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November 30, 1995

VIA HAND DELIVERY
Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W. - Room 222
Washington, D.C. 20554

DOCKET FILE COPY ORIGINAL

Re: WT Docket No. 95-157
RM-8643

Dear Mr. Caton:

The attached Comments are submitted on behalf of and for the convenience of the Fixed Point-to-Point Communications Section, Network Equipment Division of the Telecommunications Industry Association.

If there are any questions, do not hesitate to contact the undersigned at (703) 812-0400

Respectfully submitted,

FLETCHER, HEALD & HILDRETH, P.L.C.

Leonard Robert Raish

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BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

In the Matter of	)	
	)	
Amendment to the Commission's Rules Regarding a Plan for Sharing the Costs of Microwave Relocation	))))	WT Docket No. 95-157 RM-8643

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COMMENTS

Pursuant to Section 1.415 of the Commission's Rules,[1] the Fixed Point-to-Point Communications Section, Network Equipment Division of the Telecommunications Industry Association ("TIA"),[2] hereby comments on the above-captioned Notice of Proposed Rule Making ("NPRM"). In the NPRM, the Commission proposes a plan for microwave facility relocation cost sharing to facilitate clearance for the 2 GHz band for Broadband personal communications services ("PCS").[3]

THE NPRM IS IN THE PUBLIC INTEREST

This proceeding hopefully will provide the framework for PCS service providers and incumbent 2 GHz fixed point-to-point microwave service ("FS") licensees to accommodate their

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[1]47 C.F.R. Section 1.415 (1995).

[2]TIA is the principal industry association representing fixed point-to-point microwave radio manufacturers. TIA members serve, among others, companies, including telephone carriers, utilities, railroads, state and local governments, and cellular carriers, licensed by the Commission to use private and common carrier bands for provision of important and essential telecommunications services. TIA has completed its "Telecommunications Systems Bulletin No. 10-F, Interference Criteria for Microwave Systems" ("Bulletin 10-F"), which prescribes standards for implementing the new channel plan for the bands above 3 GHz and for establishing criteria regarding 2 GHz band PCS-to-microwave interference protection.

[3]NPRM at para. 2.

respective relocation cost-sharing requirements. To the extent necessary, TIA is ready to work with PCS and FS licensees and with the Commission in developing industry standards needed to implement the cost-sharing rules adopted herein.

TIA generally supports adoption of the Commission's cost-sharing proposals. It also welcomes the Commission's endorsement of Bulletin 10-F[4] as the default standard for calculating PCS-to-microwave interference. As detailed below, to ensure that the final rules adopted herein meet the Commission's goals and serve the public interest, TIA recommends that:

- The rules should make it clear that Bulletin 10-( ) is the only standard to determine interference for PCS-to-microwave operations.
- Adjacent channel interference from PCS licensees, which the Commission's rules protect FS licensees against, also must be a relevant factor in determining relocation requirements.
- PCS licensees and FS licensees must rely upon the reference to compute interference calculation model of Bulletin 10-( ) coordination distances.
- The Commission should relax its requirements for granting FS licensees Special Temporary Authority ("STA") during the relocation process.
- Operating cost must be made a factor in determining what constitutes comparable facilities.

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[4]Bulletin 10-F is undergoing update as part of TIA's ongoing standards process. Bulletin 10-G is in draft. Once rules are adopted in this proceeding, the Bulletin should be referenced as "Bulletin 10-( )" since it is constantly being updated.

