Marcus Spectrum Solutions

Question Number	NOI Para.	Question
1	17	Will it be feasible to provide mobile services in bands above 24 GHz?
2	17	To what extent will the viability of mobile service above 24 GHz be dependent on having complementary access to mobile services in lower frequency bands?
3	17	What characteristics of the anticipated technology will be relevant to the choices of frequency bands above 24 GHz such as required bandwidth, propagation, availability of electronic components, antenna designs and costs of deployment?
4	17	What characteristics of the anticipated technology are likely to inform the agency's determination of what regulatory framework (or frameworks) for mobile services in the mmW bands will best serve the public interest?
5	17	What characteristics of the technology are relevant to the manner in which mobile services in the mmW bands might coexist without impact on incumbent services that occupy the relevant frequency bands?
6	17	Are there frequency bands contemplated for mobile use that are being considered for alternative uses and, if so, what might those alternative uses be? To what extent are such uses compatible or incompatible with the kinds of mobile wireless technologies being explored in this NOI?
7	17	What technical and operational characteristics as well as interference mitigation techniques of the anticipated technologies for these bands need to be considered in assessing sharing and compatibility with in-band and adjacent band incumbent services? Are there other technical considerations the Commission should examine in enabling deployment of mobile services in bands above 24 GHz?
8	17	In addition to seeking comment on mobile use of the mmW bands, we also seek comment on alternative uses of the mmW bands.
9	18	In the section that follows, we seek comment on the current development of antenna technology in the mmW bands.
10	18	What advanced antenna technologies are anticipated to be feasible in the mmW bands?
11	18	What is the potential timeframe for commercial implementation of these technologies in mobile broadband services in the mmW bands?
12	19	We seek comment on the types of antenna arrays that may be available for base stations supporting advanced mobile services.
13	19	What do commenters anticipate the size and configuration of the antenna arrays will be, including the orientation of the vertical and horizontal elements and the predicted number of beams?

14	19	With respect to antennas located at base stations, what factors are likely to affect the physical size of and space needed for the antenna arrays?
15	20	We seek comment on the types of base station configurations that may be used to support advanced mobile services in the mmW bands, including whether there will be a similar range and mix of higher and lower power base stations.
16		What types of Power Amplifiers (PAs) and how many PAs will be needed to support the various antenna array systems?
17	20	Does each antenna element require a dedicated PA?
18	20	Are there potential configurations in which the PA(s) and the array antennas are separated?
19	20	If so, what are the options for physically connecting the PA(s) and array antennas?
20	20	How many users can simultaneously connect to the base station and what are the limiting factors?
21	21	How will the base stations manage the transmitted effective isotropic radiated power (EIRP) of each antenna beam to generate the desired gain?
22	21	What will the typical gain be for an individual element of the array?
23	21	Will each element in the antenna array have a variable power that can be managed depending on the demand placed on the base station?
24	21	Will the aggregate transmitter power for the base station increase as more elements of the array are used for operation?
25	21	What are the vertical and horizontal beamwidths that the antenna array could cover?
26	21	What type of sectorization is being considered for a base station array?
27	21	What is the desired PA output power and EIRP of the base station?
28	22	How will antenna arrays be configured to deal with varying deployment scenarios while still providing the desired level of connectivity to the user?
29	22	What potential challenges may be encountered with an indoor deployment versus an outdoor deployment?
30	22	How will the orientation of the handset affect the connectivity? How will such factors as “head loss” affect connectivity?
31	23	We ask commenters to provide information on how the technologies underlying mmW mobile wireless systems will be incorporated into mobile stations (i.e., user devices, including handsets).
32	23	The form factor of mobile stations may limit the size and number of antenna elements that may be included on the device. We seek comment on how these limitations may influence the design of advanced mobile systems.
33	23	What size antenna arrays do commenters expect, and how much physical space will they likely occupy in handsets?
34	23	Do commenters anticipate that the limited number of elements within an array will present connectivity issues?

