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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ex Parte

May 21, 1998

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
Mail Stop Code 1170
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: RM-9005 – Routine Licensing of Large Numbers of Earth Stations

Dear Ms. Salas:

Today, Mark McAllister, Technical Staff, Wireless Communications, Southwestern Bell Technology Resources, Paul Saur, Vice President, Network Operations, Cellular One-Boston, Betsey Granger, Senior Counsel, Pacific Bell Mobile Services, and I met with: Paul Misener, Senior Legal Advisor to Commissioner Furchtgott-Roth; in the International Bureau, Richard B. Engelman, Division Chief, and Pamela Gerr, Chief, Negotiations Branch, Planning and Negotiations Division, Thomas Tycz, Division Chief, Steve B. Sharkey, Chief, Satellite Engineering Branch, and Diane Garfield, Satellite and Radiocommunication Division; and from the Wireless Telecommunications Bureau, David Wye, Senior Advisor for Technology, to discuss the issues summarized in the attached material.

We are submitting two copies of this notice in accordance with the Commission's rules. Please stamp and return the provided copy to confirm your receipt. Please contact me should you have any questions.

Sincerely,

Attachments

R. Engelman
D. Garfield
P. Gerr
P. Misener
S. Sharkey
T. Tycz
D. Wye

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18 GHz Microwave Systems and Satellite Interference

Mark McAllister
Paul Saur
Betsy Granger
Gina Harrison

May 21, 1998

Introduction

- Microwave is used to provide reliable, cost effective back haul for CMRS. The availability of appropriate spectrum bands is important to meeting the wireless communication needs of the United States.
- There are 43,000 18 GHz links in the United States. Microwave is also providing important links in landline systems.
- New satellite communication systems continue to be announced that promise spectrum sharing then require compromising fixed microwave services.
- Fixed microwave services are running out of bands to relocate into.

Importance of 18 GHz to Wireless

- Microwave Interconnect and PCS
  - Microwave deployment depends on cost and capacity
  - Microwave interconnect
    - Cost
    - Availability of leased DS-1
  - Space Limitations for GSM PCS Providers
    - Single Cabinet
    - 5 rack units available for all interconnect functions
    - Microwave limited to 1 or 2 rack units at most
  - Tower limitations
  - Dish size - Path can be engineered and licensed with a 1' or 2' dish which is more acceptable in many locations.

Importance of 18 GHz to Wireless

- Examples of 18 GHz in CMRS Networks
  - 18 GHz has been used to provide interconnect to rural areas that could not be covered without substantially higher costs.
  - I-15 between Barstow and Las Vegas, NV
  - I-5 between Stockton and Bakersfield, CA
  - 18 - 20 mile range of 18 GHz fits the 35 km maximum distance of GSM
  - Single rack unit eliminates need for buildings, reduces costs, improves reliability
  - 60% of PBMS microwave interconnect is 18 GHz (5,000-6,000 DSO circuits).
  - 19% for Cellular One in Boston (5,000-6,000 DSO circuits).

18 GHz Microwave Backbone - Cellular One Boston

- Frequency Range 17.7 - 19.7 GHz TX Power, 19-29 dBm
- Currently 20 Systems in use, Capacity 4DS-1 - 1DS3
- Currently 4 systems under construction
- 2 future sites planned

Landline Uses

- Pacific Bell has 12, 384 DSO circuits at 18 GHz
- Nevada Bell has 2, 976 DSO circuits at 18 GHz
- SWBT has 1,440 DSO circuits at 18 GHz
- Two of the SWBT systems provide essential services to the El Paso 911 agencies (one provides local loop diversity for 911 calls. The other includes circuits which provide a link-up to the dispatch transmitter on the top of the mountain.)

Teledesic Interference to FS Receivers

- When Teledesic satellite is in main beam of FS receiver, interference exceeds permissible limits.
- For a given FS receiver, this situation occurs between 5 and 9 times a day, most events lasting between 4 and 13 seconds.
- The interference will reduce the margins and increase the bit error rate. Dropped calls can result.

