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June 25, 2002

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th St., S.W., Counter TW-A325
Washington, D.C. 20554

Re: *Ex Parte* Presentation
IB Docket Nos. 02-19 and 01-96

Dear Ms. Dortch:

We enclose for filing in the above-referenced dockets a technical report aimed at providing the Commission with additional background on Teledesic's concerns about the definition of in-line interference events adopted in the recently released Ku-band NGSO FSS sharing order. We hope that this information will inform the Commission's current consideration of NGSO FSS sharing in the Ka band.

If you have any questions or require any additional information, please do not hesitate to contact me at (202) 730-1331.

Respectfully submitted,

Kelly S. McGinn

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Enclosure

Defining In-Line Interference Events For Purposes of Facilitating Co-Frequency Sharing Between NGSO FSS Systems

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June 25, 2002

The Commission recently released a Report and Order addressing the implementation of intra-service sharing rules for Ku-band NGSO FSS systems premised on a band sharing model known as "Avoidance of In-Line Interference Events."[1] This same sharing model was the overwhelming favorite of those participating commenters on the options outlined by the Commission in an NPRM to establish intra-service sharing rules for Ka-band NGSO FSS systems. Although Teledesic strongly supports this sharing model, the efficacy of such a sharing regime will depend in large part on how accurately an "in-line interference event" is defined.

Teledesic strongly believes that the Commission erred in the *Ku-Band Report and Order* by adopting a definition of in-line interference events based on maintenance of a fixed, earth-station-based avoidance angle of 10°. This definition has several serious drawbacks, and Teledesic plans to file a petition for reconsideration of this decision in the Ku band.

In the NPRM to establish sharing rules for Ka-band NGSO FSS systems, the Commission wisely proposes a different definition of in-line interference events based on the percentage of time that a specified bit error rate (BER) is exceeded. The Commission should confirm its proposed approach in Ka band and reject any proposal for adopting a fixed-angle approach as the basis for a definition of in-line interference events between Ka-band NGSO FSS systems in its upcoming order for intra-service sharing in that band.

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[1] *Ku-Band NGSO FSS Service Rules,* Report and Order, IB Docket No. 01-96, 2002 FCC LEXIS 2056 (rel. Apr. 26, 2002)("*Ku-Band Report and Order*"). Curiously, the actual rules set forth in the Report and Order for inclusion in Part 25 do not seem to include any rule implementing the Avoidance of In-Line Events model, or any definition of an "in-line event." It is therefore unclear in what sense the Commission believes itself to have "adopted" such rules. Teledesic expressed concern about the absence of any proposed rules in its comments on the Notice of Proposed Rulemaking in that docket but noted its assumption that the Commission would publish proposed rules in the context of a Further Notice of Proposed Rulemaking. In light of the Commission's simultaneous release of a Further Notice addressing additional details of the in-line event definition, it might seem that the Commission has not yet finally adopted either the avoidance approach or the 10° definition, but the text of the Report and Order suggests otherwise and the staff has subsequently confirmed that the Commission's intention was to adopt both the approach and the definition.

In this presentation, Teledesic seeks to establish three points regarding the "in-line event" definition. First, a uniform earth-station-based angle of 10° is too inaccurate to serve as a useful definition of an in-line interference event; in fact, *any* definition based on a fixed angle for all systems will be so crude that it will create more problems than it solves. Second, the Commission's reasons for choosing the least accurate of the definitions that were considered do not justify the decision. Third, a definition based on the percentage of time that a specified BER is exceeded will provide a much more accurate definition that has none of the deficiencies of the fixed-angle approach and provides much more incentive for productive coordination discussions.

1. A "Fixed-Angle" Definition Is Too Inaccurate to Be Useful

The *Ku-Band Report and Order* reveals that the Commission considered three different candidates for a definition of an "in-line interference event": a specified change in total system noise power, a fixed degree of angular separation between satellites, and a specified increase in the percentage of time during which a target BER is exceeded. The Commission evidenced some appreciation for the accuracy problem inherent in the fixed-angle approach, expressly acknowledging that a fixed 10° angle would be too small to protect some systems from interference and would be overly conservative (and therefore overly constraining) for other systems.[2] However, in selecting the 10° angle, the Commission appears to have attempted to "balance" these two deficiencies against each other, as if they cancelled each other out. In reality, the inaccuracies of the model do not cancel each other out; they accumulate. If the Commission defines in-line events based on a fixed angular definition, then in-line events will

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[2] *Id. at* ¶¶ 47-48

often occur in real life when the definition says they do not, and they will often be presumed to occur for regulatory purposes when in real life they do not. The definition is both overinclusive and underinclusive.

