SpaceX Response to TRAI Consultation Paper on Assignment of Spectrum for Space-based Communications Services

Introduction

SpaceX and its local subsidiary, Starlink India, thank the TRAI for this opportunity to comment on the crucial issue of assigning spectrum for enabling Space-based Communication Services in India.

Since 2002, SpaceX has maintained unwavering commitment to – as well as demonstrated the value and potential of – a vibrant, open, and global space economy. Increased participation in the global space industry is fundamentally aligned with both SpaceX's launch business as well as its core mission of a multi-planetary future for humanity. Additionally, through Starlink, SpaceX has helped redefine global expectations of what satellite Internet can achieve. As a result, Starlink is currently authorised in 84 administrations and has grown to over 1.5 million active users (all within less than two-and-half years of initiating beta service).

SpaceX's objectives align closely with India's national goals for both its telecommunications and space industries, and we appreciate the thoughtfulness of TRAI's analysis within this consultation paper. SpaceX believes that high-speed, low-latency satellite broadband is one of the fastest ways to close the connectivity gap, and the TRAI accurately recognizes the value of NGSO systems towards bridging India's digital divide. The TRAI also identifies many of the fundamental challenges that *must* be resolved while deciding on any assignment mechanism (but even more so when considering one that is globally unprecedented). **Our strongest recommendation is thus that the TRAI must guarantee certain essential technical requirements that are fundamental for LEO, NGSO systems to be able to provide service – especially shared access nationwide to the entirety of the critical bands allocated to FSS service for all satellite operators.**

Next-generation NGSO satellite networks have been designed to share spectrum among systems, making extremely good use of the scarce spectrum resource because multiple operators can coexist, subject to mutual coordination agreements. Technical innovations including narrow, steerable beams that allow frequency reuse within and between systems support this sharing approach. SpaceX believes that any assignment process that seeks to maximise the overall value of satellite spectrum should also maximise efficient spectrum use in a manner that avoids under-utilisation of spectrum. Further, public revenue, and public benefit, can be optimised by maximising the number of operators who can provide services within the market.

In its more than two years of operation, Starlink has demonstrated that satellite spectrum can be shared between multiple systems and has learned that everyone benefits from a spectrum management model that encourages innovation and drives efficiency. Further, imposing high costs on operators will simply drive-up costs to consumers. Therefore, as detailed below, we believe the best approach for assigning access to spectrum for satellite broadband is a shared model with an administrative assignment process and a requirement for satellite operators to coordinate with each other in good faith. We believe this approach will meet the technical requirements for modern satellite systems and support them in maximizing public welfare while providing a fair return for the use of the spectrum.

We demonstrate in our response how the fundamental design characteristics and technical requirements of satellite systems render any auction design meant for terrestrial mobile systems entirely unworkable. We also show how forcing such an auction design onto satellite systems will have extreme negative effects on a number of essential national policy priorities. At its core this is because dividing spectrum (even exclusively) amongst operators has disastrous impacts on satellite systems' ability to function, while forcing rivalry and scarcity in order to make auctions work fundamentally sabotages operators' incentives, precludes competition, reduces affordability, undermines price discovery, minimises spectrum value over time, disincentivizes innovation, and discourages investments into the Indian space industry. Nonetheless, we also attempt to provide an alternate auction design framework that maintains the fundamental shared spectrum requirements of satellite systems while balancing public policy considerations.

We have structured our response across seven sections. **Sections A-C** outline a framework for analysing this issue. **Section D** provides our specific recommendations on how to proceed. **Section E** provides our attempt in good-faith at proposing an alternate auction design that protects satellite systems' fundamental spectrum requirements (but despite our best efforts still fails certain policy priorities and is thus not recommended). **Section F** provides a comparison table of options. **Section G** contains our individual responses to certain questions posed in this consultation.

A. Fundamental Requirements for LEO, NGSO systems.

Next-generation satellite systems operating in low-Earth, non-geostationary orbit are able to provide satellite broadband with much higher throughput that can serve many more users (through iteratively deploying constellations of numerous satellites), and lower latency (by virtue of being many times closer to the surface of the Earth) than previous satellite systems.

These advantages enable such systems to provide service quality that is similar to terrestrial fiber broadband networks and is far superior to legacy geostationary systems. Next-generation satellite systems enable true broadband access independent of extensive ground infrastructure. NGSO systems also maintain the advantages of satellites over terrestrial systems i.e. ubiquitous access and universal service. They are capable of rapid deployment in any location - independent of the terrestrial system economics that have previously made it unattractive to serve users in remote or low-density regions. High-speed, low-latency satellite broadband is thus demonstrably one of the fastest ways towards fulfilling the promise of *Antayodaya* and finally closing the connectivity gap for currently underserved communities.

As noted by the TRAI, next-generation NGSO satellite networks are designed to *share* the spectrum allocated to them (and allow future entrants into the same spectrum bands), rather than requiring exclusive spectrum access that precludes competition. Indeed, spectrum sharing across the entirety of the globally harmonized FSS bands is a core aspect of these systems. Next generation satellite systems use cutting-edge technology to optimize the use of the same spectrum by several different operators at once to best serve consumers with a variety of solutions.

This sharing environment is fundamental to how such systems optimise frequency use, and is made possible because of advanced satellites that (1) use narrow and steerable beams, (2) extremely advanced user terminals that immediately react to interference, and (3) systems that leverage the propagation characteristics of higher frequency bands to incorporate reuse and sharing of spectrum as baseline design parameters alongside global coordination with other operators. As a result, operating such systems depends on globally harmonious approaches to spectrum use, technology, and regulatory environments. Furthermore, many next-generation satellite systems use gateway earth stations that also depend on access to the same globally harmonized frequencies shared by all satellite operators around the world.

The ability of satellite operators to share spectrum efficiently - especially to provide "meaningful connectivity" - depends on access to the entire spectrum allocated to FSS. Next-generation systems cannot operate on narrower slivers of spectrum sliced along smaller geographic boundaries (even with exclusive access).

NGSO systems are inherently and necessarily global. LEO NGSO satellites orbit the Earth in as little as 90 minutes to provide service at locations around the world. This enables affordable connectivity deployments everywhere since the high costs of deploying cutting-edge infrastructure in space can be diffused globally, but also requires the systems to have access to the same spectrum bands across the planet. The global nature of these systems flows not just into their economics but also their technical characteristics. Since these systems must co-exist and share spectrum around the world, all of the various components – from the satellites to the user terminals and gateway infrastructure – are designed to operate in a shared environment.

Terrestrial operators do not use technology capable of similar spectrum sharing with competitors, and as a result auction designs used to assign mobile spectrum were required to contemplate underlying assumptions of exclusivity and rivalry. Such assumptions simply do not apply to next-generation satellite systems that are designed to share spectrum with other satellite systems. Forcing the same assignment models used for terrestrial services onto the assignment processes for satellite spectrum would impose unnecessary, vestigial constraints and is extremely ill-advised - it will hurt those in India who need connectivity the most by limiting their options, dramatically affect their affordability, and disincentivising innovation.

Any spectrum assignment mechanism designed for satellite services must absolutely satisfy three fundamental requirements -

1. **Predictable and guaranteed access across the entire critical bands allocated to FSS (for both user terminals and gateways) on a shared basis.**

   The TRAI correctly recognises the negative impacts on service and system capability from having access to fewer channels within a country (even if on an exclusive basis). However, it is also worth emphasising that these costs are disproportionately high. NGSO systems are designed to comply with the ITU's global rules, including with respect to the bands for which FSS systems are designed. These systems cannot provide quality service when restricted to only parts of the required Ku and Ka bands, as they are designed to use multiple wide channels in order to operate efficiently (which includes both providing sufficient capacity and avoiding interference between beams of the same and other systems). An NGSO system's user terminals also cannot operate without the associated gateway systems that route traffic to and from the internet on the ground. NGSO systems are designed to efficiently utilise and share the entirety of the bands allocated to FSS, and incorporate numerous design innovations such as steerable narrow spot beams and dynamic network architectures to do so. As a result, shared spectrum access has been - in our experience - trouble-free in providing high-speed connectivity to millions of previously underserved users around the world.

2. **Access to critical spectrum across wide and contiguous channels on a national level without geographical restrictions.**

   One of the key benefits of satellite systems is that they can serve users irrespective of geography. The use of spectrum - especially with respect to user terminals - and thus the deployment of satellite service within a country cannot be geographically divided across different NGSO systems. The primary capital infrastructure of NGSO systems (i.e. the satellite constellations) are always capable of complete coverage. As a result, users can only benefit from the lower prices enabled by these constellations when the service areas in which they operate are not artificially constrained.

   If such restrictions are imposed, they will impact end-users thrice –

   a. they must pay higher prices since the constellations are artificially under-utilised below their capabilities while the costs of deployment and operation remain unchanged;
   b. they must pay higher prices due to the artificially reduced market competition and consumer choices that emerge from unnecessary restrictions along geographical lines; and
   c. because the users most in need of satellite broadband are dispersed across the country and the costs of providing NGSO broadband are immune to location, imposing geographic limitations disproportionately hurts precisely those who need satellite broadband the most.

3. **Ensuring shared access to the entire critical bands on similar terms for all operators that provide similar services in a harmonized manner.**

   While satellite firms may compete for customers, the industry has repeatedly demonstrated both the willingness and the ability to share the common necessary resource of accessing the same spectrum. Satellite operators work with each other to coordinate spectrum access based on the specific characteristics and needs of their systems.

   It is thus essential that the regulatory framework provide similar access to spectrum for all satellite operators that are willing to coordinate in good faith and share spectrum towards the common goal of delivering potentially life-changing services to Indian citizens.

Where these requirements are met, *all* satellite operators can provide high-quality connectivity together. If these requirements are not met (or largely unmet with exclusive access), it compromises the abilities of every satellite operator to provide meaningful connectivity as well as operate in an environment of healthy competition - to the detriment of un-served or under-served Indians.

B. National policy priorities for the Indian telecom and space sectors.

SpaceX and Starlink India appreciate that the Government of India must optimise across multiple policy considerations when assigning public-good natural resources such as spectrum in a manner that maximizes the common good. Our recommendations and assessment framework for satellite spectrum assignment mechanisms recognise at least the following policy goals –

1. **Rapidly bridge the digital divide through universal broadband connectivity that maximises affordability.**

   The Government of India has taken major steps to realise the economic, social, and political potential of universal broadband via both public and private means. Next-generation satellite systems will play a fundamental role in achieving the goals first outlined under India's National Digital Communications Policy of 2018 – including universal broadband connectivity at 50 Mbps to every citizen, 100 Mbps broadband access to all developmental institutions, and ensuring connectivity across all uncovered areas. The critical contributions of next-generation satellite broadband systems stem from their ability to instantly enable broadband access across the entirety of India, at prices that are far more affordable than previously thought possible. Efficiency and speed are essential policy considerations when assessing assignment processes, and the TRAI's recommendations must thus minimise operational and regulatory delays that could impede the rapid deployment of broadband for all.

2. **Accurate price discovery to determine a fair return for accessing the spectrum resource.**

   The TRAI correctly notes that a fundamental requirement of spectrum assignment methods – particularly auctions – is accurate price discovery that determines the fair value of access to the spectrum resource. While traditional auctions for mobile spectrum rely on a combination of competitive bidding and accurate reserve price setting to satisfy this requirement, such an approach fundamentally relies on mobile operators needing spectrum on rivalrous and exclusionary grounds. As the TRAI repeatedly and correctly notes, this is simply not the case for satellite spectrum use.