FS Interference to Teledesic Earth Stations

- FS transmitters will interfere with Teledesic ground receivers if the receivers are in "exclusion zones" in front of transmitters.
- Exclusion zones are thin (widths at center = ~ 1% of length) but can extend for tens of kilometers, depending on transmitter EIRP, transmitter height and earth-station height.
- Exclusion zones will limit future placement of microwave links. They can effectively close off an entire city from the placement of new microwave links.

Spectrum Sharing Is Not An Option Because Of Interference To Both Systems

- Spectrum Sharing with Mobile Satellite Operators
  - Co-channel spectrum sharing is not a viable option.
  - Band segmentation will be required to provide sufficient frequency separation between the terrestrial and satellite services.
  - Relocation costs for the terrestrial services should be paid for by the satellite services.

18 GHz Relocation Options

- Thousands of links to relocate
- Shared by all fixed microwave services
- 23 GHz has higher attenuation
- 11 GHz has higher minimum payload requirements, will require more complex modulation at higher cost.
- 11 GHz also proposed for satellite sharing
- 6 GHz band requires more expensive and much larger equipment
- Segmentation of 18 GHz band

18 GHz Relocation Options

- Relocation to higher frequency band, for example 23 GHz. will reduce reliability in an average 18 GHz path by 10-15 dB without an increase in dish size due to higher attenuation characteristics.

- Relocation to 38 GHz would decrease reliability even more than above. 38 GHz would need to be leased by an authorized provider.

- Relocation to a lower frequency raises cost of interconnect, frequencies may not be obtainable and dish sizes will to be increased from 1' and 2' to 4' and 6'.

18 GHz Relocation Options

- 10 GHz Minimum dish size is 4'. Conditional license cannot be obtained currently without a waiver, which extends licensing period substantially. Much more congested, therefore frequency availability is non-existent in some areas.
- 11 GHz Minimum dish size is 4'. Frequency congestion problems exist in many areas.
- 6 GHz Minimum dish size is 6' which is unacceptable on many building applications as well as towers which are structurally loaded. Equipment cost higher. Congested Bandwidth throughout Massachusetts. Many frequencies have never been relinquished making it extremely difficult to obtain 6 GHz microwave links in the Boston area.

18 GHz Relocation Costs

- Depending on the specific plan selected relocation options range from replacing the outdoor units to re-building the entire microwave system.
- Loss of the 340 MHz split (and associated 5 MHz channels) will require replacement of at least the outdoor units.
- The cost of relocation depends on whether band segmentation vs. complete movement out of the band is the relocation choice.

Costs of 18 GHz Relocation

- Option One (Same Band, Different T/R Split): Frequency Coordination, FCC Application Fees, 2 person site visit, install new outdoor units: $20,000 - $30,000 per link.
- Option 2 (6 GHz Option): Frequency Coordination, FCC Application Fees, 2 new towers, 2 buildings to house 6 GHz radios, 2 new dehydrators, 2 runs of waveguide, and 2 new 6 GHz radios: $150,000 - $200,000.

Relocation Costs Should Be Paid By New Entrants

- PCS Precedent
- Faster transition
- Costs borne by those who benefit

Conclusion

- 18 GHz is an important band for providing reliable, cost effective back haul for wireless subscribers and to support landline operations also.
- Spectrum sharing on a co-channel basis with satellite services will result in impermissible levels of interference to both microwave operations and satellite operations.
- Band segmentation could provide the necessary frequency separation.
- Relocation costs for any move should be paid by new entrants.
- Opening 7 and 15 GHz bands would replace lost spectrum

Teledesic/FS Interference at 18 GHz

Mark McAllister, SBC Technology Resources, Austin, TX
512-372-5823

Teledesic Downlink Interference to FS Receivers

This is analyzed in the spreadsheet Sat_Terr_New_95_2. The Teledesic parameters are from a presentation by Tom Hayden to the JWG on March 25, and are different from those in a previous spreadsheet which were based on web site information and the outdated Teledesic application.