This lack of "fit" ultimately undercuts the entire "avoidance of in-line events" model and deprives *all* licensees of any assurance that they will be adequately protected from harmful interference. The "avoidance of in-line events" model is based on the idea that every system can count on having access to the entire 500 MHz except for the relatively small percentage of time during which co-frequency operation would cause excessive interference to one or both of the systems involved. But for this to be true, the regulatory definition of an in-line event must track the occurrence of in-line events in real life. Otherwise, some operators will find themselves experiencing significant interference across the entire band even though no satellite is within a 10° earth-station-based angle, while other operators will find themselves forced to implement mitigation throughout a 10° cone despite the absence of significant interference in most of the affected area. In either case, the public will experience a loss of service that would not otherwise occur if the regulatory definition of an in-line event matched the actual occurrence of such events in the physical world.

In the following sections, Teledesic sets forth quantitative analyses of how poorly the chosen definition fits the systems proposed in the Ka band, and why this definition will hinder successful cofrequency sharing among Ka-band NGSO FSS operators.

1.1. The angles that actually define in-line events between system proposals vary widely, and are not even closely approximated by any fixed angle.

Perhaps the most puzzling thing about the Commission's decision to employ a fixed-angle approach to the Ku-band definition of in-line events is that there is a way to determine

the right answer regarding whether two systems are experiencing significant in-line interference. Although it is time-consuming, it is not especially difficult to find out what the right answer is. Recommendation ITU-R S.1323-1 sets forth the degree of protection that ought to be required between any two NGSO FSS systems, and by using computer simulations of the constellations in question it is possible to identify fairly accurately the actual angles at which any given system will begin to experience interference in excess of the Rec. ITU-R S.1323-1 levels. By calculating these required avoidance angles for each pair of systems, one can compare the real-life avoidance angles to the fixed 10° definition chosen by the Commission for the Ku band and see how closely the definition tracks real life if this were to be applied to the Ka band.

Teledesic has performed these calculations and presents the results below. Ka-band constellations were used because Teledesic has done many more computer simulations on Ka-band systems and has more detailed information on the parameters of each constellation. Teledesic calculated the required avoidance angles not only for each system *vis-à-vis* Teledesic, but also for *each system vis-à-vis every other* – fifteen pairs of avoidance angles in all. The results are illuminating, and they are shown in Table 1.

Table 1. Avoidance angles (°) Required to Ensure Pprotection at the Levels Prescribed by Recommendation ITU-R S.1323-1.

Interfering System	Victim System					
	T30	@contact	Hughes	LM	SkyBridge	TRW
T30		11.5	6	8	3	3
@contact	3		3	2	2	2
Hughes	4.5	12		8	2	2
LM	11.5	4	13		4.5	5
SkyBridge	3	15	1.5	2.5		0.5
TRW	1	2	0	1.5	0	

The first key point that Table 1 illustrates is how widely the required avoidance angles vary, ranging from 0 to 15 degrees. Moreover, the results are highly dependent on the specific pair of systems involved. For example, when Hughes is considered to be the victim of interference from TRW, a 0° avoidance angle is indicated; but when @contact is considered vis-à-vis SkyBridge, a 15° avoidance angle is required – the largest in Table 1.

When the results in Table 1 are compared to a fixed avoidance angle of 10°, the outcomes fall into two groups. In five of the fifteen cases, one of the angles is larger than 10° and the other is smaller. In ten of the fifteen cases, both angles are smaller than 10°. Either situation has its drawbacks. In the first situation, a fixed-angle definition will overprotect one system while underprotecting the other, giving one of the systems a sort of regulatory windfall. In the second situation, both systems are overconstrained by the regulations, and each finds itself needing the other's permission to operate across the entire spectrum even at angular separations that (in real life) permit full-frequency operation by both systems without significant interference to either (*i.e.* without interference above the levels prescribed by

Recommendation ITU-R S.1323-1). These disadvantages of the fixed-angle definition are quantified in Tables 2 and 3 below.