35	23	What kind of architecture may be needed to allow the antenna array to operate in conjunction with normal handset use?
36	24	What is the likely gain of the array elements in the handset?
37	24	How many beams should a handset be capable of creating, and what types of beam pattern could be used?
38	24	Can handsets be designed to overcome obstacles that block their lines of sight to base stations?
39	24	How long will it take a handset to recognize connectivity impairments and switch connections?
40	24	What are the other RF components that need further development in order to support the beam-forming techniques that may be utilized to support advanced mobile services in the mmW bands?
41	25	We ask commenters whether the added complexity of an advanced wireless network incorporating mmW bands for mobile service will require different handset architecture than that of current-generation technologies, such as Long Term Evolution (LTE).
42	25	For example, how does the MIMO implementation for LTE handsets compare with the beam-forming implementation in 5G handsets, in terms of baseband signal processing and RF layer signal processing?
43	25	How do commenters anticipate a transition from current LTE designs will occur?
44	25	As LTE networks are redesigned for a 5G environment, will 5G architectures be integrated into current LTE designs, or added as a separate system or module, requiring, for example, use of a dual handset capable of operating on both LTE and 5G networks?
45	25	Alternatively, will another approach be used?
46	26	We also seek comment on likely advances in the design of integrated circuits (ICs) to be used in radio frequency equipment for higher frequencies.
47	26	What does industry see as the leading design for ICs that should be used in equipment for frequencies above 24 GHz?
48	26	Will developments in design produce ICs that are of a suitable size for handheld devices?
49	26	Will their power consumption be supportable by current handheld batteries?
50	26	Are these developments likely to lead to mobile devices that are capable of utilizing bands above 24 GHz?
51	26	What is the potential for using CMOS above 70 GHz?

52	26	As mentioned earlier, it seems possible that mmW band technologies within a cellular network will be a supplementary component within an architecture that will continue to use lower frequencies. Considering such a multi-layer architecture, how would a user connect to the network and how will base stations detect and transmit to a mobile user in their coverage areas, particularly given the high directivity of mmW band antenna technology?
53	26	How would handoffs between cells be coordinated?
54	26	In this multi-layer architecture, does a mmW band network rely on the overlay network for any type of assistance in order to provide a seamless service?
55	26	Do commenters anticipate any special challenges involved in handoffs between indoor and outdoor environments?
56	26	How would the network handle multipath and diffraction interference that can arise in a dense urban environment?
57	28	The configurations of multiple antenna arrays pointing at varying angles and covering different parts of the base station coverage area could lead to aggregate interference. If so, how will base stations manage power and directional coverage to avoid harmful interference among licensees?
58	29	Considering the potential use of advanced antenna technologies that include dynamic beam-forming, how will 5G mobile stations in the mmW bands identify themselves to a base station and establish an initial connection?
59	29	The limited coverage areas of mmW mobile service base stations may also require more frequent hand-offs as the handset moves between cells. If so, which would be more likely to handle the processing - the network or the handset – and to what extent?
60	29	How will adequate continuity of coverage be achieved?
61	30	We seek comment on how much contiguous spectrum will be needed to support advanced mobile services and other contemplated services in bands above 24 GHz.
62	31	We also seek comment on whether technology will allow licensees to effectively aggregate smaller, non-contiguous blocks of spectrum for use in providing mobile services, possibly reducing the need for large blocks of contiguous spectrum.
63	31	Are there any inherent advantages of using TDD in higher frequency bands as compared to FDD?
64	31	In light of the advantages of a flexible use policy, it would appear to be appropriate to allow licensees to choose their methods of duplexing for mobile wireless use in higher frequency bands. We seek comment on this issue.