The key Teledesic parameters are:

Orbit altitude = 1375 km
STL downlink transmitter power density = -66.8 dB(W/Hz)
STL transmit antenna gain = 35.7 dB
STL signal bandwidth = 396 MHz
Maximum beam deviation off nadir = 39 degrees (derived from fact that minimum elevation angle from user to satellite = 40 degrees)
# of orbital rings = 12
Satellites per ring = 24
Orbital period = 6800 sec.

The key results from the spreadsheet are summarized in Chart 2 and Chart 3.

Chart 2 shows the interference levels into an FS receiver as a satellite appears on the horizon in the main beam of the receiver and then travels to directly above the receiver. The two horizontal lines in the middle of the chart give the range of interference thresholds for FS receivers, based on a chart furnished by Dennis Couillard of Harris-Farinon at the last JWG meeting. At the horizon, all interference thresholds are exceeded..

Chart 2 represents no uptilt to the receiver antenna. The effects of uptilt can be inferred from Chart 3, which plots the FS and satellite antenna patterns as the satellite ascends above the horizon. The interference is proportional to the sum of the two patterns (in dB.) Uptilt is equivalent to sliding the FS pattern to the right a number of degrees equal to the uptilt. One can infer that uptilt has no adverse effect on the interference if the uptilt angle is 10 degrees or less, because of the null in the satellite antenna pattern. At 14 degrees uptilt, the interference is 6 dB worse than at 0 degrees.

A key question is: **what percentage of the time does an FS receiver have a satellite in its main beam?** For a 48 dBi gain FS receiver, the half-power beamwidth is 0.7 degrees.

To find the answer, we compute two percentages: The first is the *percentage of time that an orbital ring is within the half-power beamwidth of the FS antenna,* and the second is the *percentage of time that a satellite in a ring is between zero and 0.7 degree elevation with respect to the FS transmitter.*

Consider two cases: **(1)** The FS link faces north-south, and **(2)** the FS link faces east-west. Mid-level latitudes are assumed.

(1) The rings are sun-synchronous and effectively rotate about the earth approximately once per day, or one degree in 240 seconds. But the FS receiver is closer to the points on the ring at zero elevation than is the center of the earth, so the angular speed of the ring must be multiplied by 7775/4415, the ratio of the respective distances. At the FS receiver, then, a ring traverses 0.7 degrees in 240 x .568 x 0.7 = 95.4 sec. There are 12 rings, so the total time per day a ring is within the beamwidth is 95.4 x 12 = 1145 sec. With a total of 86,400 seconds in a day, the fraction of time is .0135.

Within a ring, 24 satellites pass the horizon every 6800 seconds, or one every 283 seconds. Each traversal of 0.7 degrees at the horizon requires about 13 seconds, so the fraction of time is 13/283 = .046.

Multiplying the above fractions we get .0135 x .046 = .00062. The total number of seconds in a day that the situation exists is 86,400 x .00062 = 54 seconds (on the average.)

(2) For an east-west link the ring movement is roughly parallel to the link and the satellite motion is perpendicular. In effect, the rings are in the main beam for a longer fraction of the time, but the satellites go through the main beam faster. In fact, analysis shows that the two factors cancel (for U.S.-level latitudes), so that the number of seconds per day that a satellite is in the main beam is 54 seconds in both cases.

Further analysis shows that roughly 80% of such events (satellite in main beam of FS receiver) will have duration between 7 seconds and 13 seconds (N-S link), or between 4 and 8 seconds (E-W link.) This implies that a N-S link will average about 5 events a day, and an E-W link about 9 events a day.

Condensing the above results into two sentences:

Between roughly 5 and 9 times a day, any FS receiver will have a Teledesic satellite in its main beam for a period of between 4 and 13 seconds. When these events occur, the interference will be above permissible levels.