TIA BULLETIN 10-F (AND ITS SUBSEQUENT VERSIONS) MUST BE ADOPTED AS THE STANDARD FOR DETERMINING INTERFERENCE FOR PCS-TO-MICROWAVE OPERATIONS

The Commission tentatively concluded that TIA Bulletin 10-F is the standard used to determine PCS-to-microwave interference.[5] It also notes that PCIA's proposed consensus plan includes the use of the criteria set forth in Bulletin 10-F and that the proposed use of Bulletin 10-F to determine potential interference enjoys widespread support.[6]

However, the Commission questions the availability of different propagation models for PCS-to-microwave interference determination and for reimbursement purposes. It also seeks comments on whether there is a more appropriate industry-accepted standard for determining such interference.[7]

TIA respectfully submits that, with respect to PCS-to-microwave interference, there is only one standard: Bulletin 10-F (and its subsequent versions). In Bulletin 10-F, only one propagation model is set forth, which is a smoothed merging of the HATA model for close-end interferences with the NBS Tech Note 101 study on over-the-horizon losses. Such a model was selected after years of discussion and is widely accepted. It is conservative enough to cover all interference scenarios.

However, the Bulletin 10-F PCS-to-microwave interference model should be considered as the one recognized reference propagation model, in contrast to an

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[5]NPRM at para. 52.

[6]NPRM at para. 51.

[7]NPRM at para. 52.

absolute and totally rigid rule. Indeed, Bulletin 10-F allows some flexibility in the choices of technical parameters to address particular situations. In those cases, alternative propagation models can even be used, as long as their use is supported by solid technical considerations. Such justification is especially required in cases where the computed propagation losses are more than those that would have been calculated with the reference HATA/NBS Tech Note 101 model. Particular cases requiring more flexibility in the choice of parameters and models include situations of substantial blockage, such as those created by mountain ranges or paths crossing an entire downtown area.

Given the flexibility to use alternative propagation models under limited conditions permitted in Bulletin 10-F, licensee flexibility would not be compromised. Accordingly, TIA strongly urges the Commission to adopt its tentative conclusion and rely on Bulletin 10-F (or as it may be revised, as the Commission noted in footnote 85 of the NPRM) for PCS-to-microwave interference protection.

ADJACENT CHANNEL INTERFERENCE MUST BE EVALUATED

Adjacent channel interference is an essential element in determining whether or not relocation is necessary. In the NPRM, the Commission proposes using Bulletin 10-F as an "appropriate standard for determining interference for purposes of the cost-sharing plan."[8] However, the Commission would impose artificial constraints on the use of Bulletin 10-F. Adjacent channel interference would not be considered for purposes of cost-sharing because the

[8]NPRM at para. 52.

Commission claims administration of the plan would be simplified and the number of situations triggering reimbursement would be reduced.[9]

TIA is concerned with the Commission's proposal to exclude adjacent channel interference from the cost-sharing calculus. Entire FS networks could be disabled by adjacent channel interference. As has been observed in numerous industry and government meetings, many existing analog and wide band digital receivers (both civilian and U.S. Government) will have significant sensitivity to adjacent PCS signals five to ten MHz away from the receiver's center frequency. Licensees of PCS systems easily can decrease existing system fade margin several tens of dB, potentially rendering the systems unusable. Adjacent channel interference is a well understood problem. General methods for dealing with this are detailed in Bulletin 10-F and will continue to be detailed in subsequent versions. In Bulletin 10-F and in the draft Bulletin 10-G, criteria are prescribed for predicting and minimizing such interference (see Attachment 1).

In Section 94.63 of the Commission's rules, FS licensees are protected against all interference from PCS licensees, including adjacent channel interference.[10] By excluding adjacent channel interference from the cost-sharing criteria, the Commission would erode the necessary protection to FS licensees that the rules already provide. Thus, any administrative advantages that could be realized by ignoring adjacent channel interference could be outweighed by the clearly negative impact of having adjacent channel interference cases perceived as being treated differently from co-channel interference ones. Let it be reaffirmed that adjacent channel

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[9]NPRM at para. 53.

[10]47 C.F.R. Section 94.63 (1995).

interference problems are no less serious than co-channel ones.

LICENSEES MUST HAVE FLEXIBILITY TO SELECT APPROPRIATE BULLETIN 10-( ) INTERFERENCE CRITERIA

The Commission also proposes using only "minimum coordination distance equations" in Bulletin 10-F to calculate the zone from the PCS base stations where cost-sharing obligations would be imposed.[11] It recommends that the "more complex and variable computations of potential interference" in Bulletin 10-F should not be used so that administration costs and disputes would be minimized.[12] Let it be repeated here that Bulletin 10-F has only one recommended propagation model. Use of any other model would be a non-typical case.

