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OFFICE OF THE SECRETARY

June 8, 1994

William F. Caton, Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Rm 222
Washington, DC 2055

Re: PR Docket No. 93-61, Ex Parte
Automatic Vehicle Monitoring Systems

Dear Mr. Caton,

The Telecommunications Industry Association ("TIA") hereby requests that the enclosed correspondence from Dr. Jay Padgett, Chairman of its Consumer Radio Section, to Ms. Kathleen Abernathy of AirTouch Communications, be associated with the record of the above-referenced docket.

Please contact the undersigned if you require additional information.

Sincerely,

Daniel L. Bart
Vice President,
Technical and Regulatory Affairs

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Representing the telecommunications industry in association with the Electronic Industries Association

June 8, 1994

Kathleen Q. Abernathy
Vice President, Federal Regulatory
AirTouch Communications
1818 N Street N.W.
Washington, DC 20036

Dear Ms. Abernathy:

Last October, at the suggestion of Mr. Haller, I initiated correspondence with CZ Czerner, then Vice President - Corporate Development of PacTel (now AirTouch) Teletrac, about the possibility of conducting tests to explore the potential for interference from Part 15 devices to Teletrac receivers. Subsequently, Yair Karmi, then Vice President - Technology Development, replaced Ms. Czerner as my contact at Teletrac on this matter. A total of 5 letters were exchanged; three from me and one each from Ms. Czerner and Mr. Karmi. My most recent letter to Mr. Karmi (January 4 of this year) was not answered, and to my knowledge no tests were conducted.

As Chairman of the Telecommunications Industry Association (TIA) Consumer Radio Section, I am writing to you today in another attempt to establish dialogue between Teletrac and the Part 15 industry about a possible interference testing program. I believe that a productive first step would be for us to hold a one-day meeting to develop a test program and schedule. Enclosed for your consideration is a set of notes proposing some potential elements of the test program. This document is an updated version of one included with my 11/24/93 letter to Ms. Czerner, and can be viewed as a "straw man" to serve as a focus for dialogue leading to an agreement on the details of the actual test plan.

Invitees to the planning meeting should include Teletrac representatives as well as interested Part 15 members. I am willing to coordinate Part 15 representation through my TIA Section and the Part 15 Coalition. The focus of the meeting should be technical, so the Teletrac representation should include technical personnel.

The interference testing is not necessarily a long-term proposition; as discussed in the enclosed proposal, much can be learned from a laboratory characterization of the Teletrac receiver. These "bench tests" should require only a few days. Propagation effects are already well-known and timing/redundancy effects are easily calculated. Hence, it may be possible to gather some initial data in a short time. Analysis of interference statistics based on bench tests will provide a useful guide for setting the parameters of the field tests, as well as for sanity-checking the results.

Please let me know whether you would be interested in pursuing this. Also, any comments you or your engineers have on the enclosed notes would be appreciated. I look forward to hearing from you.

Regards,

Jay E. Padgett
Chairman,
TIA Consumer Radio Section

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cc:

The Honorable Reed E. Hundt
The Honorable James H. Quello
The Honorable Andrew C. Barrett
The Honorable Susan Ness
The Honorable Rachelle Chong
Ralph A. Haller - Chief, Private Radio Bureau
Thomas P. Stanley - Chief Engineer
Richard M. Smith, Chief, Field Operations Bureau
Ruth Milkman, Esquire

NOTES ON POSSIBLE PART 15/TELETRAC INTERFERENCE TESTS

Introduction

The purpose of the set of tests proposed here is to develop a quantitative understanding of the potential for interference from Part 15 devices into the receivers used in the AirTouch (formerly PacTel) Teletrac vehicle location system in the 902-928 MHz band.

There are several factors that determine whether harmful interference occurs:

- The performance of the Teletrac receiver (e.g., rms time-of-arrival estimation error as a function of various desired and interfering signal levels).
- Propagation path loss for various scenarios of interest (different transmitter and receiver elevations, separations, and terrain characteristics).
- Timing characteristics of the interfering signal and the Teletrac reverse link. For example, a frequency-hopping Part 15 device will not always be transmitting within the RF bandwidth of the Teletrac receiver, and the Teletrac system can re-transmit if the received signal is corrupted.

Each of these factors is discussed individually below, followed by some conclusions and a proposed program outline.

Teletrac Receiver Performance

The function of the Teletrac receiver is to generate an estimate of the time of arrival (TOA) of the wideband burst from the vehicle. One way of quantifying receiver accuracy is the rms TOA estimation error. The rms error depends on the carrier-to-noise or carrier-to-interference ratio, as shown in Figure 12 of Appendix 2 to Teletrac's Comments on the Notice of Proposed Rule Making (NPRM) in PR Docket 93-61, attached here as Fig. 1.