FS Transmitter Interference to Teledesic Earth Station

Here the relevant Teledesic parameters are:

<u>Antenna size</u> = 0.3m
<u>Receiver bandwidth</u> = 396 MHz
<u>Antenna gain</u> = 34.1 dBi
<u>Receiver noise temperature</u> = 288 K.

Following the analysis outlined by Richard Barnett in a previous presentation to the JWG, we assume that the maximum permissible interference is that which raises the effective noise temperature of the receiver system by 10%.

Let I = max. interference = 0.1kTB

I(dBW) = -10 – 228.6 + 10*log(288) + 10*log(396 x 10^6)

= -238.6 + 24.6 + 86.0 = - 128 dBW

The interference cause by an FS transmitter is

FSI = EIRP + free-space loss + earth station antenna gain + earth station sidelobe loss

= EIRP + FSL + ESG + SLL
= EIRP –118 – 20*log(d,km) + 34.1 dB + SLL

To get SLL, we plot the earth station pattern in spreadsheet EarthStationPattern (Chart 1) and see that the worse-case attenuation above 40 degrees (minimum elevation angle to a Teledesic satellite) is 43 dB, so

FSI = EIRP(dBW) –118 dB – 20*log(d,km) + 34.1 dB – 43 dB

= -126.9 dB + EIRP - 20*log(d,km)

By setting FSI = I, we can now plot exclusion zone length as a function of EIRP from FS transmitter.
-128 = -126.9 + EIRP - 20*log(d,km)

20*log(d,km) = 1.1 + EIRP

d,km = 10^((1.1 + EIRP(dBW))/20)

See spreadsheet EarthStationPattern, Chart 2.

The range of FS EIRPs, from the chart furnished by Dennis Couillard and referred to above, is 27 dBW to 43 dBW, giving exclusion zones ranging from 25 to 160 km.

However, these are "free space" exclusion zones. Curvature of the earth limits exclusion zone lengths, which are a function of both FS transmitter height and Teledesic receiver height. The relationship is graphed in EarthStationPattern, Chart 3. Exclusion zone lengths of 40 km and above are seen to be achievable in a large number of cases.

The "shape" of free-space exclusion zones can be inferred from the curve in Chart 2 and the FS beam pattern as enumerated in cells n15-n20 and o15-o20 of spreadsheet Sat_Terr_New_95_2. In the latter cells we see that when the pattern is 3 dB down the beamwidth is roughly 2 x .35 = .7 degrees and when the pattern is 6 dB down the beamwidth is roughly 2 x. .53 = 1.06 degrees. Noting these and looking at Chart 2, we see that the exclusion zone for a 33 dBW transmitter has the following extent at the different angles off boresight:

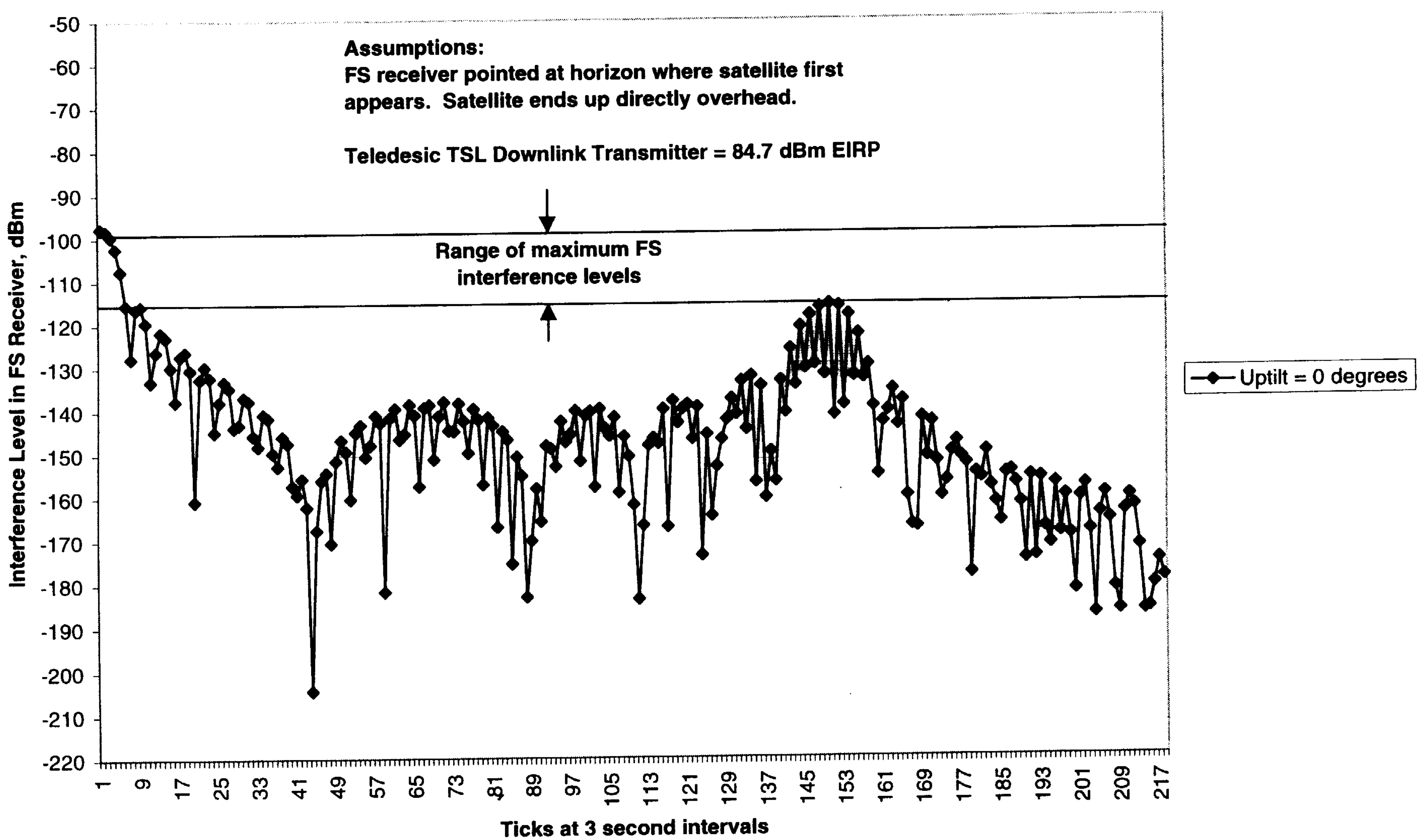
Angle	Exclusion Zone Extent
0	50 km
0.35	36 km
0.53	25 km