STAs READILY SHOULD BE AVAILABLE DURING THE RELOCATION PROCESS

Based on recent experiences of its members, TIA believes that temporary relocation of all or part of 2 GHz microwave systems frequently would be desirable or necessary while the parties are negotiating permanent relocation or reaccommodation plans. For example, while a PCS licensee may agree to pay all or part of a complete and eventually permanent system relocation, oftentimes it would be necessary to relocate 2 or 3 critical hops immediately. Grant of STAs should be readily available to accommodate such immediate and possibly temporary relocations.

Similarly, where an analog loop system would be changed to digital, partial relocation would be possible only with analog equipment because an analog loop system simply cannot be partially converted to digital. In such a situation, a critical hop

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[11] NPRM at para. 52.

[12] NPRM at para. 52.

would have to be replaced by temporary analog microwave equipment in the new frequency band while discussions continue for more complete and more complex reaccommodation at a later date. In this situation, STAs also would be necessary and would facilitate the process.

Relocation of the 2 GHz incumbents presents extraordinary circumstances where delay in commencing new operations would seriously prejudice the public interest. TIA respectfully suggests that the Commission adopt a policy for granting STAs in the relocation process without the kind of showings now required by the Commission's rules. Specifically, STAs for up to 180 days must be granted without giving public notice to such requests.

THE PROPOSAL TO REQUIRE REPLACEMENT OF ANALOG SYSTEMS WITH THE "LOWEST-COST" DIGITAL SYSTEMS SHOULD BE CLARIFIED

The Commission seeks comments on how to account for technological disparities between old and new microwave equipment. It proposes that, in situations where equivalent analog equipment is not available, "comparable facilities" would be defined as the "lowest-cost" digital system that satisfies the technical requirements of the proposed guidelines and is readily available.[13] The Commission also proposes to define "comparable" facilities as those providing comparable communications throughput, system reliability, and operating costs, apparently, regardless of the technology employed.[14]

A conflict may exist between the search for the lowest cost replacement digital

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[13]NPRM at para. 77.

[14]NPRM at para. 73.

system and the requirement to meet certain operating cost objectives. Low cost digital radios tend, over time, to involve higher operating costs than the higher priced ones. This cost difference becomes significant in the long run. Operating costs must be based upon the entire life of the system.

The Commission, in formulating criteria for determining what constitutes "comparable" facilities, should be mindful that use of analog equipment, or even relatively inexpensive digital equipment, would increase operating expenses for the FS licensee. This trade-off must be made part of the reimbursement process.

TIA recommends that the Commission should:

- Establish a specific period of time, i.e., 10 years, to evaluate annual operating costs for a proposed replacement system.
- Clarify that the lowest cost digital system proposal in Paragraph 77 does not conflict with the Commission's established policy, described in Paragraph 42, that "microwave incumbents must receive comparable facilities, regardless of their costs."

TIA SUPPORTS ADOPTION OF SPECIFIC RELOCATION COST-SHARING PROPOSALS

Implementing a fair cost-sharing plan is critical to ensuring expedited introduction of PCS. In the NPRM, the Commission balances the interests of PCS and FS licensees in developing its proposed plan. TIA generally supports these proposals. In particular, the Commission must adopt:

- The proposed restrictions on granting new primary status FS licenses.[15]
- The proposed cap on eligible relocation costs.[16]

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[15]NPRM at para. 4.

[16]NPRM at para. 42.

- The proposed criteria for "public safety" status.[17]
- The one-year trial period for a relocated FS licensee to test its new facilities.[18]
- The 10-year sunset on the cost-relocation program.[19]

CONCLUSION

The cost-sharing rules proposed in the NPRM are in the public interest and generally must be adopted. Most importantly, the Commission correctly designates Bulletin 10-F (and must designate Bulletin 10-( ) in the rules) as the appropriate PCs-to-microwave interference standard. It is the only industry-recognized method of dealing factually with interference into FS systems.

