 2, 2001), https://www.nytimes.com/2001/04/02/business/technology-bidders-plot-comeback-for-a-satellite-network.html (reporting that ORBCOMM raised $810 million in capital, but was auctioned for a winning bid of just $16 in bankruptcy); *Satellite Industry Faces Next LEO Bankruptcy*, VIA SATELLITE (Sept. 21, 2000), https://www.satellitetoday.com/uncategorized/2000/09/21/satellite-industry-faces-next-leo-bankruptcy/ [https://perma.cc/D9Q8-BR34] (describing Orbcomm's Chapter 11 bankruptcy filing and its $171 million debt burden); ORBCOMM, https://www.orbcomm.com/ [https://perma.cc/VG3S-XP7A] (last visited Mar. 26, 2023).

[55] *See* Taylor Lincoln, *Motient Emerges from Bankruptcy*, BOS. BUS. J. (Apr. 22, 2002), https://www.bizjournals.com/boston/blog/mass-high-tech/2002/04/motient-emerges-from-bankruptcy.html [https://perma.cc/FWU9-XRYY] ("Motient…will see its debt sliced from about $500 million"); Michael P. Bruno, *Beleaguered Motient Files for Chapter 11*, THE WASH. POST (Jan. 11, 2002), https://www.washingtonpost.com/archive/business/2002/01/11/beleaguered-motient-files-for-chapter-11/f5506e96-e9f7-44aa-8aa7-e2719b5bc251/ [https://perma.cc/X5XV-7PJR] ("In November, Motient sold its 9.8 million shares of stock in XM Satellite Radio Holdings Inc. to pay debts.").

[56] *See* Phil Goldstein, *TerreStar Files for Bankruptcy*, FIERCE WIRELESS (Oct. 20, 2010, 11:04 AM), https://www.fiercewireless.com/wireless/terrestar-files-for-bankruptcy [https://perma.cc/F2LH-SDZG] (explaining that TerreStar had filed for Chapter 11 bankruptcy protection and that its filing listed debt of more than $1 billion); Marie Beaudette, *The Daily Docket: TerreStar Files for Chapter*

2000	Skybridge (Alcatel)[57]	Unknown	No
2003	Teledesic[58]	$600 million	No
2012	LightSquared/Ligado[59]	$2 billion	Yes
2020	Intelsat[60]	$8 billion	Yes
2020	OneWeb[61]	$2 billion	Yes
2020	Speedcast[62]	$634 million	Yes (Anuvu)
2021	Global Eagle[63]	$488 million	Yes

11, THE WALL ST. J. (Oct. 20, 2010, 7:58 AM), https://www.wsj.com/articles/BL-BANKB-15736 [https://perma.cc/B44A-9LFC] (noting that TerreStar filed for Chapter 11 bankruptcy protection); Marc Lumpkin, *DISH Network Closes DBSD and TerreStar Acquisitions,* DISH NETWORK (Mar. 12, 2012), https://ir.dish.com/news-releases/news-release-details/dish-network-closes-dbsd-and-terrestar-acquisitions [https://perma.cc/L8L4-PSS9] (explaining that DISH acquired "substantially all of the assets of TerreStar Networks."); TERRESTAR, https://www.terrestar.net/ [https://perma.cc/82HH-GARU] (last visited Mar. 26, 2023).

[57] Fernholz, *supra* note 49 (noting that Skybridge, an Alcatel project, went bankrupt in 2000).

[58] *See* J. Clark Beesemyer, Adam M. Moss & Donna H. Rhodes, *Case Studies of Historical Epoch Shifts: Impacts on Space Systems and Their Responses*, AIAA SPACE 2012 CONFERENCE AND EXPOSITION 9 (2012) (explaining that Teledesic ceased operations in 2003); Sharon Pian Chan, *The Birth and Demise of an Idea: Teledesic's 'Internet in the Sky"* SEATTLE TIMES (Oct 7, 2002) (Teledesic raised $900 million in cash but reported assets of just under $300 million in June 2000), https://archive.seattletimes.com/archive/?date=20021007&slug=teledesic070 [https://perma.cc/E7YF-BPPZ].

[59] *See* Colin Gibbs, *LightSquared Rebrands as Ligado Networks but Spectrum Plans Remain Cloudy*, FIERCE WIRELESS (Feb. 9, 2016 6:56PM), https://www.fiercewireless.com/wireless/lightsquared-rebrands-as-ligado-networks-but-spectrum-plans-remain-cloudy [https://perma.cc/P5FH-UT75] (describing LightSquared's rebrand as Ligado Networks about a year after concluding nearly three years of bankruptcy protection); LIGADO, https://ligado.com/ [https://perma.cc/L758-PWN8] (last visited Mar. 26, 2023); David Goldman, *LightSquared Files for Bankruptcy*, CNN MONEY (May 14, 2012, 6:14 PM), https://money.cnn.com/2012/05/14/technology/lightsquared-bankruptcy/index.htm [https://perma.cc/M8S9-MJPU] (explaining that LightSquared filed for bankruptcy after defaulting on its debt and failing to agree to a deal with its lenders); Svea Herbst Bayliss, Sinead Carew, & Jonathan Stempel, *Falcone's LightSquared Files for Bankruptcy*, REUTERS (May 14, 2012, 2:26 PM), https://www.reuters.com/article/us-lightsquared-bankruptcy/falcones-lightsquared-files-for-bankruptcy-idUSBRE84D0YZ20120514 [https://perma.cc/M55M-6QUQ] (noting that LightSquared's financial statements indicated approximately $2 billion in outstanding debt).

[60] *See* Rama Venkat, *Intelsat Files for Chapter 11 Bankruptcy*, REUTERS (May 14, 2020), https://www.reuters.com/article/us-intlsat-bankruptcy-idUKKBN22Q0E0 [https://perma.cc/TX93-MDEP] (Intelsat).