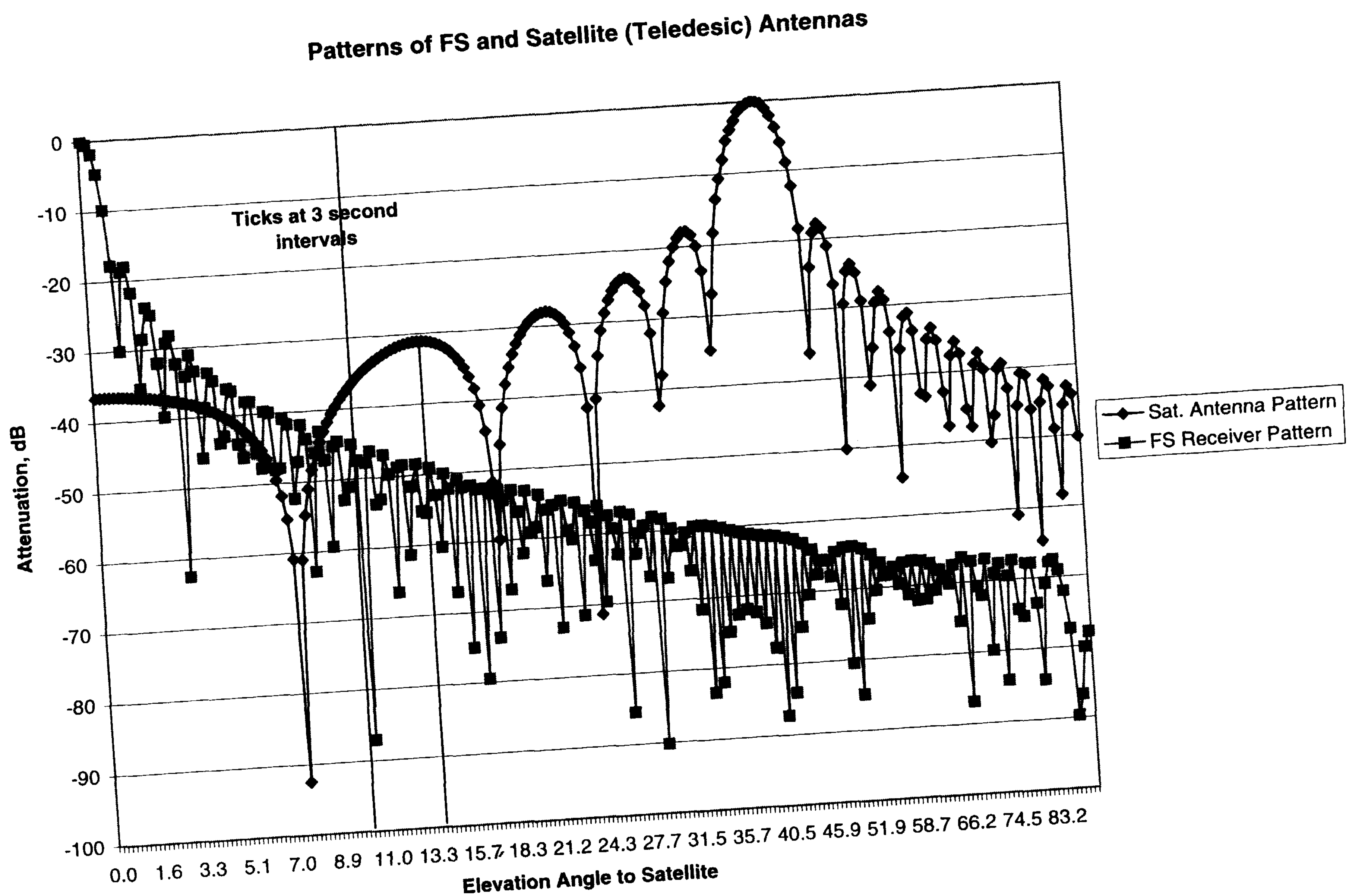
From simple trigonometry we see that at half the maximum length, the exclusion zone is 0.5 km wide. A rough rule of thumb can be inferred: the exclusion zone width at half the maximum distance is about 1% of the maximum distance.

The results can be summarized:

