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EXHIBIT C

Statistical Analysis of Potential Interference with SDARS from Mobile WCS Operations

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The Report and Order promulgating rules for the WCS auction, seeks to ensure that mobile uses of WCS bands do not interfere with Satellite Digital Audio Radio Services (SDARS) operations contemplated in the 2320-2345 MHz range. Suppose this goal is accepted without debate. It is nonetheless true that the rules overzealously pursue this goal, setting interference standards so restrictive as to prevent usage in WCS A and B blocks of even the lowest-power technologies available to offer mobile services. ***No reasonable purpose is served by such restrictive standards.***

Hughes Network Systems (HNS) has submitted reports in this docket suggesting reasonable interference standards which still permit some mobile technologies.[1] This memo indicates that the level of protection of SDARS under HNS standards is extraordinarily high: ***for these sensible standards, interference with SDARS signals from WCS handsets is such a rare occurrence as to be completely indiscernible*** amidst interference that arise unavoidably from other sources.[2]

The Appendix to this memo presents results and relevant parameters from a statistical model designed to estimate the frequency with which WCS handsets would be transmitting within a short enough distance from an SDARS antenna as to create the possibility of interfering with the SDARS signal; the number of seconds of such interference is also estimated.

How rarely WCS handsets might interfere, and how brief any interferences might be,[3] depends upon about three dozen parameters, ranging from such obvious and fundamental determinants as the extent of WCS market penetration, and the average number of minutes of usage per month, to such more subtle parameters as the pace of a pedestrian walking along conversing on a handset, or how often a driver listening to SDARS prefers to stay out of the curb lane, to proceed more smoothly.

Some parameters are not known with much precision. Hence, for each parameter, I have used two numbers, one "Unfavorable" in that it makes interference more likely, the other "Favorable" to the claim that interference will be a rare event. The attempt is to incorporate numbers so that poorly known parameters are likely to fall somewhere between the two.

Simply put, the chances of interference with SDARS under the sensible HNS standards range from very remote to inconceivably small. ***Even when every parameter is set to its unfavorable level, interference is still a strikingly remote event.***

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[1] These standards include emissions limits in the SDARS band from Subscriber Units and Base Stations operating in either the A or B WCS bands of 81 + 10 log (P) dB for Subscriber Unit Transmit and 75 + 10 log (P) dB for Base Transmit. In addition, the HSN standards include: linear polarization, SU Transmit Power limited to 200 milliwatts, RP Transmit Power standardized at 25 feet above surface to no more than 800 milliwatts, and a 12.5% Handset Duty Cycle at 312.5 msec pulsing every 2.5 msec. The estimates presented here, even for favorable parameters, are conservative in that the 12.5% duty cycle is ignored.

[2] Specifically, this interference from trees and buildings can only be prevented by siting and installing a network of ground repeaters; these same ground repeaters serve, within the scope set by their wattage, to overcome WCS interference as well as that from trees and buildings.

[3] Interferences lasting less than 1 second are ignored throughout, though this makes little difference to the results

Three principal situations are considered. The first is designed to stylize a congested urban area, like that of the central business district and nearby densely populated residential areas that occur in most large cities in the Eastern U.S. Automobile and pedestrian traffic are both dense, and broad sidewalks typically stretch from buildings to the curb. This setting creates the most potential for SDARS interference from buildings as well as from WCS handsets. The second represents a more moderate degree of urban congestion, like that in the center of newer cities in the Western U.S., as well as near-in suburbs of major metropolitan areas throughout the country. Tall buildings are rarer, but so is pedestrian traffic. The third scenario directly considers traffic on an urban expressway.

Both the probabilities of WCS interference, and the total number of seconds of such interference, per trip made by a driver listening to SDARS, are such small numbers as to be hard to comprehend. Let me convert them into descriptions of how much driving an SDARS listener can expect to do between occurrences of WCS interference. The results are in the table on the next page. (The notation #N/A indicates a number too large for Excel to display in scientific notation.)

