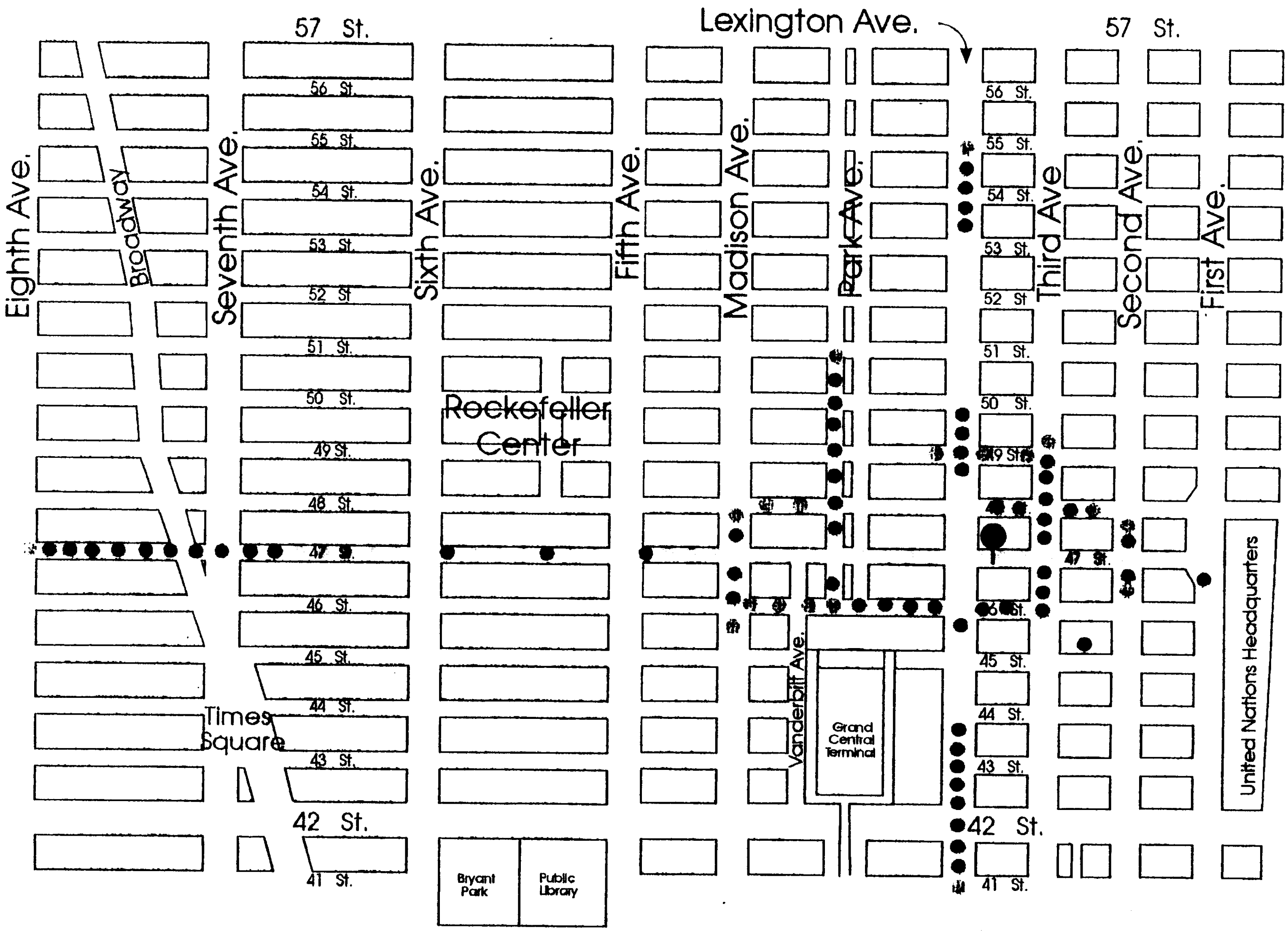


Coverage Plot: Base Site No. 1
47th St. & Lexington

mdtncv1c.cdr

Figure 1-9

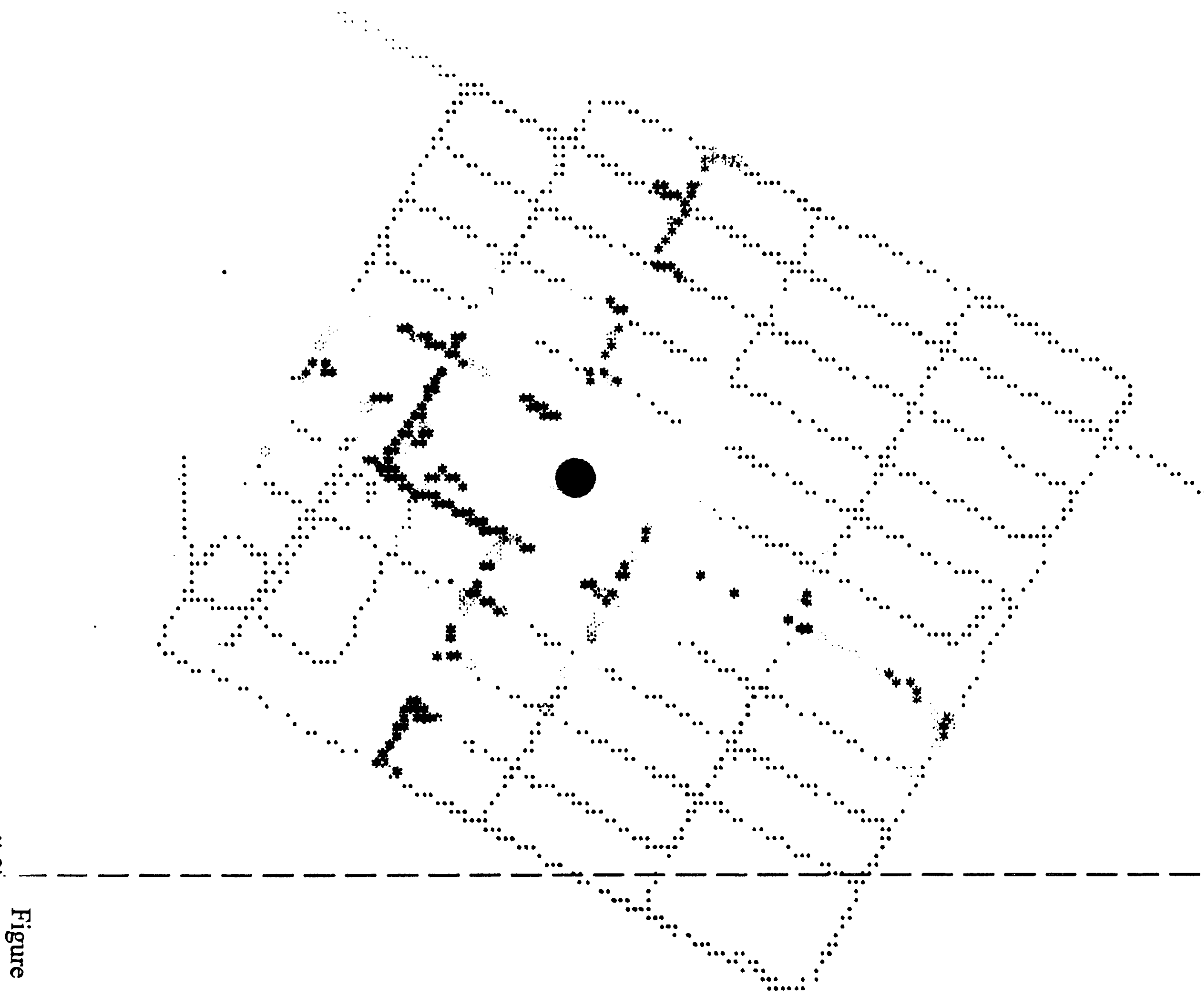


Figure 1-10

COVERAGE CHANNEL PLOT

Coverage Type: Average

Market: ERP NRMLZD TO 0.2 W

Client: BS1 LEXINGTON & 47

08/14/93 14:59:33

File	Nav	File	Nav
47EAST.MMA	ETAK	RS3.MMA	ETAK
47WEST.MMA	ETAK	RS4.MMA	ETAK
LEX.MMA	ETAK	RS5.MMA	ETAK
RS1.MMA	ETAK	RS6.MMA	ETAK
RS2.MMA	ETAK		

Chan	Char	SAT	Chan	Char	SAT
3	d	None	15	p	None
103	bz	None			

CMA V4.0
LCC Inc.

