SPACEX

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The Manager
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Via email: spectrumworkprogram@acma.gov.au

Re: *Response to Five Year Spectrum Outlook 2023-28 and 2023-24 Work Program*

To whom it may concern:

Starlink Australia Pty Ltd ("SpaceX") appreciates the opportunity to respond to the Australian Communications and Media Authority's ("ACMA") five-year spectrum outlook 2023-28 and 2023-24 work program (the "Consultation").[1] Below is a general overview of SpaceX and its Starlink product, along with specific responses to the Consultation.

I. Background

SpaceX is a private company founded in 2002 to revolutionize space technologies, with the ultimate goal of enabling humanity to become a multi-planetary species. SpaceX has achieved a series of historic milestones and is proud to have become the first private company in history to send astronauts to orbit and safely return them to Earth. To date, SpaceX has successfully launched more than 150 missions to space.

SpaceX is leveraging its accumulated expertise in space system manufacturing, design, and operations, to develop Starlink, which is served by a constellation of satellites designed to provide high-speed, low-latency, competitively priced broadband service to locations in Australia and anywhere around the globe. SpaceX's first-generation constellation consists of over 4,400 non-geostationary orbit ("NGSO") fixed-satellite service ("FSS") satellites and extensive ground infrastructure employing advanced communications and space operations technology. SpaceX has invested billions of dollars in this system and is currently launching 120 satellites per month on average, along with building gateway and end-user terminal antennas. Starlink is designed to make efficient use of radio spectrum resources by optimizing its ability to flexibly share spectrum with other licensed satellite and terrestrial users, including through advanced beam-forming and digital processing technologies. SpaceX currently links satellites to the customer user terminals in the Ku-band for both uplink and downlink frequencies, with gateway links in the Ka-band.

[1] *See* ACMA, "Five-year spectrum outlook 2023-28 and 2023-24 work program," Draft for Consultation (March 2023) ("FYSO").

The events of the past two years have reminded us all of the importance of being able to connect people and businesses through high-speed Internet service, whether to complete school lessons, connect with distant family and friends, conduct business, or even to run a government. Powerful next-generation satellite systems supported by robust backhaul connectivity will enable all consumers across Australia to use the bandwidth-intensive, real-time applications that have become essential to accessing remote work, school, and public services.

To meet these evolving consumer needs, whether in the suburbs of Sydney or the most remote parts of Western Australia, SpaceX is currently building and deploying its next iteration of its Starlink commercial satellite service. This next-generation technology includes upgraded end-user terminals, new satellite technology, and improved gateway ground stations that will provide customers with even higher speeds. For example, in addition to the Ku- and Ka-bands, SpaceX has developed satellites capable of also utilizing the 71-76 GHz and 81-86 GHz band (the "E-band"). In doing so, SpaceX can leverage the high-gain, narrow beam characteristics of E-band links to expand backhaul link capacity to meet ever-increasing consumer demand. SpaceX has also designed its gateway earth stations to utilize these spectral features to efficiently co-exist with terrestrial services using minimal separation and common frequency coordination techniques.

These innovations extend beyond FSS operations, where SpaceX has sought authorization to make better and more efficient use of mobile satellite service ("MSS") frequencies, particularly the 1-2 GHz ("L-band") and 2-4 GHz ("S-band") frequencies. These frequencies present an untapped opportunity for new entrants and can enable expanded mobile services for consumers, particularly those in traditionally unserved or underserved portions of Australia. SpaceX's state-of-the-art satellites will utilize advanced phased array beam-forming and digital signal processing techniques to efficiently utilize spectrum resources and promote co-existence with other space-based and terrestrial-licensed users within these bands. Moreover, SpaceX can support these frequencies without increasing the number of satellites in orbit, without altering any orbital characteristics on its satellites, and without requiring any additional physical coordination.

Most recently, SpaceX has sought authorization to launch satellites capable of extending the networks of mobile operators and providing service direct to consumer mobile handsets. This technology is capable of extending mobile operator networks in the mobile bands between 1600 MHz and 2690 MHz. This supplemental coverage from space will enable truly universal coverage for millions of consumers, resilient emergency connectivity in even the most challenging circumstances, and maximally efficient use of valuable mobile spectrum resources. Beyond traditional consumer services like voice and messaging, supplemental coverage from space can also enable a range of Internet of Things ("IoT") use cases—monitoring critical infrastructure, tracking vehicles, deploying smart agriculture solutions, and detecting wildfire activity in remote locations, to name a few.