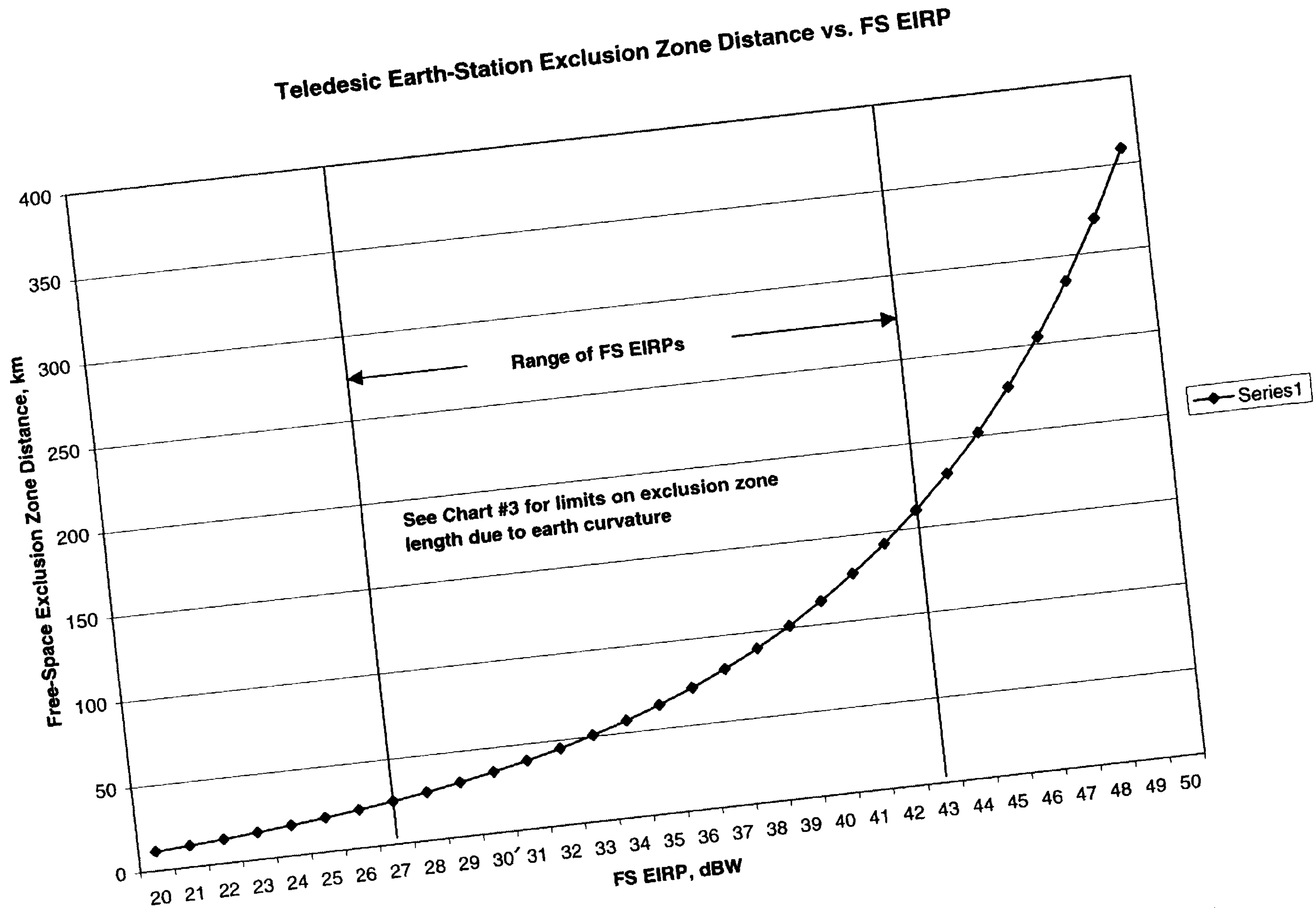
FS transmitters will cause unacceptable interference to Teledesic earth stations if the earth stations are inside exclusion zones that exist in front of each transmitter. Exclusion zone sizes are functions of transmitter EIRP, transmitter height, and earth station height, but will typically be tens of kilometers in length.