LEGEND

Threshold Values (dBm)

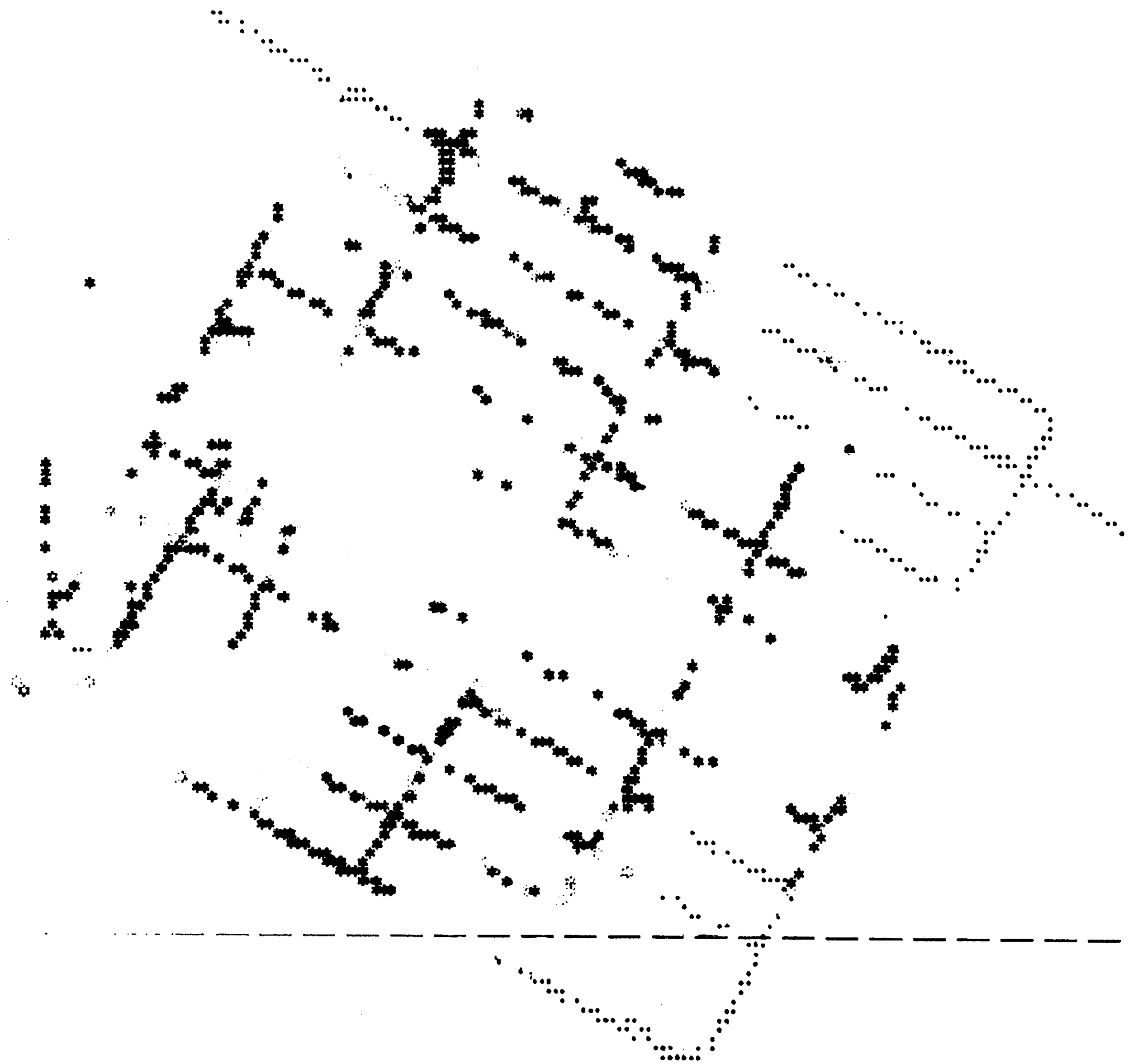
-85 + M
Sig >= -90 + M
-95 + M
Sig >= -100 + M
-105 + M
-110 + M

M = Fade Margin
M_{LOS} = 18 dB
$M_{Non\text{-}LOS}$ = 21 dB

Miles

0 0.1 0.2

SCALE: 1:8,000



COVERAGE CHANNEL PLOT
Coverage Type: Average

Market: BS1 LEXINGTON & 47TH
Client: ERP NRMLZD TO 0.2 W
08/15/93 20:20:50

File	Nav	File	Nav
47EAST.MMA	ETAK	RS3.MMA	ETAK
47WEST.MMA	ETAK	RS4.MMA	ETAK
LEX.MMA	ETAK	RS5.MMA	ETAK
RS1.MMA	ETAK	RS6.MMA	ETAK
RS2.MMA	ETAK		

Chan	Char	SAT	Chan	Char	SAT
3	d	None	15	p	None
103	bz	None			

CMA V4.0
LCC Inc.

