Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Petition of Spacenet, Inc. for a Declaratory Ruling that Section 25.134 of the Commission's Rules Permits VSAT Remote Stations in the Fixed Satellite Service to Use Network Access Schemes that Allow Statistically Infrequent Overlapping Transmissions of Short Duration, or, in the Alternative, For Rulemaking to Amend that Section	)	RM-9864

ORDER

Adopted: December 6, 2000 Released: December 7, 2000

By the Chief, International Bureau:

I. INTRODUCTION

1. By this Order, we deny a petition for declaratory ruling filed by Spacenet, Inc. (Spacenet). Spacenet requests a declaratory ruling that the Commission's rules allow networks of very small aperture terminals (VSAT networks) "to employ access schemes that entail statistically infrequent overlapping transmissions of remote earth stations."[1] We recognize, however, that, due to confusion about the rule at issue, some operators may already be using these access techniques. We grant all these operators a waiver on our own motion, so that they may continue to serve their customers. Consequently, by today's actions, we eliminate uncertainty over the interpretation of the Commission's VSAT rules. We also preserve the *status quo* until the Commission can complete a forthcoming rulemaking proceeding to consider fully the issues raised by Spacenet.

II. BACKGROUND

2. The Commission's rules permit parties to obtain a single or "blanket" license for a large number of technically identical small aperture antenna earth stations operating in the Ku-band.[2] These systems consist of one or more hub stations transmitting via a satellite to technically identical remote small aperture antennas. These systems are referred to as very small

[1] Spacenet Petition at 1.

[2] For purposes of this Order, the "Ku-band" denotes the 11.7-12.2 and 14.0.14.5 GHz frequency bands.

aperture antenna terminal (VSAT) networks.[3] VSAT networks employ different techniques to prevent or limit the transmissions to and from their remote earth stations from interfering with each other and with adjacent satellite networks. To this end, most VSAT networks originally used frequency division multiple access (FDMA), which assigns different portions of the Ku-band frequencies to different remote earth stations.[4] Subsequently, VSAT system operators developed techniques that enabled some remote earth stations to share frequency bands. One of these techniques is called time division multiple access (TDMA), in which each remote earth station is assigned a different time to transmit and receive information. Another, code division multiple access (CDMA), prevents interference between remote earth stations by assigning a different digital code to different earth stations.

3. The access technique that is the subject of Spacenet's petition is called the "slotted Aloha" technique.[5] In this technique, the hub earth station synchronizes all remote VSAT stations so that they transmit only in discrete time slots, typically tens of milliseconds in duration.[6] Unlike the TDMA techniques, however, Aloha permits two or more remote earth stations to transmit simultaneously. Aloha relies on statistical probability calculations to limit the number and duration of simultaneous transmissions. When two or more remote earth stations in Spacenet's VSAT network transmit simultaneously, those transmissions can "collide," and the resulting power level caused by these collisions exceeds the level specified in the Commission's rules during the time period of simultaneous transmission, although for no more than tens of milliseconds.[7] Increasing the power levels of a transmission increases the possibility that it will cause unacceptable interference to other satellite systems. According to Spacenet, however, because the collisions in its VSAT network are infrequent and of short duration, they do not cause unacceptable interference to adjacent satellite systems.[8]

4. Many of the requirements applicable to VSAT networks appear in Section 25.134 of the Commission's rules.[9] Section 25.134(a) states that, to qualify for routine licensing, VSAT

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[3] Routine Licensing of Large Networks of Small Antenna Earth Stations Operating in the 12/14 GHz Frequency Bands, 51 Fed. Reg. 15067 (Apr. 22, 1986) (*1986 VSAT Order*); Routine Licensing of Earth Stations in the 6 GHz and 14 GHz Bands Using Antennas Less that 9 Meters and 5 Meters in Diameter, Respectively, for Both Full Transponder and Narrowband Transmissions, Declaratory Order, 2 FCC Rcd 2149 (Com. Car. Bur. 1987) (*1987 VSAT Order*). *See also* 47 C.F.R. §25.134.

[4] Satellite systems used this access technique even before the Commission developed its VSAT policies. *See* Satellite Business Systems, 62 FCC 2d 997, 1083 (para. 247) (1977).