   The TRAI also notes that accurately determining auction reserve prices - as well as the ability of operators to correctly calculate a willingness to bid - requires substantial amounts of historical data on the underlying market and service conditions. The reliability and accuracy of extrapolative models for calculating spectrum reserve prices (as well as operators' willingness-to-bid) are extremely sensitive to the underlying data and assumptions that feed into these models. As already noted in the consultation paper, this data simply does not exist for the shared FSS bands.

   Other countries have recognized the technical need and efficiency benefits of assigning shared spectrum for satellite broadband, and thus no country has considered an auction-based process for assigning spectrum to satellite systems. Since these systems have *always* been designed to operate in shared and non-rivalrous conditions, no comparative data exists. India has also not had a private satellite broadband market thus far, and so no data exists about demand, operators' willingness to pay, or users' ability to pay. Finally (and most importantly), a purely theoretical economic approach does not consider the tremendous public benefits of a dynamic and competitive satellite sector (including but not limited to universal service, disaster preparedness, and emergency connectivity). Any mechanism that seeks to find a fair return for spectrum access must account for these benefits.

   In the absence of such data, we must recommend that the TRAI err on the side of caution, rather than forcibly attempt to set reserve prices using purely theoretical assumptions (and

entirely inapplicable) comparisons to terrestrial services. Access to a shared band is very different from exclusive assignments, so comparisons between the two are both inappropriate and very likely to lead to negative outcomes. The TRAI's choice of assignment method must thus ensure that it does not sacrifice the accuracy of this price discovery process (which should be one that improves in accuracy over time rather than one that is incorrect from the beginning).

3. **Implement a legally compliant assignment process that is predictable (and not susceptible to legal challenge).**

We recognise that the TRAI's recommendation of assignment method must ensure that the method is not overly subject to legal challenge. This is also essential to ensure a predictable rollout and operating environment for all satellite operators as well as users.

SpaceX respects the Ministry of Communications' and the TRAI's focus on ensuring that any spectrum assignment process is compliant with the Hon'ble Supreme Court's judgment. We do observe that the subject matter in this decision did not discuss the technical possibility of shared use by satellites. The Hon'ble Supreme Court notes that "*[...] while transferring or alienating the natural resources, the State is duty bound to adopt the method of auction [...]*". However, SpaceX respectfully submits that in the case of shared access by all satellite providers, spectrum is neither "transferred" nor "alienated" - its use by one operator does not prevent use by another.

4. **Ensure healthy competition, consumer choice, and sustained innovation through multiple operators and room for future entrants.**

The TRAI must exercise extreme care in ensuring that its recommendations do not sacrifice the importance of consumer choice. Such choice absolutely depends on healthy competition from both existing operators as well as future entrants (including Indian space start-ups). The space sector is undergoing unprecedented growth as reusable rockets make access to space more affordable and stimulate rapid innovation in satellite technology. Given how much the industry has changed in the last few years, we are not yet even sure what the competitive landscape will look like in a year or two, much less a decade. What is certain however is that force-fitting terrestrial spectrum valuation and assignment approaches – including auction designs - onto satellite systems will impose extreme and artificial limitations on market entry.

This will invariably create disproportionate barriers-to-entry for future operators (especially Indian start-ups), while also disincentivising the investments crucial to a vibrant future for India's telecommunications and space innovation industries. While Starlink has helped demonstrate the tremendous technological and service potential of next-generation satellite broadband around the world, we strongly urge the TRAI to recognise that it is still a nascent (albeit high-growth) industry with substantial infrastructural, development, and deployment costs on the difficult path to maturity.

5. **Maximise efficient spectrum use and avoid underutilisation of spectrum.**

The TRAI correctly recognises that satellite systems are designed to operate on shared spectrum with low or no rivalry in consumption - coordination and coexistence are a crucial part of the ecosystem. As a result, any assignment process that seeks to maximise the overall value of satellite spectrum should also maximise efficient spectrum use in a manner that avoids under-utilisation of spectrum. The TRAI should thus prefer assignment mechanisms that incentivise more efficient NGSO system designs – those that minimise interference and operate with greater tolerances for co-existence. This will further reduce rivalry in spectrum consumption to ensure more room for simultaneous operators as well as future entrants.

6. **Seek a fair return from the SATCOM industry (both tax as well as regulatory dues).**

SpaceX appreciates that in addition to the social and economic benefits of increased broadband connectivity across India, the TRAI must also take into consideration the satellite broadband industry's potential contributions to public revenue.

Where spectrum use is exclusionary (as in the case of terrestrial mobile), it follows that a substantial portion of public revenue considerations can be accurately recognised (and satisfied) through the results of an auction. This is because the number of operators that can simultaneously co-exist must be unavoidably restricted. The TRAI's auction methodologies for mobile spectrum have thus successfully demonstrated that optimally discovering realizable value for public revenue is achieved via competitive bidding (to identify operators who will extract the greatest value from exclusive access to spectrum).

For satellite broadband however – where sharing is not only possible but an underlying system design principle – public revenue generation is optimised by *maximising the number of operators* who can provide services within the market over time. This approach optimises both a variety of different consumer benefits as well as tax and regulatory revenue. The TRAI's choice of spectrum assignment process must recognise that when it comes to shared spectrum use by satellites, the triple benefits of increased competition through numerous operators, maximisation of consumer choice, and revenue optimisation are all fundamentally aligned. This is why SpaceX recommends good faith coordination principles to expand the use of spectrum and the benefits delivered from shared access.

7. **Clear, fair, transparent, non-discriminatory and non-complex rules for assignment mechanism (an assignment mechanism that ensures predictability and minimizes room for "gaming the system").**

The TRAI correctly recognises that the assignment process for accessing spectrum must have rules that are fair, transparent, fully and accurately described, and efficient. This is essential not just to ensure fairness but also to build-in predictable and desirable outcomes that minimise the potential for gaming the allocation process (or moral hazard).

Forcing an auction design meant for terrestrial spectrum creates complications that prevent such accurately described, transparent and efficient rules. Auction designs built on securing exclusive access are fundamentally incompatible with the essential requirements of NGSO systems (to access entire spectrum bands on a shared basis). Unfortunately, many of the workarounds that must then be introduced have a number of additional unintended consequences (some of which we describe in the next section).

Successfully jumpstarting the growth of private satellite communications services in India requires the TRAI to ensure that the choice of assignment process is clear, fully described, and minimises unforeseen outcomes for operators and users. Repurposing terrestrial auction designs that are unsuited to satellite systems has the opposite effect.

8. **Stimulate the future of the Indian space industry and promote continuous and increased investments into Indian space start-ups.**

We deeply appreciate the steps being taken by the Government of India towards establishing a thriving private space industry. SpaceX's driving mission is a multi-planetary future for humanity, and we recognise ISRO's contributions towards space exploration and the achievement of that goal. We are excited by the prospect of a near-future in which India's private space industry dramatically accelerates achievements in space for all of humanity. As a fellow launch services provider, SpaceX recognises the benefits that emerge from accelerating the growth of a space industry in India.

We thus cannot overstate the dangers of imposing the artificial restrictions on participation in the space communications industry that will result from an exclusionary (and unnecessary) spectrum auction process. Such restrictions will disproportionately hurt emerging space start-ups that could otherwise innovate and further revolutionize the future of space-based communications. Private space communications companies around the world have all benefited from being able to access spectrum on a globally harmonised, shared basis. As a company that was a start-up in recent memory, SpaceX appreciates the enormous difficulties and risks associated with developing viable and valuable space technology. We thus strongly advise the TRAI against imposing additional burdens that will disproportionately affect Indian start-ups in the space sector, draw their limited resources away from innovating, and force them to compete financially against current incumbents for spectrum access.

C. Repercussions of forcing assignment mechanisms developed for terrestrial mobile services onto satellite spectrum assignment.

1. India will need to impose artificial scarcity in order to make satellite spectrum "rivalrous" and conduct an auction.

The Consultation Paper correctly notes that repurposing exclusionary mobile spectrum auctions for satellite systems means imposing artificial restrictions on the number of operators that can provide service. This artificial scarcity is unavoidable in order to force operators into bidding competitively for what is otherwise a high-utility but non-rivalrous good.

The TRAI refers to the "Diamond-Water Paradox" when comparing shared satellite spectrum to water. It notes that both are high-utility goods that can still have low prices due to their relative abundance and shareability. Extending this analogy, we ask the TRAI to briefly contemplate the implications of forcing such an exclusionary method to water i.e. artificially restricting access to a valuable and highly abundant resource for all but the highest bidders in order to conduct an auction. The Indian space start-up industry is similar - we strongly argue that current and future start-ups must not be denied the ability to use this shared spectrum for developing shared public benefits. This is especially problematic on the grounds that they currently have less financial power than incumbents participating in an auction held today.

Such a comparison also helps illustrate how forcing a traditional auction approach will misalign bidders' incentives *against* public policy outcomes. Terrestrial mobile auctions help winners roll out infrastructure by protecting their ability to use the spectrum they need exclusively. However, forcing this design on an industry that has and continues to design its systems to share spectrum only serves to protect winners from current and future competition. Participants would thus be bidding on the underlying value of obtaining a regulatory oligopoly, and not on the value of the resource they can realise. This is especially true when the value of exclusive access to only parts of the spectrum is actually less than the value of accessing the entire allocated band on a shared basis (which also has the additional benefit of greater flexibility in operating alongside other operators).

2. Such an assignment mechanism will discourage innovation and limit new entrants.

In addition to the fact that any bidders will be acting under the perverse incentives of simply preventing competition from future entrants, such a "forced" auction design will also create incentives against innovation and divert resources away from innovation. Incumbent operators could repurpose R&D funds towards higher bids in an auction if it helps preclude the threat of future competition, and once auction winners are artificially protected from competition they will have far less incentive to innovate.

Furthermore, such a process will also exclude the possibility of future entrants and competition. Potential investors in Indian space start-ups will be forced to begin pricing-in the costs of accessing spectrum in India (at auction prices set by current incumbents) when assessing the value of a return on their investment. Indian start-ups will thus be uniquely disadvantaged by being evaluated not on the merits of their innovations or the scalability of the solutions they develop, but also the artificial costs they will suffer simply to participate within their home market. This is a potentially disastrous (and entirely avoidable) outcome for an infant industry that is fundamentally important to the future of the global space economy.

3. This approach will impose higher costs on users and undo the key benefit of NGSOs – universal and affordable access to high-speed broadband and life-saving services.

Forcing artificial scarcity via a mobile auction design (and the accompanying moral hazard) will necessarily result in increased prices for NGSO services. This impact on affordability will undo the benefits of next-generation NGSO systems and their ability to finally bridge the price/viability gaps that have perpetuated the digital divide. This will directly disadvantage users that are most in need of connectivity, and have not been served by the terrestrial market thus far.

Please note that the issues of increased prices from an auction for satellite spectrum are different than those for terrestrial mobile services. In mobile broadband, exclusive access to spectrum is currently a technical necessity. The dynamics of a mobile spectrum auction are thus driven by the need to identify operators who will make the most efficient use of a limited resource.

For satellite systems that have been designed to share spectrum, forcing an auction will simply provide winners the opportunity to increase their prices in the absence of competition. Unfortunately, such healthy competition could easily exist but for an artificially limiting auction process.

4. **Restricting access now will reduce the total realised value of satellite spectrum in the future.**

SpaceX firmly believes that we are currently at an inflection point in the space industry that will see dramatic increases in participation (including from India), and rapid technological developments in the very near future. While there may only appear to be a few market participants to participate in an auction process today, there will be many more operators capable of deriving additional value from the same shared spectrum very soon. The price discovered by forcing an exclusionary auction today will thus only indicate the willingness-to-pay of current incumbents to exclude future competition, not the underlying value and potential of the spectrum or of a vibrant satellite industry in India.