SpaceX began its beta Starlink service in Australia in April 2021 in the Ku and Ka bands. Today, Starlink is capable of serving large parts of the country. Starlink customers in Australia typically experience speeds exceeding 100 Mbps, with reliability nearing 100 percent. SpaceX is excited to serve even more Australians, with a particular desire to reach those who are currently unserved or underserved by expanding services in E-band, L-band, and S-band.

II. Response to the Five-Year Spectrum Outlook

SpaceX appreciates the ACMA's focus in the FYSO 2023-28 on ensuring that next-generation satellite systems have the spectrum resources necessary to meet growing consumer demand for high-speed, low-latency broadband to connect to real-time applications for work, school, health care, and government services. As the ACMA finalizes this FYSO, SpaceX urges it to (1) protect essential co-primary spectrum for FSS; (2) prioritize opening high-priority high-frequency spectrum—including the E-band—that is necessary to keep pace with growing consumer demand; (3) maintain the ACMA's successful light-touch approach to satellite regulation that rightly encourages private operator-to-operator coordination and cooperation to drive efficient outcomes without massive administrative overhead that would harm consumers, competition, and innovation; and (4) adopt the Cost Recovery method to spectrum license fees coupled with other policy incentives for sharing spectrum efficiently between all spectrum users.

A. Protect co-primary satellite spectrum

As an initial matter, SpaceX urges the ACMA to protect essential co-primary spectrum for the FSS so that consumers in all parts of Australia can receive competitive, high-speed, low-latency broadband.

Even in areas that are nominally covered by terrestrial service, next-generation satellite broadband can provide a competitive alternative comparable or superior to existing terrestrial, fixed networks for both speed and latency. As terrestrial networks seek higher-frequency bands for mobile communications, including in more densely populated areas, favoring mobile use to the detriment of satellite broadband could risk harming consumers by reducing necessary capacity in critical satellite user-link bands and by limiting the ability of satellite networks to deploy gateway sites that serve rural and remote end users.

For these reasons, as the ACMA considers new allocations for terrestrial services, it should protect current and future customers of next-generation satellite services by preserving full access to critical co-primary satellite spectrum (e.g., Ku-, Ka-, Q/V-, and E-band) and adopting appropriate technical and operational rules to ensure satellite operators have sufficient spectrum resources to meet growing demand for high-speed, low-latency broadband.

B. Expedite authorization of higher-frequency bands for satellites

Consumer demand for next-generation satellite services is quickly outstripping the supply of spectrum allocated for backhaul. SpaceX therefore recommends that the ACMA expedite the authorization of higher-frequency bands that have already been allocated to the FSS and evidence a strong near-term interest from next-generation satellite providers in using the bands to serve consumers. By quickly authorizing access to these critical spectrum bands, the ACMA can ensure operators can stay ahead of consumer needs and Australians never experience unnecessarily diminished service.

The ACMA has done impressive and necessary work over the last several years to make available Ku-band and Ka-band spectrum to facilitate the deployment of non-geostationary satellite networks in Australia, and to reduce licensing fees that lower barriers to deployment and costs for consumers. As shared spectrum bands with limited capacity, however, these bands will face an imminent crunch as more consumers use increasingly bandwidth intensive applications and competitors seek to deploy in the market.

To avoid a spectrum crunch and keep pace with rapidly changing consumer needs, the ACMA can make additional spectrum available for NGSO satellite systems expeditiously, including Q/V- and E-band spectrum. Many NGSO providers have filed at the ITU and at the national level (e.g., in the United States) for these bands, and the technology is ready for imminent deployment to serve consumers. To make these bands available immediately, ACMA can adopt a "default" rule that permits operators to license allocated spectrum bands that do not yet have service-specific rules on a case-by-case basis (as the United States does[2]), and in parallel adopt durable, light-touch service rules—such as light-licensing—for earth stations that leverage existing rules and self-coordination to drive rapid deployment and consumer benefit.