65	31	We seek comment on whether developers of 5G services are considering new technologies such as "Any Division Duplexing" (ADD), which proposes the possibility of using self-interference cancellation techniques.
66	31	In light of the advantages of a flexible use policy, it would appear to be appropriate to allow licensees to choose their methods of duplexing for mobile wireless use in higher frequency bands. We seek comment on this issue.
67	32	Do commenters anticipate that systems incorporating mmW bands for mobile use will initially use simpler modulation and coding schemes?
68	32	What would be the difference in the cost and timeline to develop more complex systems initially?
69	32	How should the tradeoffs between simplicity and efficiency be taken into account as advanced mobile service technologies are developed in the mmW bands, and how should the Commission's future consideration of these bands take account of these tradeoffs?
70	33	We seek comments on the multiple access schemes for mmW mobile systems.
71	33	What are the limiting factors or considerations for determining the best multiple access schemes for those bands?
72	34	We also seek comment on the specifications for data throughput, latency and other performance metrics that would be associated with advanced mobile services in the mmW bands.
73	34	At least one source suggests that 5G would provide data rates up to 10 Gbps maximum and at least 100 Mbps at cell edges, with latencies of less than 1 millisecond. We ask whether these are reasonable expectations for the performance of advanced mobile services in these bands.
74	34	If so, how will access to these types of data rates affect businesses and consumers?
75	34	Would such capabilities create opportunities for new applications that do not exist today or ameliorate network congestion that would otherwise occur due to anticipated growth in traffic?
76	35	However, we encourage commenters to describe how to characterize coverage in comparison with today's networks that typically provide coverage over wide areas.
77	35	What are the likely or possible coverage areas of individual mmW base stations that enable mobile service as part of a 5G network?
78	35	How do the coverage areas scale as the number of base stations increases?

79	35	Are the coverage areas sufficient to provide service outside of dense urban areas? For a given coverage claim, the Commission invites commenters to explain the relevant assumptions, such as frequency band, cell-edge throughput, RF environment (urban/suburban/rural, LOS/NLOS, etc.), antenna complexity (size of array for beam-forming) for access points, and end-user equipment and the interference environment from other access points and users.
80	35	For a given coverage claim, the Commission invites commenters to explain the relevant assumptions, such as frequency band, cell-edge throughput, RF environment (urban/suburban/rural, LOS/NLOS, etc.), antenna complexity (size of array for beam-forming) for access points, and end-user equipment and the interference environment from other access points and users.
81	39	What type of deployment model – operator-driven, user-driven, or a new model or models – do commenters envision for mmW mobile services, and what network architectures could support the anticipated scale of deployment?
82	39	How would mmW mobile network architecture compare with the current 3G/4G architecture or Wi-Fi-like hotspot architecture?
83	39	Would there be a hybrid model that can support various types of deployment, and what are the enabling technologies to achieve such goals?
84	39	Note that we discuss the benefits and costs of different licensing mechanisms, which roughly correspond to some of these architectural distinctions, in Section C, below.
85	40	We therefore seek comment on certain technical parameters, which will help us develop the general outlines of technical rules that we could adopt for mobile and other services in the bands above 24 GHz.
86	40	In addition to the specific issues discussed below, we seek general comment on any other technical requirements we should consider within our rules, including any information about new technologies that will facilitate the assessment of protection for incumbent services in the bands above 24 GHz that are proposed as suitable.
87	41	What maximum transmit power and/or EIRP limits would be appropriate for mobile services in the mmW bands?
88	41	Is the +55 dBW EIRP limit currently applicable in the 27.5-28.35 GHz band and 39 GHz band appropriate?
89	41	Given the probability of these systems using small cell architecture, are lower power limits more appropriate?
90	41	What are the tradeoffs?
91	41	Would a power spectral density or power flux density limit be more appropriate, and, if so, at what minimum unit of bandwidth?
92	41	Considering the potential for complex antenna arrays and multiple simultaneous beams, should the limits be set for each antenna beam, or should our requirements be applied to the aggregate of all beams?