The value of a shareable, non-rivalrous resource (such as critical satellite spectrum) increases with the number of users that can simultaneously use it. This is why current shared access regimes around the world help incentivize innovations in more efficient sharing systems, which increases the total potential value of the spectrum for all users. Restricting the number of users arbitrarily in order to work a mobile-spectrum auction design for satellite systems will have the opposite effect.

5. **The need to ensure combined User Terminal and Gateway spectrum will dramatically increase the complexity of any auction process, and the potential for unintended consequences.**

Satellite systems need access to spectrum for communicating back and forth with consumer user terminals, but also for allowing the satellites to deliver traffic to and from the internet on the ground via gateway earth stations (gateways). To provide high-speed and low-latency service in a country the size of India, an operator may require several or even many gateways. Satellite operators will therefore need access to spectrum to support the user terminals as well as gateways.

This requirement introduces complexity in the assignment mechanism as an operator could face a classic exposure problem if they are able to get access to either only user terminal or gateway spectrum (but not both). Additionally, as an operator gains more users and requires more capacity, they will need to add more gateways to accommodate the demand, so the assignment mechanism needs to take that into account. A traditional terrestrial mobile auction approach will not provide the flexibility needed to get access to additional spectrum when it is needed.

D. Recommendations.

1. Ensure adequate and predictable spectrum access to drive high-quality broadband for consumers.

- ***Ensure access to critical satellite bands in their entirety.*** Next-generation satellite systems are optimized to leverage several critical spectrum bands, such as the Ku-band and the Ka-band, to provide high-speed, low-latency broadband to consumers, businesses, and anchor institutions. Satellite operators must have access to the entire band to effectively share the spectrum among operators and maximize competition. As administrations consider competing demands from other services for these bands, they should ensure that these other services do not cause harmful interference to or hinder deployment of next-generation satellite services.

- ***Permit timely access to next-generation satellite bands***. Satellite systems will increasingly rely on flexible access to millimetre wave spectrum bands, such as the E-band (71-76 GHz/81-86 GHz) and 100+ GHz bands, which have been allocated on a co-primary basis to fixed and mobile-satellite services. SpaceX recommends that regulators provide access to these bands, including through default service rules that permit satellite operators to license them even before band-specific rules have been adopted, contingent on good faith coordination negotiations with incumbent users.

- ***Limit spectrum and license fees to administrative cost recovery.*** High or complex fee regimes have the pernicious effects of increasing costs for consumers; dissuading market entry and competition among providers; driving resources away from innovation and customer service toward fees; and adding administrative burden to ensure that fee structures keep pace with changing market dynamics. In contrast, use of a cost-recovery model minimizes the cost of deploying vital services, including to unserved consumers, by basing fees only on the cost to recover the administrative expenses of processing the license. The use of a fixed fee will increase transparency, consistency, and equity, thereby reducing barriers to entry and promoting a competitive market.

2. Establish Rules that Promote Private Satellite Coordination and Efficient Use of Spectrum

- ***Establish reasonable satellite coordination requirements.*** Good-faith operator-to-operator coordination is the gold standard for satellite spectrum sharing. SpaceX encourages regulators to balance their obligations to protect existing satellites with the expectation of reasonable timeframes to complete necessary spectrum coordination negotiations and agreements. For example, rather than require a satellite operator to fully complete coordination with other satellite operators before granting a license, regulators should approve the license on a non-interference, non-protection basis while coordination is pending, so long as the operator is negotiating in good faith.

- ***Adopt sharing rules that drive efficient outcomes.*** Regulators should adopt sharing rules between satellite systems that encourage cooperation, competition, and efficient use of spectrum. For example, regulators could consider a spectrum-splitting last-resort where satellite operators would have to evenly split available spectrum *during in-line events* if they have not completed private coordination before they both commence service. Ideally, this backstop would never be used because the prospect of non-ideal spectrum splitting will incentivize both operators to find a better solution through coordination. To create further incentives to build efficient systems, regulators could also consider awarding first choice in the split to the more efficient, flexible, and robust system.

- ***Ensure efficient interference protection criteria.*** Overly conservative technical protection criteria for incumbent systems can impose unnecessary constraints on next-generation satellites, limiting service quality for consumers with no offsetting benefit. Regulators should ensure that technical protection criteria are as efficient as possible, reflecting the actual likelihood of harmful interference.

E. Alternate auction design exercise.

SpaceX cannot recommend strongly enough *against* enforcing an exclusionary auction design for assigning satellite spectrum. Those mechanisms (e.g. the simultaneous multiple round ascending auction or the combinatorial clock auction format) were carefully designed to assign exclusive licenses to operators whose systems must use discreet frequencies in specific geographies.

Satellite systems could not be more different – they are designed to share channels across a wide range of frequencies and provide service over wide geographic areas on a non-exclusive basis. Nonetheless, we have endeavoured in good faith to find a potential design for a non-exclusionary auction mechanism that attempts to satisfy the fundamental operating requirements of next-generation satellite systems while balancing the largest number of public policy goals. We do so recognising the need for examining an assignment method that is entirely immune to legal challenge, although we reemphasize our analysis from Section B (Item 3).

Despite our best efforts, we are unable to identify any design that does not have the critical flaw of artificially reducing competition by foreclosing access to shared spectrum, and needlessly restricting access for some operators in order to make the auction mechanism function. While we believe this alternate design is more suitable than the two auction design proposals in the consultation paper, it still falls short when compared against the benefits to society, government, and industry from a well-designed administrative mechanism (see Section F below for a table of comparison).

An auction where bidders commit a percentage of annual revenue as a "spectrum value fee" in lieu of upfront currency bids.

- The auction would be for a number of winning slots, where the government would determine the number of slots to be auctioned. Winners would obtain the right to use the *entirety* of the allocated FSS band spectrum for User Terminals as well as Gateway site deployment on a shared basis with each other. In order to deter spurious bidding or anti-competitive behaviour, applicants must commit non-refundable upfront deposits and timely deployment milestones prior to participation.
- Each round of bidding will take the form of a simple clock auction, with the TRAI proposing the percentage of adjusted gross revenue that operators would be willing to commit as "spectrum value fees". Rounds continue with the TRAI incrementally increasing the proposed percentage of adjusted gross revenue to be committed, **until the number of winning slots equals the number of willing bidders at the latest rate.**
- At the end of the auction all winning bidders commit to the same winning-bid percentage, since all winners must be able to access the same spectrum on the same shared terms.
- **Winners receive the right to use the entire spectrum bands (shared amongst themselves)** without any new market entrants being allowed to use this spectrum **for a limited initial time-period** (e.g. five years).
- After this time, any willing operators may apply to use the same spectrum on the same shared terms by committing the same percentage of their revenue as a spectrum value fee and making the same non-refundable deposit.

While this auction design lowers entry barriers and grants access to the necessary spectrum, the auction design is still inferior to a reasonably-priced and well-defined administrative process as it still artificially restricts access to the shared bands. It is only a better choice of mechanism than forcing an exclusionary terrestrial spectrum auction design onto satellite systems. Most importantly, this approach satisfies all three of the fundamental satellite system requirements of –

1. Predictable and guaranteed shared access to the entire allocated bands for both user terminals as well as gateways;
2. Access to critical spectrum across wide and contiguous channels without geographical restrictions; and
3. Ensuring similar terms for all qualifying operators that provide similar services in a harmonized manner.

At the same time, such a design would

1. help arrive at a far more accurate measure of value discovery for the spectrum over time;
2. incentivize efficient use and rapid rollout by operators;
3. provide a clear, transparent, efficient and fully described process for accessing spectrum that is legally predictable and auction-based;
4. ensure an open door for future operators to enter the market and encourage investments towards the growth of the Indian space industry; and
5. optimize revenue-generation from the SATCOM industry as a function of the auction-described percentage fee over time.

However, such a design would still suffer from the issues of

1. imposing an unnecessary and arbitrary limitation on the number of potential participants (albeit more temporarily);
2. requiring clear qualifying criteria to prevent bids being gamed or artificially increased by non-committed bidders with perverse incentives;
3. artificially increasing satellite broadband prices (although less so than traditional designs as spectrum payments would now scale with operators' system rollout and business operations);

SpaceX evaluated the various options proposed under the consultation paper alongside administrative pricing and the proposal above, and benchmarked them on their ability to satisfy NGSO system requirements and to meet various policy goals. The results are tabulated in the following section and are used as a reference to respond to the specific questions in the consultation.

F. COMPARISON BETWEEN VARIOUS MODELS OF ASSIGNMENT

	Parameters	Consultation Paper Auction Design #1	Consultation Paper Auction Design #2	Well-designed Admin Pricing	Poorly-designed Admin Pricing	Revenue Share Auction Design
Fundamental NGSO Requirements	**Predictable and guaranteed shared access to entire critical band allocated to FSS for both User Terminals and Gateways**	No	No	Very likely	Possibly	Yes
	National access to necessary spectrum across wide and contiguous channels without geographical restrictions	No	No	Very likely	Possibly	Yes
	Access to spectrum on similar terms for all satellite operators providing similar services in a harmonized manner	No	No	Very likely	No	Yes
Policy Goals	**Rapidly bridge the digital divide through universal broadband connectivity that maximises affordability**	Reduced affordability and less choice between operators	Reduced affordability and less choice between operators	Highest affordability	Reduced affordability	Higher affordability and operators with live systems will bid more
	Accurate price discovery to determine a fair return for accessing the spectrum resource	Unlikely since no data available to set reserve price or optimally decide number of slots	Unlikely - no data and participants would "price-in" value of regulatory oligopoly	Likely since there are global precedents to rely on for input data in design	Unlikely if such a mechanism uses India's prior pricing as a benchmark	Very likely (over time)
	Implement a legally compliant assignment process that is predictable (and not susceptible to legal challenge)	Unlikely since operators with different system designs would be unfairly excluded	Unlikely - second-best price would still have a gap b/w "perceived value" and actual payment	Susceptible to legal challenge	Very Unlikely	Likely
	Ensure healthy competition, consumer choice, and sustained innovation through multiple operators and room for future entrants	Very unlikely since new operators must wait for next auction round and winners will have no incentive to innovate		Likely for competition, but unlikely for future entrants if legal challenges burden SATCOM industry		Likely
	Maximise efficient spectrum use and avoid underutilisation of spectrum	Very unlikely – less-efficient operators could set obstructionist terms for sharing		Very Likely	Unlikely	Unlikely – temporarily restricts supply to create excess demand for bidding
	Seek a fair return from the SATCOM industry (both tax as well as regulatory dues)	Very unlikely, as operators will be forced to increase prices and some will be prevented from operating entirely		Likely unless legal challenges burden SATCOM industry	Very unlikely as high spectrum costs will prevent affordable services	Likely
	Stimulate the future of the Indian space industry and promote continuous and increased investments into Indian space start-ups	Very unlikely since new operators must wait for next auction round and investors will be disincentivized by pricing in auction costs as market entry costs (biased disadvantage for Indian start-ups)		Very likely	Unlikely	Still restricts access for new entrance for an initial period
	Clear, fair, transparent, non-discriminatory, and non-complex rules for assignment mechanism that minimize potential for gaming	Very unlikely	Very unlikely	Very likely as there are numerous global precedents to design from	Unlikely	Likely, however fairness may be questioned given the artificial scarcity

G. Question-wise Responses.

Q1. For space-based communication services, what are the appropriate frequency bands for (a) gateway links and (b) user links, that should be considered under this consultation process for different types of licensed telecommunications and broadcasting services? Kindly justify your response with relevant details.