[61] *See Britain's Government Bail out OneWeb in 2020. Now It's in Trouble*, THE ECONOMIST, (Mar. 12, 2022), https://www.economist.com/britain/2022/03/12/britains-government-bailed-out-oneweb-in-2020-now-its-in-trouble [https://perma.cc/JHC7-UQPZ] (discussing OneWeb filing for bankruptcy in 2020 bankruptcy after SoftBank, its biggest funder, refused to give the firm $2 billion); ONEWEB, https://oneweb.net/ [https://perma.cc/9VJ4-RHYQ] (last visited Mar. 26, 2023).

[62] *See* Caleb Henry, *Speedcast Files for Chapter 11 Bankruptcy*, SPACE NEWS (Apr. 23, 2020), https://spacenews.com/speedcast-files-for-chapter-11-bankruptcy/ [https://perma.cc/BU5L-5CXV] (Speedcast).

[63] *See* Jason Rainbow, *Global Eagle Entertainment Completes Chapter 11 Restructuring*, SPACE NEWS (Mar. 23, 2021), https://spacenews.com/global-eagle-entertainment-completes-chapter-11-restructuring/ [https://perma.cc/ZFL5-ECEH] ("Around half a dozen of the satellite communication provider's lenders took control of the company March 23, shedding about $488 million of its debt in the process."); *See* Anuvu Website, https://www.anuvu.com (last visited 11/5/2023).

The economic carnage was so widespread that observers looked approvingly on the bankruptcies, or even early withdrawals in which investors refused to sink additional risk capital, as financing "mechanisms" to advance the health of the industry. In a 2009 *Time* article on "the biggest Tech failures of the last 10 years," Iridium made the list for its 1999 bankruptcy for losing $5 billion and constituting "one of the 20 largest bankruptcies in US history."[64] Yet, observers of the satellite industry saw this performance as, perhaps, relatively successful:

> Interestingly, when considering systems that were actually built and continue delivering value to this day, Globalstar and Iridium might be viewed as a success. In a perverse way, these systems succeeded in responding to their environment, using bankruptcy as a change option. While initial investors lost big money, from the system point of view, bankruptcy allowed the system to shed the downside losses that Teledesic avoided. This could possibly be an actual strategy for getting a system into operations, sacrificing investors' money to end up with an inexpensively acquired system. This strategy, however, comes with risks such as 'spoiling the well,' and leading to the decrease of investment in all space-based communications, which is what Teledesic suffered from after the bankruptcies of Iridium and Globalstar.[65]

III. SMALL IS BEAUTIFUL: THE 21ST CENTURY SATELLITE BOOM AND SCARCITY IN THE SKY

> The whole satellite industry is reinventing itself," says Susan Irwin, the head of satellite consulting firm Euroconsult's US office. "The fact that television is going to be internet is changing the way that data, voice and video are distributed. There are advances in satellite communications that are making satellites more efficient, in value and bandwidth, and the use of satellites for internet traffic distribution is a business that is evolving."[66]

> Terrestrial competition was the primary driver of the 2000 satellite bankruptcy cycle. The 2020 cycle, by contrast, was primarily driven by new satellite technology rendering old satellite technology obsolete . . . . The satellite industry is undergoing a process that the late Austrian political economist Joseph Schumpeter referred to as 'creative destruction'….[67]

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64 McIntyre, *supra* note 52.

65 Beesemyer, Moss & Rhodes, *supra* note 52, at 11.

66 Fernholz, *supra* note 49.

67 J. Armand Musey, *Satellite Bankruptcies Circa 2000 vs. 2020: We've Come a Long Way!*, SPACE NEWS (Apr. 15, 2021), https://spacenews.com/op-ed-satellite-bankruptcies-circa-2000-vs-2020-weve-come-a-long-way/ [https://perma.cc/UKV6-2YFS].

And then, in the late 2010s, the market displayed another oscillation in the fortunes of satellite systems. Firms embracing the new, miniaturized technologies, LEOs, and mega-constellations attracted more massive investments than ever before and commenced operations in the U.S. and around the world. The newer operations, which might be traced to the 2014 announcement for broadband satellite service, Starlink, delivered by Elon Musk's privately held SpaceX, captured lessons from previous generations. How well the solutions have been crafted is still too early to tell. But investors have been bullish. SpaceX is now valued at over $135 billion.[68] While it has thousands of spacecraft in orbit and supplies global broadband services across many countries (most famously, it has emerged as an important communications network in war-torn Ukraine), reporting total subscribership of over one million customers.[69]

Starlink, with competitors Kuiper (Amazon), ViaSat, OneWeb and others,[70] is aiming at global reach and to compete directly with terrestrial broadband services. The ambitious gambit seeks to correct the business errors of the last generation. As industry analyst MoffettNathanson summarizes:

> The advantages and disadvantages of LEO constellations have been understood for a long time . . . . Early LEO constellations Iridium and Globalstar were conceived more than twenty years ago . . . . Twenty years on from these early failures, there is now a common belief that the costs of creating a LEO constellation have come down far enough to create a viable business (meanwhile, the portion of the globe unserved by terrestrial alternatives is now much smaller than in the past).[71]

In short, major challenges continue to loom. But the data about utilization of space for communications are clear: change is in the air. The sheer numbers of satellites used for commercial communications are (not sorry) skyrocketing. See

[68] Lora Kolodny, *SpaceX Raising $750 Million at a $137 Billion Valuation, Investors Include Andreessen-Horowitz*, CNBC (Jan. 3, 2023), https://www.cnbc.com/2023/01/02/spacex-raising-750-million-at-137-billion-valuation-a16z-investing.html [https://perma.cc/7FTJ-HZ6X].

[69] Rachel Jewett, *SpaceX Starlink Internet Service Surpasses 1M Subscribers*, VIA SATELLITE (Dec. 19, 2022), https://www.satellitetoday.com/broadband/2022/12/19/spacex-starlink-internet-service-surpasses-1m-subscribers/ [https://perma.cc3R7Q-JPGU] (noting that Starlink now has more than 1,000,000 active subscribers and is available in Canada, Mexico, the Caribbean, Chile, Brazil, Japan, Australia, New Zealand, and parts of the United States and Western Europe); *see also How Elon Musk's Satellites have Saved Ukraine and Changed Warfare*, The Economist (Jan. 5, 2023), https://www.economist.com/briefing/2023/01/05/how-elon-musks-satellites-have-saved-ukraine-and-changed-warfare [https://perma.cc/CC2Q-4PHW].