[5] With the "unslotted Aloha" technique, remote earth stations in the VSAT network can transmit randomly at any time, meaning that the transmissions are not synchronized in time or duration. The "unslotted Aloha" technique is distinguishable from the "slotted Aloha" technique, in which remote earth stations transmit in specific time slots, which means that the transmissions are synchronized but not coordinated. In other words, the remote earth stations transmitting in a given time slot can transmit regardless of whether there are other earth stations transmitting in the same time slot. G. Maral, *VSAT Networks* at 144-45 (John Wiley and Sons, ed. 1995).

[6] Spacenet Petition at 6.

[7] Spacenet maintains that the duration of an inbound transmission is typically between 15 and 50 milliseconds. Spacenet Petition at 8.

[8] Spacenet Petition at 7.

[9] 47 C.F.R. § 25.134.

remote earth stations must operate with an input power density no higher than -14 dBW/4 kHz.[10] Section 25.134(b) states that VSAT network license applicants planning to use a power spectral density higher than -14 dBW/4 kHz must submit additional information in their applications, including an Adjacent Satellite Interference Analysis (ASIA), to demonstrate that use of the higher power level will not cause unacceptable interference into adjacent satellite systems.[11] In addition, Section 25.134(c) requires operators of VSAT networks to coordinate with operators of subsequently launched satellites, and to lower the VSAT power levels to those specified in Section 25.134(a) if a coordination arrangement cannot be reached.[12]

5. On April 5, 2000, Spacenet filed a petition for declaratory ruling or rulemaking requesting that the power levels generated by the Aloha access technique during transmission collisions do not violate Section 25.134 of the Commission's rules. Spacenet's petition was placed on public notice on April 28, 2000. Hughes Network Systems (Hughes) and PanAmSat Corporation (PanAmSat) filed comments, and ALOHA Networks, Inc. (ALOHA Networks) filed electronic comments. Spacenet and Hughes filed replies.[13]

III. DISCUSSION

A. Aloha Access Technique

6. As Spacenet describes the slotted Aloha technique, the VSAT network operator first derives the proportion of time slots occupied by exactly one transmission.[14] Then, the VSAT network operator uses statistical methods to determine the probability of two or more transmissions from remote terminals "colliding" at various peak network loads.[15] By this method, the VSAT network operator can adjust the number of transmissions to limit the number of anticipated "collisions." This methodology is discussed in detail in Appendix A to this Order.

7. Spacenet maintains that VSAT operators have used multiple access techniques like Aloha for years.[16] Spacenet requests us to declare that the slotted Aloha technique is consistent with Section 25.134 of the Commissions' rules, provided that:

> (i) each station individually satisfies the power density limits of Section 25.134(a);

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[10] 47 C.F.R. § 25.134(a).

[11] 47 C.F.R. § 25.134(b).

[12] 47 C.F.R. § 25.134(c).

[13] In addition, Spacenet filed an *ex parte* statement on September 15, 2000.

[14] This proportion is derived by the following formula: $S = G*e^{(-G)}$, where S is the utilization or throughput per slot, G is the load or average transmissions per slot, and e is Euler's number, a constant equal to approximately 2.73. Spacenet Petition at 6.

[15] Spacenet Petition at 5-7.

[16] Spacenet Petition at 8-10. *See also* PanAmSat Comments at 2.

(ii) the probability P of k stations transmitting, for k greater than 1, is below the limit defined by $P[k] = (0.38/k!)*e^{(-0.38)}$, and
(iii) the maximum duration of any single collision is less than 100 milliseconds.[17]

In the alternative, Spacenet requests a rulemaking to add these requirements to Section 25.134.[18]