We consider first the situation in which the avoidance angle that ensures protection to one of the systems is above and the other is below 10°. The five pairs of systems for which this situation occurs are listed in Table 2, where the avoidance angle • required to protect both systems of the pair (• is the larger of the two corresponding avoidance angles shown in Table 1) is also given. If the 10° angle is employed then one of the systems is overprotected while the other is underprotected. Although this situation can in theory be resolved through coordination, the overprotected system has no incentive to agree to any angle larger than 10°, because such an agreement would only increase constraints on its operation without offering any offsetting benefit. The incentive for the overprotected system *not* to agree to expand the avoidance angle can be measured by the reduction in the percentage of time during which it potentially has to mitigate interference. On the other hand, the negative impact on the underprotected system can be measured by the reduction in the maximum link availability that can be offered by this system. For each pair of systems in Table 2 and for an earth station at 40° latitude, the percentages of time for which one or more satellites of the overprotected system are unconstrained (not subject to an in-line event) are included, both for a 10° avoidance angle and for the angle • that ensures protection of the two systems. Table 2 also presents the maximum availability in the controlling link of the underprotected system, for an avoidance angle of 10° and for the angle that ensures protection of both systems. The percentage increase in the minimum unavailability that can be achieved by the underprotected system is also shown. This can be thought of as a sort of "availability penalty" that the 10° fixed-angle definition imposes on the underprotected system.

Table 2. Situations Where Using a 10° Default Avoidance Angle Overprotects One System and Underprotects the Other

Overprotected System (A)		T30	LM	Hughes	LM	SkyBridge
Underprotected System (B)		@contact	T30	@contact	Hughes	@contact
Avoidance Angle (•) That Protects A and B (°)		11.5	11.5	12	13	15
Overprotected System (A)	Percentage of Time with One or More Unconstrained Satellite For 10° Avoidance Angle (%)	97.223	100.0	99.873	100.000	100.000
	Percentage of Time with One or More Unconstrained Satellite For •° Avoidance Angle (%)	96.442	99.996	99.510	100.000	100.000
Underprotected System (B)	Maximum Availability For 10° Avoidance Angle (%)	99.838	99.445	99.854	98.312	99.936
	Maximum Availability For •° Avoidance Angle (%)	99.969	99.604	99.971	99.774	99.971
	Percentage Increase in Minimum Unavailability (%)	422.6	40.2	403.5	646.9	120.7

As indicated in Table 2, in all cases the decrease in maximum availability is very significant for the underprotected system. For example, in the case of interference from Lockheed Martin into Hughes the maximum availability of the Hughes system drops from 99.774% to 98.312% or in other words, the minimum unavailability increases by nearly 650% when a 10° avoidance angle is used instead of the required avoidance angle of 13°.

The second situation that can be identified in Table 1 involves system pairings in which the avoidance angle required to protect both systems (larger of the two avoidance angles given in Table 1 for each pair of systems) is smaller than 10°. In this situation, both systems may have an incentive to agree on an avoidance angle smaller than 10°. However, if there is no agreement on the avoidance angle then the 10° default will cause mitigation techniques to be

implemented when they would not be at all necessary. This is certainly an inefficient use of the spectrum because capacity will be unnecessarily reduced in one or both systems during a certain percentage of time. The pairs of systems for which this situation occurs are listed in Table 3, where the avoidance angles required to protect both systems of each pair (larger of the two corresponding avoidance angles shown in Table 1) are also given. As illustrated in Table 3, if the 10° angle is employed, satellites of the two systems will be considered to be in an in-line event more often than they need to be, and thus be forced to split spectrum and/or implement diversity unnecessarily.