[70] Chris Young, *Here's Why SpaceX and OneWeb Just Asked the FCC to Forget All Past Disputes*, INTERESTING ENG'G (June 17, 2022), https://interestingengineering.com/science/spacex-and-oneweb-asked-fcc-to-forget-disputes [https://perma.cc/X6TA-4D36] (describing the companies involved in the satellite "mega-constellation competition").

[71] MOFFETTNATHANSON, IS STARLINK A SUBSTITUTE FOR, OR A SUPPLEMENT TO WIRED BROADBAND 4-5 (Apr. 5, 2021) (on file with author).

Figure 2. Between 2016 and 2020, commercial satellite launches rose from less than 200 to more than 1200.

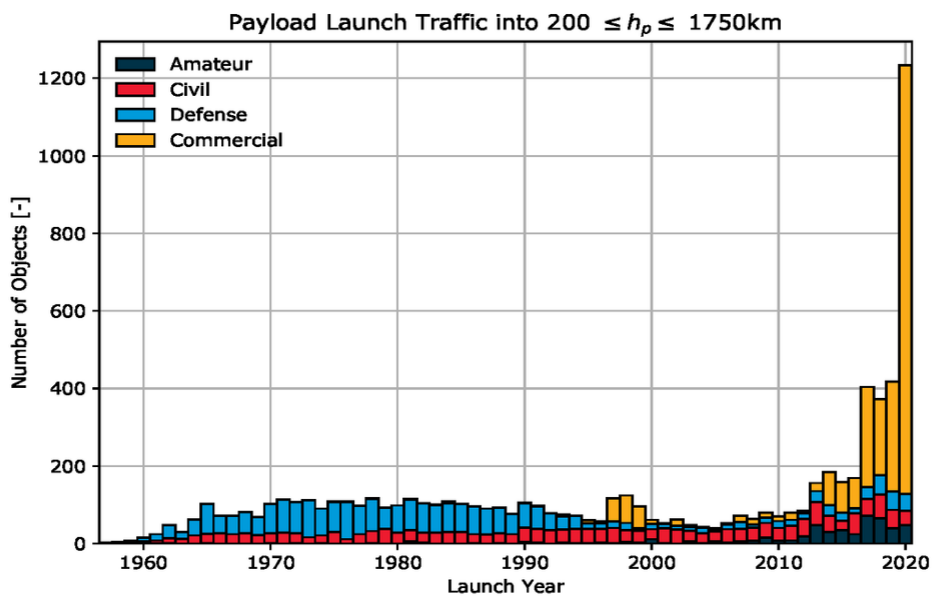

FIG. 2. SATELLITES LAUNCHED, 1960 TO 2020[72]

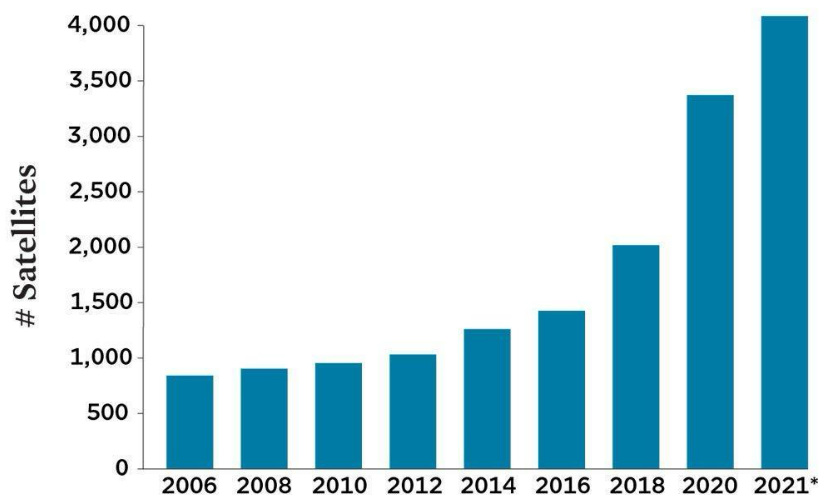

FIG. 3. SATELLITES IN ORBIT (GLOBAL), 2006-2021 (* THROUGH APRIL)[73]

[72] William Webb, Presentation to SpectrumX, A National Science Foundation Spectrum Innovation Initiative (Jan. 13, 2021).

[73] Stephen Young, *The Number of Active Satellites in Space Skyrockets . . . Literally*, EQUATION (July 27, 2021), https://blog.ucsusa.org/syoung/number-of-satellites-skyrockets/ [https://perma.cc/EVQ6-GEQK] (citing Union of Concerned Scientists).

Such launches, not surprisingly, have dramatically increased the number of satellites in orbit. In May 2021, some 4,084 operational satellites were reported—of which about half had begun operations only in 2019, 2020, and the first five months of 2021.[74]

Coordination issues of the increasingly crowded skies necessarily involve not just orbital slots (avoiding collisions between satellites), but other objects in space, including rockets and debris. Of course, radio spectrum access is also required in the operation and performance of satellites, and implicate rights definition, distribution, and enforcement methods. As seen in Figure 4, congestion is increasing and is presumably increasing the probability of damages from accidents or other conflicts.