8. PanAmSat agrees with Spacenet that the Commission should clarify or amend its rules to permit random access techniques, provided that the probability of collisions is within a defined range.[19] PanAmSat argues further that the Commission's VSAT rules have become outdated, and that the Commission should increase the power level limits to reflect technological advances.[20] Hughes questions whether any action is required to clarify Section 25.134, but agrees that, if clarification is necessary, a declaratory ruling is better than a rulemaking proceeding.[21] Hughes argues, however, that the second requirement in Spacenet's proposed rule is unnecessarily detailed, and could unreasonably restrict the flexibility of VSAT operators to adapt their networks to future technological developments.[22] Hughes proposes the following requirement as an alternative: "(ii) the total average power radiated toward the target satellite by all the remote earth stations in the network, using an averaging period of one second, is less than that of a single remote earth station transmitting continuously."[23] Spacenet supports PanAmSat's proposal to relax the power level standards in a future proceeding, but opposes delaying action on its petition while considering PanAmSat's proposal.[24] Finally, Spacenet expresses support for Hughes's proposed rule as an alternative to its own proposal.[25]

9. We decline to adopt any declaratory ruling at this time because both Spacenet's and Hughes's proposals raise issues that require further analysis. Sections 25.134(a) and (b) establish finite limits for individual earth station antenna input power densities.[26] When signals from two or more earth stations within a VSAT network collide, the resulting power level exceeds the limits specified in Sections 25.134(a) and (b), and so the Aloha method, and variants such as slotted Aloha, cannot be construed to comply with the letter of Section 25.134 if each terminal transmits at the maximum power density limit. This result is discussed in more detail in Appendix A.

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17 Spacenet Petition at 9.

18 Spacenet Petition at 11.

19 PanAmSat Comments at 1-2.

20 PanAmSat Comments at 2-3.

21 Hughes Comments at 2-4.

22 Hughes Comments at 3-4.

23 Hughes Comments at 4-5. *See also* ALOHA Networks Comments (recommending amending Section 25.134 to permit VSAT networks to exceed the power limits by no more than one second per hour when the network is operated at peak load for one hour).

24 Spacenet Reply at 5.

25 Spacenet *Ex Parte* Statement at 1.

26 47 C.F.R. § 25.134(a), (b).

10. We also decline to adopt a declaratory ruling at this time because it would not adequately address cases where the bandwidth used by the earth station(s) causing interference to other earth stations is wider than the bandwidth used by the victim earth station(s) of the interference. Assuming the transmission bandwidth for the interfering earth stations is a few hundred kHz, the potential interference resulting from co-channel carrier collisions to a victim earth station operating over a wider bandwidth (*e.g.*, greater than ten times the interfering bandwidth) may corrupt only a fraction of the victim earth station's transmission data. The victim's corrupted data would likely be recovered by the error correction techniques employed by the victim satellite system. Thus, this issue is not as problematic as might be thought. However, if the victim earth station(s) is operating in a narrower bandwidth or approximately the same as the interfering earth station, the victim earth station's transmission data would be significantly degraded, possibly beyond recovery. The narrow-bandwidth problem can be compounded as satellite-based voice/data traffic increases.

11. Instead of addressing the issues raised by the Aloha access technique in this proceeding, the Commission will address these issues in a forthcoming rulemaking. In that proceeding, the Commission will also examine the current power limit rules, as PanAmSat requests.[27]

12. Nevertheless, based on our review of Spacenet's calculations, and the record we have developed on Spacenet's random access technique, we find that Spacenet has shown persuasively that its random access technique does not, at this time, cause harmful interference to other satellite systems. Accordingly, we find that Spacenet has shown good cause for a waiver of Sections 25.134(a) and (b) for purposes of continuing to use its Aloha random access technique. Further, because of confusion and to prevent disruption in service, we grant all VSAT operators a waiver, on our own motion, for purposes of continuing to use any multiple access techniques VSAT operators are using at the time this Order becomes effective. The waiver we grant here will remain in effect only until the upcoming rulemaking on this and other related issues takes effect, and does not prejudge any decision in that rulemaking proceeding. These VSAT operations will then be subject to implementation of the final rulemaking decision.

B. Probability Distribution

13. ALOHA Networks maintains that Spacenet used the wrong probability formula for slotted Aloha networks. ALOHA Networks projects that the number of collisions is three times greater than Spacenet's estimate. According to ALOHA Networks, the probability formula Spacenet used applies only to unslotted networks.[28] Spacenet maintains that ALOHA Networks

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[27] PanAmSat Comments at 2-3.

