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United States GPS Industry Council

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Marlene H Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Written *Ex Parte* Presentation in MB Docket No. 03-185

Dear Ms. Dortch:

On April 26, 2004 the U.S. GPS Industry Council ("the Council") filed a written *ex parte* presentation in the referenced docket providing the Commission with a technical analysis of the potential for interference from UHF digital low power television transmitters into Radionavigation Satellite Service ("RNSS") receivers. Since the filing of this analysis, the Council has worked with a supplier of microwave filters to verify the potential *de minimis* cost to Digital LPTV operators of implementing the Council's recommendations with respect to reducing out-of-band emissions into the RNSS bands. With the attached document, the Council updates its April 26, 2004 analysis to include this new information and to provide a copy of a quotation from a microwave filter manufacturer for the record of this proceeding.

Pursuant to the Commission's rules regarding *ex parte* communications, 47 C.F.R. §§ 1200, et seq., the original and one copy of this letter and the accompanying statement are being provided for inclusion in the files of the referenced proceeding.

Please address any questions you may have to the undersigned.

Respectfully submitted,

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Executive Director

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EXECUTIVE SUMMARY

On April 26, 2004, the U S GPS Industry Council ("the Council") submitted written ex parte comments in MB Docket No 03-165 to provide the Commission with a technical analysis of potential interference from UHF Digital low power television ("D-LPTV") transmitters into receivers in the Radionavigation Satellite Service ("RNSS"). In these supplemental comments, the Council updates its earlier comments with newly obtained information about the design of D-LPTV filters needed to provide additional attenuation to protect the Global Navigation Satellite Service ("GNSS") receivers in the RNSS bands GNSS is comprised of radionavigation satellite signals provided by the U.S. GPS system, the Russian GLONASS system and the soon-to-be-launched European Galileo system

Preliminary engineering design of the filter which will be required to meet the FCC NPRM proposed stringent mask by a microwave filter company found that there was zero marginal cost (verbal quote) to provide the extra attenuation needed to protect the GPS service bands. This verbal finding was included in the Council's April 26, 2004 ex parte comments in this docket.

Since then, the Council received a written quotation from this same company, which is provided as an attachment to these supplemental comments. This quotation includes subsequent engineering analysis they performed which shows that an additional standard low pass filter that protects GNSS is required at a cost that is less than $300 over the cost of the filter required to meet the FCC NPRM proposed stringent mask. This additional standard filter will provide the attenuation needed to protect the entire RNSS bands for the GNSS, to the recommended 110 dB attenuation level

Please note that out of professional courtesy to the microwave filter company providing this quotation (and agreeing to its inclusion with the submission of these revised comments), the Council has provided a reasonable upper price boundary to protect their company pricing information

Impact to UHF DTV Transmitter Filtering

The proposed scenario-based out-of-band emissions ("OOBE") limits for GNSS require an increase in attenuation of about 34 dB beyond the NPRM-proposed 76 dB to protect the RNSS bands from 1160 MHz to 1610 MHz

In order to understand the cost impact, the Council looked at two implementations for achieving this additional attenuation:

- developing a new television transmitter output filter to meet both the FCC proposed emission limits and the additional attenuation needed to protect GNSS, or
- including a second external, add-on filter to an existing TV broadcast filter which will need to be modified to address the NPRM proposed emission limits. This external add-on filter could be designed to include both the NPRM proposed emission limits and the additional attenuation to protect GNSS in the RNSS bands.

The cost impact of adding a low pass filter to the basic filter needed to meet the NPRM proposed stringent mask is less than $300

The cost impact of adding an external filter varies by the power handling needs. For a 100 Watt transmitter, the additional cost is on the order of $500-800 for a single filter

For the higher power transmitters, the cost for an external filter will increase as shown in the following table·

	Table 11 Filter Costs/ Quantity 10		
Filter Requirement	Basic NPRM Mask	Additional Attenuation (110 dB)	Total
	< $2,500 00	<$300 00	< $2,800.00

The estimated cost for a filter suitable for a 100 W amplifier is less than $2,500 in quantities of 10 units to meet the FCC NPRM proposed stringent mask. This estimate was provided by the Microwave Filter Company (attached) The Council estimates that the cost for a 15 kW amplifier will be at least double to meet the NPRM-proposed emission mask requirements. The additional cost to include the attenuation needed to protect the GNSS services in the RNSS bands is less than $300

Summary

The Council examined the existing FCC database for LPTV broadcast licensees and looked at their locations and tower heights. The Council then examined existing GNSS users who will be affected by OOBE from the transition to digital LPTV broadcast, including lower power and high power digital LPTV broadcast. The Council developed operationally significant scenarios as a first step in determining OOBE that would protect these affected GNSS users

To protect the growing broad range of GNSS use, including potentially the most affected -- GPS timing for networks and program synchronization -- the Council recommends:

- OOBE limits 34 dB beyond the NPRM-proposed 76 dB (to 110 dB);
- this additional attenuation should be provided in the frequency range from 1164 to 1610 MHz to include GNSS in the entire RNSS bands

To achieve the same protection for the GNSS bands and make it easier for the Digital Low Power TV stations, the Council also recommends the following:

- using an absolute level of interference to make it easier for D-LPTV stations to meet the OOBE limits rather than the NPRM "one size fits all" emission limit referenced to broadcast power;
- the allowable OOBE also may be a function of tower height.

Finally, the Council recommends that·

- these OOBE limits also need to be technically feasible and economically fair for the digital LPTV broadcast industry as it embarks on a new digital broadcast service and will be adopting new filters to address its own co-service interference needs. Engineering design shows that the additional cost to provide OOBE protection to the GNSS services in the RNSS bands is less than $300 (in quantities of 10).