AND

Q2. What quantum of spectrum for (a) gateway links and (b) user links in the appropriate frequency bands is required to meet the demand of space-based communication services? Information on present demand and likely demand after about five years may kindly be provided in two separate tables as per the proforma given below:

Type of service	Name of the satellite system	Type of satellite (GSO/ LEO/ MEO)	Frequency range and quantum of spectrum required							
			User Link (Earth to space UL)		User Link (Space to Earth DL)		Gateway Link (Earth to space UL)		Gateway Link (Space to Earth DL)	
			Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)	Frequency range	Quantum (in MHz)
Access										
Internet										
NLD										
ILD										
GMPCS										
VSAT CUG (Commercial)										
Captive VSAT CUG										
Machine to Machine (M2M)										
DTH										
Teleport										
DSNG										
HITS										
IFMC										
Any other relevant service (please specify)										

SpaceX strongly recommends ensuring the availability of all frequency bands allocated to Fixed Satellite Services under the Indian National Frequency Allocation Plan and at the International Telecommunications Union. These include -

Frequency band	Space to Earth (GHz)	Earth to Space (GHz)	Service
VHF	0.137-0.138	0.148-0.15005	FSS

Ku band	10.7-12.75	12.75-13.25 13.75-14.0 14.0-14.5 14.5-14.8 17.3-18.1	FSS
Ka Band	17.7-21.2	27-31	FSS /MSS
Q/V Band	37.5-43.5	47.2-50.2 50.4-51.4	FSS
E Band	71-76	81-86	FSS
D Band	123-130 158.5 to 164 167 to 174.5	*Please see comment.*	FSS

SpaceX very strongly recommends the inclusion of the E-band allocated to FSS within India's National Frequency Allocation Plan (81 to 86 GHz and 71 to 76 GHz), which will be critical for providing greater backhaul capacity at gateways that is essential to ensure Indian users can benefit from the highest quality satellite broadband. We caution against excluding this essential frequency and the resultant consequences of such exclusion preventing the deployment of existing and near-future technological improvements within India. Additionally, SpaceX and Starlink India strongly recommend the inclusion of VHF band (137 to 138 MHz and 148 to 150.05 MHz) in order to enable low bit-rate IOT/M2M services such as those offered by SpaceX's Swarm constellation to be operable in India. We also recommend the inclusion of Q/V Band (47.2 to 50.2 GHz and 50.4 to 51.4 GHz, which are also allocated to FSS).

Finally, we recommend including frequencies ranging from 123 to 130 GHz, 158.5 to 164 GHz, and 167 to 174.5 GHz (which are allocated to FSS, although currently only in the space-to-Earth direction which appears to be imbalanced with respect to the Earth-to-space direction in those frequencies). Today, the fixed-satellite service is allocated to FSS at the ITU and under the Indian National Frequency Allocation Table 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 and 210-310 GHz bands—are more useful to serve consumers of fixed-satellite services 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.

SpaceX strongly recommends against distinguishing between categories of satellite-based communications services.

Q3. Whether there is any practical limit on the number of Non-Geo Stationary Orbit (NGSO) satellite systems in Low Earth Orbit (LEO) and Medium Earth Orbit (MEO), which can work in a coordinated manner on an equitable basis using the same frequency range? Kindly justify your response.

Given the rapid developments (recently and in the near-future) in NGSO system development and deployment, there is currently not enough information available to provide an accurate response to this question. **However, as a general rule we submit that any assignment mechanism should recognize how any practical limit on co-existence is a function not just of the number of systems in operation but also their design efficiency. More efficient systems with higher tolerances will allow more systems to co-exist now and in the future. As a result, we strongly recommend that the TRAI ensure any assignment mechanism be designed to enable shared use of critical spectrum resources between systems as well as reward greater capacity for sharing.**

Full access to co-primary satellite spectrum is also essential to the facilitation of global coordination between satellite operators. Pursuant to their space station authorizations and ITU Radio Regulations, next-generation satellite operators reach coordination agreements with other operators. These arrangements provide clarity to all operators and allow them to meet their system requirements regardless of the markets in which they are deployed. Adopting national allocations or assignments that conflict with coordination agreements can undermine carefully crafted global sharing arrangements, especially as the requirement for next-generation satellite systems to operate at lower power levels necessitates the availability of wider channel sizes to maintain service quality. By contrast, well-coordinated operators sharing the entirety of these bands can all provide much higher quality of service simultaneously, while also enabling new market entrants - an essential policy goal for Indian future constellations as well. Individually restricting systems to accessing only parts of this essential spectrum has the contrary effect.

SpaceX recommends that the TRAI require good faith coordination between operators and adopt sharing rules between satellite systems that encourage cooperation, competition, and efficient use of spectrum. As discussed in our narrative response above, fragmenting access between operators will constrain *all* operators. Conversely, operators that are efficiently coordinated can share the entire band in a manner that allows all providers to have much higher levels of service and serve more users across the board. Such fragmentation will also reduce the number of current and future operators who can co-exist, while allowing shared access will incentivize continuous improvements in system design efficiency and pave the road for ever-increasing co-existence.

Q4. For space-based communication services, whether frequency spectrum in higher bands such as C band, Ku band and Ka band, should be assigned to licensees on an exclusive basis? Kindly justify your response. Do you foresee any challenges due to exclusive assignment? If yes, in what manner can the challenges be overcome? Kindly elaborate the challenges and the ways to overcome them.

SpaceX recommends extremely strongly *against* any frequency assignment for space-based communication services on an exclusive basis.

The successful development and deployment of next-generation satellite constellations (including those operated by India in the very near future) will invariably depend on such systems being able to provide services to users across the planet. This in turn requires predictable and dependable regulatory environments that allow similar levels of access to entire spectrum bands across numerous national administrations. SpaceX strongly recommends that in examining assignment paths for satellite spectrum, the TRAI ensure that India displays leadership with a technology-forward regulatory environment for deploying satellite-based services.

From a technical perspective, most satellite systems have been designed to operate across the entirety of each of the shared bands set out in our response to Q2. The access to wide frequency ranges allows for efficient frequency reuse within a system and also supports sharing between systems. Within a system, having access to a wide frequency range allows for channelization where beams serving different users in adjacent areas operate on different frequencies (channels) to prevent interference within the system. These channels can then be reused in non-adjacent

geographic areas. The same concept applies for multiple systems sharing the spectrum – operators can use different channels to serve customers in the same areas. When some channels are taken away (e.g. exclusively assigned to one operator), there are fewer options for the other operators to manage inter- and intra-system interference. Further, many operators seek global coordination and sharing arrangements that are based on these sharing arrangements.

Fragmented access to essential spectrum will constrain all satellite operators without providing any benefits to counterbalance these harms. TRAI should therefore ensure that all satellite operators have access to the entirety of the co-primary satellite spectrum bands required to (1) provide consumers with high-speed, low-latency broadband; (2) ensure technical flexibility in designing efficient systems; and (3) facilitate efficient sharing between multiple next-generation satellite operators.

- ***High-Speed Broadband Service.*** Operators require full access to co-primary spectrum bands—for both gateway links and user terminals—to provide high-quality service to users. Specifically, gateway links require wide channels to bring traffic to and from many users on the network. User links similarly require full access to co-primary spectrum to provide service necessary for today's needs (speeds of 100 Mbps+) in bandwidth-intensive applications across work, school, healthcare, and government services (both at fixed locations as well as through earth stations in motion). Any operators that do not have access to this entire band of spectrum will have no choice but to either constrain the number of users they serve, or dramatically reduce the quality of service that users receive. Indeed, fragmenting access between operators will constrain *all* operators. Conversely, operators that are efficiently coordinated can share the entire band in a manner that allows all providers to have much higher levels of service and serve more users across the board.

- ***Technical Flexibility.*** Because NGSO systems must be global, satellite operators design their systems on a global basis to leverage spectrum efficiently, and may use different band plans and channelization to optimize their system for end users. In some cases, an operator may not have the capability to "split" their channels, such that any restriction on one channel would render the entire channel inoperable, significantly impairing both the number of consumers that an operator can serve as well as the quality of the service. Additionally, the characteristics of spectrum use in these higher bands (such as the Ka-band) necessitate wider challenges for any services making use of them. If India were to adopt an assignment scheme that conflicted with operators' channelization, it could render the market less attractive, or even not viable, for that operator.

SpaceX cautions TRAI against an assignment mechanism that ignores the technical requirements of these systems in favour of a fractured or exclusionary method that restricts both the deployment of service as well as the potential for positive competition and consumer choice.

Q5. In case it is decided to assign spectrum in higher frequency bands such as C band, Ku band and Ka band for space-based communication services to licensees on an exclusive basis,

(a) What should be the block size, minimum number of blocks for bidding and spectrum cap per bidder? Response may be provided separately for each spectrum band.

(b) Whether intra-band sharing of frequency spectrum with other satellite communication service providers holding spectrum upto the prescribed spectrum cap, needs to be mandated?

(c) Whether a framework for mandatory spectrum sharing needs to be prescribed? If yes, kindly suggest a broad framework and the elements to be included in the guidelines.

(d) Any other suggestions to ensure that that the satellite communication ecosystem is not adversely impacted due to exclusive spectrum assignment, may kindly be made with detailed justification. Kindly justify your response.

As described under the section on "Fundamental Requirements for LEO NGSO systems", we recommend strongly against *any* assignment mechanism that imposes restrictions against predictable and guaranteed shared access to the entirety of the critical bands allocated to FSS and used by satellite communications systems. The TRAI recognises in its consultation paper that any such steps would artificially restrict the ability of operators to fully utilise constellation capacity. The negative impacts of such restrictions are disproportionately high and fragmenting access will negatively impact *all* operators and ultimately un-served and under-served Indians.

Q6. What provisions should be made applicable on any new entrant or any entity who could not acquire spectrum in the auction process/assignment cycle?

(a) Whether such entity should take part in the next auction/ assignment cycle after expiry of the validity period of the assigned spectrum? If yes, what should be the validity period of the auctioned/assigned spectrum?

(b) Whether spectrum acquired through auction be permitted to be shared with any entity which does not hold spectrum/ or has not been successful in auction in the said band? If yes, what measures should be taken to ensure rationale of spectrum auction and to avoid adverse impact on the dynamics of the spectrum auction?

(c) In case an auction based on exclusive assignment is held in a spectrum band, whether the same spectrum may again be put to auction after certain number of years to any new entrant including the entities which could not acquire spectrum in the previous auction? If yes,

(i) After how many years the same spectrum band should be put to auction for the potential bidders?

(ii) What should be the validity of spectrum for the first conducted auction in a band? Whether the validity period for the subsequent auctions in that band should be co-terminus with the validity period of the first held auction?

Kindly justify your response.

AND

Q7. Whether any entity which acquired the satellite spectrum through auction/assignment should be permitted to trade and/or lease their partial or entire satellite spectrum holding to other eligible service licensees, including the licensees which do not hold any spectrum in the concerned spectrum band? If yes, what measures should be taken to ensure rationale of spectrum auction and to avoid adverse impact on the dynamics of the spectrum auction? Kindly justify your response.

AND

Q8. For the existing service licensees providing space-based communication services, whether there is a need to create enabling provisions for assignment of the currently held spectrum frequency range by them, such that if the service licensee is successful in acquiring required

quantum of spectrum through auction/ assignment cycle in the relevant band, its services are not disrupted? If yes, what mechanism should be prescribed? Kindly justify your response.

The basis of Questions 6, 7 and 8 recognises the undesirable impact of restricting market entry, competition, and consumer choice (all of which we discuss as important national policy priorities). These questions also reinforce our analysis of the repercussions of forcing assignment mechanisms developed for terrestrial services onto satellite spectrum assignment. Restricting market entry for current and future satellite systems that could easily co-exist with shared spectrum access is an inefficient use of spectrum, creates perverse incentives for existing incumbents, and risks the rules for participation in an assignment process or accessing shared spectrum being arbitrarily determined.