LEGEND

Threshold Values
(dBm)

Sig >= -90

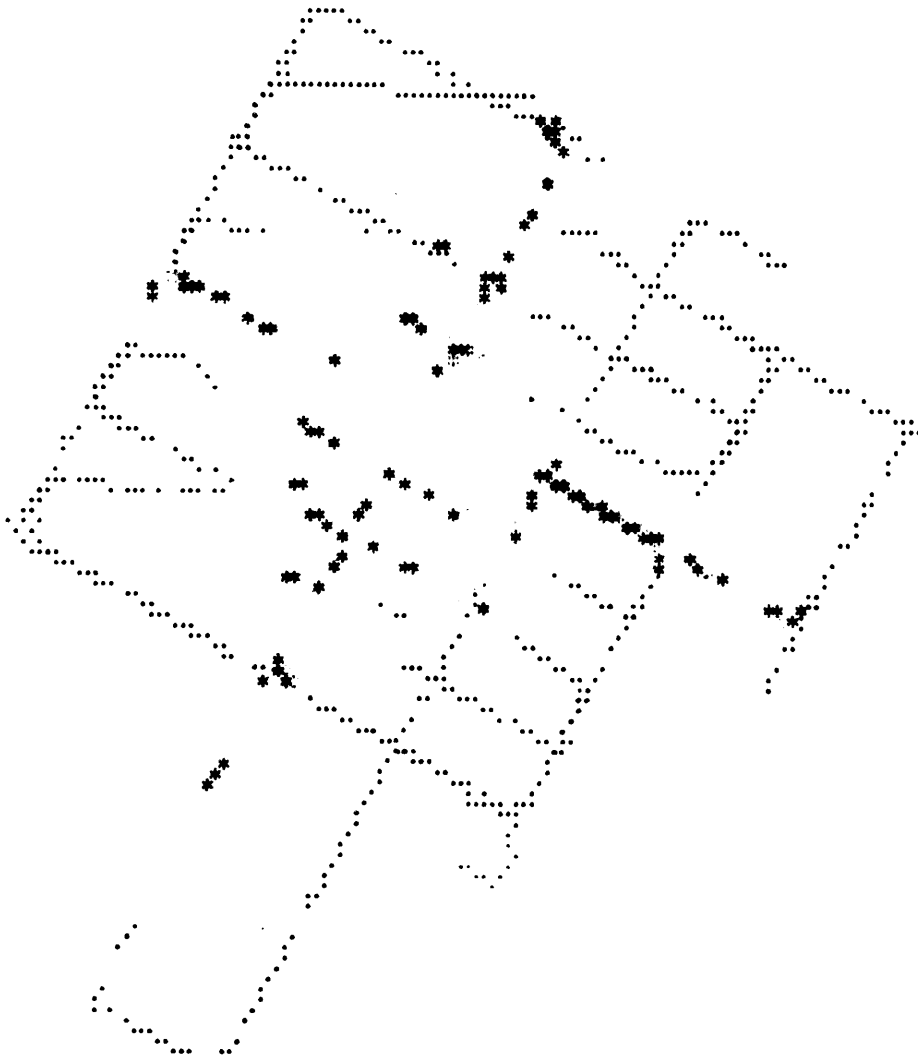
Sig >= -100

Miles
0 0.1 0.2

SCALE: 1:8,000

N

Figure 1-11



COVERAGE CHANNEL PLOT

Coverage Type: Average

Market: ERP NRMLZD TO 0.2 W

Client: BS-3: 5TH AVE & 55TH ST

08/14/93 22:56:42

File	Nav	File	Nav
55TH.MMA	ETAK	AL2.MMA	ETAK
AL1.MMA	ETAK		

Chan	Char	SAT
31	F	None
231	gx	None

LEGEND

Threshold Values (dBm)