The Council believes that a joint industry agreement is the optimum solution. To this end, the Council looks forward to working with the digital LPTV broadcast industry.

INTERFERENCE FROM UHF DIGITAL LOW POWER TELEVISION, TELEVISION TRANSLATOR, AND TELEVISION BOOSTER STATIONS TO GPS RECEIVERS

INTRODUCTION

In section III.D 2 of NPRM 03-198[1], the FCC seeks comment on the allowable emission levels for Digital Low Power Television (LPTV), Translators and Booster Stations outside the channel of operation Overall, the NPRM proposes modified emission levels in the TV broadcast band to address co-channel interference to other TV broadcasts. However, except for comments provided by NTIA (Paragraph 68), the effect of these modifications in terms of out-of-band emissions (OOBE) on other frequency bands is ignored, including, for example, the bands where the Global Positioning System (GPS) service operates. In this document we develop OOBE interference requirements for GPS and use these to suggest out-of-band operating limits for LPTV which will take into account the feasibility and economy of implementation.

The FCC NPRM proposes emission limits that are a fixed number of dB down from the fundamental digital TV carrier broadcast power. These NPRM limits also propose to reduce the maximum transmit power level by 19 dB from 60 dBW (1 MW) to 41 dBW (15 KW). However, since these proposed emission limits also reduce the attenuation by as much as 24 to 29 dB, in comparison to the previously adopted level of 110 dB, the *allowable EIRP would actually increase by 5 to 10 dB* over the former limit of -50 dBW to -40 dBW.

Instead, we propose using an absolute level of interference that may be broadcast. We believe that this approach makes it easier for lower power digital TV stations to meet the OOBE limits than a "one size fits all" emission limit referenced to broadcast power. From our survey of the FCC database for existing TV broadcast licensees, we further propose that the allowable OOBE be a function of tower height since higher power stations are located on significantly taller towers The GPS scenarios include timing receivers, E911 receivers (indoors and outdoors), and geographic information systems for both public and private use. After reviewing the location of existing TV towers and the location of existing GPS timing receivers, we believe that this is the scenario of operationally significant concern that needs to be addressed in developing appropriate OOBE.

We looked at the Commission's own analysis that calculates a "zone of interference".

"The emission from digital television (DTV) transmitters is -110 dBc and will result in a zone of interference that is as much as a circle of 270 meters (884-foot) radius at the same height as the antenna. As a consequence these transmitters do not have to be located next to a GPS receiver to disrupt signal reception in land-based applications "[2]

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[1] FCC 03-198, Amendment of Parts 73 and 74 of the Commission's Rules to Establish Rules for Digital Low Power Television, Television Translator, and Television Booster Stations and to Amend Rules for Digital Class A Television Stations, NOTICE OF PROPOSED RULE MAKING (NPRM), MB Docket No. 03-185, August 29, 2003.

[2] *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, First Report and Order, ET Docket 98-153 (April 22, 2002)

We would like to work with the TV broadcast industry to craft a commercial best practices solution that is technically feasible, economically viable, and fair. Telecommunications and financial industries are dependent on GPS time synchronization Even the TV broadcast networks are becoming more dependent on the worldwide use of GPS timing due to its reliability and accuracy (e.g., synchronization of national broadcast programs, such as sports events or live news programs, with local commercials during programming breaks). In fact, the conversion to digital broadcasting has placed an increased demand on the synchronization of video and audio signals. Consequently, developing a joint industry solution would be an achievable goal

Preliminary engineering design (verbal quote) by a microwave filter company found that there was zero marginal cost to provide the extra attenuation needed to protect the GPS service bands after meeting the FCC NPRM proposed stringent mask. This verbal finding was included in our original comments filed with the FCC

The written quote from this same company is provided as an attachment to these revised comments. It is based on subsequent engineering analysis which shows that, to provide the additional attenuation needed to protect the entire Radio Navigation Satellite Service (RNSS) bands for the Global Satellite Navigation Services (GNSS), which include GPS, GLONASS, and Galileo services, to the recommended 110 dB attenuation level, an additional standard low pass filter is required for less than $300 00 over the cost to meet the required FCC NPRM proposed stringent mask.

Please note that out of professional courtesy to the microwave filter company providing this estimate (and agreeing to its inclusion with the submission of these revised comments), we have provided a reasonable upper boundary to protect their company pricing information.

HISTORY AND BACKGROUND

A link budget for satellite communication, of which GPS is a form, is set by extensive analysis and experience. Only the minimum margin is provided for in satellite communication link budgets since any additional margin requires additional in-orbit transmit power. Such increased in-orbit transmit power converts directly into increased launch and satellite costs, due to increased transmitter weight and power consumption, and shorter operational life in orbit. Furthermore, once an operational link budget is set and satellites are launched, changes become prohibitively expensive. Given this background, interference from other bands has to be carefully managed to avoid eroding the noise floor of the GPS service, particularly in public safety applications, thus protecting the past and continuing large public investment that develops and maintains the system. Furthermore, there are millions of GPS users across a broad range of applications, including public safety, who depend on the reliability of this service

Television broadcasts traditionally have had out-of-channel limits set exclusively by what adjacent television channels could tolerate While the actual limits have not been theoretically adequate to protect GPS, analog television stations are strongly motivated to broadcast a signal free from harmonic content in an effort to provide good picture quality to the viewers. Even so, when commercial GPS receivers began using the L2 frequency at 1227 6 MHz[3], significant interference was discovered in the band, particularly from the second harmonic of television channels 36 and 37 when located within a couple of kilometers of the transmitter.