SpaceX strongly recommends allowing shared access for all current and future operators to the spectrum bands allocated to FSS under good faith coordination among operators without priority or preference. SpaceX regularly coordinates with other satellite systems and has been able to reach national and global coordination agreements with both GSO and non-GSO systems.

Q9. In case you are of the opinion that the frequency spectrum in higher frequency bands such as C band, Ku band and Ka band for space-based communication services should be assigned on shared (non-exclusive) basis, -

(a) Whether a broad framework for sharing of frequency spectrum among satellite communication service providers needs to be prescribed or it should be left to mutual coordination? In case you are of the opinion that broad framework should be prescribed, kindly suggest the framework and elements to be included in such a framework.

(b) Any other suggestions may kindly be made with detailed justification.

Kindly justify your response.

SpaceX recommends that sharing of frequency spectrum should be left to mutual coordination, allowing operators to coordinate in good faith to reach agreements that best meet the needs of the specific systems. Coordination is the "gold standard" for ensuring efficient spectrum sharing that promotes competition and high-quality service for consumers.

SpaceX has extensive experience coordinating with other satellite operators and has successfully reached global coordination agreements. Further, SpaceX shares all of the spectrum it uses worldwide with other operators and services, and SpaceX has not received any substantiated claims of actual harmful interference based on its operations.

By contrast, a broad framework for sharing among satellite operators would unnecessarily constrain the flexibility necessary for operators to reach efficient sharing arrangements, and indeed may conflict with already-established global sharing arrangements.

Q10. In the frequency range 27.5-28.5 GHz, whether the spectrum assignee should be permitted to utilize the frequency spectrum for IMT services as well as space-based communication services, in a flexible manner? Do you foresee any challenges arising out of such flexible use? If yes, in what manner can the challenges be overcome? Kindly elaborate the challenges and the ways to overcome them.

AND

Q11. In case it is decided to permit flexible use in the frequency range of 27.5 - 28.5 GHz for space-based communication services and IMT services, what should be the associated terms and

conditions including eligibility conditions for such assignment of spectrum? Kindly justify your response.

SpaceX strongly recommends against licensing 28 GHz spectrum for terrestrial IMT use cases at this time.

As described above, next-generation satellite systems depend on full access to the 28 GHz band to provide high-speed, low-latency broadband service to consumers. To achieve low-latency service and reduce infrastructure costs that can affect the affordability of broadband service for end users, satellite operators also require flexibility to place gateway sites near essential ground infrastructure, including data centres and fiber optic cables near urban areas.

Because IMT deployments in the 28 GHz band typically focus on urban areas, introducing IMT into the band would make it more difficult for satellite operators to deploy gateway sites by reducing available bandwidth and reducing the ability to deploy need ground infrastructure.

If the TRAI still adopts a flexible use framework including IMT in the 28 GHz band, that framework must clarify that any IMT deployments must be secondary to satellite gateways in the band to avoid needlessly constraining the deployment of satellite gateways.

SpaceX also notes that mobile use of the millimetre wave bands has been slow, if not non-existent, making it untimely to consider allowing IMT services in more MMW bands.

Q12. Whether there is a requirement for permitting flexible use between CNPN and space-based communication services in the frequency range 28.5-29.5 GHz? Kindly justify your response.

AND

Q13. Do you foresee any challenges in case the spectrum assignee is permitted to utilize the frequency spectrum in the range 28.5-29.5 GHz for cellular based CNPN as well as space-based communication services, in a flexible manner? What could be the measures to mitigate such challenges? Suggestions may kindly be made with justification.

SpaceX recommends against opening the 28.5-29.5 GHz band for cellular CNPN at this time. As explained above in response to Q10 and Q11, these bands are essential for satellite gateways to provide high-speed, low-latency broadband for end users. If there are spectrum needs for CNPN, SpaceX encourages TRAI to focus on creating incentives to implement it in bands already identified for terrestrial use, such as the 26 GHz band, where cellular is more likely to be deployed following the recent auction. In the event that the TRAI still considers this band for cellular-based CNPN it should *only* do so on a secondary basis to avoid needlessly constraining the ability of satellite operators to site gateways.

Q14. Whether space-based communication services should be categorized into different classes of services requiring different treatment for spectrum assignment? If yes, what should be the classification of services and which type of services should fall under each class of service? Kindly justify your response. Please provide the following details:

a) Service provider-wise details regarding financial and market parameters such as total revenue, total subscriber base, total capital expenditure etc. for each type of service (as mentioned in the Table 1.3 of this consultation paper) for the financial year 2018-19, 2019-20, 2020-21, 2021-22, and 2022-23 in the format given below:

Type of service: _____				
Financial Year	Revenue (Rs. lakh)	Subscriber base	CAPEX for the year (Rs. lakh)	Depreciation for the year (Rs. lakh)
2018-19				
2019-20				
2020-21				
2021-22				
2022-23				

b) Projections on revenue, subscriber base and capital expenditure for each type of service (as mentioned in the Table 1.3 of this consultation paper) for the whole industry for the next five years starting from financial year 2023-24, in the format given below:

Type of service: _____			
Financial Year	Revenue (Rs. lakh)	Subscriber base	CAPEX for the year (Rs. lakh)
2023-24			
2024-25			
2025-26			
2026-27			
2027-28			

SpaceX strongly recommends against segmenting space-based communication services into different classes requiring different treatment for spectrum assignment. As explained above, we also strongly recommend against allowing the usage of spectrum critical to next-generation satellite communications service for use by IMT/5G services.

With respect to Q.14(a) and Q.14(b), we reiterate our previous statement from the section analysing "National policy priorities for the Indian telecom and space sectors" -

> *"The TRAI correctly notes that a fundamental requirement of spectrum assignment methods – particularly auctions – is accurate price discovery that determines the fair value of access to the spectrum resource. While traditional auctions for mobile spectrum rely on a combination of competitive bidding and accurate reserve price setting to satisfy this requirement, such an approach fundamentally relies on mobile operators needing spectrum on rivalrous and exclusionary grounds. As the TRAI repeatedly and correctly notes, this is simply not the case for satellite spectrum use.*
>
> *The TRAI also notes that accurately determining auction reserve prices - as well as the ability of operators to correctly calculate a willingness to bid - requires substantial amounts of historical data on the underlying market and service conditions. The reliability and accuracy of extrapolative models for calculating spectrum reserve prices (as well as operators' willingness-to-bid) are extremely sensitive to the underlying data and assumptions that feed into these models.* ***As already noted in the consultation paper, this data simply does not exist for the shared FSS bands.***
>
> ***Other countries have recognized the technical need and efficiency benefits of assigning shared spectrum for satellite broadband, and thus no country has considered an***

> ***auction-based process for assigning spectrum to satellite systems. Since these systems have always been designed to operate in shared and non-rivalrous conditions, no comparative data exists. India has also not had a private satellite broadband market thus far, and so no data exists about demand, operators' willingness to pay, or users' ability to pay.*** *Finally (and most importantly), a purely theoretical economic approach does not consider the tremendous public benefits of a dynamic and competitive satellite sector (including but not limited to universal service, disaster preparedness, and emergency connectivity). Any mechanism that seeks to find a fair return for spectrum access must account for these benefits. "*
>
> [Emphasis added]

In the absence of this data, we would recommend erring on the side of caution rather than forcibly attempting to set reserve prices on the basis of purely theoretical assumptions and inapplicable comparisons to terrestrial services.

Q16. What should be the methodology for assignment of spectrum for user links for space-based communication services in higher spectrum bands like C-band, Ku-band and Ka-band, such as

(a) Auction-based

(b) Administrative

(c) Any other?

Please provide your response in respect of different types of services (as mentioned in Table 1.3 of this consultation paper). Please support your response with detailed justification.

As explained in our analysis across Sections A through D in the narrative above and as demonstrated by the summary table (Section F), SpaceX believes that the most appropriate approach for assigning access to spectrum for satellite systems is a well-designed administrative approach. Based on the comparative analysis provided in Section F, we feel the only other reasonable (though far less desirable) alternative is the revenue-share alternative auction design we have supplied under Section E, noting that the artificial limitation in access to the market in this approach will have a negative impact on competition and innovation for the entire space-based communications market in India. This in turn has the numerous disadvantages of limiting competition and consumer choice, artificially increasing consumer prices, and temporarily reducing the viability of investments into Indian space start-ups.

Q17. Whether spectrum for user links should be assigned at the national level, or telecom circle/ metro-wise? Kindly justify your response.

As mentioned above, SpaceX cannot emphasise enough the extreme importance of ensuring "access to spectrum across wide and contiguous channels **on a national level** without geographical restrictions." We repeat our previous analysis here for convenience –

> *"The use of spectrum - especially with respect to user terminals - and thus the deployment of satellite service within a country cannot be geographically divided across different NGSO systems. The primary capital infrastructure of NGSO systems (i.e. the satellite constellations) are always capable of complete coverage. As a result, users can only benefit from the lower prices enabled by these constellations when the service areas in which they operate are not artificially constrained.*
>
> *If such restrictions are imposed, they will impact end-users thrice –*

a. *they must pay higher prices since the constellations are artificially under-utilised below their capabilities while the costs of deployment and operation remain unchanged;*

b. *they must pay higher prices due to the artificially reduced market competition and consumer choices that emerge from unnecessary restrictions along geographical lines; and*

c. *because the users most in need of satellite broadband are dispersed across the country and the costs of providing NGSO broadband are immune to location, imposing geographic limitations disproportionately hurts precisely those who need satellite broadband the most."*

Q18. In case it is decided to auction user link frequency spectrum for different types of services, should separate auctions be conducted for each type of services? Kindly justify your response with detailed methodology.

As explained in our analysis across sections A through D in the narrative above, satellite communications systems use spectrum on a shared basis, unlike the exclusive use conditions that are the foundation for mobile terrestrial communications. SpaceX strongly recommends ensuring that all satellite-based communications services have access to the entirety of critical spectrum bands allocated to FSS on a shared basis under a well-designed administrative approach. This will best support access across different types of satellite services, and thus there is no need to consider other more restrictive approaches.

Q19. What should be the methodology for assignment of spectrum for gateway links for space-based communication services, such as

(a) Auction-based

(b) Administrative

(c) Any other?

Please provide your response in respect of different types of services. Please support your response with detailed justification.

Due to the narrow, directional nature of beams in millimeter wave bands, which allow many users to coexist within close proximity without interference, regulators should consider adopting database-assisted "light licensing." This administrative approach relies on a central, public database of fixed installations, and permits gateway earth stations to register new ground equipment on a self-coordinated, first-come, first-served basis without the need for auctions or manual review of individual gateway applications. In this way, database-assisted light-licensing promotes rapid deployment of critical backhaul infrastructure while protecting incumbent users from harmful interference.

Q20. In case it is decided to auction gateway link frequency spectrum for different types of services, should separate auctions be conducted for each type of services? Kindly justify your response with detailed methodology.

SpaceX cautions TRAI against an exclusionary auction-based assignment mechanism that ignores the technical requirements of these systems in favour of a fractured or exclusionary method that restricts both the deployment of service as well as the potential for positive competition and consumer choice.

As explained in our analysis across sections A through D in the narrative above, satellite communications systems use spectrum on a shared basis, unlike the exclusive use conditions necessary for mobile terrestrial communications. These systems cannot provide quality service when restricted to only parts of the required Ku and Ka bands, as they are designed to use multiple wide channels in order to operate efficiently (which includes both providing sufficient capacity and avoiding interference between beams of the same and other systems). An NGSO system's user terminals also cannot operate without the associated gateway systems that route traffic to and from the internet on the ground.