Teledesic Interference to FS Receivers

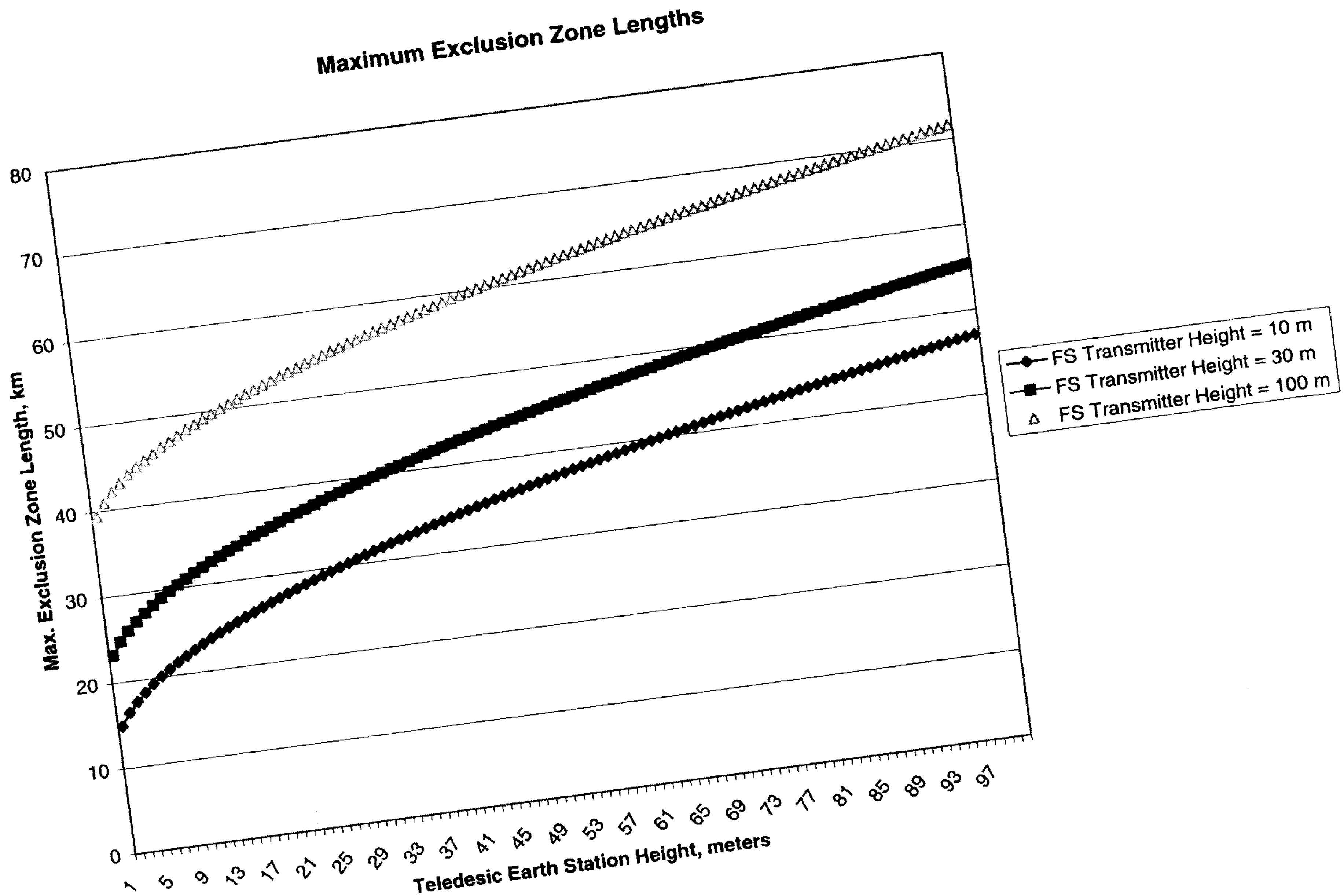




Patterns of FS and Satellite (Teledesic) Antennas
Ticks at 3 second intervals
Attenuation, dB
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0.0 1.6 3.3 5.1 7.0 8.9 11.0 13.3 15.7 18.3 21.2 24.3 27.7 31.5 35.7 40.5 45.9 51.9 58.7 66.2 74.5 83.2
Elevation Angle to Satellite
Sat. Antenna Pattern
FS Receiver Pattern



Teledesic Earth-Station Exclusion Zone Distance vs. FS EIRP
Free-Space Exclusion Zone Distance, km
0
50
100
150
200
250
300
350
400
Range of FS EIRPs
See Chart #3 for limits on exclusion zone length due to earth curvature
Series1
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
FS EIRP, dBW


Maximum Exclusion Zone Lengths
Max. Exclusion Zone Length, km
0
10
20
30
40
50
60
70
80
1
5
9
13
17
21
25
29
33
37
41
45
49
53
57
61
65
69
73
77
81
85
89
93
97
Teledesic Earth Station Height, meters
FS Transmitter Height = 10 m
FS Transmitter Height = 30 m
FS Transmitter Height = 100 m