-85 + M

Sig >= -90 + M

-95 + M

Sig >= -100 + M

-105 + M

-110 + M

M = Fade Margin

M_{LOS} = 18 dB

$M_{Non\text{-}LOS}$ = 21 dB

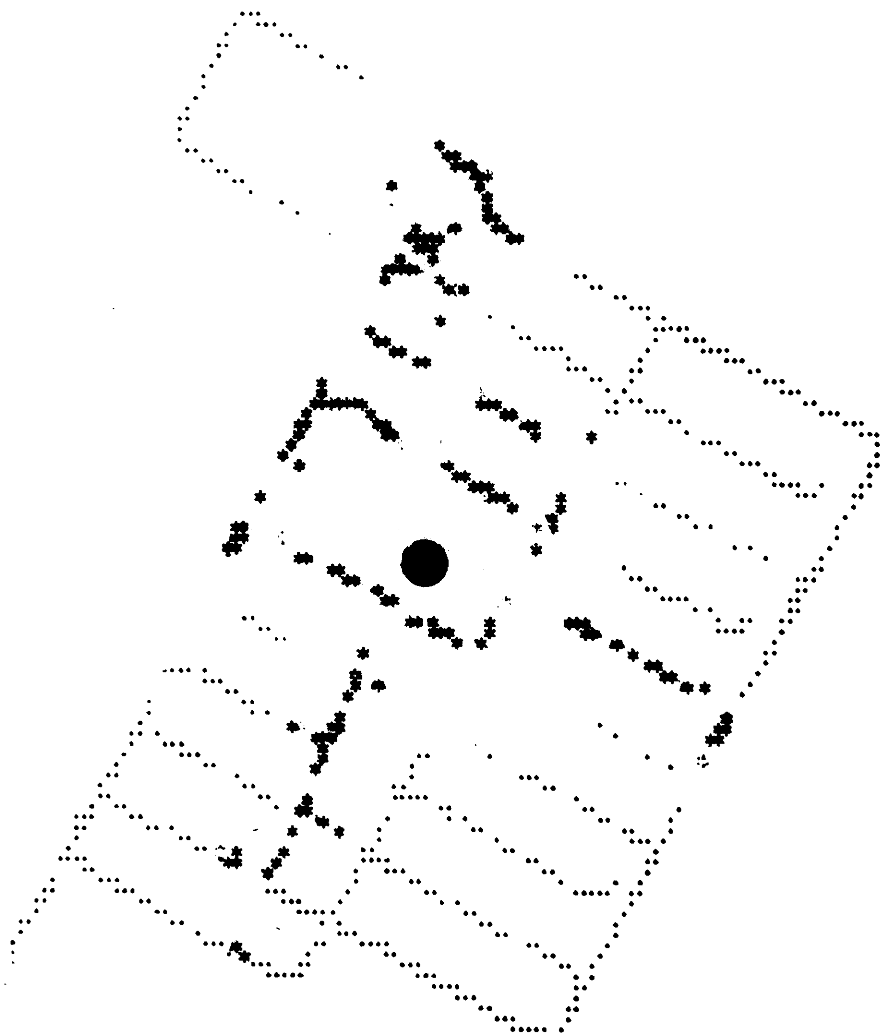
CMA V4.0
LCC Inc.

Miles

0 0.1 0.2

SCALE: 1:8,000

Figure 1-12



COVERAGE CHANNEL PLOT
Coverage Type: Average

Market: ERP NRMLZD TO 0.2 W
BS4 BROADWAY & 55
08/14/93 15:48:02

File	Nav	File	Nav
55TH.MMA	ETAK	WW3.MMA	ETAK
BRDWY.MMA	ETAK	WW4.MMA	ETAK
WW1.MMA	ETAK	WW5.MMA	ETAK
WW2.MMA	ETAK		

Chan	Char	SAT	Chan	Char	SAT
7	h	None	207	fz	None
107	cd	None			

LEGEND

CMA V4.0
LCC Inc.