SpaceX strongly recommends ensuring that all satellite-based communications services be allowed to access the entirety of critical spectrum bands allocated to FSS (for both User Terminals and Gateways) on a shared basis under a well-designed administrative approach. This will best support access across different types of satellite services, and thus there is no need to consider other more restrictive approaches.

Q21. In case it is decided to assign frequency spectrum for space-based communication services through auction,

(a) What should be the validity period of the auctioned spectrum?

(b) What should be the periodicity of the auction for any unsold/ available spectrum?

(c) Whether some mechanism needs to be put in place to permit the service licensee to shift to another satellite system and to change the frequency spectrum within a frequency band (such as Ka-band, Ku-band, etc.) or across frequency bands for the remaining validity period of the spectrum held by it? If yes, what process should be adopted and whether some fee should be charged for this purpose?

Kindly justify your response.

While we believe a well-designed administrative approach is superior to an auction approach, regardless of the assignment mechanism, to provide predictability so that operators can best serve consumers while justifying their significant upfront deployment and operational costs, regulators should establish license terms for a period of not less than 10 years, with an expectation of renewal. One of the key benefits of using an administrative approach for shared access to the bands coupled with a good-faith coordination requirement is that you need not worry about unsold spectrum. As new entrants deploy satellites and need access to spectrum, they can apply and coordinate with existing authorized users. This approach recognizes the dynamism in the space industry right now with new operators regularly announcing plans to launch and provide service.

Q22. Considering that (a) space-based communication services require spectrum in both user link as well as gateway link, (b) use of frequency spectrum for different types of links may be different for different satellite systems, and (c) requirement of frequency spectrum may also vary depending on the services being envisaged to be provided, which of the following would be appropriate:

(i) to assign spectrum for gateway links and user links separately to give flexibility to the stakeholders? In case your response is in the affirmative, what mechanism should be adopted such that the successful bidder gets spectrum for user links as well as gateway links. or

(ii) to assign spectrum for gateway links and user links in a bundled manner, such that the successful bidder gets spectrum for user link as well as gateway link? In case your response is in the affirmative, kindly suggest appropriate assignment

methodology, including auction so that the successful bidder gets spectrum for user links as well as gateway links.

As noted above, SpaceX strongly recommends allowing shared access for all satellite-based service providers to the entire critical spectrum bands allocated to FSS, and bundling access to spectrum for both user terminals as well as gateways.

Q23. Whether any protection distance would be required around the satellite earth station gateway to avoid interference from other satellite earth station gateways for GSO/ NGSO satellites using the same frequency band? If yes, what would be the protection distance (radius) for the protection zone for GSO/ NGSO satellites?

The TRAI need not establish minimum protection distances to enable satellite operators to share spectrum. These minimum separation distances have the perverse effect of constraining efficient sharing and reduce incentives for operators to improve their systems to better share spectrum.

Instead, the TRAI should adopt sharing rules between satellite systems that encourage cooperation, competition, and efficient use of spectrum. For example, the TRAI could consider a spectrum-splitting last resort where satellite operators would have to evenly split available spectrum only during in-line events if they have not completed private coordination before they both commence service. Ideally, this backstop would never be used because the prospect of non-ideal spectrum splitting will incentivize both operators to find a better solution through coordination. To create further incentives to build efficient systems, regulators could also consider awarding first choice in the split to the more efficient, flexible, and robust system.

Q24. What should be the eligibility conditions for assignment of spectrum for each type of space-based communication service (as mentioned in the Table 1.3 of this Consultation Paper)? Among other things, please provide your inputs with respect to the following eligibility conditions:

(a) Minimum Net Worth

(b) Requirement of existing agreement with satellite operator(s)

(c) Requirement of holding license/ authorization under Unified License prior to taking part in the auction process.

Kindly justify your response.

SpaceX recommends that any assignment mechanism allow shared access to the entire critical spectrum bands allocated to FSS for all current and future operators. As a result, SpaceX recommends requiring a legal undertaking to acquire the appropriate Unified License authorisation for providing satellite-based services prior to using such spectrum (which brings with it the associated Unified License minimum net worth requirements). SpaceX recommends against imposing additional net-worth requirements outside of those required for obtaining Unified Licenses to provide space-based communications. Additionally, the TRAI should consider recommending the requirement of a reasonable upfront deposit as well as commitments to deployment milestones prior to being allowed shared access to satellite spectrum, which would help deter speculation and anti-competitive behaviour.

Q25. What should be the terms and conditions for assignment of frequency spectrum for both user links as well as gateway links for each type of space-based communication service? Among other things, please provide your detailed inputs with respect to roll-out obligations on space-based

communication service providers. Kindly provide response for both scenarios viz. exclusive assignment and non-exclusive (shared) assignment with justification.

SpaceX recognises the value of rollout obligations in ensuring that exclusive access to spectrum for terrestrial mobile operators is met with a concomitant usage of the spectrum to provide services. However, in the case of shared access to the entire spectrum bands allocated for FSS (which we strongly recommend), operators are not precluded by each other from rolling out services. As a result, there are clear and strong market incentives for operators to ensure rapid rollout. Additionally, space-based communications services such as Starlink already generally provide complete geographic coverage rendering rollout obligations unnecessary. As a result, simply ensuring shared access based on good-faith coordination amongst all space-based communications operators does away with the need for rollout obligations as a pre-condition for access to spectrum. At the same time, operators will continue to have to pay regulatory fees which provides additional incentives to operationalise their infrastructure as soon as possibility.

TRAI must also take care to ensure that rollout obligations or conditions do not disproportionately impact space-based operators since these would condition access to critical spectrum on burdensome requirements they would not face in any other market today.

Q27. Keeping in view the provisions of ITU's Radio Regulations on coexistence of terrestrial services and space-based communication services for sharing of same frequency range, do you foresee any challenges in ensuring interference-free operation of space-based communication network and terrestrial networks (i.e., microwave access (MWA) and microwave backbone (MWB) point to point links) using the same frequency range in the same geographical area? What could be the measures to mitigate such challenges? Suggestions may kindly be made with justification.

Due to the narrow, directional nature of beams in millimeter wave bands, which allow many users to coexist within close proximity without interference, the TRAI should consider adopting database-assisted "light licensing." This approach permits gateway earth stations to register new ground equipment alongside fixed service installations on a self-coordinated, first-come, first-served basis, promoting rapid deployment of critical backhaul infrastructure while protecting incumbent users from harmful interference.

Q28. In what manner should the practice of assignment of a frequency range in two polarizations should be taken into account in the present exercise for assignment and valuation of spectrum? Kindly justify your response.

The TRAI should NOT include polarization as a factor in its assignment or valuation mechanisms. Satellite systems (both GSO and NGSO) can use both polarization methods. In practice, most NGSO systems that are currently being deployed or planned depend on access to both polarizations simultaneously in order to operate(across User Terminals, Satellites, and Gateway Earth Stations - depending on the system).

Q29. What could be the likely issues, that may arise, if the following auction design models (described in para 3.127 to 3.139) are implemented for assignment of spectrum for user links in higher bands (such as C band, Ku band and Ka band)?

a. Model #1: Exclusive spectrum assignment

b. Model#2: Auction design model based on non-exclusive spectrum assignment to only a limited number of bidders

What changes should be made in the above models to mitigate any possible issues, including ways and means to ensure competitive bidding? Response on each model may kindly be made with justification.

As discussed in the narrative above and detailed in the comparison table provided in Section F, neither Model #1 nor Model #2 are mechanisms that should be used for spectrum assignment for satellite services. Model #1 is not appropriate because global satellite systems have been designed to share across the entire bands they use, making exclusive spectrum assignment inefficient and impractical. Model #2 artificially restricts access to the market and doesn't reflect the fact that the new space industry is evolving rapidly. Model #2 would close out new entrants for some period of time to the detriment of the citizens of India as well as the Treasury.

As stated in Section E above, we have offered an alternate auction design approach for access to the entirety of the critical spectrum band allocated to FSS based on percentage of annual revenue. We reemphasize that even this option is inferior to a well-designed administrative approach as it forces the Government to artificially restrict spectrum access to only a set number of operators, despite the satellite industry having designed its system to effectively share spectrum among many operators.

Q30. In your opinion, which of the two models mentioned in Question 29 above, should be used? Kindly justify your response.

As stated in Sections D, E and F, SpaceX believe a well-designed administrative approach is superior to either of the models mentioned in Question 29. Neither of the two models mentioned in Question 29 should be used for assigning spectrum to satellite services.

Q31. In case it is decided to assign spectrum for user links using model # 2 i.e., non-exclusive spectrum assignment to limited bidders (n+ Δ), then what should be (a) the value of Δ, in case it is decided to conduct a combined auction for all services (b) the values of Δ, in case it is decided to conduct separate auction for each type of service Please provide detailed justification.

As discussed in the narrative above, imposing any artificial restriction or scarcity in order to force-fit terrestrial auction design onto satellite spectrum access is extremely ill-advised. Any suggestions on the value of Δ would be both arbitrary and ill-advised since the data to make any such determination does not exist, and would stifle future entry and growth into India's space economy.

This problem exists even in our best attempt at providing a good-faith suggestion for an alternative auction design based on revenue sharing – any artificial restriction on access to shared satellite spectrum necessarily requires creating a system of "winners and losers" for market entry, even when there does not need to be.

Q32. Kindly suggest any other auction design model(s) for user links including the terms and conditions? Kindly provide a detailed response with justification as to how it will satisfy the requirement of fair auction i.e., market discovery of price.

As stated in Section E above, we have offered an approach to auctioning shared access to the entirety of the critical spectrum band allocated to FSS based on percentage of annual revenue, but we also note that this option is inferior to a well-designed administrative approach as it forces the Government to artificially restrict access participation to only some operators when the satellite industry has designed its system to effectively share spectrum amongst many operators.

Q33. What could be the likely issues, that may arise, if Option # 1: (Area specific assignment of gateway spectrum on administrative basis) is implemented for assignment of spectrum for gateway links? What changes could be made in the proposed option to mitigate any possible issues?

Since the number and preferred location of gateway stations is unique to each provider, and providers may need to increase the number of gateway stations as consumer demand increases, SpaceX believes an administrative approach is most appropriate. We reiterate and emphasize that in order to achieve low-latency service and control the infrastructure costs that in turn impact the affordability of satellite broadband for end users, satellite operators must have the flexibility to place gateway sites *in and near urban areas* that enable access to essential ground infrastructure, including data centres, fiber optic cables, and reliable redundant power supply.

Q34. What could be the likely issues, that may arise, if Option # 2: Assignment of gateway spectrum through auction for identified areas/ regions/ districts is implemented for assignment of spectrum for gateway links? What changes could be made in the proposed option to mitigate any possible issues? In what manner, areas/ regions/ districts should be identified?

An auction mechanism will not offer the flexibility that systems will need as demand increases and may slow the ability of any one system to meet consumer demand by forcing the operator to wait for a future auction to get access to spectrum for an additional gateway site. We reiterate that in order to achieve low-latency service and control the infrastructure costs that impact the affordability of satellite broadband for end users, satellite operators must have the flexibility to place gateway sites in and near urban areas with access to essential ground infrastructure, including data centres, fiber optic cables and reliable redundant power supply.

Q35. In your view, which spectrum assignment option for gateway links should be implemented? Kindly justify your response.

SpaceX strongly recommends allowing shared access for all satellite-based service providers to the entire critical spectrum bands allocated to FSS, and bundling access to spectrum for both user terminals as well as gateways.

Q36. Kindly suggest any other auction design model(s) for gateway links including the terms and conditions? Kindly provide a detailed response with justification as to how it will satisfy the requirement of fair auction i.e., market discovery of price?