Here are a few examples of how these numbers are interpreted. Suppose someone is listening to SDARS while driving along an urban expressway. Then, for favorable parameter values, that driver will find SDARS reception interfered by a WCS handset *once every 250,000 miles*--for most of us, this means ***less than once in a lifetime***. In terms of time spent driving on the expressway, *for every second* when WCS interferes with reception, there are on average nearly ***12 million seconds*** when reception is either clear, or prevented by some technological factor beyond the control of the FCC, not by WCS. These astronomical numbers actually have a conservative bent, in that they assume interference actually occurs whenever physical proximity might make interference possible. Numbers this large stem from several favorable but reasonable assumptions about urban expressway driving, such as a traffic density of 90 vehicles per mile per lane. However, even when every parameter is switched from favorable to unfavorable, WCS interference on expressways remains remote: it happens on average once every 375 miles, with duration totaling 1 second in every 22,000. This means that a commuter with a 70-minute commute will have his/her SDARS signal interfered with by WCS handsets less then 1 second per week.

Neither all parameters being that unfavorable or all parameters being that favorable is at all likely. The odds are very high, though, that parameters are sufficiently removed from the all-unfavorable levels to limit WCS interference to ***less than 3 seconds per year*** for the average commuter listening to SDARS.[4] **This is the level of interference that the FCC inexplicably decided was insufficient protection for SDARS!**

[4]As a combination of the two extremes, this puts about a 97% weight on the unfavorable case, and a 3% weight on the favorable one.

Statical Estimates Indicate that WCS Interference with SDARS Is Extremely Rare

		Eastern City Center		Western City		On Expressway	
		Unfavorable	Favorable	Unfavorable	Favorable	Unfavorable	Favorable
Average Miles of Uninterfered Driving,:	WCS Handset in Moving Vehicle	588	371,186	325	195,536	374	259,556
Between Occurrences of Interference from:	Pedestrian Using WCS	28.0	#N/A	#N/A	#N/A		
Average Number of Seconds of Driving,:	WCS Handset in Moving Vehicle	125,022	35,867,006	29,900	14,104,334	22,231	11,854,256
For Each Second of Interference from:	Pedestrian Using WCS	11,633	#N/A	#N/A	#N/A		

Interference due to WCS transmissions from moving vehicles is almost as remote an event for an SDARS driver on local streets in a Western city or Eastern near-in suburbs: once every 195,000 miles for favorable parameters, or once every 325 miles for completely unfavorable parameters. Somewhere between these two scenarios, it is not very likely that a driver listening to SDARS in areas with this level of congestion will face WCS interference more than 2-3 times per year. Moreover, these rare interferences will be of even shorter duration than those occurring on expressways (because drivers talking on handsets are often traveling further below average traffic speed on suburban roads than on expressways, among other reasons); the 14 million number translates into 1 second's interference about every 4,000 hours of driving. The #N/A appearing under the Western city headings means that interference with SDARS reception due to pedestrian-held WCS handsets is absolutely no worry: before it happens twice, all land-based means of transportation will likely be obsolete.

The high level of congestion characteristic of central cores of large Eastern-U.S. cites creates the greatest frequency of proximity between WCS handsets and SDARS antennas. However, this is also where interference from buildings will force SDARS providers to install a considerable network of ground repeaters to have any hope of commercially feasible reception. In ex parte discussions with the FCC on March 5, 1997, Primosphere engineer Richard Cooperman stated that Primosphere is not yet ready to talk about the density with which these repeaters will be needed, or the wattage likely to be effective. Hence, we have had to guess more or less blindly at these parameters; the results appear not to be very sensitive to these particular assumptions.

Vehicular interference from WCS on congested urban streets that is not rendered moot by SDARS ground repeaters is clearly an order of magnitude less likely than on expressways; we should live so long. Congested urban areas are the only place where the impact on SDARS reception of WCS-using pedestrians might even be measurable, and even then only when most of the conditions come very close to the unfavorable parameters. The results show that, under about the worst of circumstances, a driver downtown in a megalopolis will detect interference that is due to WCS pedestrians once every 28 miles. This translates into about once in every half-dozen fares for a Manhattan cabdriver; under less dramatically unfavorable conditions, probably less than once in a couple hundred fares. In terms of the duration of pedestrian-WCS interference in urban areas, 1 second of interference every 11,600 seconds means about a second every 200 minutes. Less extreme parameters could easily reduce this likelihood by a factor of 1,000 or more.