The first step of the experimental program should be a more complete characterization of the Teletrac receiver. The curve in Fig. 1 characterizes the receiver only for a carrier-to-noise ratio (CNR) down to -25 dB, and the noise power was set at -80 dBm. The TOA estimation error should be determined for CNR levels less than -25 dB (which apparently is the threshold of the Teletrac receiver). The error also should be measured as a function of the CNR for higher noise power (e.g., -40 dBm), to explore automatic gain control (AGC) and analog-to-digital (A/D) conversion dynamic range effects.

The receiver performance characterization probably is the most important component of the experiment, since the effects of the other two factors (propagation and timing characteristics) can easily be investigated via analysis and/or simulation. Fortunately, receiver performance measurements can be made on the bench, using known and controlled desired and interfering signals.

A further step would be to introduce multipath effects into the bench test via a fade simulator, to characterize the impact of different multipath delay profiles on the rms TOA estimation error.

Propagation Path Loss

Path loss is important because it determines the strength of the desired and interfering signals received by the base station. The technical literature is rich with papers discussing propagation phenomena and models for a wide variety of frequencies, terrain conditions, and applications. Empirical models have been developed based on analysis of measurement data, and models also have been built directly from electromagnetic theory. In most circumstances, propagation path loss must be viewed statistically because of the random factors (multipath, shadow fading) that influence it. Because of this statistical nature, measurement programs typically involve many thousands of individual data points to accurately characterize propagation behavior. As a result, they tend to be fairly tedious and time-consuming, and require a certain degree of specialized equipment and expertise to perform reliably.

To draw general conclusions about the interference problem, we probably should use some of the existing propagation models based on the published work of experts in the field. The alternative is to conduct our own propagation measurement program, which would be time-consuming and probably not very enlightening; it is unlikely that we would observe any new phenomena which have not already been observed, analyzed, and documented. Of course, if we conduct field tests, we will need to make isolated measurements of the received signal strength for specific paths to determine the levels of the desired and interfering signals, and we should note the approximate distances from the receiver of the desired and interfering transmitters.

Timing Factors

If the interfering signal does not continuously overlap the Teletrac reverse link passband, then "time diversity" (re-transmission) can help to mitigate the effects of interference (although it will reduce throughput). Time diversity may work if the

interfering device is a frequency hopper, but the relationship between the re-transmit interval and the hopping rate will be a factor. If there are multiple hoppers near multiple bases, the statistics of the problem rapidly become quite complicated and will be difficult to characterize fairly with a simple experiment. However, analysis of the situation would be fairly straightforward once all the parameters are known. Therefore, measurements should use a continuous interfering signal to determine the inherent receiver susceptibility, and transmission timing can be taken into account by analysis.

Conclusions

The first part of the test program should be a more thorough characterization of the Teletrac receiver. Without this, it may be difficult to correctly interpret field test results. Such a characterization should be fairly straightforward on the bench using an approach similar to that described by Teletrac in Appendix 2 of its Comments on the NPRM. However, the effects of a larger range of CNR and higher noise (and carrier) power need to be explored. In addition, multipath effects could be introduced using a fade simulator. If time is extremely critical, many useful and valid conclusions could be drawn from such measurements using existing propagation data and models. If time allows, field experiments of interference effects associated with different interfering and desired signal source positioning could be conducted. The strength of the interfering and desired signals at the receiver should always be measured, so results can be checked against the receiver bench tests.

The effects of time-diversity and fractional duty cycles of the interfering signals (such as those from frequency hoppers) will be difficult to characterize completely with experiments, but can be understood easily with analysis. Therefore, the field tests should use fixed-frequency transmitters to simulate the interference sources. The results can easily be extrapolated to account for time variations.

PROPOSED PROGRAM OUTLINE

Based on the considerations discussed above, one possible set of steps is:

1. Assemble interested parties, review proposed plan, add detail, determine participants, develop schedule.
2. Conduct bench tests of the Teletrac receiver for CNR ranging from -15 dB to -40 dB and noise from -40 dBm to -80 dBm in 5 dB increments (no multipath).

3. Repeat (2) but introduce multipath with a fade simulator. Explore effect of multipath for delay spreads up to 25 μs. Make detailed measurements over a range of CNR for cases of interest. [More detail to be added during planning meeting.]