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[3] The GPS L2 signal resides in the band 1215-1350 MHz; GPS L5 signal is in the band 1164-1215 MHz ; GPS L1 is in the band 1559-1610 MHz

It can reasonably be expected that the carrier harmonics from digital television stations will be much higher than those from an analog television. Considering the nature of digital modulation, picture quality will not be as sensitive to harmonic distortion, and television stations will thus take advantage of their own increased immunity to distortion to pack as much broadcast signal as possible within the allowable effective radiated power (ERP). Thus it is vitally important that an out-of-band emission limit be chosen that protects the extensive GPS user base from the advent of DTV

EMISSION LEVEL DISCUSSION

There is a cumulative effect on the GPS noise floor from multiple sources of interference. This was recognized by the FCC in a ruling[4] where the Commission identified additional interference sources which need to be included in any subsequent interference analyses in order to preserve the noise floor in the GPS bands

> *"In addition to the potential interference from UWB devices, several other potential sources of interference to GPS receivers have been identified. These potential sources of interference include but are not limited to: 1) adjacent band interference from mobile-satellite service Mobile Earth Terminals (METs), 2) harmonics from television transmitters; 3) spurious emissions from 700 MHz public safety base, mobile, and portable transmitters; and 4) spurious emissions including harmonics from 700 MHz commercial base, mobile, and portable transmitters. Multiple sources of interference, which might individually be tolerated by a GPS receiver, may combine to create an aggregate interference level that could prevent the reliable reception of the GPS signal The emission limit of the MSS METs, 700 MHz public safety and commercial transmitters is -40 dBm/MHz for noise-like interference. The zone of interference of each of these transmitters could be as much as a circle of 30-meter (100-foot) radius, if it emits out-of-band radiation at the limit. The emission from digital television (DTV) transmitters is -110 dBc and will result in a zone of interference that is as much as a circle of 270 meters (884-foot) radius at the same height as the antenna. As a consequence these transmitters do not have to be located next to a GPS receiver to disrupt signal reception in land-based applications In this conservative operational scenario one half of the total allowable interference budget is allotted to UWB devices and the other half is allotted to all other interfering sources combined. The factor for UWB device interference allotment is computed from 10 Log (UWB interference allotment ratio). For a UWB device interference allotment of 50% (a ratio of 0.5), a 3 dB factor is included in this analysis.... The use of allotments for multiple sources of interference is not a new concept in studies examining interference from one radio service to another For example, ITU-R Recommendation F.1094-1 specifies an interference allotment of 89% for transmitters of the same radio service, an interference allotment of 10% for radio transmitters in other radio services, and a 1% interference allotment for all other sources (e.g., unlicensed transmitters).[5] This is also consistent with*

[4] *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, First Report and Order, ET Docket 98-153 (April 22, 2002)

[5] ITU-R Recommendation F 1094-1, *Maximum Allowable Error Performance and Availability Degradations to Digital Radio-Relay Systems Arising from Interference from Emissions and Radiations from Other Sources.*

ITU-R Recommendation M 1477, which states that when there is a potential for more than one source of interference at the same time, it will be necessary to apportion the interference threshold among the potential interference sources.[6] *Since the GPS/UWB measurements that are part of the public record in this proceeding did not include other potential sources of interference, it may be appropriate to include a factor in the analysis to take them into account .* "

In addition to the interference sources cited in this Report and Order, there are now subsequent sources, such as Mobile Satellite-services (MSS) Ancillary Terrestrial Component (ATC).

It is clear that the OOBE limits of any new entrant that uses spectrum either in close proximity, or with harmonic content, to the GPS service must be set to maintain the operational noise floor. Furthermore, these OOBE limits must be technically and economically feasible for the new entrant

Leveraging the new entrants' need to manage co-channel interference to preserve their own noise floor can also provide noise floor protection to the GPS service.

Emissions That Cause an Acceptable Rise in the GPS Noise Floor

Given the cumulative effect on the GPS noise floor from multiple existing interference sources, we suggest allocating an additional 0.25db rise in the GPS noise floor to out-of-band DTV emissions.

From a 0.25db noise floor rise, we can compute the interference to noise ratio, I/N in the GPS band as -12 3dB Given the generally accepted noise floor in the GPS bands of -201.5 dBW/Hz, this gives an interfering power of -213.8 dBW/Hz. Since television interference is often measured in a 500 kHz bandwidth, the tolerable interfering power can be expressed as -156.8 dBW/500 kHz at the GPS receiver.

SCENARIO AND LINK BUDGET DEVELOPMENT

In this section and those that follow, we use the tolerable rise in the GPS noise floor computed above to determine how much interference can be present at the transmitting antenna. We do this by first developing a link equation. The link equation will then be applied to real-world scenarios of GPS use. For each scenario, assumptions that are

applied to the link equation and results from the link equation will appear in a table. These scenarios are then compiled to determine what a reasonable LPTV OOBE should be in the GPS bands.

Given a 0.25 dB rise in the GPS noise floor as the allowable level of interference to a GPS user, the corresponding out-of-band emissions at the transmitting antenna is then based upon the distance between the emitter and the GPS user and their GPS antenna orientation, and the frequency of emission The allowable emission at the transmitter is then

$$E_T = I_T - G_R - A - P - G_T$$

[6] ITU-R M 1477 at Annex 5

where I_T is the interference at the receiver, G_R is the gain of the receiving antenna, A is the aperture, P is the path loss, G_T is the gain of the transmitting antenna.
These values are computed as follows.