All these results treat 12 feet as enough distance to prevent interference; this is one of the few parameters with a quadratic rather than linear impact on the calculations. Even here, though, the results are quite robust. If this number were way off, and a 15 foot distance from WCS handset to SDARS antenna were needed to ensure no interference, none of the results decrease by an order of magnitude. Pedestrian interference is still only an issue in Eastern city centers and still only under unfavorable conditions, and a driver would then be able to drive over 16 miles between pedestrian-WCS interference occurrences, and have over 5,300 seconds of clear reception for each second of WCS interference. The biggest change would be to cut the number of seconds between expressway interferences about in half, to 1 second out of every 9,376, still an abundance of protection for SDARS.

Another way to put these small numbers in context is to compare them with the frequency of interference from trees and large buildings. The *Report of the Field Test Task Group; Field Test Data Collection and Presentation*, an independent industry task force considering such interference,

concluded that, for the 2320-2345 MHz band, "In major urban areas, S-band system failure rate exceeded 90%." This leads to my original characterization that WCS interference would be completely indiscernible. In terms of the number of seconds of interference for an urban driver listening to SDARS, ***trees and buildings*** *will cause* ***between 9,600 times*** *(under unfavorable parameters!)* ***and 32,000,000 times*** *(favorable)* ***as much interference as WCS transmissions****, mobile and pedestrian combined.* Even if the Field Test Task Group has vastly overestimated the SDARS failure rate, and it is only 45%, that only halves these extremely high ratios of the causes of interference. Whatever the precise parameters, it seems clear that the interference which cannot be outlawed is at least one million times as likely as the WCS interference the FCC is unreasonably trying to outlaw.

	Direction of Bias in Estimating Parameters:	Unfavorable	Favorable	Unfavorable	Favorable	Unfavorable	Favorable
	Situation Being Modeled:	Dense, City	Eastern Center	Western	City, or Suburbs	Along Expressway	
	Results:						
	Miles of Driving, Listening to DARS, per Event of:						
	Interference due to use of WCS in a vehicle:	588	371,186	325	195,536	374	259,556
	Interference due to Pedestrian use of WCS:	28.0	#N/A	#N/A	#N/A		
	Seconds of Driving, Tuned to DARS, per Second of:						
	Interference due to use of WCS in a vehicle:	125,022	35,867,006	29,900	14,104,334	22,231	11,854,256
	Interference due to Pedestrian use of WCS:	11,633	#N/A	#N/A	#N/A		
	Avg Number of Seconds of Interference from Trees	(0.90)	(0.90)	(0.80)	(0.80)	(0.60)	(0.60)
	& Bldgs, per Second of Interference from WCS:	9,578	32,280,305	8,514	28,693,605	6,386	21,520,203
	Key Parameters:						
1	WCS Market Penetration:	10.0%	3.0%	10.0%	3.0%	10.0%	3.0%
2	Average WCS Usage, in minutes/month	800	200	800	200	800	200
3	Average Number, SDARS Ground Repeaters, per road mile	1.5	3	0.6	1	0.4	1.5
4	Average Gound Repeater Coverage, in linear miles of road	0.17	0.25	0.2	0.3	0.2	0.25
	Average distance, WCS handset to SDARS antenna:						
5	--Sufficient to Assure Against Interference, in feet	12	12	12	12	12	12
6	--When WCS vehicle 1 lane to the left of SDARS vehicle	10.9	11.5	11.5	11.8	11.5	11.8
7	--When WCS vehicle 1 lane to the right of SDARS vehicle	9.1	10.2	9.5	10.5	9.2	10.5
	When SDARS Vehicle Is in the Curb Lane,						
8	Average Distance from Antenna to Curb, in feet	4.6	6	7	10.5		
9	Distance from Antenna to Pedestrian Walking in Road, feet	6.5	8	8	10		
10	Average Vehicle Density, per mile, per lane of road	230	120	170	80	200	90
11	Average Number Lanes in 1 Direction, per road	2	2.5	2.2	2.7	2.8	3.6
12	Average Vehicular Speed, in miles per hour	10	30	28	42	40	60
13	Average Pedestrian Speed, in feet per second	5	4	5.5	4.5		
	Average Pedestrian density, per linear mile:						
14	--One Side of Road, where there is a sidewalk	200	50	20	6		
15	--One Side of Road, where there is no sidewalk	20	4	4	1		
16	Average Width of Sidewalk, in feet, where it exists	8	14	3.6	4.2		
	The Following Parameters Are in Percentages:						
17	WCS Minutes Transmitted from Moving Vehicle	15%	5%	15%	5%	15%	5%