Table 3. Situations Where Both Systems Can Be Protected with an Avoidance Angle Smaller Than the 10° Default

System A	System B	• °	Percentage of Time With One or More Unconstrained Satellites (%)			
			System A		System B	
			10°	•°	10°	•°
T30	Hughes	6	97.422	99.134	99.055	99.902
T30	SkyBridge	3	98.909	99.909	100.000	100.000
T30	TRW	3	97.113	99.779	96.012	99.782
@contact	LM	4	94.813	99.988	100.000	100.000
@contact	TRW	2	99.263	100.000	98.435	99.968
Hughes	SkyBridge	2	99.844	100.000	100.000	100.000
Hughes	TRW	2	99.936	100.000	98.647	99.953
LM	SkyBridge	4.5	100.000	100.000	100.000	100.000
LM	TRW	5	100.000	100.000	95.211	99.190
SkyBridge	TRW	0.5	100.000	100.000	99.412	99.998

As Table 3 shows, the resulting percentages for such unnecessary avoidance vary from 0% for systems with a high degree of multiple satellite coverage, such as SkyBridge or Lockheed Martin, to 5.2% (99.988 - 94.813) of the time for @contact (unconstrained single coverage when operating vis-à-vis Lockheed Martin).

Table 3 also illustrates that the use of a 10° avoidance angle rather than the smaller avoidance angle actually required can result in quite different impacts for the two systems involved. For instance, in the case of T30 and SkyBridge, the impact of using a 10° avoidance angle versus a 3° avoidance angle for SkyBridge results in no additional unconstrained single coverage, while the impact to T30 would be a 1% reduction in unconstrained single coverage – which is a significant impact. Again, although this situation can in theory be resolved through coordination, the system with little or no impact has no incentive to agree to an angle smaller than 10°, because such an agreement would only improve things for a competitor while providing little or no improvement for its own system.

1.2. The inaccuracy of the fixed-angle definition cannot be adequately corrected by adopting a second fixed angle for "high-powered" systems.

To its credit, the Commission recognized the existence (if not the extent) of the "lack of fit" problem with a definition based on uniform angular separation. For this reason, the "Further Notice" portion of the *Ku-Band Report and Order* seeks comment on whether a different angle (possibly wider) should be used with "high-powered systems" and, if so, on the possible value of this angle and on the definition of a "high-powered system."[3] In addition, the Commission requests comment "on whether an off-axis PFD limit may be utilized with or without an additional off-axis angle to limit harmful interference to satellites of different networks that are 10 degrees or farther apart."[4]

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[3] *Id.* at ¶ 89.

[4] *Id.* at ¶ 91.

The arbitrariness of a fixed avoidance angle cannot be remedied simply by defining another fixed angle applicable to a specific subset of the situations under consideration. Defining different angles for different systems is a step in the right direction and the ideal would be a different set of angles for each pair of systems, calculated according to Rec. ITU-R S.1323-1. But the variety among the systems proposing to operate in the Ku and Ka bands is too great to be captured by just two broad system design categories. And even the move from one standard definition to two different definitions certainly undercuts the Commission's stated intention to make the applicable definition as simple as possible.

There are, however, even more fundamental reasons why the inaccuracies of the chosen definition cannot be corrected by associating a wider avoidance angle with "high-powered systems." First, avoidance angles depend on a variety of system parameters, not on power alone. Depending on the other system parameters involved, two systems with the same antenna input power density might have very different "trigger" angles defining the onset of an in-line event *vis-à-vis* a third system.

Second, as far as power levels are concerned, avoidance angles depend on the *relative* power levels of the two systems involved rather than on the levels associated with any of the systems in isolation. Therefore, even if the Commission were to use a wider angle to define in-line events with a "high-powered system," it is conceivable that this choice of angle would be even less accurate than the original 10° fixed-angle definition. Two very similar "high-powered" systems might well require *narrower* avoidance angles vis-à-vis one another than would two "low-powered" systems that differed significantly with respect to other parameters (e.g. link margin).

Thus, going from one threshold (10°) to two thresholds (10° and a second, wider angle) would not solve the problem with the Commission's definition because it would not necessarily produce more accurate results. The appropriate angle depends on the relative values of too many parameters of each pair of two systems involved, and may vary over a wide range of values.

1.3. It Is Sometimes More Efficient to Use a Satellite-Based Angle.

Another problem with the Commission's chosen fixed-angle definition arises from the fact that it is always defined as an angle that has its vertex at an earth station. However, as Teledesic has previously pointed out, "when there is a large difference between the altitudes of the two non-GSO systems and avoidance is being implemented by the system with the higher orbit altitude, the burden of employing avoidance angles will be minimized if the mitigating system uses both an earth station-based avoidance angle and a satellite station-based avoidance angle."[5] For this reason, defining in-line events based only on an earth-station-based angle may lead to inefficiencies. Specifically, the use of earth-station-based angles in all cases will make it very likely that in some cases the "avoidance of in-line events" approach will require two systems to implement mitigation measures over a longer period and/or a larger area than would otherwise be required. This decreases the total capacity available to the operators and to the public.