C. Maintain the ACMA's successful light-touch regulatory approach

The ACMA's long-standing policy of "encourag[ing] cooperation and coordination between satellite networks to achieve mutual benefit, without the burden and delays of additional prescriptive regulation,"[3] has been a boon for Australians, and a model for policy frameworks around the world. The ACMA's approach has been the gold standard for maximizing use of spectrum, as operators themselves are in the best position to understand how their systems can cooperate with each other to provide the best services and the most choices for Australian consumers.

Maintaining the ACMA's current approach would be consistent with most other regulators that have considered how best to encourage cooperation among operators. SpaceX is currently operating in more than 50 countries and has engaged deeply with the governments in each. While some operators have attempted to have regulators step into coordination discussions, nearly every time the regulator has decided that these issues are best handled by the operators directly without regulatory intervention. For example, when the Chilean government was asked to intercede in a negotiation over placement of gateways between two operators, the regulator evaluated the request and opted to issue only a brief statement summarily dismissing the request. The regulator correctly

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2 *See* 47 C.F.R. § 25.217 (setting default service rules that permit the FCC to issue "licenses to operate a satellite system [including earth stations] in a frequency band granted after a domestic frequency allocation has been adopted for that frequency band, but before any frequency-band-specific service rules have been adopted for that frequency band"). This default framework is an important way that the FCC encourages innovation beyond experimental licenses so that multi-year regulatory processes do not serve as a gate on fast-moving innovation that could benefit consumers across Australia.

3 *Id.*

determined that it should not relieve the parties of the burden to coordinate in good faith, and ultimately the discussions resulted in an agreement.

SpaceX is not aware of a case that merits changes to the existing successful licensing framework. A departure from the ACMA's successful light-touch approach would harm consumers by raising barriers to entry for innovative companies and delaying service deployment, particularly in rural and remote areas that lack terrestrial service. Moreover, designing and managing complex regulatory regimes such as public consultations, auctions, and beauty contests would require massive additional administrative overhead for speculative or no benefit compared to the existing, successful model. Finally, adopting an interventionist approach would directly contravene the Deregulation Agenda as it applies to satellite regulation and spectrum management, reversing the many strides that the ACMA has taken over the last several years to foster a robust, competitive, and consumer-focused satellite market.

Rather than adopt interventionist policies that require the ACMA to intermediate private coordination discussions, SpaceX recommends light-touch policies that create incentives for timely, good faith coordination without delaying serving provision to consumers. For example, the ACMA should permit next-generation satellite systems to operate in Australia on a non-interference, non-protection basis while undertaking coordination with other operators, so long as the operators are coordinating in good faith. In addition, the ACMA should adopt "default" spectrum-splitting rules to encourage efficient resolution of coordination discussions. For example, the United States also has adopted a default spectrum-sharing rule under which, if two operators have failed to reach a coordination agreement by the time they are operational, the operators will split the available spectrum. This "Solomonic" spectrum-splitting approach presents certain advantages. First, because no operator desires to operate with access to less than a full allotment of spectrum, all operators will have the incentive to reach a coordination agreement quickly that is better suited to its particular system. Second, this straightforward resolution limits the degree to which the ACMA would need to involve itself in operator-to-operator negotiations. Of course, the ACMA also has the opportunity to tailor it own approach to maximize preferred public policy outcomes. For example, the ACMA can give first choice of spectrum to the operator with the more efficient system, creating an incentive to invest in spectral efficiency. Alternatively, the ACMA could require both operators to split any encumbered spectrum evenly once operational, making all spectrum truly fungible. If the ACMA does alter its current, successful light-touch approach, this spectrum-splitting model would create the proper incentives for operators to build more efficient systems, to coordinate in good faith, and ultimately to offer competitive services for Australian consumers.

D. Adopt the Cost Recovery method for license fee calculation

SpaceX urges ACMA to consider policies and tax formulas that specifically reward the use of advanced wireless technology that improves spectrum efficiency and enables sharing both within and across platforms. Therefore, SpaceX believes ACMA's spectrum efficiency goals would be better served with a Cost Recovery method for spectrum fee pricing, tied with other policy incentives for efficiency, as opposed to the Opportunity Cost method that currently forms the basis of ACMA's license fee philosophy.