18	WCS Minutes Transmitted Streetside or as Pedestrian	20%	5%	20%	5%		
19	Time SDARS Vehicle Is Stopped (traffic light or jam)	40.0%	15.0%	18.0%	10.0%	2.0%	0.5%
20	Cars Going Moderately Faster or Slower than SDARS Car	7.0%	7.0%	25.0%	14.0%	25.0%	15.0%
21	(Average Speed Difference from SDARS Car, miles/hour)	3	5	4	6	5	6
22	Cars Going Much Faster or Slower than SDARS Car	1.0%	3.0%	12.0%	8.0%	14.0%	15.0%
23	(Average Speed Difference from SDARS Car, miles/hour)	6	8	8	10	10	12
24	Percentage of Pedestrians Walking in the Same (or Opposite) Direction as SDARS Vehicle (the Rest: Stationary, or Moving in Perpendicular Direction)	37.5%	30%	32%	27%		
25	Roads without Bike Lane & with Sidewalk Abutting Road	95%	70%	15%	2.5%		
26	Roads without Bike Lane or Sidewalk	2%	0%	12.5%	0%		
27	Chances Road Has Parked Vehicles (Legal or Illegal) (Frequently Enough to Disrupt Travel in Curb Lane)	20%	50%	60%	80%		
28	If One of an SDARS Vehicle and a Driver Holding a WCS Handset Passes the Other, in an Adjacent Lane, --Percentage of Time the WCS Vehicle Is to the Left:	30%	50%	40%	50%	40%	50%
29	Ratio of How Often SDARS Driver Prefers Another Lane to How Often SDARS Driver Prefers Curb Lane:	2.7	3.1	2.3	2.7	2.4	2.6
	When Sidewalk Abuts Road without Bike Lane,						
30	Pedestrians Walking near Road	20%	15%	15%	7.5%		
31	(Average Distance from Curb, in feet)	1.5	3	0.3	0.5		
32	Pedestrians Walking in Segment Further from Road	50%	5%	15%	7.5%		
33	(Average Distance from Curb, in feet)	4.6	5	0.7	1		
34	Pedestrians Walking in Segment Closest to Buildings	30%	80%	70%	85%		
35	(Average Distance from Curb, in feet)	6.8	6	1.4	1.5		

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Curriculum Vitae

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International Journal of Game Theory

Member, Editorial Board, 1992-
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Grants:

1993 Co-Principal Investigator, National Science Foundation grant, SBR 93-09333, "Enriched Modeling of Auctions and Bidding," (with M. H. Rothkopf).

1991 Co-Principal Investigator, National Science Foundation grant, SES 91-08551, "Enriched Modeling of Auctions and Bidding," (with M. H. Rothkopf), funded for two years.

1984 Co-Principal Investigator, National Science Foundation grant, IST 84-08396, "The Role of Information and Information Processing in Auctions: Theory and Experimentation," (with J. H. Kagel and D. Levin), funded for two years.

1979 Project Director, National Science Foundation grant, SES 79-15356, "Interactive Behavior Experimentation," (with J. K. Murnighan, A. E. Roth, F. Schoumaker), renewed 1980, 1981, 1982.

Publications:

Refereed Articles:

"Withdrawable Bids as Winner's Curse Insurance" (with M. H. Rothkopf), *Operations Research*, 43 (1995), 983-94.

"Comparative Static Effects of Number of Bidders and Public Information on Behavior in Second-Price Common-Value Auctions" (with J. H. Kagel and D. Levin), *International Journal of Game Theory*, 24 (1995), 297-319.