Threshold Values (dBm)

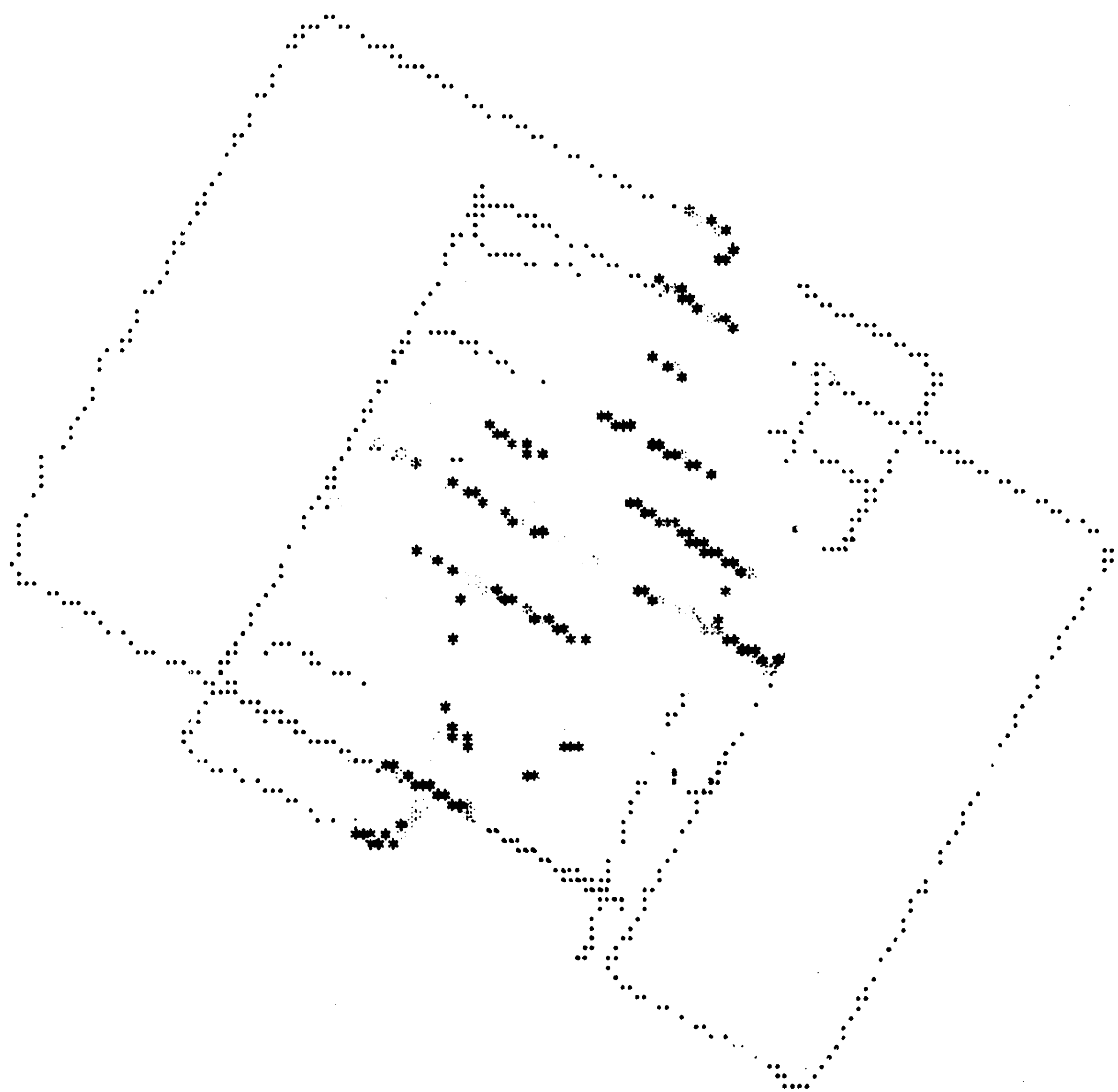
-85 + M
Sig >= -90 + M
-95 + M
Sig >= -100 + M
-105 + M
-110 + M

M = Fade Margin
M_{LOS} = 18 dB
$M_{Non-LOS}$ = 21 dB

Miles
0 0.1 0.2

SCALE: 1:8,000

Figure 1-13



COVERAGE CHANNE' PLOT
Coverage Type: Average

Market: ERP NRMLZD TO 0.2 W
BS5 EIGHTH & 51
08/14/93 19:39:05

File	Nav	File	Nav
8TH.MMA	ETAK	HJ3.MMA	ETAK
HJ1.MMA	ETAK		
HJ2.MMA	ETAK		

Chan	Char	SAT
11	I	None
211	gd	None

LEGEND

CMA V4.0
LCC Inc.