1.4. A Uniform 10° Angle Does Not Account for Multiple Systems.

Assuming for the sake of argument that a 10° fixed angle is a reasonable choice for the avoidance angle to be observed when two NGSO systems are operational, this angle cannot at

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[5] Teledesic Comments at Appendix I-2 (filed in IB Docket No. 02-19 on April 3, 2002).

the same time be an appropriate choice when three or more systems are operational. This flaw might theoretically be fixed by defining larger angles when three or more NGSO systems become operational. However, these other angles would again be arbitrary choices that would in turn aggravate all of the drawbacks discussed so far with respect to the 10° fixed avoidance angle.

In summary, then, the fixed-angle approach provides a very poor indication of when two systems are actually having an in-line event. In a significant number of cases, a 10° fixed-angle definition can be expected to overprotect one system while underprotecting the other; and in perhaps the majority of cases the 10° definition will significantly overprotect both systems. These deficiencies cannot be cured by adopting a "second-tier" definition for any subset of systems. Moreover, because the Commission's definition is in every case an earth-station-based angle, it systematically calls for more mitigation than is necessary between systems at very different altitudes. Finally, the definition does not take into account the additive nature of interference from multiple NGSO FSS constellations. The next section evaluates the Commission's stated reasons for selecting a definition that matches up so poorly with the real world.

2. The Commission's Reasons for Selecting the Least Accurate Definition Do Not Justify the Decision.

In adopting the 10° fixed-angle definition for the Ku band, the Commission articulated two broad policies: first, its "long-standing policy of encouraging private coordination among satellite operators"[6]; and second, its desire "to adopt an indisputable standard easily understood

[6] *Ku-Band Report and Order* at ¶ 46.

by all parties."[7] In addition, the Commission at several points referred to its decision to impose a 2° spacing requirement on geostationary domsats in the 1980s, and expressed its hope that a fixed-angle approach would guide NGSO FSS system designers much as the 2° spacing rule guided domsat satellite engineers a generation ago.[8] Regardless of whether these policies are weighty enough to justify the adoption of a definition that bears so little relation to the physical world, the inaccuracy of the fixed-angle definition is so substantial that it will often discourage and invariably complicate coordination between and among operators. Moreover, there is no reason whatsoever to expect that a fixed-angle approach will lead to any substantial degree of homogenization among NGSO FSS systems, and even less reason to think that 10° is in any sense an "ideal target" for efforts at homogenization. These points are discussed in turn below.

2.1. A Uniform 10° Definition Will Not Encourage Coordination Because the Inaccuracies Will Often Favor One of the Parties.

As noted above, the Commission acknowledges explicitly that its chosen fixed-angle definition is both overinclusive and underinclusive; it will define in-line events so as to *include* many situations in which permissible levels of interference *will not* be exceeded, and so as to *exclude* many situations in which permissible levels of interference *will* be exceeded. The analysis presented above in section 1.1 illustrates this phenomenon with respect to Ka-band systems, and shows just how great the disparity between the regulatory definition and physical reality is. However, the Commission appears to consider this problem a minor detail because

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7 *Id.* at ¶ 47.

8 *Id.* at ¶¶ 49, 52, 55.

it "believe[s] that smaller angles of separation can be negotiated during coordination between the parties."[9]

Obviously, smaller angles of separation *could* be negotiated during coordination, but the selection of a fixed-angle definition for in-line events will actually tend to prevent this from occurring. This follows directly from the inaccuracy of the definition. With a perfectly accurate definition, the parties know exactly which situations require some type of mitigation, and neither party can ignore the other's interference problems because they are mutually responsible for resolving the in-line event and will each face consequences if they cannot. But with a definition as inaccurate as the fixed-angle definition, there exist long periods and/or large areas in which either (a) at least one party experiences significant interference but the rules say there is no "in-line event"; or (b) the rules say there is an in-line event but neither party experiences significant interference. These situations create perverse bargaining incentives, which the Commission apparently failed to consider.