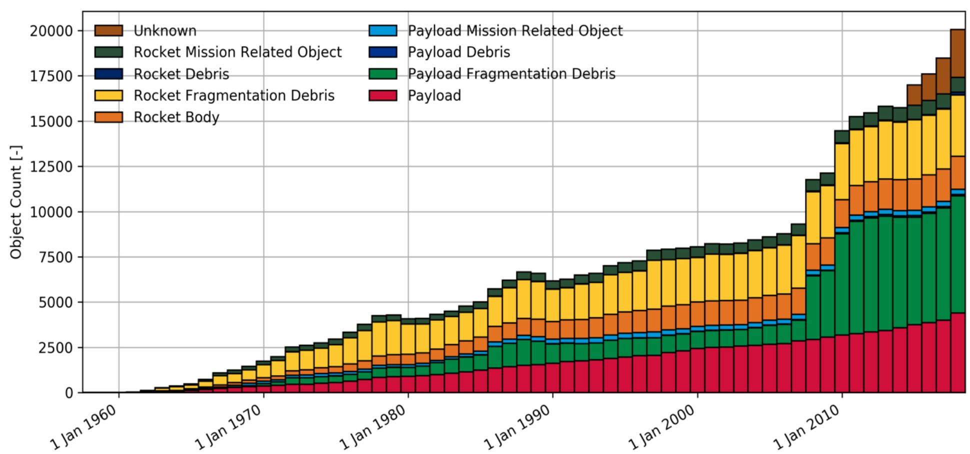

FIG. 4. OBJECTS IN SPACE, 1960-2020[75]

The increasing use of space communications is a product of advances making launches and satellites more cost-effective and improving the capacity of orbiting devices to supply valuable services in telecommunications markets. It is a standard outcome that this gain in productivity prompts not abundance but scarcity, despite widespread commentary of the reverse. This argument appears commonly, for example, in spectrum allocation policy debates that superior radios (particularly receivers) obviate conflicts, reduce the importance of coordination or property rights, and facilitate sharing or even "open access."[76] While intensifying use of space

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[74] *Id.* (explaining that 304 satellites became operational in 2019, 925 in 2020, and 836 between January 1 and May 1, 2021).

[75] *See About Space Debris*, The Eur. Space Agency, https://www.esa.int/Space_Safety/Space_Debris/About_space_debris [https://perma.cc/V59Y-XQBS].

[76] *See* Thomas W. Hazlett & Evan T. Leo, *The Case for Liberal Spectrum Licenses: A Technical and Economic Perspective*, 26 BERKELEY TECH. L.J. 1037, 1100 (2011) ("Smart radios do not portend the 'end of scarcity' but constitute yet another ascending pathway on the mountain wireless entrepreneurs have been climbing since Marconi blazed a trail for wireless innovations in 1895.").

communications obtains with the enhanced systems, and lower costs, available in current satellite deployments, these opportunities increasingly present potential conflicts. Just as radio spectrum scarcity was non-existent prior to the invention of radios by Guglielmo Marconi, and very little conflict existed in actual usage of radio waves until the discovery of broadcasting as a business model in the U.S. in the 1920s,[77] market growth is fueling demand for more exacting rules defining rights of access.

IV. ORBITAL SLOT AND RADIO SPECTRUM ALLOCATIONS FOR SATELLITE OPERATIONS

> The 'orbit/spectrum resource' refers to the fact that satellites are assigned both a space on the geostationary orbit and a frequency on the radio spectrum. In addition to occupying a physical 'slot,' a satellite is also assigned a specific frequency in order to avoid interference between transmissions. The dual nature of the orbit/spectrum resource requires that both aspects be exploited simultaneously, and thus the current system to allocate orbits and frequencies necessarily encompasses both aspects.[78]

The joint award of orbital slot and radio transmission rights is likely an efficient bundling, given the tight complementarity in the productive use of either asset. This is the general test applied to delineation of property rights, given that it is transactionally efficient to pre-empt the necessary costs (and potential hold-ups) associated with distributing assets that must necessarily be re-aggregated.[79]

The evolution of property rights is commonly triggered by such changes in demand conditions, often a result of technological change.[80] Investments in defining and enforcing property rights are not free, and there is little social interest in creating such rules when unrestricted competition ("open access") produces as desirable an outcome and yet saves the expense of rulemaking. In fact, one simple rule that tends to economize on overhead is the "priority in use" or "first in time" method, where the legal system essentially allows a first mover in the market to define the space that is being "homesteaded" or "pioneered" in use. Such rules have been often employed in satellites, even by the International Telecommunications Union (ITU),

[77] *See* HAZLETT, *supra* note 36, at 20 (2017) (noting that the emergence of broadcasting in the U.S. in the 1920s produced competition because transmitters had to coordinate and frequency use rights were first come, first served).

[78] Jannat C. Thompson, *Space for Rent: The International Telecommunications Union, Space Law, and Orbit/Spectrum Leasing*, 62 J. AIR L. & COM. 279, 280 n.2 (1996).

[79] DAVID D. FRIEDMAN, LAW'S ORDER: WHAT ECONOMICS HAS TO DO WITH LAW AND WHY IT MATTERS 112-15 (2000) (discussing the bundling of rights and which rights belong together).

[80] *See* Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 350 (1967) ("[T]he emergence of new private or state-owned property rights will be in response to changes in technology and relative prices.").

as a low-cost way to allow investment in satellites. The party undertaken to create a valuable enterprise can readily gain access to the orbital slot (and associated radio frequencies) that complements the project, while being protected against future encroachments, and yet the upfront costs of administration tend to be modest.

The trick that confronts both private actors and public policy makers is to know when a more formal, forward-looking system of rights is efficient. The idea is that competition that would otherwise dissipate resources can now be effectively channeled into productive enterprise. A useful example, as discussed by Ronald Coase, is a government auction of radio wave access rights.[81] Instead of unrestrained rivalry for spectrum, in which coordination between rival claimants is difficult given the lack of ownership rights, the state allocates frequency spaces by competitive bidding. Transactions now more easily accommodate the flow of rights to their highest valued uses.[82]

Policy makers have been talking about the scarcity of orbital slots and space frequencies since at least 1968, when the Rostow Report argued that "[the] spectrum shortage and the limited number of orbital 'parking slots' necessitate a single, multiple-purpose satellite system."[83] Yet, the disaggregated nature of the system that developed both allowed for entry by disparate, innovative players, and following the "Open Skies" reform in the U.S., appeared to be a pro-competitive approach. In international markets, distributing geosynchronous orbital slots (which are far more limited than orbital slots for low-earth or middle-earth orbits), also appeared to stimulate competitive entry—small countries like Tonga and Luxembourg strategically used their assets to provide new services and to challenge existing inter-governmental cartels.[84]

That only a tiny number of satellites were accessing space and radio spectrum in the 1960s and 1970s, and that thousands of satellites are now doing so today,

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[81] *See* R.H. Coase, *The Federal Communications Commission*, 2 J.L. & ECON. 1 (1959) (discussing the history of the Federal Communications Commission regulation of broadcasting station licensing).