Respectfully submitted

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SECTION, NETWORK EQUIPMENT DIVISION
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[17]NPRM at para. 80.

[18]NPRM at para. 84.

[19]NPRM at para. 39.

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ATTACHMENT 1

2.5 Interference Criteria

2.5.1 Considerations relating to victim FM-FDM links

Only discrete channel capacities are considered, appropriate to the specific band, in the Annex A C/I objective curves. Both emphasized and non-emphasized victim receiver basebands were considered for the interfering FM-FDM system as well as the victim system. Since the difference between an emphasized and non-emphasized baseband in an interfering transmitter was considered negligible, no distinction has been made.

In co-channel cases involving FM-Video or FM-FDM victim receivers and interfering signals, the required C/I ratio depends on the maximum frequency differential that can exist between the transmitter emitting the interfering signal and the transmitter emitting the desired signal. An unlikely maximum differential occurs when one transmitter has drifted to its maximum tolerance limit in one direction, and the second transmitter to its maximum tolerance in the other direction. Since FCC stability requirements differ by bands, the values used in the curves are appropriate to the specific band. It is recognized that in real systems a 0°C to +40°C ambient operational stability is better than the -20°C to +50°C maximum (type accepted) stability values. Thus, calculations employ the operational stability for practical interference analysis. Considerations are included to deal with grandfathered systems having tolerances that exceed current requirements.

In co-channel cases involving digital interfering signals, the C/I ratio depends on the thermal noise-like spectral characteristic of the digital signal, not the RF frequency stabilities of either the digital or FM-FDM signals.

The following kinds of co- and adjacent-channel interference are considered:

a. Sideband overlap
b. Intercarrier beat
c. Digital Spectrum Overlap
d. Threshold degradation

Intercarrier beat interference is usually controlling for the co-channel case where the interfering signal is FM-Video or FM-FDM and one of the transmitters involved is of low stability causing the beat tone to fall into a message "pay-load" channel (above the 12, 60, 300 kHz service channel spectrum, for example, depending upon the multiplexing arrangement of the victim receiver); otherwise, co-channel sideband beat interference is usually controlling. Carrier beat interference is, therefore, not applicable to adjacent or semi-adjacent cases. Either sideband interference or threshold degradation will be controlling in the adjacent and semi-adjacent cases. Digital interfering signals cause thermal-like interference which increases idle noise and degrades victim receiver thresholds.

2.5.2 Interference objectives in FM-FDM systems

The allowable per exposure baseband interference levels are as follows:

(1) Co-channel intercarrier beat interference levels shall not exceed 50 pWp0.

(2) Co-channel, semi-adjacent channel, and adjacent channel sideband overlap interference levels shall

not exceed the range of 5 to 250 pWp0, dependent on system length[3] as determined by reference to Annex A.

Sideband overlap interference levels are summed on tandem paths to derive the system total. Intercarrier beat interference is not summed, affecting only one message channel at any time or falling below the message baseband "payload" spectrum.

Interference criteria are normally expressed as a C/I ratio in dB, where "C" is the unfaded power of the desired signal and "I" is the power of the interfering signal, at the RF input to the victim receiver. In some instances, such as threshold degradation discussed in Section 2.5.4 and Annex A, it is appropriate to express interference as a maximum tolerable interfering signal level in dBm.

Considerable attention has been devoted to the development of recommendations for total noise allowable due to interference in a complete system. Various methods of expression were evaluated, such as a maximum number of exposures per system and a maximum number of exposures per receiver. While certain hypothetical total system noise values were assumed in developing the "per-exposure" analysis, it is impractical to promulgate a discrete value for total system noise due to multiple per-hop interference signals in real systems. Such findings are based on the impractical situations that would result in a nearly impossible housekeeping task for complex new and existing systems. The total interference environment will be most difficult to ensure. Each real system is designed to its specific transmission criteria depending on application peculiarities.