To explore situation (a) above, suppose that System A is protected from interference *vis-à-vis* System B when a 5° avoidance angle is employed, but System B is protected only if a 15° avoidance angle is used. System B will be extremely motivated to negotiate a solution that expands the 10° avoidance angle set forth in the Commission's rules. However, at a 10° avoidance angle System A is experiencing no interference and no alternative avoidance angle would be beneficial to System A. On the contrary, sticking with the 10° rule will require A to split spectrum or implement diversity less frequently than under the 15° avoidance angle System B would like to negotiate. Moreover, from A's perspective the 10° rule has the unintended but perhaps welcome side effect of reducing a competitor's available capacity. With

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[9] *Id.* at ¶ 48.

no interference problem of its own and no regulatory duty to take any mitigation measures, System A is unlikely to implement additional mitigation in a gratuitous act of charity toward its competitor. In any case, system B has very little negotiating power.

Conversely, in situation (b), the parties may both be motivated to negotiate a narrower angle for mitigation purposes – to a point. For example, if System A requires an 8° avoidance angle for full protection and System B requires a 3° avoidance angle, it may be easy for the parties to negotiate to 8°. But because the two systems may begin experiencing interference at different degrees of angular separation, the fixed-angle definition once again leads to distortions. System A will be perfectly happy with an 8° avoidance angle, and any further reduction in the avoidance angle would depend on System A's willingness to confer a gratuitous benefit on System B. It might well be in A's interest to let the coordination exercise fail and accept the default 10° avoidance angle rather than accept a compromise with B. The Commission realized this possibility when discussing wider angles in the Ku-band Further Notice of Proposed Rulemaking, stating that "imposing a wider angle for some systems may discourage coordination between parties, because a system that can operate under the "benefit" of a wider-angle trigger has no incentive to coordinate with other systems."[10] In any case, System B has very little negotiating power.

The Commission notes at one point that "[s]ufficiently motivated coordination should be able to use any or all of the proposed definitions to more precisely define the occurrence of in-line interference events between two coordinating systems."[11] If "sufficiently motivated" means something like "motivated to maximize service to the public and abjuring all self-

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[10] *Id.* at ¶ 89.

[11] *Id.* at ¶ 46.

interest," then the statement is probably true. But in that case it could also be said that "sufficiently motivated coordination" will result in the optimal sharing arrangement without any default rules from the Commission. And in fact, bilateral coordination without any default rules would probably produce excellent results even without any heroic assumptions about the operators' motivations. However, if the Commission decides to intervene in the coordination process by setting forth default rules in advance of the coordination, it is essential for the rules to reflect accurately the physical reality of what is occurring in the sky. Adopting an inaccurate rule creates disincentives to coordinate, and when the inaccuracies are large the disincentives are strong. The effect of the fixed-angle definition on coordination incentives is an argument against the definition, not a justification for its inaccuracy.

2.2. A Uniform 10° Definition Is Not Simple.

The Commission explicitly states, "Our goal is to adopt an indisputable standard easily understood by all parties."[12] Although a laudable objective, simplicity in itself should not be enough to justify any choice. Moreover, simplicity is only superficially achieved in this case, and the superficial simplicity masks the fact that the actual application of the rule during coordination between operators will be much more complicated than it would be if the definition were based on Rec. ITU-R S.1323-1.

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[12] *Id.* at ¶ 47.

The superficial simplicity lies in the fact that the fixed-angle approach is relatively easy to codify – same angle for everyone, no messy references to ITU recommendations, and no calculations required. However, even the superficial simplicity of being easy to codify would be lost if the Commission were to adopt a second fixed angle to define in-line events with "high-powered" systems, as proposed.