93	41	What should the appropriate limits be for mobile units?
94	41	What other factors should be considered in the assessment of incumbent service protection?
95	42	We also seek comment on appropriate OOBE limits.
96	42	Would an attenuation of 43 + 10log (P) for out-of-band emissions be appropriate?
97	42	If not what OOBE limits or range of limits would be appropriate for the mmW bands above 24 GHz?
98	42	Again, considering the possibility of large antenna arrays and multiple simultaneous beams, would OOBE limits need to be specified for each antenna element, or do they need to take into account the aggregate signals from all beams?
99	43	We seek comment on the rules that will be necessary to prevent harmful interference between licensees in adjacent geographic areas using the same frequency bands.
100	43	Will interference management issues be different for wireless networks using so-called 5G technologies?
101	43	In the 39 GHz and LMDS bands, licensees are required to coordinate with other licensees if they propose to operate near the license area of another licensee, but the rules do not contain any PFD limits at the boundaries of license areas.] Will we need to establish PFD limits to prevent harmful interference?
102	43	Alternatively, would it be appropriate to establish field strength limits at the borders of license areas, as we currently do in certain Part 27 services?
103	43	Given the dynamic characteristics and robustness anticipated for new mobile technologies in the mmW bands, what would constitute appropriate protections against harmful interference?
104	44	In addition, other parties may contemplate that the mmW bands would be used for non-mobile services. We invite those parties to explain their current and proposed uses of the mmW bands.
105	44	Those parties should explain whether their uses would be compatible with mobile services as well as existing incumbent operations.
106	44	We also ask parties proposing service rules for mobile use to offer rules that would accommodate as wide a variety of services and uses as possible.
107	45	We specifically inquire about the utility of the mmW bands for backhaul.
108	45	We seek comment on the extent to which it is feasible to use bands above 24 GHz for backhaul, particularly non-line-of-sight (NLOS) backhaul, which may be necessary for dense cell deployments.
109	45	Are there enabling technologies that will facilitate the shared use of bands for different types of uses?
110	45	Could the 5G technologies discussed above also provide backhaul capabilities?

111	45	Would it be possible to use “in band” service in which backhaul reuses frequencies that are also used for access?
112	45	Given the short ranges of developing 5G technologies, would mesh or multi-hop architectures be viable?
113	45	To what extent could mmW band-based backhaul address gaps or high costs to extend fiber optic networks?
114	48	To that end, how essential is global harmonization of technical and regulatory requirements to the success of advanced mobile services?
115	48	What are the economic benefits of global harmonization within the bands above 24 GHz for these services?
116	48	Do certain bands suit these services better because of existing global allocations and/or regulatory frameworks in various countries?
117	49	We also note that research and development efforts underway for 5G envision devices that will use adaptive software-defined air interfaces and software-defined networking techniques. These types of interfaces may provide intelligence and flexibility that can enable handsets and user equipment to operate seamlessly across different networks, different technologies, and different frequency bands. What effect would the use of such technology have on the suitability of certain bands for mobile mmW services?
118	49	Would the use of such technology reduce the need for large blocks of contiguous spectrum?
119	49	Would the use of such technology allow for different network architectures that would enable devices to work seamlessly across different frequency bands?
120	49	What effect would the capability of operating across different frequency bands have on the appropriate regulatory licensing framework?
121	50	In the discussion below, we invite comment on the suitability of the Local Multipoint Distribution Service (LMDS) bands, the 39 GHz band, the 37/42 GHz bands, the 60 GHz band, the 70/80 GHz bands, and the 24 GHz band for advanced mobile services. but might be appropriate.
122	50	We seek comment and discussion on bands above 95 GHz that commenters believe would be suitable candidates for mobile services.
123	50	We also invite comment on any other bands above 24 GHz that are not included in this list
124	55	We seek comment on the suitability of the LMDS band for advanced mobile services of the kind discussed above.
125	55	Does the 29.1-29.25 GHz band contain sufficient spectrum to make it useful for advanced mobile services, and is there any way to authorize mobile use while protecting co-primary MSS feeder links? With respect to the 31-31.3 GHz band, we ask commenters whether that band contains sufficient spectrum to be useful for advanced mobile services.