Depending on resources of records and ongoing engineering support, one can recognize existing interference noise sources and exercise some judgment for new contributors. Interfering level predictions are not a precise science due mainly to wide variabilities in antenna sidelobe patterns (worst case coupling is always assumed but rarely occurs in the field), and results must be treated accordingly. Values of tolerable interfering signals included in this paper have been developed with the difficulties of housekeeping a total system environment in mind. Under normal circumstances, extensive records for total interference exposures are unnecessary providing that the individual criterion for each exposure set forth in this Bulletin are followed. In the practical world, the number of potential exposures will not increase excessively. One need only to evaluate each new instance of exposure according to the criteria of this Bulletin. Only in very unusual circumstances does the system designer need an overall assessment of interference noise from all sources.

2.5.2.x.x Noise Performance Objectives Summary

As noted previously, interference into an FM receiver can fall into one of four cases. Radio systems must be engineered in such a way that noise introduced by potentially interfering transmitters is within industry established objectives. The following four cases must be considered:

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[3] Interstate telephone, pipeline, and other microwave systems with tandem path lengths exceeding 400 km and sometimes even 2,500 km (often characterized as "long haul") have more critical per-hop noise and per-exposure interference criteria as compared to shorter systems (sometimes characterized as "short haul") where the sum of the tandem path lengths is less than 400 km and not part of an existing or planned larger system.

2.5.2.x.x Adjacent channel noise when the desired carrier is at the nominal (unfaded) power level (Normal Quality Objective):

Case 1: Sideband Overlap from Other FDM-FM Radio Systems

Objectives: Section 2.5.2
Section A-15.4
Section A-15.5

Calculation Methods: Section A-3
Section A-5
Section A-6

Case 2: Intercarrier Beat from Other FDM-FM Radio Systems

Objectives: Section 2.5.2
Section A-6

Calculation Methods: Section A-14

Case 3: Spectrum Overlap from Adjacent Digital Radio Systems

Objectives: Section 2.5.2
Section A-15.4
Section A-15.5

Calculation Methods: Section A-5
Section A-6

2.5.2.x.x Noise degradation when the desired carrier is near its minimum acceptable (faded) power level (Worst Case Quality Objective):

Case 4: Noise Threshold Degradation

Objectives: Section 4.2.2
Section A-15.2
Section A-15.3

Calculation Methods: Section 2.5.4
Section 4.2.3
Section 4.4
Section A-7
Section A-9
Section A-13

2.5.3 Considerations related to victim FM-Video systems

Interference criteria are normally expressed as a C/I ratio in dB, where C is the unfaded power of the desired signal and I is the power of the undesired signal both at the RF input to the victim receiver. In some instances, such as threshold degradation, it is appropriate to express interference as a maximum tolerable interfering signal level in dBm.

- Only interference into an FM-Video system with an upper frequency limit of 5 MHz in accordance with the EIA/TIA-250-C standard is considered. Interference into FM subcarriers and into mixed, narrowband, and wideband video systems is not considered in this document.

- Kinds of degradation
  a. Carrier beat (tonal) interference
  b. Threshold degradation
  c. Digital interference

For the co-channel case, intercarrier beat (tonal), thermal noise (in IRE units), or digital interference, as applicable, is controlling. For adjacent and semi-adjacent cases, threshold degradation or digital interference is usually controlling.

The criteria for FM-Video systems have been calculated in accordance with the single-hop (short-haul) objective in EIA/TIA-250-C. Annex C provides the calculations used to obtain the C/I objective.