At the core of the Opportunity Cost method is the idea that a regulatory body should evaluate the cost of assigning one use of spectrum over any other use, then attribute those costs to the spectrum license holder. This method results in a skewed assessment for three reasons: 1) it does not account for spectrum sharing among different services, 2) it discourages coordination among users, and 3) it unrealistically relies on the regulator having perfect information about different services. Instead, a Cost Recovery method through which ACMA charges only to recover its own costs, coupled with policies to encourage spectrum efficiency, will lead to faster deployment, more competition, and ultimately better and more choices for Australian consumers.

The Cost Recovery method avoids the problems of the Opportunity Cost method by rejecting the idea of spectrum licensing fees as a primary lever for influencing license holder behavior and instead conceptualizes spectrum license fees more simply as a way of recovering the administrative costs of processing the license itself. As one example, the United States employs a fixed application fee for spectrum use, where the licensing fees for a fixed satellite earth station would range in the hundreds of dollars, instead of hundreds of thousands of dollars. This pricing structure allows the government to recover expenses for processing applications but does not discourage new entrants, new technologies, or network expansion.

In fact, the Cost Recovery method is the primary approach of most advanced Western telecom regulatory bodies, reflected by the stark contrast of spectrum licensing fees between Australia and other countries. SpaceX, as a global system, is currently engaging regulators around the world, and it so far appears that Australian spectrum licensing fees are indeed <u>the highest</u> in the world.

Alongside the Cost Recovery fee method, ACMA would be well served to embrace policies that actively incentivize spectral efficiency for all spectrum users—whether in space or on the ground. Mechanisms that enable and encourage technologies and techniques for spectrum sharing between fixed satellite service and terrestrial users on a more co-equal and technologically neutral basis will allow multiple technology platforms to flourish, as innovation across the communications industry has disproven the historical presumption that satellite and terrestrial technologies cannot share spectrum.

III. Response to the 2023-24 Work Program

SpaceX appreciates the ACMA's ambitious work program for the 2023-24 period. To ensure that the work program sufficiently addresses the most pressing needs of satellite operators to meet growing consumer demand now and in the future, SpaceX recommends that the ACMA elevate the following two issues into its 2023-24 work program: (1) adopting self-coordinated light-licensing for Q/V- and E-band satellite gateway earth stations, (2) expanding shared MSS use of the S- and L-bands, and (3) unlocking spectrum above 100 GHz for satellites.

A. Adopt light-licensing for FSS gateways in the Q/V- and E-bands

To best serve the needs of consumers and businesses across Australia, the ACMA should add a 2023-24 work program item to expedite FSS licensing regimes in the Q/V- (37.5-42.5 GHz / 47.2-50.2 GHz / 50.4-51.4 GHz) and E-bands (71-76 GHz / 81-86 GHz) — proceeding expeditiously toward the implementation stage so that consumers can benefit from this essential spectrum as soon as possible. Specifically, the ACMA should extend its database-assisted light-licensing framework in these bands to enable both fixed links and FSS to register ground equipment on a first-come, first-served basis through a self-coordinated process. This process could build upon existing rules, regulations, and licensing mechanisms for apparatus licensing above the Ku and Ka bands, while streamlining the review process through self-coordination using the same process that is currently available to fixed links in the band.

A unified light-licensing approach in the Q/V- and E-bands to drive next-generation satellite connectivity for Australian consumers and businesses is warranted for several reasons. First, a unified light-licensing approach would respect the co-primary allocation of FSS in the Q/V- and E-bands. The ITU Radio Regulations and the ACMA have already allocated the Q/V- and E-bands on a co-primary basis to the FSS, with specific protections for the FSS band viz-a-viz terrestrial services. To respect this co-primary allocation and ensure that future deployments of FSSs in the band stand on equal footing with terrestrial deployments, it is important that the ACMA develop a common approach that allows both services to deploy with equal ease. Since fixed links can currently avail themselves of a rapid self-coordinated licensing process, the same process should be available to FSS gateways.