[82] *See* Thomas W. Hazlett & David Porter, *Radio Spectrum and the Disruptive Clarity of Ronald Coase*, 54 J.L. & ECON. S125, S129 (2011) (noting that the Federal Communications Commission now sells spectrum use rights to the highest bidder to rationalize distribution).

[83] Richard Gabel, *The Early Competitive Era in Telephone Communication, 1893-1920*, 34 L. & CONTEMP. PROBLEMS 340, 359 (1969).

[84] *See* Harvey J. Levin, *Trading Orbit Spectrum Assignments in the Space Satellite Industry*, 81 AM. ECON. ASS. 42, 42-43 (1991) ("The latest evidence on spectrum value probably derives from the Kingdom of Tonga's proposed orbit slot auctions."); *see also* Henry Goldberg, Clay Thomas Whitehead Papers 5 (2015) (unpublished manuscript) (on file with the Library of Congress) ("Crafted Administration Policy 'Open Skies' domestic satellite policy that allowed any qualified private company to launch communications satellites."); *Papers of Clay T. (Tom) Whitehead*, C-SPAN, at 23:39 (Jan. 11, 2013), https://www.c-span.org/video/?310332-1/papers-clay-t-tom-whitehead [https://perma.cc/Z5DE-6UUM] ("[Whitehead] conceived, founded, and chaired Coronet, SES Astra, later on in little Luxembourg. . . . [H]e pioneered the idea of direct-to-consumer, small-dish satellite communications. . . . [He] used the scheme of national allocation of the electromagnetic frequency spectrum to obliterate the European state television monopolies. . . .").

suggests that the first-in-time rules have worked reasonably well. Indeed, in 1986, it was noted that "the total number of satellites capable of remaining in geostationary orbit is approximately 2000. The current number of satellites in geostationary orbit is 220. Crowding of the geostationary orbit is a concern . . . ."[85] The perceived constraints may not have been as tight as imagined. Of course, the transition from GEO to MEO and LEO technologies was part of the capacity relaxation. But innovation is a standard part of the response to scarcity; the role of rules is to channel the competitive search for such discovery in socially efficient ways.

Would earlier rules to organize the "bidding" process for claiming rights have outperformed the "right of user" approach actually utilized? One way to explore this, and more importantly to better understand the current policy margin, would involve quantifying the cost of negotiations among satellite carriers. Devising and implementing a metrics to use in such an accounting would not be a trivial exercise. Setting that aside, we offer a testable hypothesis: negotiation costs undertaken between conflicting satellite operations are now accelerating at a rapid pace. If so, then evidence is mounting that social costs may be reduced by devising improved methods for claiming rights.

First, expensive conflicts like the more than the decade-long Ligado v. GPS battle are imposing significant costs on the economy. In this tussle, the terrestrial rights granted to a satellite licensee, LightSquared, in 2004 were used to motivate some $12 billion in investment for a new national LTE network. Yet, while the network was still being constructed, and about $4 billion had been sunk, the FCC revoked the mobile communications licenses held by LightSquared. This was in response to alleged conflicts with neighboring GPS band users. The firm promptly went bankrupt.[86] Its successor firm, Ligado, has emerged from bankruptcy, but is (as of 2023) still waiting for authorization to use 40 MHz of the L band spectrum allocated its satellite licenses for terrestrial service. The loss to the U.S. economy, in terms of lost capacity for 4G and (now) 5G services, estimated at $120 billion in present value.[87]

Second, another dispute over potential interference in satellite broadband services appears to be delaying substantial progress. In the 12.2 GHz to 12.7 GHz band, used by incumbent licensees in satellite TV (DISH and DirecTV, both operating GEOs) and multichannel video data and distributions services (MVDDS), is also open to use by LEOs such as SpaceX/Starlink. On grounds of potential

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[85] Michael J. Finch, *Limited Space: Allocating the Geostationary Orbit*, 7 NORTHWESTERN J. INT'L L. & BUS. 788, 789 (1986).

[86] *See* Thomas W. Hazlett & Brent Skorup, *Tragedy of the Regulatory Commons: Lightsquared and the Missing Spectrum Rights*, 13 DUKE L. & TECH. REV. 1, 4 (2014) (indicating that three months after the FCC suspended LightSquared's ATC authorization, LightSquared declared bankruptcy).

[87] *Id.* at 14 ("LightSquared estimated that its network using 40 MHz L Band would generate about $120 billion (present value) in consumer surplus.").

interference, Starlink has petitioned the FCC to deny the request by MVDDS licensees to relax their fixed broadband usage rights to include mobility—making the bandwidth prime real estate for distributing highly valued 5G network services. In considering the rights liberalization, on petition at the Commission since April 2016,[88] the rights—which were sold at auction by the FCC in 2004—are highly restrictive: transmissions are to fixed receivers, only, and one-way (not interactive). The delay in adjudicating a more liberal interpretation of MVDDS rights is costly; the MVDDS 5G Coalition funded a study calculating up to $54 billion in annual losses.[89] Because the rights to fully utilize the 12.2—12.7 GHz band are not defined and assigned to any party, there can be no productive use of much if not most of the capacity of the band and no demand revelation—say, by an auction or secondary market trading—of the rights. This dissipation of resources calls out for an improved rights regime.

Third, other governments or international organizations employ a rights system that arguably reduces such social waste. "Whereas the ITU gives preference to the first filer, the FCC requires operators to share spectrums" in the satellite bands.[90] The reason for imposing priority rules, as does the ITU, is to attempt to economically (at reasonable administrative cost) protect investment incentives and to then facilitate the trading of rights (supporting the flow of resources to higher valued uses). This suggests that other (non-US) policy makers see value in the rules. "The FCC rule requires equal sharing among operators, absent coordination between them."[91] This regime uses the splitting of frequencies into swaths equal to 1/N of an allocated band (N=number of licensed operators) as a threat to encourage cooperative agreements. The threat has been reported by the FCC to be highly successful, as it has yet to be implemented.[92] But the fact that the rule has been instituted as a potential substitute suggests that U.S. regulators see sharing agreements as potentially problematic—i.e., no longer cheap and easy to achieve.