2.5.4 Threshold degradation considerations in analog (FM-FDM, FM-Video) systems

C/I ratios for threshold degradation are often misleading since they require the use of assumed values for receive signal level and fade margin. When the fade margin required for the desired path reliability (outage) is limited by thermal noise, a more suitable approach is the stipulation of the maximum allowable interfering signal level. Threshold degradation interference results primarily in the degradation of the victim's practical threshold which defines its mute (outage) point. In FM-FDM systems, this threshold is usually defined as that faded RF carrier level that produces a flat S/N of 30 dB in the worst voice channel. For FM-Video systems, this threshold is defined as that RF carrier level that produces a 37 dB peak-to-peak luminance signal to RMS noise ratio with EIA weighting. In an FM system, the post detection S/I or S/N (in a message channel or across the video passband) is perhaps 10-20 dB larger than the input C/I or C/N in the RF/IF bandwidth. As an example, the S/I (or S/N) in the top (2,540 kHz) 3.1 kHz VF channel in a 600 channel link deviated ±140 kHz RMS (±200 kHz peak) with a 10 MHz IF bandwidth is

$$\frac{S}{I}\left(\frac{S}{N}\right) = \frac{C}{I}\left(\frac{C}{N}\right) + 10\log\left(\frac{\Delta f}{f}\right)^2 + 10\log\left(\frac{B_{IF}}{2B_{VF}}\right) + \textit{Emphasis}$$

$$= \frac{C}{I}\left(\frac{C}{N}\right) + 10\log\left(\frac{0.2}{2.54}\right)^2 + 10\log\left(\frac{10{,}000}{2\times 3.1}\right) + 4.0 \qquad (2.5.4\text{-}1)$$

$$\simeq \frac{C}{I}\left(\frac{C}{N}\right) + 14.0, \quad \textit{dB (signal to flat noise or interference ratio)}$$

The above formulas assume the desired signal "C" is 20 to 30 dB above the receiver front end noise and "C" is 10 to 20 dB larger than "T".[6]

For FM-Video systems (f = 4.2 MHz, Δf = ±4 MHz peak), and other non-multiplexed, non-sinusoidal broadband signals like radar with a 25 MHz IF bandwidth (*see also* Annex C),

$$\frac{S}{I}\left(\frac{S}{N}\right) = \frac{C}{I}\left(\frac{C}{N}\right) + 10\log\left(3\left[\frac{\Delta f}{f}\right]^2\right) + 10\log\left(\frac{B_{IF}}{2f}\right) + (\textit{Emphasis} + \textit{Weighting}) + \frac{P-P}{RMS}$$

$$= \frac{C}{I}\left(\frac{C}{N}\right) + 10\log\left(3\left[\frac{4}{4.2}\right]^2\right) + 10\log\left(\frac{25}{8.4}\right) + 9.2 + 6.1 \qquad (2.5.4\text{-}2)$$

$$= \frac{C}{I}\left(\frac{C}{N}\right) + 24, \quad \textit{dB p-p luminance signal to RMS weighted noise ratio}$$

where

B_{VF}	=	VF channel baseband, kHz
B_{IF}	=	IF bandwidth, MHz or kHz
Δf	=	peak per-channel deviation, kHz
	=	peak video deviation, MHz
f	=	VF channel frequency, kHz
	=	video bandwidth, MHz
I	=	in-band interference level, dBm
N	=	in-band thermal noise level, dBm
	=	$-114 + 10\log(B_{IF}) + NF$
NF	=	noise figure, dB

Similar computations derive the S/I(S/N) for links with other parameters (bandwidth, deviations, *etc.*). The Annexes A (FM-FDM) and C (FM-Video) curves derive C/I criteria to meet the S/I objectives for the co- and adjacent-channel coordination of victim and interfering FM systems with both similar and dissimilar baseband and FM modulation characteristics.

The following equation may be used to establish the maximum interfering signal level for analog receiver threshold degradation in FM-FDM and FM-Video links. Short, non-fading, and other hops with high receive signal levels will accept higher interference levels and continue to meet performance (unfaded noise, fade margin, and outage) objectives.

$$I_{max} = R_t + F_\alpha + S_g(f_s) - 10 \qquad (2.5.4\text{-}3)$$

where:

I_{max}	=	maximum interfering signal level, dBm
R_t	=	receiver threshold, dBm

[6] Kizer, G.M., *Microwave Communication*, Ames, Iowa State University Press, pp. 25-29, 1990.