126	55	In addition, commenters are requested to address any adjacent band protection requirements related to federal FSS and MSS (Earth-to-space) in the 30-31 GHz band if the 31-31.3 GHz band is proposed to be suitable for advanced mobile services.
127	55	We invite comments on PFD limits and any additional requirements that might be necessary to prevent harmful interference between adjacent LMDS operators if we authorize them to begin providing mobile services.
128	61	We seek comment on the suitability of the 39 GHz band for advanced mobile services.
129	61	As noted above, the Commission assumed that geographic area licensees would be in the best position to coordinate fixed and mobile uses in that band. Is that assumption still accurate, or are additional procedures or rules necessary?
130	61	Also, in the *39 GHz Order,* the Commission required that 39 GHz operators follow Part 101 Fixed Service rules to coordinate frequency use with operators in adjacent license areas, but it did not establish power-flux-density limits or other rules to govern interference between geographically adjacent licensees. As mentioned above, we generally find it necessary to establish such specified limits whenever we authorize the provision of mobile services by licensees holding exclusive GSA service rights. We invite comments on the need for such a requirement to accommodate the provision of advanced mobile services in the 39 GHz band.
131	61	With respect to the FSS, do the existing limitations on satellite power flux density make such operations compatible with mobile operations?
132	61	Are there any additional measures needed in terms of OOBE limits that are needed to protect federal MSS and FSS downlink operations in the adjacent 40-40.5 GHz band? We also seek comment on whether any limitations or special rules on mobile use would be necessary in order to protect Federal military FSS use of the 39.5-40 GHz band.
133	61	What other technology characteristics should be taken into account to assess compatibility between potential commercial mobile broadband service with existing incumbent operations including federal MSS and FSS?
134	69	We seek comment on the suitability of the 37 GHz and 42 GHz bands for advanced mobile services.
135	69	Since we have not developed any terrestrial service rules for these bands, we seek comment on the appropriate licensing mechanism for those bands, as discussed below.
136	69	With respect to the 42 GHz band, would authorizing mobile operations be consistent with protecting radio astronomy observations in the 42.5-43.5 GHz band?
137	69	As an alternative, we seek comment on FWCC's proposal to authorize fixed point-to-point use of the 42-43.5 GHz band.

138	69	Would fixed point-to-point use be more consistent with other uses in that band?
139	74	We seek comment on the advisability of amending our rules to allow unlicensed Part 15 operations in the 64-71 GHz band segment.
140	74	As an alternative, we seek comment on the possibility of authorizing licensed operations in that band.
141	74	We request commenters to provide supporting information on existing or in development viable technology that would be envisioned for this band.
142	74	We also seek comments on any interference that either licensed or unlicensed advanced mobile operations in the 65-71 GHz band segment could cause to any inter-satellite operations that might eventually develop in the 65-71 GHz band.
143	91	We seek comment on whether mobile operations in the 70 GHz and 80 GHz bands could coexist with existing Federal and non-Federal fixed operations.
144	81	Could elements of the licensing model that presently applies to the 70/80 GHz bands be adapted to facilitate coordination with advanced mobile service if it were to be authorized in those bands?
145	81	Could the automated coordination and registration system that applies to fixed stations in this band be applied to advanced mobile service base stations, and, if so, would that adequately protect Federal government operations and other non-Federal government operators from interference from commercial base stations?
146	81	Alternatively, we seek comment on the advisability of allowing unlicensed Part 15 operations in the 70/80 GHz band segments.
147	82	We also seek comment on what rules would be needed to authorize mobile subscriber units while avoiding harmful interference to other authorized operations.
148	82	Could the potential for interference be limited if the mobile subscribers were required to refrain from transmitting except when operating under the control of a nearby base station?
149	82	If such precautionary measures would not be sufficient by themselves, should we consider adopting a system of dynamic access control using databases similar to those used to control access to TV White Spaces, in this case to enforce exclusion zones around important Federal and radio astronomy sites?
150	82	We invite commenters to evaluate the extent to which such measures could prevent non-Federal subscriber units from causing interference to Federal government operations or to other non-Government operators in the 70 GHz and 80 GHz bands.
151	87	We seek comment on the advisability of adding a mobile allocation and developing advanced mobile service rules in the 24 GHz band.
152	87	Is there sufficient spectrum available in the band to make it useful for this purpose?