[28] Aloha Network Comments at 1-2. Hughes maintains that the Aloha Network's approach has "technical validity," but argues that the language of its proposed rule is more flexible, and so more workable in practice. Hughes Reply at 1-3. Specifically, ALOHA Network criticizes Spacenet for using a Poisson probability distribution rather than a binomial distribution. The binomial distribution, one of the more common statistical distributions, is designed for cases like determining the probability of flipping a coin and getting heads a certain number of times in a row. More generally, for each trial, there are only two possible outcomes, the probability of each outcome is known, and the probability does not vary from trial to trial. The Poisson distribution is designed for cases where the probability of an event occurring is very low, but the number of opportunities for such occurrences are very high. Examples are estimating the number of people who will contract a rare disease in a population of several million, or the number of atoms that will undergo radioactive decay in a large amount of uranium.

is mistaken in asserting that its probability function underestimates the number of collisions.[29] Spacenet also maintains that, if its system had the potential to cause unacceptable interference, then space station operators would have opposed its petition.[30] Finally, Spacenet maintains that ALOHA Networks' probability equation would limit the number of collisions more than necessary to prevent interference, and so would render its slotted Aloha system commercially nonviable.[31]

14. Because we are not granting Spacenet's petition for declaratory ruling, we need not address the probability formula for projecting the number of collisions here. Rather, the Commission will examine probability formulas, if necessary, in the context of its rulemaking.

IV. ORDERING CLAUSES

15. Accordingly, IT IS ORDERED, pursuant to Section 1.2 of the Commission's rules, 47 C.F.R. § 1.2, that the petition for declaratory ruling filed by Spacenet, Inc. on April 5, 2000, IS DENIED.

16. IT IS FURTHER ORDERED, pursuant to Section 1.3 of the Commission's rules, 47 C.F.R. § 1.3, that current operators of VSAT networks ARE GRANTED a waiver of Section 25.134 of the Commission's rules, 47 C.F.R. § 25.134, for purposes of continuing to use any multiple access techniques being used at the time this Order becomes effective, pending a Commission rulemaking addressing the use of such techniques.

17. This Order is issued pursuant to Section 0.261 of the Commission's rules on delegated authority, 47 C.F.R. § 0.261, and is effective upon release.

FEDERAL COMMUNICATIONS COMMISSION

Donald Abelson
Chief, International Bureau

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[29] Spacenet Reply at 6.

[30] Spacenet Reply at 6-7.

[31] Spacenet Reply at 7.

APPENDIX A

Technical Analysis of Spacenet's Aloha Random Access Scheme

I. Spacenet's Proposed Rule

Spacenet proposed adding a new paragraph (e) to Section 25.134. Spacenet's proposed rule is as follows:

1. Each station individually satisfies the antenna input power density limit of the rule;
2. The probability P of k stations simultaneously transmitting, for k being greater than 1, is below the limit defined by
$$P\{k\} = (0.38^{k}) * \exp(-0.38) / k!)$$
where the channel load G is set for 0.38 as a numerical constant; and
3. The maximum duration of any individual collision is less than 100 milliseconds.

Spacenet's proposed Section 25.134(e)(1) merely restates an existing requirement. Proposed Section 25.134(e)(3) does not appear to be controversial based on the record in this proceeding. Accordingly, we will direct our attention to proposed Section 25.134(e)(2).

Proposed Section 25.134(e)(2) raises two questions: (1) What is the probability that a "collision" of transmissions from two or more earth stations will occur? and (2) How much do power levels increase during a collision? We address these two issues below.

II. Probability of Collisions

Spacenet based its probability determination on a Poisson probability distribution, such that, for the standard Aloha approach,

(1) $$S = G*e^{(-2G)}$$

where S is throughput, G is channel loading, and e is a constant equal to approximately 2.73. The Poisson probability distribution is similar for the slotted Aloha approach

(2) $$S = G*e^{(-G)}$$

We replace the "-2G" term with "-G" because the collision-vulnerable period in the slotted-Aloha approach is half of that in the standard Aloha approach.