I_T = -156.8 dB/500kHz (from the previous section),
G_R = 3 dB for elevations greater than 15 degrees above the horizon, 0db for elevations within 15 degrees of the horizon,
$A = 10\log_{10}(\lambda^2/4\pi)$, which is -25 4 dB for L1, -23 2 dB for L2, and -22.9 dB for L5,
$P = -10\log_{10}(4\pi R^2)$, where R is the distance from the transmitter to the receiver, and
G_T is given by an FCC bulletin[7], the cardinal values of which are 0 dB at the horizon, and -16.5 dB at 10 or more degrees below the horizon for UHF radiators.

Since the aperture is the greatest for L5, and since L5 is also closest in frequency to television, L5 represents the worst case for interference to GPS Thus L5 is used exclusively in the computations that follow.

Transmitting DTV Antenna Located On Towers at 100 Meters In Height

Our review of existing FCC television licenses shows that the majority of the television transmission towers are 100 meters or higher Since existing TV infrastructure will be converted to DTV, we propose to use this TV tower height as the baseline in developing operational scenarios. Typical GPS applications include ground-based (E911, Survey, GIS) and building mounted (timing) Since the worst condition for GPS occurs at L5, we will use L5 as the limiting case.

Our review of the existing FCC television licenses shows that many geographical areas include urban and suburban locations where existing ground-based GPS users can be as close as 120 meters to the transmitting antenna located on a TV tower at 100 meters in height. An individual walking on the sidewalk across the street from the TV tower is using an E911 cellphone to make an emergency call for help. The GPS E911 cellphone antenna is pointed at the sky and is in direct line of sight of the TV antenna on the tower. The resulting link budget indicates that -67.9 dBW/500 kHz is the OOBE for DTV required to protect this GPS public safety user.

Table 1 Interference from a 100 Meter Tower to Ground-based Receivers	
I_T, Rise in GPS noise floor	-156.8 dBW/500 kHz
G_R, Receiving antenna gain	3 dB
A, Aperture at L5	-22.9 dB
P, Path loss (R = 120 meters)	-52.6 dB
G_T, Transmitting antenna gain	-16.5 dB
E_T, Allowable interference at transmitting antenna	-67.9 dBW/500 kHz

In these same geographic locations, building-mounted GPS timing receivers may be as close as 140 meters to the transmitting antenna located on a TV tower at 100 meters in height. The slant range from the transmitting TV antenna to the GPS receiver antenna will increase slightly as

[7] FCC Office of Engineering Technology bulletin no 69

much as 140 meters The GPS antenna gain will be +2 dB. The resulting link budget shows that -65 5 dBW/500 kHz is the OOBE for DTV required to protect this GPS timing use.

Table 2 Interference from a 100 Meter Tower to Building-based Receivers	
I_T, Rise in GPS noise floor	-156.8 dBW/500 kHz
G_R, Receiving antenna gain	2 dB
A, Aperture at L5	-22.9 dB
P, Path loss (*R* = 140 meters)	-53.9 dB
G_T, Transmitting antenna gain	-16.5 dB
E_T, Allowable interference at transmitting antenna	-65.5 dBW/500 kHz

Transmitting DTV Antenna Located on Towers at 30 Meters in Height

There are three scenarios of operational significance to GPS using transmitting DTV antenna located on towers at 30 meters in height, including ground-based GPS receivers, E911, and timing.

Our review of the existing FCC television licenses also found that some geographical areas include urban and suburban locations where existing ground-based GPS users could be as close as 50 meters to the transmitting antenna located on a TV tower at 30 meters in height. An individual using an E911 cellphone to make an emergency call is sitting at a desk in front of a large picture window located in an office building across the street from this TV tower. The GPS E911 cellphone antenna could be pointed at the sky and angled in the direct line of sight of the TV antenna on this tower. The resulting link budget indicates that -89.0 dBW/500 KHz is the OOBE for DTV required to protect this GPS public safety user.

Table 3 Interference from a 30 Meter Tower to E911 Receivers	
I_T, Rise in GPS noise floor	-156.8 dBW/500 kHz
G_R, Receiving antenna gain	0 dB
A, Aperture at L5	-22.9 dB
P, Path loss (*R* = 50 meters)	-45.0 dB
G_T, Transmitting antenna gain	0 dB
E_T, Allowable interference at transmitting antenna	-89.0 dBW/500 kHz

In these same geographic locations, building-mounted GPS timing receivers may be as close as 50 meters to the transmitting antenna located on a TV tower at 30 meters in height. The GPS antenna gain will be 0 dB, but the user will be within the main beam of the television signal, so the transmitting antenna will have a gain of 0 dB. The resulting link budget shows that -89 0 dBW/500 KHz is the OOBE for DTV required to protect this GPS timing use.

Table 4 Interference from a 30 Meter Tower to Timing Receivers	
I_T, Rise in GPS noise floor	-156.8 dBW/500 kHz
G_R, Receiving antenna gain	0 dB
A, Aperture at L5	-22 9 dB
P, Path loss (R = 50 meters)	-45.0 dB
G_T, Transmitting antenna gain	0 dB
E_T, Allowable interference at transmitting antenna	-89.0 dBW/500 kHz

For 30 meter towers, ground-based users, such as mapping or survey users may be as close as 40 meters to the transmitting antenna. In this case the GPS antenna gain will be 3db and the transmitting antenna will have the minimum gain of -16.5dB The resulting link budget shows that -77 39 dBW/500 KHz is the OOBE for DTV required to protect this GPS timing use.