More fundamentally, this type of simplicity does not actually achieve any results. The Commission notes at one point "that a 10-degree angle of separation allows all systems to operate in the entire Ku-Band spectrum for at least 82 percent of the time, whereas with a 20-degree angle of separation, all systems achieve full-spectrum operation approximately 41.6 percent of the time,"[13] but this seems to confuse the regulations with real life. If two systems are experiencing an in-line event (*i.e.* mutual interference exceeds permissible levels), then full-spectrum operation by both systems is not possible during that event no matter what definition the Commission has adopted. To solve their interference problem, the two systems will need to coordinate, and the first thing they will do is calculate the avoidance angles they need *in real life* in order to operate without harmful interference for as much of the time as possible. The Commission's fixed-angle definition will not have simplified this calculation in any way; on the contrary, the Commission will have missed its opportunity to define in the rules exactly how the truly relevant calculations are to be made. Standardizing the *methodology* – such as by adopting the BER time allowance approach suggested by Teledesic or even the "sync loss" approach suggested by SkyBridge – would be much more useful (and would have much more of a simplifying effect in real life) than standardizing the avoidance angle itself.

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[13] *Id.*

Furthermore, at the time that coordination discussions actually occur, the Commission's fixed-angle definition will have become somewhat worse than irrelevant. If it were truly irrelevant, it could simply be ignored, but the fixed-angle definition will actually have the effect of *limiting* some operators' obligation to avoid non-permissible interference to their competitors. As noted above, this will create incentives toward impasse, which will make real-life coordination anything but simple.

2.3. A Fixed-Angle Definition Will Not Promote Homogenization Like the Two-Degree Spacing Requirement Did.

In addition to the two policies upon which the Commission expressly relies, the *Ku-Band Report and Order* suggests that the Commission intends its fixed-angle definition to be a standard toward which system designers should aim.[14] The Commission notes, "The end result of our two-degree separation policy is that communication links of adjacent systems have been balanced . . . . We expect the same result when NGSO FSS systems in the Ku-band coordinate with each other . . . ."[15]

The hope that homogenization of NGSO FSS systems in either the Ku band or the Ka band can be achieved by manipulating the definition of an in-line event is unrealistic for at least two reasons. First, it appears to neglect a fundamental difference between the GSO and NGSO environments, namely that there is no common fundament among all NGSO FSS systems that is analogous to the common orbit shared by all GSO satellites. In the GSO environment, the

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[14] *E.g., id.* at ¶ 49.

[15] *Id.* at ¶ 52.

orbital altitude is fixed and the maximum allowable pfd on the surface of the Earth is fixed by rule. Furthermore, satellite beam characteristics tend to be homogeneous (*e.g.*, full CONUS coverage at Ku band) and adjacent satellites typically employ opposite polarizations. This makes it relatively easy for a system architect to optimize for 2° spacing, even without knowing detailed characteristics of the neighboring system. By contrast, in the NGSO environment, the lack of a common altitude, the various proposed NGSO satellite beam structures and characteristics, as well as the time-varying nature of the interference make it impossible to say with any confidence that a given system will always be able to operate at more than 10° of any other NGSO satellite.

Second, in the GSO environment the 2° spacing rules were adopted in a multilateral rulemaking process. Little bilateral coordination is required after this common set of parameters is agreed, with the exception of some traffic planning to avoid co-frequency operation of incompatible traffic, such as high power density carriers (*e.g.*, TV/FM) being placed opposite low density carriers (*e.g.* SCPC carriers). Also, since the GSO positions are fixed, the interference from the second adjacent satellites (at 4° spacing) and subsequent satellites is much lower than that arising from the two closest neighbors (at 2° spacing). Therefore detailed coordination involves mostly two other systems. On the other hand, in the NGSO environment the sharing arrangement is based on a sequence of bilateral coordinations and no formal multilateral coordination is expected. As a result, an overall link balancing can hardly be expected since it would depend on a succession of independent balancing exercises. Which design changes help and which hurt depends in large part on which other systems actually are launched and brought into use.

In addition, there is no particular reason why 10° *should* be held out as a goal for system designers. As seen in section 1.1, actual required avoidance angles in Ka-band are much lower in most cases. A rule that accurately identified the avoidance angles necessary for co-existence would promote much greater co-frequency sharing than would result if all system designers actually harmonized their parameters around a 10° "target."

The Commission's desire for link balancing and greater homogeneity is understandable, but there is no shortcut to such an outcome. Harmonization of both link and orbit parameters was the basis for the Option IV proposed in the Ku-band NPRM. Since for good reasons the Commission has discarded this option, it is not possible to expect that any significant harmonization will result from Option III. The avoidance of in-line events approach has many other advantages but has not been designed to promote overall harmonization.