F_e = the difference between the operating fade margin and that required to meet the outage objective, dB

S_e = effective selectivity of the victim receiver to the interfering signal, dB

(f_i) = interfering signal frequency at which S_e is defined

Effective selectivity (in dB) is supplied by the equipment manufacturer and is mainly a function of the IF filter bandwidth(s). In particular, threshold extension IF filtering selectivity in some FM-FDM receivers can have a substantial positive effect on semi-adjacent and adjacent channel interference. However, threshold extension (narrower) IF filters could increase sensitivity to co-channel interference by lowering the threshold of the victim receiver.

2.5.5 Interference Criteria and Considerations related to victim digital systems

The primary interference consideration for digital victim systems is threshold degradation because performance is not significantly affected when the desired signal level is more than about 10 dB above its outage (10^{-3} BER) threshold. The interference effects are primarily related to the total power of the analog or digital interference falling into the digital receiver's noise ("baud-rate") bandwidth rather than to its spectral shape or modulation type. Most digital systems employ data stream regeneration at each hop to prevent an accumulation of interference and spectrum distortion (dispersion) effects. For this reason, it is possible to consider the effects of interference separately for each digital hop regardless of whether it is part of a long-haul or short-haul system.

Previous versions of this Bulletin addressed coordination only in the Private Operational-Fixed Microwave Service bands. As of December 1993, FCC *ET Docket 92-9* re-channelized all of the fixed microwave bands and opened them to both private and common carrier users. Prior to this action, slightly different interference calculations were used for coordination in the common carrier and private microwave bands. In order to accommodate these changes, this version of the Bulletin provides an approach which mediates between the previous methods. This harmonized approach and its relation to the previous methods is described in this section. Since available information on existing systems is not sufficient to allow any of these methods to be applied to all the situations that can arise in practice, a set of default calculations is provided in Annex B.

More accurate assessments of interference effects can be made when appropriate information is obtained from the equipment manufacturers. A discussion of the possible form of this information and its application is also given in Annex B. Until the form and application of this information is agreed to by the user community and the information is available, the method described below should be used where possible; otherwise one of the default procedures in Annex B can be used.

The effect of interference on a victim digital receiver is determined from the threshold-to-interference (T/I) ratio which provides the means of specifying the sensitivity of a victim receiver to an interferer. The static (non-fading) threshold (T) of a digital receiver is defined, for purpose of interference (T/I) calculations, as that manually faded (with attenuators) receive carrier level that produces a Bit Error Rate (BER) of 10^{-6}. T/I is defined as that ratio of desired (10^{-6} BER) to undesired (interfering) signal levels that degrades this threshold by 1 dB. The 10^{-3} dynamic (outage) threshold is similarly degraded 1 dB by this level of interference.

The advantages of T/I are that the differences in thresholds, due to bit rate, modulation technique (transmission efficiency), coding gain and noise figure, are all taken into account, that the absolute level of allowable interference can be easily determined by subtracting the T/I ratio from the 10^{-6} static threshold of a particular digital receiver, and that this measurement can be verified in service without disrupting traffic. However, in any actual situation, the value of T/I depends primarily on the victim receiver's total (RF/IF/baseband) selectivity (bandwidth), the interfering signal's RF spectrum bandwidth, and the separation between their center frequencies.

The measurement of T/I for a digital radio is accomplished by fading the receiver to the point where a 10^{-6} BER is present on the link. The signal level is then increased 1 dB and interference injected until a BER of 10^{-6} is again achieved on the link. The ratio of the initial (10^{-6} BER) power level of the desired received signal to the interference power, as measured, is the T/I ratio. Note that this value may vary for different interferers, especially if the interfering signal is offset from and/or has a spectrum wider than the victim receiver's bandwidth.

In principle, one would need to know the T/I as a function of frequency separation for all possible interferers into a digital receiver. Examples of such a T/I curve, which shall be designated as $TI_{sp}(f_d)$ to denote its dependence on the specific equipments and the frequency separation, is shown in Figure B-3. While it would be desirable to require a manufacturer to provide specific T/I curves for all possible interferers and separations into each type of victim receiver, such requirement is clearly impractical.