Table 5 Interference from a 30 Meter Tower to Ground-based Receivers	
I_T, Rise in GPS noise floor	-156.8 dBW/500 kHz
G_R, Receiving antenna gain	3 dB
A, Aperture at L5	-22.9 dB
P, Path loss (R = 40 meters)	-43.0 dB
G_T, Transmitting antenna gain	-16.5 dB
E_T, Allowable interference at transmitting antenna	-77.4 dBW/500 kHz

Aviation Scenario

Aviation represents a special case. During an aircraft approach to an airport runway, the GPS receiver may be in the direct line of sight to a DTV transmitting antenna. Tower heights are limited within 3,000 meters of airports by 14 Code of Federal Regulations part 77, subparts B and C. Further away, towers of any height may be found. Thus, in an aviation scenario, we may expect to find the transmitting antenna gain of 0 dB; the receiving antenna gain of 0 dB; and a separation distance of 3,000 meters. This yields an interference level at the transmitter of -53 4 dBW/500 kHz Including an additional 6 dB of margin for safety-of-life, this puts the OOBE limit at -59.4 dBW/500 kHz.

Table 6 Interference from a 100 Meter + Tower to an Aviation Receiver	
I_T, Rise in GPS noise floor	-156 8 dBW/500 kHz
G_R, Receiving antenna gain	0 dB
A, Aperture at L5	-22.9 dB
P, Path loss (R = 3000 meters)	-80.5 dB
G_T, Transmitting antenna gain	0 dB
Additional margin for safety of life	6 dB
E_T, Allowable interference at transmitting antenna	-59.4 dBW/500 kHz

We defer to the Radio Technical Commission Aeronautics (RTCA) Special Committee (SC-159), Working Group 6 for a more authoritative analysis of aviation scenarios.

DERIVATION OF SCENARIO-BASED OOBE AND COMPARISON TO NPRM PROPOSED MASKS

Using the same methodology followed for the 100 meter tower (above), we can derive emission limits based on the same scenarios for different tower heights. These results are summarized in the following table.

Table 7
Summary of GPS Interference Scenarios Versus Television Transmitter Tower Height

GPS Scenario	Tower height (meters)	Slant Range (meters)	Receiving antenna gain (dB)	Transmitting antenna gain (dB)	OOBE at Transmitter (dBW/500 kHz)
Timing/E911	30	50	0	0	-89.0
Ground	30	50	3	-16.5	-77.4
Ground	50	70	3	-16.5	-72.5
Timing	50	70	0	-10.0	-76.0
Ground	70	90	3	-16.5	-70.3
Timing	70	90	1	-16.5	-68.4
Ground/E911	100	120	3	-16.5	-67.9
Timing	100	140	2	-16.5	-65.5
Aviation	100	3000	0	0	-59.4
Ground/E911	150	170	3	-16.5	-64.8
Aviation	150	3000	0	0	-59.4
Ground/E911	200	220	3	-16 5	-62 6
Aviation	200	3000	0	0	-59.4
Ground/E911	250	270	3	-16.5	-60.8
Aviation	250	3000	0	0	-59 4
Ground/E911	300	320	3	-16.5	-59.3
Aviation	300	3000	0	0	-59 4

For the purposes of comparison to the limits suggested in the NPRM, the emissions are expressed as the number of dB down from a 15kW ERP power source, and also as a number of dB different from the stringent out-of-channel mask (-76dB) quoted by the NRPM from Sgrignoli The maximum 15 kW ERP source is converted to EIRP (isotropic) by adding 2 14 dB. Thus an EIRP of 43.9 dBW is used as a reference.

Table 8 Summary of GPS Interference Scenarios Compared with NPRM Proposed Limit					
GPS Scenario	Tower height (meters)	Range to GPS rx (meters)	OOBE (dB) at Transmitter (dBW/500kHz)	OOBE (dB) relative to 15kW ERP	OOBE compared to Sgrignoli Stringent Mask
Timing/E911	30	50	-89.0	-132.9	-56 9
Ground	30	50	-77.4	-121.3	-45 3
Ground	50	70	-72.5	-116.4	-40 4
Timing	50	70	-76.0	-119.9	-43.9
Ground	70	90	-70 3	-114.2	-38.2
Timing	70	90	-68 4	-112.3	-36.3
Ground	100	120	-67.9	-111.8	-35.8
Timing/E911	100	140	-65.5	-109.4	-33.4
Aviation	100	3000	-59 4	-103.3	-27.3
Ground/E911	150	170	-64.8	-108.7	-32.7
Aviation	150	3000	-59.4	-103.3	-27.3
Ground/E911	200	220	-62.6	-106.5	-30.5
Aviation	200	3000	-59 4	-103.3	-27.3
Ground/E911	250	270	-60 8	-104.7	-28.7
Aviation	250	3000	-59 4	-103.3	-27.3
Ground/E911	300	320	-59.3	-103.2	-27.2
Aviation	300	3000	-59.4	-103 3	-27.3

One of the questions the FCC poses in the NPRM is whether the two emission limits proposed are sufficient to protect GPS users. The last column of the table makes it clear that the answer is no This result is not surprising, however, since the proposed emission limits were developed only with a view of protecting one television station from another, and does not address the effect of television transmissions on other services.

In suggesting limits that would effectively protect GPS users, we are struck by the form the current limits take. Today, out-of-channel limits for television are expressed as the attenuation the out-of channel signal must have with respect to the transmitted signal power. However, interference depends on the absolute level of emissions received by the GPS receiver (and for that matter, the receiver of any other service) rather than the power level of the fundamental being broadcast. Therefore, limiting out-of-band emissions by an attenuation specification from the transmitted fundamental doesn't serve either the television industry or GPS users well. It doesn't serve the television industry well because a blanket attenuation must be met no matter how modest the broadcast power is It doesn't serve GPS users well because they are not adequately protected from the highest-power transmissions.

To improve this situation, we suggest out-of-band emission limits that remove the dependency of emission limits on broadcast power, and instead are expressed as an amount of out-of-band energy that may be emitted in any 500 kHz band.