SpaceX strongly recommends allowing shared access for all satellite-based service providers to the entire critical spectrum bands allocated to FSS, and bundling access to spectrum for both user terminals as well as gateways.

As stated in Section E above, we have offered an approach to auction shared access to the entirety of the critical spectrum band allocated to FSS based on percentage of annual revenue. We note once again that this option is still inferior to a well-designed administrative approach as it forces the Government to artificially restrict spectrum access to only some operators, when the satellite industry has designed its system to effectively share spectrum among many operators. This in turn has the numerous disadvantages of limiting competition and consumer choice, artificially increasing consumer prices, and temporarily reducing the viability of investments into Indian space start-ups. However, it does satisfy all three of the fundamental satellite system requirements of –

- Predictable and guaranteed shared access to the entire allocated bands for both user terminals as well as gateways;
- Access to critical spectrum across wide and contiguous channels without geographical restrictions; and
- Ensuring similar terms for all qualifying operators that provide similar services in a harmonized manner.

It also ensures that such a design can

- help arrive at a far more accurate measure of value discovery for the spectrum over time;
- incentivize efficient use and rapid rollout by operators;
- provide a clear, transparent, efficient and fully described process for accessing spectrum that is legally predictable and auction-based;
- ensure an open door for future operators to enter the market and encourage investments towards the growth of the Indian space industry; and
- optimize revenue-generation from the SATCOM industry as a function of the auction-described percentage fee over time.

We reiterate our analysis from Section B ("National policy priorities [...]") on price discovery and ensuring a fair return from industry –

> *"The TRAI correctly notes that a fundamental requirement of spectrum assignment methods – particularly auctions – is accurate price discovery that determines the fair value of access to the spectrum resource. While traditional auctions for mobile spectrum rely on a combination of competitive bidding and accurate reserve price setting to satisfy this requirement, such an approach fundamentally relies on mobile operators needing spectrum on rivalrous and exclusionary grounds. As the TRAI repeatedly and correctly notes, this is simply not the case for satellite spectrum use.*
>
> *The TRAI also notes that accurately determining auction reserve prices - as well as the ability of operators to correctly calculate a willingness to bid - requires substantial amounts of historical data on the underlying market and service conditions. The reliability and accuracy of extrapolative models for calculating spectrum reserve prices (as well as operators' willingness-to-bid) are extremely sensitive to the underlying data and assumptions that feed into these models. As already noted in the consultation paper, this data simply does not exist for the shared FSS bands.*
>
> *Other countries have recognized the technical need and efficiency benefits of assigning shared spectrum for satellite broadband, and thus no country has considered an auction-based process for assigning spectrum to satellite systems. Since these systems have always been designed to operate in shared and non-rivalrous conditions, no comparative data exists. India has also not had a private satellite broadband market thus far, and so no data exists about demand, operators' willingness to pay, or users' ability to pay. Finally (and most importantly), a purely theoretical economic approach does not consider the tremendous public benefits of a dynamic and competitive satellite sector (including but not limited to universal service, disaster preparedness, and emergency connectivity). Any mechanism that seeks to find a fair return for spectrum access must account for these benefits.*
>
> *In the absence of such data, we must recommend that the TRAI err on the side of caution, rather than forcibly attempt to set reserve prices using purely theoretical assumptions (and entirely inapplicable) comparisons to terrestrial services. Access to a shared band is very different from exclusive assignments, so comparisons between the two are both inappropriate and very likely to lead to*

negative outcomes. The TRAI's choice of assignment method must thus ensure that it does not sacrifice the accuracy of this price discovery process (which should be one that improves in accuracy over time rather than one that is incorrect from the beginning). [….]

[….] Where spectrum use is exclusionary (as in the case of terrestrial mobile), it follows that a substantial portion of public revenue considerations can be accurately recognised (and satisfied) through the results of an auction. This is because the number of operators that can simultaneously co-exist must be unavoidably restricted. The TRAI's auction methodologies for mobile spectrum have thus successfully demonstrated that optimally discovering realizable value for public revenue is achieved via competitive bidding (to identify operators who will extract the greatest value from exclusive access to spectrum).

For satellite broadband however – where sharing is not only possible but an underlying system design principle – public revenue generation is optimised by maximising the number of operators who can provide services within the market over time. This approach optimises both a variety of different consumer benefits as well as tax and regulatory revenue. The TRAI's choice of spectrum assignment process must recognise that when it comes to shared spectrum use by satellites, the triple benefits of increased competition through numerous operators, maximisation of consumer choice, and revenue optimisation are all fundamentally aligned. This is why SpaceX recommends good faith coordination principles to expand the use of spectrum and the benefits delivered from shared access."

Q37. Any other issues/suggestions relevant to the subject, may be submitted with proper explanation and justification.

We have provided our analysis on issues and suggestions relevant to the subject in the sections preceding these question-wise responses.

Q38. In case it is decided for assignment of spectrum on administrative basis, what should be the spectrum charging mechanism for assignment of spectrum for space-based communications services.

i. For User Link
ii. For Gateway Link Please support your answer with detailed justification.

SpaceX supports an administrative basis for assigning spectrum access for space-based communications services and believes the best approach is an administrative cost recovery model with low, predictable fees tailored to cover the costs of processing the licenses. Establishing a flexible approach to spectrum access for space-based services along with a rational fee structure is essential to promote competition, innovation, connectivity, and consumer value.

A cost-recovery model minimizes the cost of deploying vital services to otherwise unserved Indian consumers by basing spectrum licence fees on the cost to recover the administrative expenses of processing the licence itself. This approach will help ensure that satellite operators can focus their limited resources on serving customers and bringing vital communication services to those who have been left behind in the digital revolution.

This approach can and should apply both to user links and gateway links, because, as described above, both are necessary to support satellite broadband services. This approach has been

effectively employed in several countries to create a vibrant and affordable satellite communications market, including in the United States and in European Union countries including Ireland.

Q39. Should the auction determined prices of spectrum bands for IMT /5G services be used as a basis for valuation of space-based communication spectrum bands

i. For user link
ii. For gateway link

Please support your answer with detailed justification.

AND

Q40. If response to the above question is yes, please specify the detailed methodology to be used in this regard?

The TRAI must *not* use the auction determined prices of spectrum bands for IMT/5G services as a basis for valuing space-based communication spectrum plans. As explained throughout our response, there are fundamental differences between terrestrial mobile and satellite communications services in how they use spectrum, the nature and costs of the associated infrastructure and its deployment, the target and addressable market for these services, as well as the existing technology ecosystem and the current stage of the industry's development. All of these mean that such an approach would be extremely ill-advised.

As the TRAI already notes, its determination of reserve prices for spectrum use by IMT services relied on *"**extensive datasets** consisting of certain market parameters, financial parameters related to the particular band, existing spectrum holding of the particular band, past auction prices etc. **However, in case of the satellite-based communication spectrum bands, there is no historical auction data available to conduct comparative analysis involving auction determined prices in India or using valuation models involving data related to the spectrum bands.**"*

[Paragraph 4.12].

We have also emphasised that *"[...] The reliability and accuracy of extrapolative models for calculating spectrum reserve prices (as well as operators' willingness-to-bid) are extremely sensitive to the underlying data and assumptions that feed into these models. As already noted in the consultation paper, this data simply does not exist for the shared FSS bands.*

Other countries have recognized the technical need and efficiency benefits of assigning shared spectrum for satellite broadband, and thus no country has considered an auction-based process for assigning spectrum to satellite systems. Since these systems have always been designed to operate in shared and non-rivalrous conditions, no comparative data exists. India has also not had a private satellite broadband market thus far, and so no data exists about demand, operators' willingness to pay, or users' ability to pay. Finally (and most importantly), a purely theoretical economic approach does not consider the tremendous public benefits of a dynamic and competitive satellite sector (including but not limited to universal service, disaster preparedness, and emergency connectivity). Any mechanism that seeks to find a fair return for spectrum access must account for these benefits.

In the absence of such data, we must recommend that the TRAI err on the side of caution, rather than forcibly attempt to set reserve prices using purely theoretical assumptions (and entirely inapplicable) comparisons to terrestrial services. Access to a shared band is very different from exclusive assignments, so comparisons between the two are both inappropriate and very likely to lead to negative outcomes. The TRAI's choice of assignment method must thus ensure that it does

not sacrifice the accuracy of this price discovery process (which should be one that improves in accuracy over time rather than one that is incorrect from the beginning). [....]"

[Emphasis added]

In the absence of this data, we would recommend erring on the side of caution rather than forcibly attempting to set reserve prices on the basis of purely theoretical assumptions and inapplicable comparisons to terrestrial services. Using the auction-determined prices of IMT/5G spectrum is an extremely poor (and dangerous) substitute in making up for the lack of data necessary for an accurate valuation of the spectrum used by satellites.

Q41. Whether the value of space-based communication spectrum bands

i. For user link
ii. For gateway link

be derived by relating it to the value of other bands by using a spectral efficiency factor? If yes, with which spectrum bands should these bands be related to and what efficiency factor or formula should be used? Please support your response with detailed justification.

The spectral efficiency factor methodology used by the TRAI for determining the value of terrestrial mobile spectrum is entirely inapplicable to the case of satellite spectrum. At its core, using mobile spectral efficiency factors to determine the value of certain frequencies relative to others relies on assumptions that plainly do not apply to satellite spectrum. These assumptions include -

- **Exclusionary and rivalrous use**, since mobile operators value *exclusionary access to* certain frequencies higher than others because mobile operators cannot co-exist within the same frequency. Since satellite systems are designed to share, exclusive access is not only unnecessary but also undesirable.
- **Substitutability of frequencies**, since mobile operators value exclusive access between different assigned frequencies based on the performance and propagation characteristics of those frequencies, but can substitute across frequencies within their systems. In contrast, satellite systems share spectrum but fundamentally require access to the entire bands allocated to FSS service for both gateways and user terminals. Access to the entire frequencies across bands is thus an essential operating condition, and satellite systems cannot choose between one or the other (irrespective of exclusivity).
- **Limits on data throughput potential per frequency,** since a frequency exclusively assigned to one mobile operator's system cannot be reused by another. However, because different satellite systems can share and reuse the same frequency, the total data that can be carried by assigned spectrum increases with the number of operators.

The TRAI also notes that the "*spectral efficiency factor is available only with respect to IMT/5G.",* recognising that the data simply does not exist to apply this concept to satellite systems. We recommend very strongly against forcing such an incompatible approach for mobile spectrum valuation onto satellite spectrum assignment frameworks. We reiterate that *"as a general rule [...] any assignment mechanism should recognize how any practical limit on co-existence is a function not just of the number of systems in operation but also their design efficiency. More efficient systems with higher tolerances will allow more systems to co-exist now and in the future.* ***As a result, we strongly recommend that the TRAI ensure any assignment mechanism be designed to enable shared use of critical spectrum resources between systems as well as reward greater capacity for sharing."***

[Emphasis added]

Q42. In case of an auction, should the current method of levying spectrum fees/charges for satellite spectrum bands on formula basis/ AGR basis as followed by DoT, serve as a basis for the purpose of valuation of satellite spectrum

i. **For user link**
ii. **For gateway link**

If yes, please specify in detail what methodology may be used in this regard.

SpaceX recommends against forcing an auction methodology on to assigning spectrum for satellite.