Fourth, something of a market to claim satellite rights has already emerged, in two forms. This is seen in the actions taken routinely by U.S. satellite firms, which file a large number of "claims" for orbital slots to seize implicit property rights—often, firms now register thousands more rights than they may plausibly actually

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[88] 86 Fed. Reg. 13266, 13269-70 (Mar. 8, 2021) ("Since the petition was filed in 2016, the Commission has taken action in several proceedings . . . .").

[89] Coleman Bazelon & Paroma Sanyal, *Valuing the 12 GHz Spectrum Band with Flexible-Use Rights*, THE BRATTLE GROUP 1, 36 (2021) ("[W]e expect the incremental value of allowing mobile 5G services into the 12GHz to be all or nearly all of $27.1-$54.1 billion . . . .").

[90] Craig Moffett, Clay Griffin, Jessica Moffett & Jay Li, *Is Starlink a Substitute for, or a Supplement to, Wired Broadband?*, MOFFETT NATHANSON 21 (2021).

[91] *Id.*

[92] *See* Randall Berry, Pedro Bustamante, Dongning Guo, Thomas W. Hazlett, Michael Honig, Whitney Lohmeyer, Ilia Murtazashvili, Scott Palo & Martin B.H. Weiss, *Spectrum Rights in Outer Space: Interference Management for Mega-Constellations*, SSRN, Aug. 2012, at 2 (discussing the FCC's Part 25 Rules).

use.[93] Moreover, as Doug Brake points out, "there is functionally a market for 'first filings,' with equipment manufacturers now often filing themselves to attract business… [s]ervice operators approaching equipment companies to manufacture a new satellite are sometimes offered a packaged deal—the satellite along with the first filing rights."[94]

Fifth, in settling disputes between competing claimants, the assignment of rights often assists in eliciting demand revelation. Indeed, the classic rationale for an auction is that when the items to be sold are assigned ownership, the bids tendered explicitly set values on the assets and indicate the order of preference. This is not only informative to policymakers who are otherwise left to infer appropriate usage from the vaguely documented and self-interested claims of rival rent seekers but offers an expeditious way to dispense with a dispute. As satellites "become small and many instead of large and few," the transaction costs associated with the existing system of ad hoc regulatory assignments will become more daunting.[95]

V. SUPRA-TERRESTRIAL RIGHTS FOR SATELLITE SPECTRUM[96]

Here we inquire into possible forms of access rights in outer space in those frequency bands that may most cost-effectively be defined in terms of exclusive access rights assigned to a particular responsible party. This does not impose a judgment as to how intensively such frequency spaces will be shared among users, but it does involve judgments on how the initial rights might be defined and then assigned to facilitate arrangements for efficient sharing of access. As a practical matter, it is straightforward to understand that the satellites are rarely, if ever, devoted to an "exclusive use," barring the definitional case in which one institution—say, the U.S. Air Force, NASA, or Hughes Corporation—is designed as an "individual." Our purpose in considering alternative definitional arrangements is to create an initial ownership and control structure that will directly or indirectly (say, through negotiated trading or other forms of social cooperation) lead to

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[93] *See id.* at 7, 15, 17 (explaining how property rights provide incentives to parties such as allow the granting of exclusive rights).

[94] Doug Brake (Special Rapporteur), *Spectrum Policy and the Future of Satellites*, Aspen Inst. Roundtable on Spectrum Pol. 12 (2019).

[95] *Id.* at 16.

[96] Given the common reference to "terrestrial rights" or "terrestrial services" in telecommunications regulation, it is appropriate to use terms such as "non-terrestrial" or "super-terrestrial" to denote the Outer Space contours with which we are concerned. The preference of one of the authors was to use the expression "extra-terrestrial rights" in this context. He was voted down. *See Terrestrial Rights definition*, LAW INSIDER (Mar. 13, 2023, 3:51 PM), https://www.lawinsider.com/dictionary/terrestrial-rights [https://perma.cc/45MN-25AX] (defining terrestrial rights as the scope granted for broadcasters to work); *see also*, John L. Hult, *Sharing the UHF between Space and Terrestrial Services*, RAND CORP. 1 (Sept. 1970) (discussing how terrestrial services were used in satellites/outer space).

activities—including investments, research & development, and consumption—that maximize output for the spectral and orbital inputs available.

As a preliminary matter, we here use *outer space* to refer to spheres from ten kilometers to tens of thousands of kilometers above sea level. This includes the atmosphere of Earth from the stratosphere to the exosphere (12 km to 10,000 km) and beyond. To construct an access right regime in this space has some unique challenges: 1) Most transceivers in outer space traverse orbits with very high ground speeds; 2) Due to the transceivers' high altitudes, many directional, extremely long-distance links cross paths and the "footprint" of a transmission may be very large. In this context, boundaries (separating rights among rival users) may be more difficult than elsewhere to identify.

The motivation for considering regime changes that would define new rights for controlling frequencies in outer space is to efficiently guide the competitive forces now seeking to appropriate increasingly constrained spectral and orbital resources. Accordingly, we seek solutions that will be highly permissive where economic costs of entry are low yet bind when constraints are caused by the existence of mutually incompatible plans for the productive use of outer space for communications and sensing services—and assist in reducing transaction costs in arranging gains from trade in the employment of radio resources. Specifically, we consider allocational reforms that might be introduced to allow rights to be competitively acquired and deployed.