The probability of a collision of transmissions is P{k}, where k is the number of stations transmitting simultaneously. According to the equation in Spacenet's proposed Section 25.134(e)(2), setting the channel loading G equal to 0.38, the following results:

Table 1: Probability of Collisions

Number of Earth Stations Transmitting Simultaneously	Probability of Collision involving N transmissions P(N)	Probability of Collision in Percentage Terms
0		
1	0.260	26%
2	0.049	4.9%
3	0.00625	0.625%
4	0.00059	0.059%
5	0.00005	0.005%

The probability of collision for six or more stations is remote and so we can ignore it.

III. Excessive Power Emissions

In a multiple access scheme such as slotted ALOHA, a carrier collision occurs when two or more stations are transmitting simultaneously on the same frequency. If we assume that each transmitter in the network is operating at the maximum authorized power level, then a single transmitter would not cause any increase over the maximum authorized power level. In other words, there would be a 0 dB increase in potential interference. A two-transmission collision, however, would double the potential interference (*i.e.*, cause a 3.0 dB increase in power), and a three-transmission collision would triple the potential interference (*i.e.*, cause a 4.77 dB increase in power). The increase in power level is

(3) $10*\log(N)$

where N is the number of colliding transmissions. Clearly, the potential for interference to adjacent satellite operations increases whenever a collision takes place.

Table 2: Power Increases Caused by Collisions

Number of Colliding Transmissions	Power Increase in dB
1	0
2	3.0
3	4.7
4	6.0
5	7.0

Spacenet argues that we should discount high power levels for the low probability of occurrence. Specifically, Spacenet argues that the Net Power Increase (NPI) should be –5.85 dB for a single-station transmission, -10.09 dB for a two-station collision, and so on. Based on this, Spacenet claims that Over-Time Net Power Increase (ONPI) from two simultaneously transmitting remote stations is 4.20 dB below the emission of a single station transmitting constantly at the maximum authorized power under the current Rule. By using ONPI, Spacenet demonstrates the inbound carrier collisions over time do not generate excessive emission in violation of the Commission's Rules.

Table 3: Power Increases Caused by Collisions, Spacenet's Approach

Number of Earth Stations Transmitting Simultaneously	Probability P(N)	Power Increase: 10log(N) [dB]	Net Power Increase Adjusted for Probability of Occurrence: 10log(P(N)) + 10log(N) [dB]
1	0.260	0	-5.85
2	0.049	3.0	-10.09
3	0.006	4.7	-17.52
4	0.001	6.0	-24.00

By summing all the net power increases adjusted for probability of occurrence, we obtain

(4) $$ONPI = 10\log[10^{-5.85/10} + 10^{-10.09/10} + 10^{-17.52/10} + 10^{-24.00/10}]$$
$$\simeq -4.2 \text{ dB}$$

We can draw two relevant observations from Spacenet's proposal. First, we recognize that Spacenet's showing assumes that the described events are taking place randomly under a Poisson distribution and the network traffic is being held to a 38% load, which yields about 26% throughput (or efficiency). Based on these assumptions, we can obtain a set of probabilities of carrier collisions and draw certain conclusions. For example, at 38% load, the probability of a three-carrier collision is 0.6%, which we are willing to dismiss as *de minimis*. However, if the load is doubled to about 75%, the probability of a three-carrier collision becomes 3.3%, which may be difficult to dismiss as *de minimis*. Therefore, in Spacenet's approach, Spacenet must be able to maintain the 38% channel load at all times so that the number of undesired carrier collisions can be controlled within the network.

Second, Spacenet claims that interference is not an issue because the ONPI is 4.2 dB less than the total power emission from a single continuously transmitting earth station. We do not agree. This by itself is not sufficient to comply with the Commission's rules. Specifically, we are concerned that the power overruns due to collisions could lead to excessive emissions that may cause harmful interference to neighboring satellites in the orbit, (even though the probability of occurrence is low and the total time of occurrence are brief) if there is a significant deviation from the parameters represented in Spacenet's Petition. During the very instance of a carrier collision, short burst of excessive emissions are generated, and the resulting power level will likely violate the Commission's rules if each network station is operating at maximum permitted power level. The Commission rule places a limit on power density, rather than a threshold that may be exceeded. Consequently, the Commission has responsibility to ensure that these excessive emissions will not interfere with the operation of neighboring satellites in orbit even for brief instances.