While we commend the numerous recommendations the TRAI has previously made on simplifying fees for spectrum *use* by satellite systems to 1% of AGR, we recommend against using it as a basis for auction valuation. We reiterate -

> "[...] *The reliability and accuracy of extrapolative models for calculating spectrum reserve prices (as well as operators' willingness-to-bid) are extremely sensitive to the underlying data and assumptions that feed into these models. As already noted in the consultation paper, this data simply does not exist for the shared FSS bands.*
>
> *Other countries have recognized the technical need and efficiency benefits of assigning shared spectrum for satellite broadband, and thus no country has considered an auction-based process for assigning spectrum to satellite systems. Since these systems have always been designed to operate in shared and non-rivalrous conditions, no comparative data exists. India has also not had a private satellite broadband market thus far, and so no data exists about demand, operators' willingness to pay, or users' ability to pay. Finally (and most importantly), a purely theoretical economic approach does not consider the tremendous public benefits of a dynamic and competitive satellite sector (including but not limited to universal service, disaster preparedness, and emergency connectivity). Any mechanism that seeks to find a fair return for spectrum access must account for these benefits.*
>
> *In the absence of such data, we must recommend that the TRAI err on the side of caution, rather than forcibly attempt to set reserve prices using purely theoretical assumptions (and entirely inapplicable) comparisons to terrestrial services. Access to a shared band is very different from exclusive assignments, so comparisons between the two are both inappropriate and very likely to lead to negative outcomes. The TRAI's choice of assignment method must thus ensure that it does not sacrifice the accuracy of this price discovery process (which should be one that improves in accuracy over time rather than one that is incorrect from the beginning). [....]"*

We also very strongly recommend against imposing the previous formula-based methods of charges based on per unit of spectrum, since the assumptions underlying these formulas are entirely incompatible with the technical characteristics, frequency use, and performance characteristics of modern NGSO systems. Importing the previous formula-based methods of determining spectrum usage charges would derail the economic and technical viability of any next-generation private satellite communications market in India.

Q43. Should revenue surplus model be used for the valuation of space-based spectrum bands

i. **For user link**
ii. **For gateway link**

Please support your answer with detailed justification.

No. The referenced TRAI revenue-surplus model was designed to arrive at a per MHz valuation of spectrum in the 1800 MHz band for exclusive use by terrestrial mobile systems and is thus contingent on a fundamental presumption that simply does not hold true for satellite spectrum. Furthermore, the model makes numerous presumptions that fundamentally break in any analysis of satellite-based spectrum use and requirements including geographical divisions across LSAs, financial reports from operators serving a mature and well-defined market with a heterogenous ecosystem, assumptions of comparable capital cost across operators, assumptions of a proportional relationship between capital investment requirements and subscriber growth within an LSA etc. It also then converts the blended present value of spectrum holdings across a number of bands that can all be used by user devices within the mobile ecosystem by using a factor of technical efficiency for spectrum between the 1800 MHz and other bands.

Absolutely none of these inputs correctly translate or correspond to how satellite services are designed to use spectrum on a shared basis. As we have described in detail throughout our narrative analysis, recommendations and previous responses – it is extremely ill-advised to force-fit auctions tailored for terrestrial mobile spectrum use onto satellite services.

Q44. Whether international benchmarking by comparing the auction determined prices of countries where auctions have been concluded for space-based communication services, if any, be used for arriving at the value of space-based communication spectrum bands:

i. For user link
ii. For gateway link

If yes, what methodology should be followed in this regard? Please give country-wise details of auctions including the spectrum band/quantity put to auction, quantity bid, reserve price, auction determined price etc. Please support your response with detailed justification.

No other countries currently auction licenses for access to the shared satellite bands used by next generation satellite systems.

Q45. Should the international administrative spectrum charges/fees serve as a basis/technique for the purpose of valuation in the case of satellite spectrum bands

i. For user link
ii. For gateway link

Please give country-wise details of administrative price being charged for each spectrum band. Please specify in detail terms and conditions in this regard.

Both the United States and Ireland use cost-recovery approaches for administrative pricing. For example, the FCC charges $620 per license or authorization for a blanket license for user antennas or for a license for a gateway link. This approach allows the regulator to recoup the costs of administering the license while allowing the service to focus its resources on developing and deploying capital-intensive space-based communication services. Further, this administrative cost-recovery approach is flexible in that new entrants can be added at any point as new satellites are launched, so operators can request access when their systems need it, subject to sharing and coordination requirements.

Current FCC fees for user link blanket licenses and gateway link licenses can be found at: https://www.fcc.gov/document/fy-2022-regulatory-fees-international-services-fact-sheet

Q46. If the answer to above question is yes, should the administrative spectrum charges/fees be normalized for cross country differences? If yes, please specify in detail the methodology to be used in this regard?

An administrative cost recovery model is based on the cost of the regulator processing and issuing the license, so doesn't require any adjustment or normalization. However, if a fee above cost recovery is implemented, any referenced fee approach should be normalized to reflect affordability for the users most in need of such services within India.

Q48. Should the valuation arrived for spectrum for user link be used for valuation for spectrum for gateway links as well? Please justify.

SpaceX supports an administrative cost-recovery model, so the cost of these licenses would likely be roughly equal. As noted above in Q.45, the FCC charges the same fee for a blanket user link licenses as for a gateway license.

Further, to speed consumer access to next-generation satellite connectivity, SpaceX recommends that regulators adopt "blanket licensing" regimes for user terminals. Simplified procedures for end-user terminal authorization can provide flexibility for efficient, widespread deployment of user terminals to meet consumer demand without the administrative burden of individual earth station licensing for regulators, operators, and consumers.

Similarly, SpaceX supports adopting a database-assisted light-licensing for gateway earth stations. Due to the narrow, directional nature of beams in millimeter wave bands, which allow many users to coexist within close proximity without interference, regulators should consider adopting database-assisted "light licensing." This approach permits gateway earth stations to register new ground equipment alongside fixed service installations on a self-coordinated, first-come, first-served basis, promoting rapid deployment of critical backhaul infrastructure while protecting incumbent users from harmful interference.

Q49. If the answer to the above is no, what should be the basis for distinction as well as the methodology that may be used for arriving at the valuation of satellite spectrum for gateway links? Please provide detailed justification.

AND

Q50. Whether the value arrived at by using any single valuation approach for a particular spectrum band should be taken as the appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please support your answer with detailed justification.

AND

Q51. In case your response to the above question is negative, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, or some other approach like taking weighted mean, median etc. should be followed? Please support your answer with detailed justification.

AND

Q52. Should the reserve price for spectrum for user link and gateway link be taken as 70% of the valuation of spectrum for shared as well as for exclusive assignment? If not, then what ratio should be adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands in case of

(i) exclusive
(ii) shared assignment and why?

Please support your answer with detailed justification.

SpaceX does not support an auction approach to spectrum awards for space-based services, therefore a reserve price isn't necessary.

As we have previously noted, it is impossible to arrive at any reasonable valuation for the use of shared satellite spectrum in India. We reiterate our previous statement from the section analysing "National policy priorities for the Indian telecom and space sectors" -

> *"The TRAI correctly notes that a fundamental requirement of spectrum assignment methods – particularly auctions – is accurate price discovery that determines the fair value of access to the spectrum resource. While traditional auctions for mobile spectrum rely on a combination of competitive bidding and accurate reserve price setting to satisfy this requirement, such an approach fundamentally relies on mobile operators needing spectrum on rivalrous and exclusionary grounds. As the TRAI repeatedly and correctly notes, this is simply not the case for satellite spectrum use.*
>
> *The TRAI also notes that accurately determining auction reserve prices - as well as the ability of operators to correctly calculate a willingness to bid - requires substantial amounts of historical data on the underlying market and service conditions. The reliability and accuracy of extrapolative models for calculating spectrum reserve prices (as well as operators' willingness-to-bid) are extremely sensitive to the underlying data and assumptions that feed into these models. As already noted in the consultation paper, this data simply does not exist for the shared FSS bands.*
>
> *Other countries have recognized the technical need and efficiency benefits of assigning shared spectrum for satellite broadband, and thus no country has considered an auction-based process for assigning spectrum to satellite systems. Since these systems have always been designed to operate in shared and non-rivalrous conditions, no comparative data exists. India has also not had a private satellite broadband market thus far, and so no data exists about demand, operators' willingness to pay, or users' ability to pay. Finally (and most importantly), a purely theoretical economic approach does not consider the tremendous public benefits of a dynamic and competitive satellite sector (including but not limited to universal service, disaster preparedness, and emergency connectivity). Any mechanism that seeks to find a fair return for spectrum access must account for these benefits.*
>
> *In the absence of such data, we must recommend that the TRAI err on the side of caution, rather than forcibly attempt to set reserve prices using purely theoretical assumptions (and entirely inapplicable) comparisons to terrestrial services. Access to a shared band is very different from exclusive assignments, so comparisons between the two are both inappropriate and very likely to lead to negative outcomes. The TRAI's choice of assignment method must thus ensure that it does not sacrifice the accuracy of this price discovery process (which should be one that improves in accuracy over time rather than one that is incorrect from the beginning). [....]*
>
> *[....] Where spectrum use is exclusionary (as in the case of terrestrial mobile), it follows that a substantial portion of public revenue considerations can be accurately recognised (and satisfied) through the results of an auction. This is because the number of operators that can simultaneously co-exist must be unavoidably restricted. The TRAI's auction methodologies for mobile spectrum have thus successfully demonstrated that optimally discovering realizable value for public revenue is*

achieved via competitive bidding (to identify operators who will extract the greatest value from exclusive access to spectrum).

For satellite broadband however – where sharing is not only possible but an underlying system design principle – public revenue generation is optimised by maximising the number of operators who can provide services within the market over time. This approach optimises both a variety of different consumer benefits as well as tax and regulatory revenue. The TRAI's choice of spectrum assignment process must recognise that when it comes to shared spectrum use by satellites, the triple benefits of increased competition through numerous operators, maximisation of consumer choice, and revenue optimisation are all fundamentally aligned. This is why SpaceX recommends good faith coordination principles to expand the use of spectrum and the benefits delivered from shared access."

[Emphasis added]

Furthermore, the valuation methodologies used for terrestrial mobile spectrum auctions and valuation cannot be force-fit to shared satellite spectrum use. As the TRAI already notes, its determination of reserve prices for spectrum use by IMT services relied on *"**extensive datasets** consisting of certain market parameters, financial parameters related to the particular band, existing spectrum holding of the particular band, past auction prices etc. **However, in case of the satellite-based communication spectrum bands, there is no historical auction data available to conduct comparative analysis involving auction determined prices in India or using valuation models involving data related to the spectrum bands.**"* Absolutely none of these inputs correctly translate or correspond to how satellite services are designed to use spectrum on a shared basis. As we have described in detail throughout our narrative analysis, recommendations and previous responses – it is extremely ill-advised to force-fit auctions tailored for terrestrial mobile spectrum use onto satellite services.

Q53. If it is decided to conduct separate auctions for different class of services, should reserve price for the auction of spectrum for each service class be distinct? If yes, on what parameter basis such as revenue, subscriber base etc. this distinction be made? Please support your answer with detailed justification for each class of service.

SpaceX supports a common approach for different classes of space-based services as generally these services have been designed to operate on shared spectrum and typically make use of the entire bands (e.g. Ku- or Ka-bands). SpaceX does not support mobile services in the 28 GHz band, but note that if it is made available to IMT, it should be with protections for SATCOM, and should be a fundamentally different assignment method.

Q54. In case of auction based and/or administrative assignment of spectrum, what should the payment terms and associated conditions for the assignment of spectrum for space-based communication services relating to:

i. Upfront payment
ii. Moratorium period
iii. Total number of installments to recover deferred payments
iv. Rate of discount in respect of deferred payment and prepayment

Please support your answer with detailed justification.

Well-designed auctions include competitive safeguards such as upfront payments and trading moratorium periods to discourage speculative bidding. Likewise, administrative assignments should discourage speculative entry.