Looking again at the table, we observe that lower tower heights have the greatest potential for interference. Rather than use a 30 meter tower as the basis for a blanket limit, however, we suggest that the allowable out-of-band emissions from a television transmitter be dependent on the height of the transmitting antenna

A survey of the FCC database shows that most television licensees whose transmitting antenna heights are 100 meters or less tend to be lower power repeaters or translators, for which a lower out-of-band energy restriction is reasonable. Thus a height-dependent limit would better serve the television industry than a blanket limit

Based on the table above, we recommend that out-of-band emissions from LPTV be set according to the following table Note that the limits given are absolute power numbers rather than relative to the intended radiated power. All these recommended limits apply to GPS L5. If we were to derive separate limits for L2 and L1, they would be 0.3 dB and 2.5 dB less stringent, respectively, than those below. As a practical matter, relaxing the specification slightly at L1 and L2, which are further away in frequency from television than L5, will probably not make any difference in the required filtering

Table 9
Recommended Out-of-band LPTV Radiation Limits

Antenna height	OOBE dBW/500kHz
250 meters and above	-60
200 meters – 249 meters	-63
150 meters – 199 meters	-65
100 meters – 149 meters	-68
70 meters –99 meters	-74
50 – 69 meters	-81
Below 50 meters	-89

Any analysis of OOBE limits should take into account the costs of applying such limits. To do this we will first compare the recommended radiation limits given above with the ones set forth in the NPRM from Sgrignoli. Looking again at the FCC television license database, we find the shorter towers never host transmitters of the maximum power. Short towers are always used as lower power repeaters and translators. We can construct two worst-case scenarios using the above limits of what happens in industry. The highest power signals tend to occur at no less than 200 meter antenna height, while 30 meter antenna heights tend to host 100 watt signals. This results in the following comparison

Table 10
Comparison of Recommended OOBE Limits with Sgrignoli

Tower height (meter)	Transmitter Power (watts)	Transmitter Power "XP" (dBW)	Recommended OOBE limit "LIM" (dBW/500kHz)	Sgrignoli Limit "SL" (dB)	Added Attenuation to Protect GPS[8] (dB)
200	15,000	43.9	-63	-76	-30.9
30	100	22.1	-89	-76	-35.1

Impact to UHF D-LPTV Transmitter Filtering

The proposed scenario-based OOBE limits for GNSS require an increase in attenuation of about 34 dB beyond the NPRM-proposed 76 dB to protect the RNSS bands from 1160 MHz to 1610 MHz.

[8] Added attenuation = "LIM" – "XP" –"SL"

In order to understand the cost impact, we looked at two implementations for achieving this additional attenuation:

1) developing a new television transmitter output filter to meet both the FCC proposed emission limits and the additional attenuation needed to protect GNSS, or

2) including a second external, add-on filter to an existing D-LPTV broadcast filter which will need to be modified to address the NPRM proposed emission limits. This external add-on filter could be designed to include both the NPRM proposed emission limits and the additional attenuation to protect GNSS.

The cost impact of adding a low pass filter to the basic filter needed to meet the NPRM proposed stringent mask is less than $300 00.

The cost impact of adding an external filter varies by the power handling needs. For a 100 Watt transmitter, the additional cost is on the order of $500-800 for a single filter.

For the higher power transmitters, this cost for an external filter will increase.

	Table 11 Filter Costs/Quantity 10		
Filter Requirement	**Basic NPRM Mask**	**Additional Attenuation (110 dB)**	**Total**
Quote	< $2,500.00	<$300 00	< $2,800.00

The estimated cost for a filter suitable for a 100 W amplifier is less than $2,500.00 in quantities of 10 units to meet the FCC NPRM proposed stringent mask. This estimate was provided by the Microwave Filter Company (attached) We estimate that the cost for a 15 kW amplifier will be at least double to meet the NPRM-proposed emission mask requirements. The additional cost to include the attenuation needed to protect the GNSS services in the RNSS bands is less than $300.00.

Summary

We examined the existing FCC database for LPTV broadcast licensees and looked at their locations and tower heights We then examined existing GNSS users who will be affected by OOBE from the transition to digital LPTV broadcast, including lower power and high power digital LPTV broadcast. We developed operationally significant scenarios as a first step in determining OOBE that would protect these affected GNSS users

To protect the growing broad range of GNSS use, including potentially the most affected-- GPS timing for networks and program synchronization-- we recommend:

- OOBE limits 34 dB beyond the NPRM-proposed 76 dB (to 110 dB)

- this additional attenuation should be provided in the frequency range from 1164 to 1610 MHz to include GNSS in the entire RNSS bands.

To achieve the same protection for the GNSS bands and make it easier for the D-LPTV stations, we also recommend the following.

- using an absolute level of interference to make it easier for lower power digital LPTV stations to meet the OOBE limits rather than the NPRM "one size fits all" emission limit referenced to broadcast power
- the allowable OOBE also may be a function of tower height

Finally, we recommend that·

- these OOBE limits also need to be technically feasible and economically fair for the digital LPTV broadcast industry as they embark on a new digital broadcast service and will be adopting new filters to address their own co-service interference needs. Engineering design shows that the additional cost to provide OOBE protection to the GNSS services in the RNSS bands is less than $300 00 (in quantities of 10).

We believe that a joint industry agreement is the optimum solution. We look forward to working with the digital LPTV broadcast industry.

Attachments

QUOTATION

Microwave Filter Co., Inc.

6743 Kinne Street, E Syracuse, NY 13057

Phone: (800)448-1666 or (315)437-3953 FAX: (315)463-1467 E-MAIL: mfcsales@microwavefilter.com

Customer Type 12C Quotation xx Budget Estimate ___
(Quote Valid thru 6/15/04)

Our Independent Representative in your area is:

Product Type

__ MTV xx LPTV
__ CATV __ RFMW
__ Wireless __ FastTrap
__ Ferro __ Chestfld

Terms: 1% 15 days, net 30 for established accounts.
[xx] A prepayment of _ 25% _ is required for custom filters. Please note this deposit is not credit related.