Second, regulatory bodies around the world, including the ACMA, have recognized that the unique properties of E-band links permit coexistence with minimal physical and angular separation, justifying a self-coordinated approach to licensing.[4] Like fixed links, FSS gateway antennas will use high-gain, directional "pencil" beams that an coexist in close proximity to other users. While gateway antennas require higher main-beam power levels than fixed links to close links with faraway satellites, they also typically use high minimum elevation angles (e.g., 25 degrees), nearly eliminating the risk of inline events with terrestrial links. Moreover, using techniques such as shielding and low sidelobes toward the horizon, satellite operators can dramatically reduce EIRP toward the horizon—the operative metric for measuring gateway interference risk to terrestrial links. In this way, FSS gateways will present an interference risk

[4] *See* ITU Recommendation ITU-R F.2006, 1 (rev. Mar. 15, 2012) (noting that in the E-band "high directivity antennas are achievable even with small size antennas, increasing the density of equipment and further reducing risk of interference with same and other services."); ECC Rec. (05)07, 1 (rev. 2013) (finding that due to the "inherent reduced interference occurrence probability" in the E-band, "[m]ultiple services and applications can be implemented, with simplified coordination mechanisms, ensuring highly efficient re-use of the frequency band."); *Allocations and Service Rules for 71–76 GHz, 81–86 GHz and 92–95 GHz Bands*, 18 FCC Rcd 23318, ¶ 45 (2003) (noting that links in the band "may be engineered to operate in close proximity to other systems so that many operations can co-exist in the same vicinity without causing interference to one another"); "Millimetre Wave Point to Point (Self-Coordinated) Stations," RALI FX20, § 2.1 (May 19, 2016).

comparable to the fixed links under RALI FX20, supporting a common approach to E-band licensing.

Third, unified light-licensing is the most administratively efficient means of expanding access to the E-band and driving rapid deployment to benefit consumers, including in rural and remote areas. The ACMA has already allocated the E-band to the fixed satellite service and has adopted technical, licensing, and fee frameworks that apply to apparatus above Ku and Ka bands. A multi-service, self-coordinated light-licensing approach in the E-band would further speed review and approval time, reducing administrative cost and labor associated with manual reviews for all but the most complex interference scenarios. Moreover, a self-coordinated approach would facilitate coordination between different co-primary services in a manner that permits efficient deployment of both services to the benefit of people and businesses alike. This model could dramatically improve the satellite earth station licensing process in Australia while providing better connectivity for Australian consumers.

Together, these factors more than justify advancing authorization discussions and swiftly moving toward implementation of rules to permit NGSO FSS networks to license gateway earth stations in the Q/V- and E-bands through a self-coordinated light-licensing framework.

B. Expand shared MSS use in S- and L-bands

Rapidly evolving consumer demands are not limited to fixed service alternatives, as demand for ubiquitous connectivity grows more pronounced. Next-generation satellite services can now scale to the degree necessary to provide robust and reliable MSS connectivity that complements existing FSS services. As the ACMA has already recognized, the existing MSS allocations in the S and L-band are insufficient to support the capacities required for future use implementations and services envisioned by modern network architectures. Current proposals to expand MSS operations in portions of the S-band, particularly the 1980-2005 MHz and 2170-2190 MHz bands, will facilitate the development of these innovative satellite services to the benefit of all Australians, and SpaceX supports the ACMA in proceeding with licensing these bands for MSS operations. In addition, SpaceX supports the ACMA in making additional L-band spectrum available for more expansive MSS services, as currently proposed. Enabling broader access to MSS frequencies will enable enhanced mobile services through satellite connectivity.

To these ends, it is crucial that the ACMA explore licensing frameworks that do not involve exclusive licensing or auctioning of these MSS frequencies. Numerous instances have demonstrated that auctioning satellite spectrum is uneconomical and preclusive of efficient sharing between next-generation satellite systems to the benefit of consumers. Rather, next-generation satellite systems, such as SpaceX, employ advanced capabilities that enable effective and efficient spectrum sharing between systems. Modern communication technologies, such as sophisticated phased arrays and advanced beam scheduling protocols, enable modern MSS systems to capably co-exist with other licensed users of the band, space-based or terrestrial. The ACMA should leverage these innovative capabilities to maximize access to these scarce spectrum resources, rather than implementing policies that forestall technology development and lead to underutilization of these bands.