4. Select a single Teletrac receiver site that will allow a controlled variation in the positioning of both the interfering and desired signal sources. Set up a test control system that will allow the desired transmitter (in a vehicle) to repeatedly transmit its signal on command. This will allow enough samples to be taken to support a statistically valid determination of the rms TOA estimation error. Received signal levels for the vehicle and the interference source should be recorded. Take sample sets of TOA estimation error and signal strength measurements for desired positions of vehicle and interference source. [Details of test conditions to be added during planning meeting.] Note: with the complete bench characterization of the receiver, and knowledge of the path loss characteristics for the scenario of interest, these measurements are not completely necessary, but they may serve as useful confirmation of predicted results.

5. Share relevant information on timing characteristics of potential interference sources, and retransmission (time diversity) discipline of the Teletrac system. Using this timing information and the results of the tests discussed above, compute the effect of interference on system throughput for scenarios of interest.

6. Prepare report summarizing problem, outlining general approach, reviewing procedure and equipment, showing data, summarizing results/conclusions, and identifying any remaining open issues.

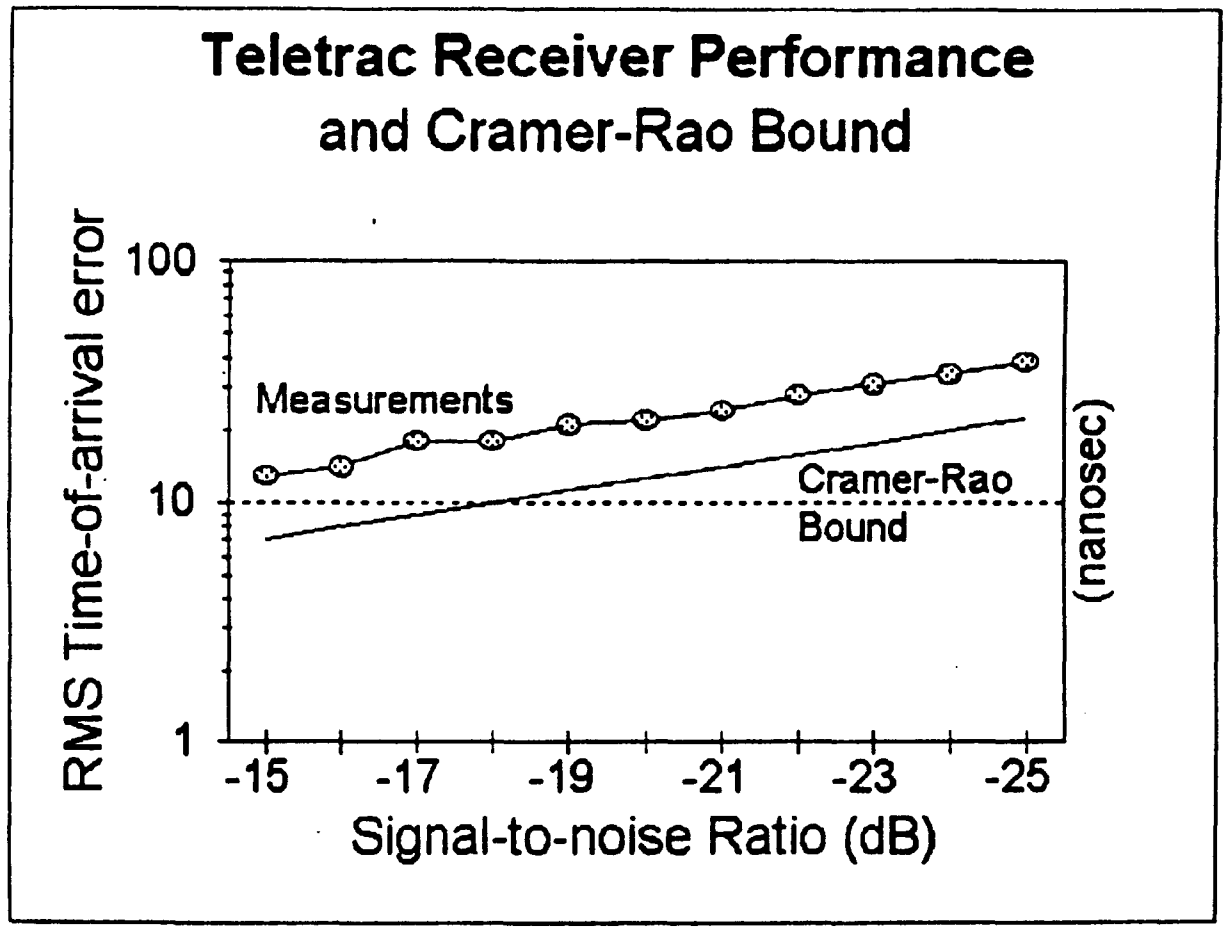

Figure 1

(reproduced from Appendix 2 of Teletrac's Comments, Fig. 12)