Enclosures MFC Drawings 15384 and 15395

FOB: Origin

Date: MAY 12, 2004

To: **U.S. GPS Industry Council**
1140 Connecticut Ave. NW Suite 950
Washington, D.C. 20036

Attn.: **F. MICHAEL SWIEK**, Executive Director
Tel: 202 223 7683 Fax: 202 223 7687
Email: mswiek@samuelsinternational.com

To place an order· call and ask for the order desk

If you have any technical questions, concerns with Pricing or delivery or if the quotation is unsuitable in any way, please contact

Jean Downer

QUOTATION NUMBER: 20040420JD3, Rev. A

Item #	Quantity	Description	Unit Price (U.S. dollars)	Estimated Delivery
		CUSTOM UHF DIGITAL MASK FILTER		
1	1	*MFC P/N 15384*, Prototype	< $ 3000.00	4 WEEKS
	10	SUBSEQUENT PRODUCTION MODELS	< $ 2500.00	* 6 WEEKS
		SPECIFICATIONS PER MFC DRAWING 15384 INCLUDED WITH THIS QUOTE.		
		CUSTOM UHF DIGITAL MASK FILTER W/LOW PASS FILTER		
2	1	*MFC P/N 15395*, Prototype	< $ 3300.00	8 WEEKS
	10	SUBSEQUENT PRODUCTION MODELS	< $ 2800.00	* 10 WEEKS
		SPECIFICATIONS PER MFC DRAWING 15395 INCLUDED WITH THIS QUOTE.		

* **NOTE:** DELIVERY OF SUBSEQUENT PRODUCTION MODELS IS FROM PROTO APPROVAL.

Custom, not returnable for credit. Special orders are non-cancelable.

Name or description of electronic system in which filter will be used. UHF DIGITAL TRANSMIT
Function of filter in system MASK FILTER

Warranty: Products returned to MFC within one year of purchase for original defects will be replaced or repaired free of charge or refunded, at our option, if manufacturer's defect is confirmed Otherwise customer will be notified of repair charges before work is begun. MFC cannot accept responsibility for consequential damages.

By ________Paul Mears ________ [j.d.]

Paul Mears, V P of Engineering

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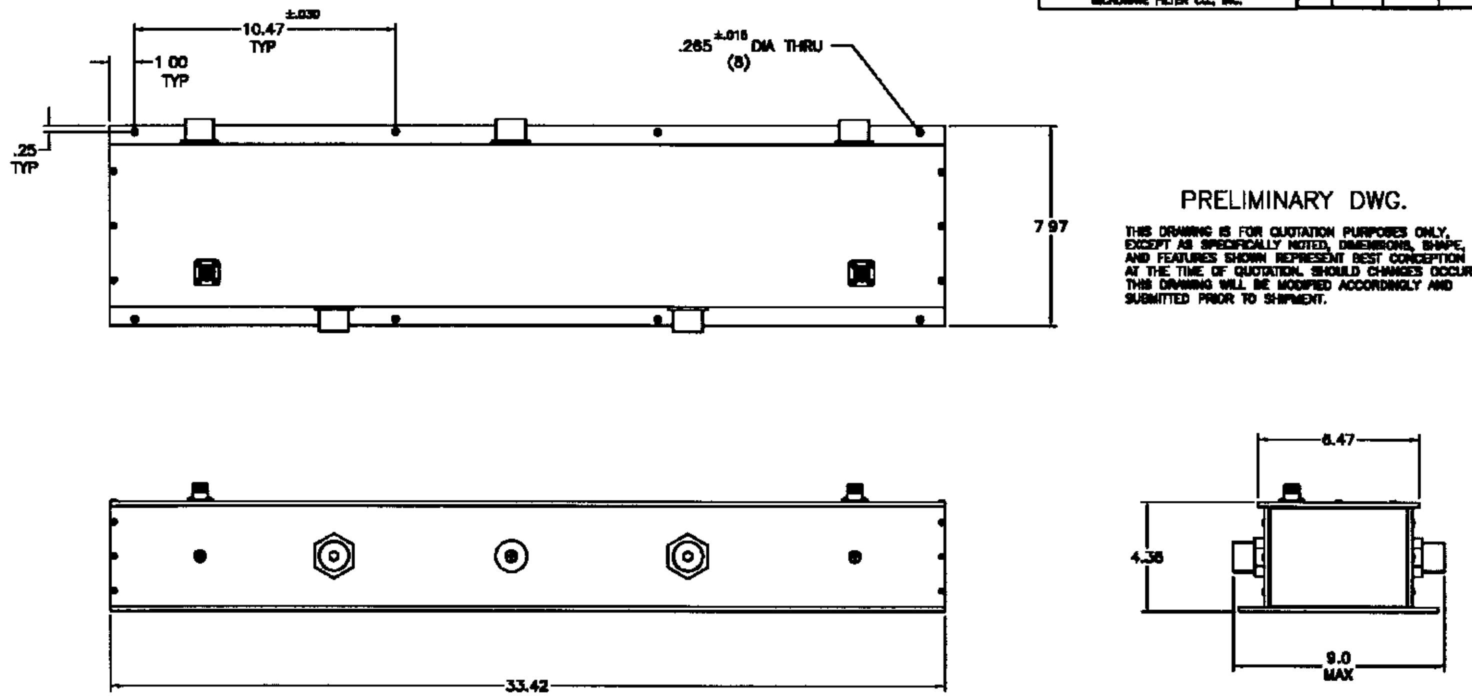
REVISION			
LTR	ECN	DATE	APPR'D



PRELIMINARY DWG.