With respect to service requirements, the ACMA should not avoid preemptively adopting broader international proposals that may forestall the potential MSS services that are emerging. In particular, the ACMA should avoid predetermined technical limits, including acceptable MSS uses or power limits. In evaluating the S-band allocation, ACMA has already recognized that administrations are in the best position to make such determinations and that a broader MSS ecosystem is in interests of the Australian public.

Expanded MSS operations is a critical step to enhancing broadband connectivity and reaching a more equitable broadband environment that is inclusive of all Australians. SpaceX supports the ACMA in exploring broader MSS frequencies and expanding the use of satellite services for enhanced mobile services.

C. Unlock spectrum above 100 GHz

As it monitors trends in spectrum needs of space-based communication systems and technological developments as a part of its satellite planning, the ACMA should consider next-generation satellite services in any investigation of spectrum above 100 GHz. Spectrum above 100 GHz will play an important role in supporting high-speed, low-latency satellite networks in the future, helping consumers meet the growing demand for real-time applications and services. Timely access to this spectrum will be particularly important to support next-generation non-geostationary orbit satellite networks, which can reach consumers and businesses across the Australia, including in rural and remote areas that lack terrestrial networks.

Today, the FSS is allocated at the ITU on a co-primary basis in a number of promising spectrum bands above 100 GHz, including several bands in the Space-to-Earth direction (e.g., 123-130 GHz, 158.5-164 GHz, 167-174.5 GHz, and 232-240 GHz) and others in the Earth-to-Space direction (e.g., 209-226 GHz and 265-275 GHz). In terms of prioritization of these frequencies for assignment, frequencies closer to 100 GHz—including the 120-170 GHz and 210-310 GHz bands—are more useful to serve consumers of FSSs in the near term than even higher frequency bands. This is because lower frequencies generally experience lower levels of atmospheric attenuation. This relatively lower attenuation is essential to enable satellite ground infrastructure to close long links with satellites. In contrast, bands in the 310 GHz – 20 THz range have extremely high atmospheric attenuation, causing the atmosphere to be nearly opaque to electromagnetic waves and therefore difficult to use with current technology, except over short distances. As the ACMA assesses how to maximize the value of these bands for consumers, it should consider the impact of atmospheric attenuation on various use cases, avoid misallocation of scarce spectrum resources, and seek opportunities to optimize 100-310 GHz spectrum (e.g., making available additional uplink spectrum), noting that these frequencies may not be as fungible as those in other lower-frequency bands.

With respect to licensing, SpaceX agrees with Ofcom's recent discussion paper that regulators should adopt "spectrum sharing by default"[5] for spectrum above 100 GHz through a light-touch model to promote rapid deployment of robust backhaul connectivity to benefit consumers. However, spectrum sharing is not monolithic, and it will be important to choose the right spectrum sharing model for these bands. As with the E-band, a multi-service light-licensing approach in higher frequency bands would have several benefits: it speeds review and approval time by automating basic compliance and coexistence checks; reduces administrative cost and labor associated with manual reviews for all but the most complex interference scenarios; facilitates coordination between different co-primary services; and promotes rapid deployment of ground equipment for high-speed, low-latency wireless networks, benefitting people and businesses alike.

Finally, SpaceX appreciates the importance of high-frequency spectrum for earth observation and other space sciences. Fortunately, next-generation satellite operators have deep experience successfully coordinating with other co-primary users and are readily able to coexist with space services. SpaceX encourages the ACMA to assess how the large swaths of spectrum allocated to those services might be shared efficiently with next-generation satellite broadband networks.

IV. Conclusion

SpaceX is very grateful for the ACMA's consideration and collaboration and looks forward to continuing to serve Australian customers with even faster speeds as we continue to launch more satellites and deploy more ground infrastructure around the world.

Respectfully submitted,

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5 *See* Ofcom, "Unlocking the potential of Terahertz radio spectrum," Discussion Document, 3 (2 Dec. 2021).