De Vany et al. provide a legal-economic-engineering study of a property system for lower frequencies (up to 1 GHz) informed by radio technologies anticipated at the time.[97] In 2006, now informed by the success of the terrestrial cellular networks and other modern radio technologies, the U.K. telecommunications regulator, Ofcom, refined the approach. Specifically, Ofcom proposed that every slice of spectrum be defined in terms of spectrum management rights (SMRs), with spectrum usage rights (SUR) falling within the SMRs. The SMR-assigned party would functionally operate as an "owner," while access rights to the spectrum resource would be distributed to parties as SURs. The SMR rights describe general rights over segments of the spectrum across locations. The SMR rights would include (but not be limited to):

- "Exclusive" management rights to a block defined by frequency and geography;
- Rights to create/modify SURs;
- Right to operate up to an envelope of parameters;

[97] Arthur S. De Vany, Ross D. Eckert, Charles J. Meyers, Donald J. O'Hara & Richard C. Scott, *A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study*, 21 STANFORD L. REV. 1499, 1501-02, 1559-60 (1969) (explaining the property rights in the spectrum between the frequency 50 MHz and 1,000 MHz).

- Right to negotiate changes to the SMR parameters with neighbors subject to certification that changes will not cause harmful interference to third parties;
- Right to trade all or part of the SMR.

Under a parent SMR, SURs describe the right to transmit at specific locations or service area subject to constraints on the power spectral density and receive at a specific location with guarantees on the level of interference. That is, SURs would give:

- Rights to operate according to a set of defined transmission parameters and receive specified levels of interference protection;
- Rights for their receiver characteristics to be taken into account when a proposed change from a potential interferer is assessed;
- Right to trade the SUR;
- Rights to cede or alter current rights with respect to negotiated changes to transmission parameters with neighbors, perhaps subject to the approval of the SMR owner, as per contractual terms (SMR-SUR).

Ofcom used the SUR concept for an auction of the L-band (1400 MHz) spectrum in 2006. However, for most other terrestrial applications, existing licensing regimes that focus on transmitted power have been adopted instead, with boundary interference issues generally resolved through private negotiations among the service providers.

The SMR/SUR framework and its limited use provide an important reference for defining supra-terrestrial rights for satellite spectrum. While the SMR/SUR framework aims at clearly defining usage rights, the requirement that the specification includes sufficient detail to allow any change of use analysis is reminiscent of regulatory desires. In outer space, it is technically and economically very challenging to specify a large number of radio parameters[98] that can guarantee interference levels at different locations. The fact that supra-terrestrial transceivers are rapidly moving without a fixed location or boundary and that they typically use long-range directional transmissions presents additional challenges in specifying radio parameters and dimensional boundaries. For example, an uplink beam directed

[98] Ofcom proposed defining a Spectrum Management License (SMR) so as to limit the in-band power flux density (PFD) at the boundary and either the out-of-band (OOB) PFD within a range of the reference areas or the OOB effective isotropic radiated power (EIRP). The methods specify both key transmit parameters and key receive parameters, which may include indictive interference level (IIL) at a given separation distance and a receiver mask. A Spectrum Usage License (SUR) is one which defines the radio characteristics of a system in sufficient detail so as to allow adequate interference analysis as well as any change of use analysis. Ofcom noted the need for a large number of key transmit and receive parameters to be collected. *See Spectrum Usage Rights: Technology and Usage Neutral Access to the Radio Spectrum,* OFCOM, Apr. 2006, at 44-45 (explaining spectrum management and spectrum usage rights); *see also* William Webb, *Licensing Spectrum: A Discussion of the Different Approaches to Setting Spectrum Licensing Terms*, OFCOM, at 26-29 (discussing the PFD limits and how these limits impact spectrum licensing terms).

towards one's own satellite may spill emissions in the path of another operator's satellite when that asset moves closer in space.[99]

In the following, we consider a framework based primarily on setting interference limits rather than permissions to transmit (this is still needed to a lesser degree). The difference may appear subtle but can be consequential.

Initial access rights recipients are generally those parties able to productively deploy the resource. Assigning rights to other parties would then imply that at least one additional transaction is required to initiate gainful activity; directing awards to the productive party can be seen as saving resources. This need not be done by administrative fiat but perhaps via auction (bidding) or a variant of "right of user." Importantly, damages due to conflicts in radio space may be mitigated by changes (avoidance) either at the impacted receiver(s) or the transmitter(s) or, perhaps, via a remedy implemented somewhere in the space in between.

Some scholars argue that an appropriate policy arrangement consists of defining access rights at (potential) receiving locations.[100] Separate rights are then defined for the two directions in case of a two-way communication link, as signals from either direction often use different slices of spectrum.[101] To be more specific, rights on the ground can be defined similarly to cellular services, i.e., the right to impinge a given geographical area on earth with radio waves subject to certain power constraints. Likewise, rights in space can be defined similarly as the right to impinge a given geometric region with radio waves subject to certain power-spectral constraints. This way, rights on the ground and rights in space are defined in a fundamentally consistent manner.

To define receiver rights in the special case of NGSO systems, these forms of delineating rights in space (and surely others) are conceivable:

- *Spectrum Cells.* Divide the sky near the satellites' altitudes into cells. For example, a certain cell may be *x* degrees longitude and *y* degrees latitude above Washington, DC, which covers the metropolitan area. Suppose the

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[99] Transmissions in cellular systems with multiple antennas at the base station and mobiles can also be directional; however, the mid-band urban propagation environment, which tends to scatter signals, and mobility, make it more difficult to specify interference levels at particular locations than for satellites. *See* Carlo G. Riva, Lorenzo Luini, Alberto Panzeri, Filippo Morandi, Laura Resteghini, Danilo De Donno, Christian Mazzucco & Renato Lombardi, *A Clutter Loss Model for Satellite Communication Systems*, ELECTRONICS, Dec. 2023, at 1-2; Ghaith Hattab, Prakash Moorut, Eugene Visotsky, Mark Cudak & Amitava Ghosh, *Interference Analysis of the Coexistence of 5G Cellular Networks with Satellite Earth Stations in 3.7-4.2GHz*, IEEE, July 2018, at 1-2.

[100] *See* J. Pierre de Vries, *Optimizing Receiver Performance Using Harm Claim Thresholds*, 37 TELECOMM. POL'Y 757, 758, 761 (2013) (recommending the use of harm claim thresholds based on receiver strength profile and measurements of harmful interference to determine optimal receiver performance).