3. A Definition Based on BER Time Allowances Is More Accurate and More Conducive to Coordination, Without Undue Complexity.

As noted above, the Commission's definition has to track the actual beginning and ending of interference exceeding permissible levels reasonably well, or else it is useless or worse. If Recommendation ITU-R S.1323-1 defines the levels of protection to which systems are entitled, then the angles at which in-line events between two systems begin and end should be based on that Recommendation. Teledesic has previously proposed a definition for in-line events:

> An "in-line event" is defined as the occurrence of any physical alignment of space and/or earth stations of two satellite networks in such a way that the angular separation between operational links of the two networks is less than the minimum angular separation required to guarantee that interference is not responsible for more than 10% of the time allowance for the BER specified in the short term performance objectives of either network, or more than a 10% decrease in the amount of reserve capacity available to links that require heavier coding to compensate for rain fading in either network, as applicable. (See Recommendation ITU-R S.1323-1.) If three satellite

networks are in co-frequency operation, the coordination threshold shall be 7% rather than 10%, and if four or more satellite networks are in co-frequency operation, the coordination threshold shall be 5%. [16]

This definition, based on the condition that mutual interference is kept within the levels prescribed in Recommendation 1323, cures all the drawbacks identified in section 1 above in connection with the 10° avoidance angle definition.

When considered in light of the many deficiencies of the fixed-angle approach that have been examined in detail, the advantages of a BER time allowance definition stand out. Among the most important are:

- The definition is completely general and eliminates any need for classifying NGSO systems into different categories (*e.g.* "high-powered systems");
- The definition is directly based on keeping mutual interference within the levels prescribed in Recommendation ITU-R S.1323-1 and therefore gives licensees reasonable certainty about the protection of licensed systems without overconstraining operations that would not cause interference to exceed permissible levels;
- The definition encourages rather than discourages coordination because both parties have a strong incentive for reaching agreement on the avoidance angles that will ensure mutual protection;[17]
- The definition includes the required flexibility to allow earth station-based and/or satellite-based angles to be used as required; and
- The definition proposed by Teledesic also addresses the need for keeping the mutual interference between two systems within permissible levels when three or more systems are operational.

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[16] Reply Comments of Teledesic LLC at Attachment A-1 (filed in IB Docket No. 02-19 on April 18, 2002).

[17] In the unlikely event that the parties cannot agree on the avoidance angles to be used they will be subject to arbitration. Therefore, any attempt to deviate from what is mathematically correct and reasonable with respect to the choice of avoidance angles is not going to be rewarded in the end.

In its explanation of why the BER time allowance definition as proposed by Teledesic was not adopted in the *Ku-Band Report and Order*, the Commission expresses concern that the time allowance would be used as a coordination trigger while "coordination will likely be required between most NGSO FSS systems" when avoidance of in-line interference is the adopted sharing method.[18] This interpretation is not accurate because according to the Teledesic proposal coordination is always required.[19] Actually, agreement on the avoidance angles is part of the coordination process and, even if there is no agreement on the avoidance angles, a mechanism exists for safely determining avoidance angles that will ensure protection for both NGSO systems involved.

The Commission further states that the BER time allowance "method may be overly complicated for use in defining a baseline sharing arrangement." [20] While it is recognized that sharing between two NGSO FSS systems is a complicated issue, Teledesic disagrees that this method is *overly* complicated because there is no simple way to solve the problem at hand. As discussed in sub-section 1.1 above, the Commission recognizes the weaknesses of using a fixed avoidance angle and attempts to deal with them in a Further NPRM. As noted before, not only does this approach eliminate the alleged simplicity of the adopted definition but also the proposed measures do not cure its flaws. The BER time allowance method directly measures the impact of the inter-system interference between NGSO systems and as such will be the methodology used for bilateral coordination. Finally, it is worth noting that this is the same methodology that was used in developing the sharing environment between NGSO and GSO systems in most bands between 10-30 GHz in the development of epfd limits.

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[18] *Id.* at ¶ 51.

[19] See Reply Comments of Teledesic LLC at 14 (filed in IB Docket No. 02-19 on April 18, 2002).

[20] *Ku-Band Report and Order* at ¶ 51.