A specific T/I curve, determined from measurement, should always be used for coordination with a specific interferer if it is available. If one is not available, the procedure described in Annex B should be used to develop the specific T/I curve.

The acceptable value of interference in a coordination process, I_{coord}, dBm, is then given by

$$I_{coord} = T_s - TI_{sp}(f_d) - MEA \qquad (2.5.5\text{-}1)$$

with

$$MEA = \text{Greater of} \begin{cases} 5 \\ 10\log(BW_v/BW_i) \end{cases} \qquad (2.5.5\text{-}2)$$

where

T_s	=	static threshold power for 10^{-6} BER, dBm
TI_{sp}	=	specific T/I curve, dB
f_d	=	separation of interference and receiver center frequencies
MEA	=	multiple exposure allowance, dB
BW_v	=	RF channel bandwidth of victim receiver, MHz
BW_i	=	RF channel bandwidth of interferer, MHz

MEA, the multiple exposure allowance, is intended to account for the high usage density in the former common carrier bands and for the multiple near-adjacent channel exposures in the mixed-bandwidth frequency plans in these and other bands that were adopted in December 1993 by *FCC ET Docket 92-9*. There is general agreement that a 5 dB MEA is to be used. However, further study as to the upper level of MEA is needed since MEA levels even greater than 5 dB may be appropriate in congested areas due to a higher probability of multiple exposures.

The preceding results can also be expressed in terms of the ratio of the nominal carrier power to the interference power, which is usually referred to as the C/I. The C/I, dB, due to a single specific interferer separated in frequency by f_d, would be given by

$$C/I = C - T_s + TI_{sp}$$
$$= TFM_s + TI_{sp} \qquad (2.5.5\text{-}3)$$

where TFM_s is the static Thermal Fade Margin to 10^{-6} BER in dB.

It is worth noting for reference that in the common carrier bands prior to 1994, frequency coordination was based on meeting C/I objectives, which in the present terminology would be written as

$$(C/I)_{obj} = TFM_s + TI_{sp} + MEA \qquad (2.5.5\text{-}4)$$

The default static thermal fade margins in dB at 10^{-6} BER upon which these high C/I objectives were based were the following: 35 (2 GHz), 40 (6 and 18 GHz), 45 (11 and 13 GHz).

2.5.6 Digital microwave fade margins

The composite fade margin (CFM) of a digital microwave link, described in Section 4.2.3, is a more complex parameter than the thermal fade margin for analog radio links. Unlike analog links affected by interference during non-fading periods, interference and spectral distortion effects are a routine and acceptable part of the digital radio composite fade margin calculation used in outage (path reliability) calculations.

CFM is one of the parameters necessary to compute the expected outage on a given hop. When the C/I objective is not met, interference degrades the CFM which increases link outage. However, interference levels even 1-10 dB or more above the 1 dB threshold degradation objective are usually acceptable on shorter or other non-fading digital paths since performance is not adversely affected.

Section 4.2 of this Bulletin, "Performance as a Coordination Criterion in Victim Microwave Links", provides one possible design procedure that could be used to determine these higher interference levels into digital microwave receivers on short and other low fade activity hops and into very short-haul routes.

2.6 Potential for Weather Radar operating in the 2700-2900 MHz and 5350-5650 MHz bands causing Interference to Digital Microwave Systems in the 3700-4200 MHz and 5925-6425 MHz Bands

2.6.1 Background

The National Telecommunications and Information Administration (NTIA) is responsible for managing the Federal Government's use of the radio frequency spectrum. Because of reports of radar interference into common carrier digital microwave systems, NTIA initiated a study to investigate this interference. The study concluded with the issuance of NTIA *Report 90-260* entitled "Ground-Based Weather Radar Compatibility with Digital Radio-Relay Microwave Systems." The analysis, interference effects, and mitigation options contained herein are from that report.