[101] If two-way communication occurs only over a relatively short range, i.e., the transceivers are near each other, it is often convenient and sufficient to define one right/license over the same area for both directions. This is manifest in auctions of spectrum for cellular market areas, e.g., FCC's Auction 97 [https://www.fcc.gov/auction/97].

spectrum is also divided into sub-bands of, say 500 MHz each. In that case, operators may acquire rights to transmit in some sub-bands to satellites as they fly above Washington, DC (and avoid noisy emissions into neighboring jurisdictions). An operator may bid for a bundle of such rights to provide national, continental, or even global coverage. As a satellite can switch channels as it crosses cell boundaries, an operator may acquire rights in different sub-bands in different cells to provide such coverage. Leases or roaming agreements (as in cellular services) could accommodate such coverage.

- *Orbital Spectrum Rights.* An alternative is to define one unit of access right for each orbit. The FCC has granted such rights to GSO satellites, stationary in the sky. In contrast, an NGSO orbit in the sky is a function of time, but an analogous right may cover a spatial band along an orbital path. The right protects a region that "moves" with a satellite's planned orbit. In particular, a static directional transmission may infringe on the right at one time (when the satellite flies into the beam) but not at other times. (Since an operator currently needs approval to occupy an orbit, the approval process efficiently bundles the procedure with parceling out spectrum access rights.)[102] Such an approach protects (moving) satellites rather than a stationary region. A consequence is that if a lone satellite is in a large region, its operator can transmit to it using the entire allocated band without infringing rights. Potential radio conflicts may arise when two satellites come close to each other or when a beam's sidelobes cover an unintended receiver. Such "collisions" would be remedied by dispute resolution mechanisms, with rules (such as incumbency or right of the user) establishing parameters for negotiated, arbitrated or imposed settlements.

The preceding definitions of rights, embedded in a system of liberal licenses, enable an operator to acquire access rights on ground and in space in the market to provide network services. It enables trading, leasing, or even open access (should the owner be so inclined or competitive conditions dictate) to spectrum resources. Such definitions are synergistic with advances in sensing, spectrum monitoring, and automated frequency assignments that can exploit side information about satellite trajectories to avoid interference and enable enforcement when conflicts arise. It is conceivable that NGSO access rights be merged or further divided to facilitate their most productive use as technologies, satellite utilization, and economic conditions evolve. Moreover, with receivers at the focal point of spectrum rights and relatively

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[102] Satellites may need to occasionally alter their orbits. *See Achieving and Maintaining Orbit*, NASA: EARTH OBSERVATORY (Sept. 4, 2009), https://earthobservatory.nasa.gov/features/OrbitsCatalog/page3.php [https://perma.cc/VBG6-AKJE] (discussing how a satellite achieves and maintains orbit).

loose requirement on transmitters, an operator is free to share downlink spectrum between supra-terrestrial and terrestrial transmitters.

Thus, defining transmission limits alone may leave key access rights ill-defined, hampering coordination. Methods to efficiently monitor interference levels and identify spillovers harming rival receivers may reduce conflict costs, including those resulting from uncertain enforcement. In particular, interference conflicts may not be easy to predict, and when they arise, it may be highly costly to identify the offending transmitter(s). It is notable that the FCC has already, in effect, embarked on this mission by proposing to divvy spectrum access for satellite on a 1/N basis when voluntary agreements for coordination fail.[103] A somewhat tricky case is when small interference from multiple parties collectively infringes on someone's right, even though a single party may be perfectly within tolerance. Rules have been conceived to hold identifiable trespasser(s) accountable.[104] The identification problem tends to be tractable when only a small number of operators are suspects, especially if every operator is equipped with a large number of transceivers that double as sensors. Moreover, the operators themselves may create standards imposing self-identifying "fingerprints" in transmissions to facilitate policing.

We have yet to resolve the challenge presented by the fact that transmissions are not precisely confined to a defined region. We have, however, made progress in the sense that it is now (as designed, at any rate) clear whose rights are infringed. Market transactions are thereby of lower cost to execute. In fact, the FCC's proposed change to limit the 1/N rule to parties granted access in the same round also aims to confine the parties in dispute, lowering transaction costs (among them, free rider problems). Until the regulator intervenes, it is up to the operators to resolve conflicts, including by trading. Often such trading takes place by sharing facilities rather than radio spectrum. This happened spontaneously early in the history of U.S. satellites when transponder space on orbiting satellites was sold to various parties, allowing many individual companies to share the broadcasting capacity of a given space vehicle. This has been called the "condominiums."[105]

VI. CONCLUSION

The U.S. satellite industry has enjoyed a tumultuous history. It has brought high-valued innovations to telecommunications services and provoked pro-competitive

[103] *See* Berry et al., *supra* note 81, at 6-7 (discussing how the 1/n rule is applied when there is unacceptable interference and conflict exists between systems).

[104] *See* De Vany et al., *supra* note 86, at 1503-04 (explaining that there are three precautions taken to reduce radiation: consistent rate of transmission and method of modulation, careful design of transmitter and receivers, and adequately maintaining transmitters and receivers).

[105] *See* Owen, *supra* note 8, at 147 (discussing selling satellites as "condominiums" instead of the entire satellite because they were so expensive).

reforms throughout the sector. Technological advances are once again producing great excitement, with a new generation of small, inexpensive, modular satellites clustered in large constellations supplying competitive broadband networks. This rivalry to terrestrial wired and wireless infrastructure augurs to be of central importance in the Internet Economy. How public policy adjusts to these market disruptions and enables competitive access to the orbital slots and radio spectrum on which it depends figures to have a large impact on economic development.

In a world of little contentiousness, property rules may not be worth their expense. In satellites, we have some experience with casual rules of access doing a reasonable job coordinating conflicts, even as many experts warned of over-crowded skies decades ago—when a tiny percentage of today's satellite traffic was observed.

But it appears that the investment in a more formal and fulsome rights regime may, at last, be at hand. First-in-time rules, as used in many satellite contexts, are becoming utilized and more valuable. Alternative means of initial assignments may provide efficiencies. In this paper, we consider how defining spectrum spaces in outer space might work, alternatively focusing on transmission rights or receiver rights. The approach is preliminary and hopefully sparks debate. Much more thinking needs to be done.