THIS DRAWING IS FOR QUOTATION PURPOSES ONLY. EXCEPT AS SPECIFICALLY NOTED, DIMENSIONS, SHAPE, AND FEATURES SHOWN REPRESENT BEST CONCEPTION AT THE TIME OF QUOTATION. SHOULD CHANGES OCCUR, THIS DRAWING WILL BE MODIFIED ACCORDINGLY AND SUBMITTED PRIOR TO SHIPMENT.

SPECIFICATIONS

PASSBAND:	524–530 MHz
PASSBAND LOSS:	0.75 dB MAX, 0.6 dB TYP
POWER:	100 WATTS MAX
GROUP DELAY VARIATION:	110 nSEC APPPROX.
REJECTION:	25 dB MIN 30 dB TYP AT 521 MHz AND AT 533 MHz
IMPEDANCE:	50 OHMS
CONNECTORS:	N FEMALE
INDOOR USE	

UNLESS SPECIFIED
ALL TOLERANCES ±.060

ENVELOPE DRAWING

MFC	FSCM27834		
DATE 5/12/04	TITLE		
DWN BY M.W.	UHF DIGITAL MASK FILTER		
ENGINEER T. HOWARD	SIZE B	DRAWING NO 15384	REV –

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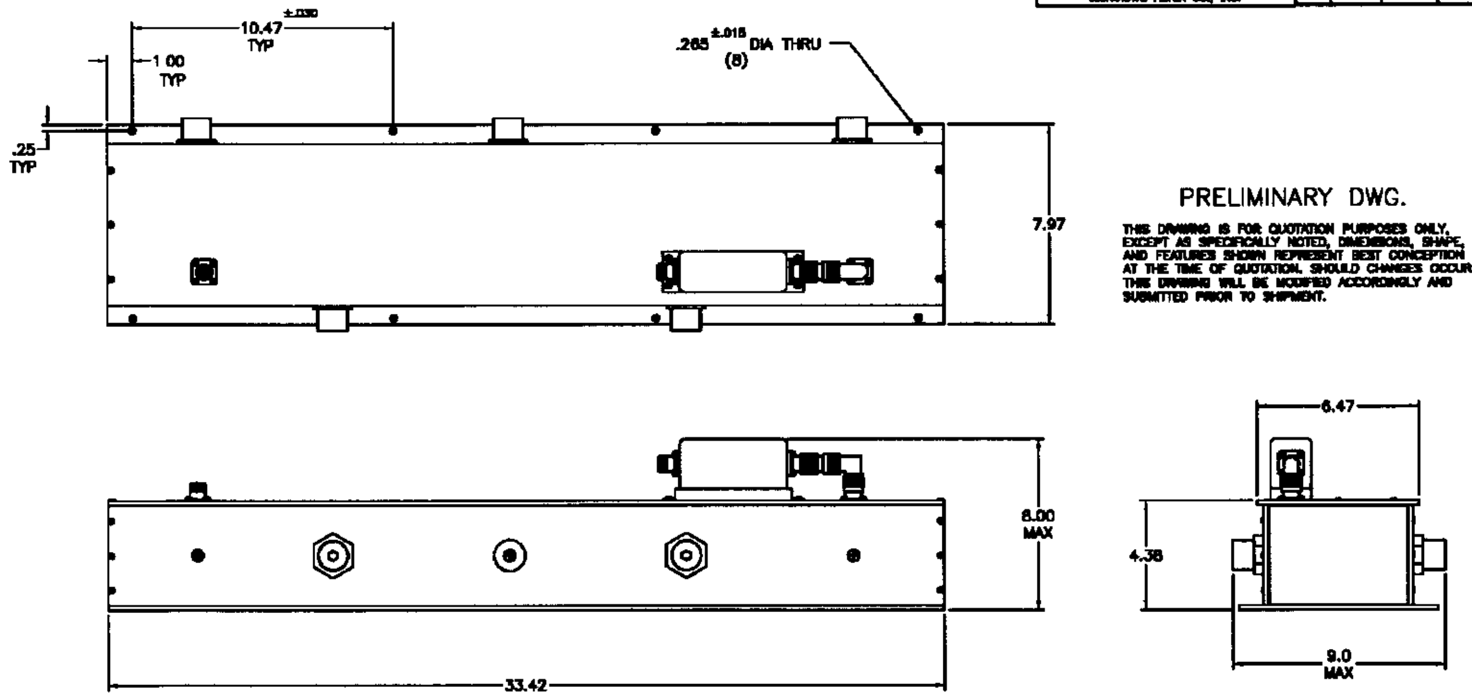
REVISION			
LTR	ECN	DATE	APPR'D



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SPECIFICATIONS

PASSBAND:	524–530 MHz
PASSBAND LOSS:	0.95 dB MAX, 0.8 dB TYP
POWER:	100 WATTS MAX
GROUP DELAY VARIATION:	110 nSEC APPPROX.
REJECTION:	25 dB MIN 30 dB TYP AT 521 MHz AND AT 533 MHz
	110 dB MIN FROM 1150 MHz -1600 MHz
IMPEDANCE:	50 OHMS
CONNECTORS:	N FEMALE
INDOOR USE	

UNLESS SPECIFIED
ALL TOLERANCES ±.060

ENVELOPE DRAWING

MFC	FSCM27834
DATE 5/12/04	TITLE
DWN BY M.W.	UHF DIGITAL MASK FILTER
ENGINEER T. HOWARD	SIZE B / DRAWING NO. 15395 / REV –