153	87	Is it possible to allow mobile operations while protecting Earth-to-space satellite services in the 25.05-25.25 GHz band segment?
154	87	Should we establish exclusion zones around the 17/24 GHz BSS feeder links that operate in that band segment?
155	87	In light of the small number of existing terrestrial licenses in this band, if we decide to authorize mobile service, should we adopt a new licensing framework for this band?
156	87	What other technology characteristics should be taken into account to assess compatibility with and ensure protection of federal radar operations in the adjacent 24.05-24.25 GHz band?
157	88	We seek comment here on the appropriate authorization and/or assignment mechanisms that will ensure flexibility of technology and use as well as compatibility with incumbent federal and non-federal operations.
158	88	Specifically, we seek comment on whether, and if so how, we should authorize incumbent licensees that are currently licensed to provide fixed service, to begin mobile operations in these bands, as well as the means by which we should assign any new (or unassigned) rights for mobile use in these bands.
159	91`	With the above considerations in mind, we seek comment on the licensing options discussed below and invite suggestions for additional alternatives.
160	91	We acknowledge that some of these options will be more appropriate for certain frequency bands than for others, and that the most reasonable outcome could involve a diversity of options applied to different bands. To the extent that commenters suggest modifying licensing mechanisms that currently exist in given bands, they should address how such changes would affect the incumbent licensees, if at all, and the relative costs.
161	93	One potential concern with geographic area licensing is that portions of license areas outside of high-traffic areas could end up lying fallow. We seek comment on the following three ways that might successfully address this problem, and we invite suggestions for any alternatives.
162	96	We seek comment on ways in which geographic area licensing could be tailored most effectively for mobile services in the bands above 24 GHz to ensure greater utilization of spectrum.
163	96	What is the optimal geographic area size?
164	96	At some size, construction requirements become difficult to generalize across different licenses in different areas. What kind of construction requirement is best?
165	96	We also note that as the geographic license area shrinks, the burden of administering the licensing scheme, including verifying build out, increases. How can we accommodate these issues?
166	99	Option 2*: Adopt nonexclusive licensing rules using automated frequency coordination:* How would this scheme work for mobile operations above 24 GHz?

167	99	How would licensees effectively coordinate to avoid interference along the borders of their areas of operations?
168	99	How would we encourage the use of the spectrum while minimizing potentially inefficient “land rush” behavior?
169	99	Can some of the burden of coordination be handled through a centralized database or databases, as used for TVWS devices?
170	100	We seek comment on authorizing mobile operations in bands above 24 GHz pursuant to Part 15 of our rules.
171	100	We seek comment on any special rules or protocols that would be needed to allow Wi-Fi type wireless uses in bands above 24 GHz.
172	100	For example, would Wi-Fi operations be less likely to lead to congestion if we restricted Wi-Fi operations in these bands to dynamically pointed “pencil” beams, with omnidirectional pilot signals restricted to lower bands?
173	100	What are the costs and benefits of a system with flat hierarchical and distributed control?
174	101	Would it be possible and appropriate to grant owners and tenants the right to deploy base stations or access points indoors because mmW signals will be less able to penetrate into the interiors of buildings?
175	101	Should such lower priority rights be granted on a licensed or unlicensed basis?
176	102	We invite commenters to present alternative licensing mechanisms not discussed here, including the costs and benefits of such options.