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"Implementation of Mechanisms by Processes: Public Good Allocation Experiments" (with M. Marrese), *Journal of Economic Behavior and Organization*, 2 (1981), 129-51.

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"Efficiency and Incentive Compatibility When Bidders Have Private Information about Competitors" (with M. H. Rothkopf and K. Waehrer), pp. 1-13 in: M. R. Baye (ed.), *Advances in Applied Micro-Economics*, Volume 6, *Auctions*, JAI Press, Greenwich, Ct., 1996.

"Lottery Qualification Auctions" (with R. F. Bordley), pp. 157-83 in: M. R. Baye (ed.), *Advances in Applied Micro-Economics*, Volume 6, *Auctions*, JAI Press, Greenwich, Ct., 1996.

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"Interaction Between Resource Extraction and Futures Markets: A Game-Theoretic Analysis" (with L. Phlips), pp. 289-307 in Volume II of: R. Selten (ed.), *Game Equilibrium Models*, Springer, Berlin, 1991.

"Perfect Equilibria of Speculative Futures Markets" (with L. Phlips), pp. 157-74 in J. J. Gabszewicz, J.-F. Richard and L. A. Wolsey (ed.), *Economic Decision-Making: Games, Econometrics and Optimisation - Contributions in Honour of Jacques Dreze*, Elsevier Science Publishers, 1990.

Publications in an Editorial Capacity:

"Laboratory Investigations of Expectations in Games: The Amsterdam Papers," *International Journal of Game Theory*, forthcoming.

"Introduction to Methods, Morals and Markets," pp. 3-8 in Volume II of: R. Selten (ed.), *Game Equilibrium Models*, Springer, Berlin, 1991.

Contributions to Conference Volumes:

"Franchise Bidding with Vickrey Auctions" (with M. A. Crew), pp. 117-30 in M. A. Crew (ed.), *Innovative Approaches to Utility Regulation*, Kluwer Academic Publishers, 1992.

"Dual Ceteris Paribus Comparisons: Some Initial Thoughts on Laboratory Isolation of Equilibrium Forces in Auction Markets," pp. 173-83 in: R. Tietz, W. Albers and R. Selten (ed.), *Modeling Bounded Rational Behavior in Experimental Games and Markets*, Springer, Berlin, 1988.

Papers in Requested Revise-and-Resubmit Status:

"Computationally Manageable Combinational Auctions" (with M. H. Rothkopf and A. Pekec).

"Auction Form Preferences of Risk-Averse Bidtakers" (with K. Waehrer and M. H. Rothkopf).

"Franchise Bidding without Holdups: Utility Regulation with Efficient Pricing and Choice of Provider" (with M. A. Crew).

"Oligopolistic Manipulation of Spot Markets and the Timing of Futures Market Speculation" (with L. Phlips).

Papers Currently Submitted:

"Is Subsidizing Inefficient Bidders Actually Costly?" (with M. H. Rothkopf and Y. Fu).

"Experimental Design and Elicitation of Values" (with G. W. Harrison and E. E. Rutström).

"Combinational Auctions with Synergies" (with M. H. Rothkopf).

"Dominant Strategy Adoption, Efficiency, and Bidder's Experience with Pricing Rules."

"Efficiency of Area-Wide Oil Leasing with a Constrained Public Budget" (with M. H. Rothkopf).

Papers Currently Circulating for Comment, and in Preparation for Submission:

"Auctions with Endogenous Bidder Participation."

"An Alternating Recognition Model of English Auctions" (with M. H. Rothkopf).

"Competitive Bidding Magnifies Adverse Selection" (with R. F. Bordley).

"The Way It Is: Exercise of Governmental Monopoly Power Given a Distortive Tax System" (with M. H. Rothkopf).

"Reasoning without Common Knowledge of Reasoning."

Prior Appointments:

1987-1993 Virginia Commonwealth University
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Economic Science Association:
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Econometric Society:
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Public Choice Society:
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Midwest Mathematical Economics Society:
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Supervisor, co-supervisor or dissertation committee member in the 1990s for a dozen PhD students at universities in four nations

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