Threshold Values
(dBm)

-85 + M
Sig >= -90 + M
-95 + M
Sig >= -100 + M
-105 + M
-110 + M

M = Fade Margin
M_{LOS} = 18 dB
$M_{Non\text{-}LOS}$ = 21 dB

Miles
0 0.1 0.2

SCALE: 1:8,000

Figure 1-14

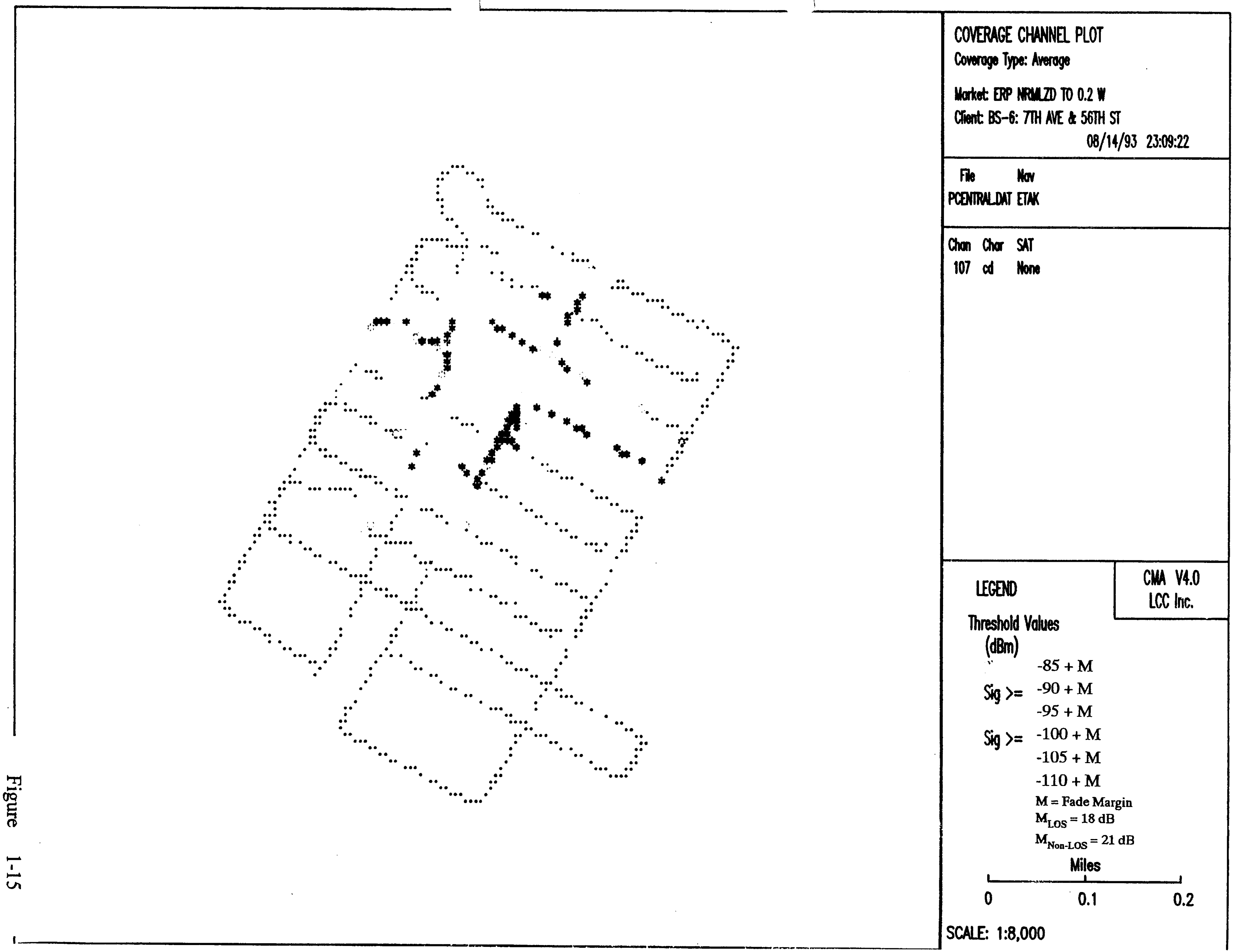
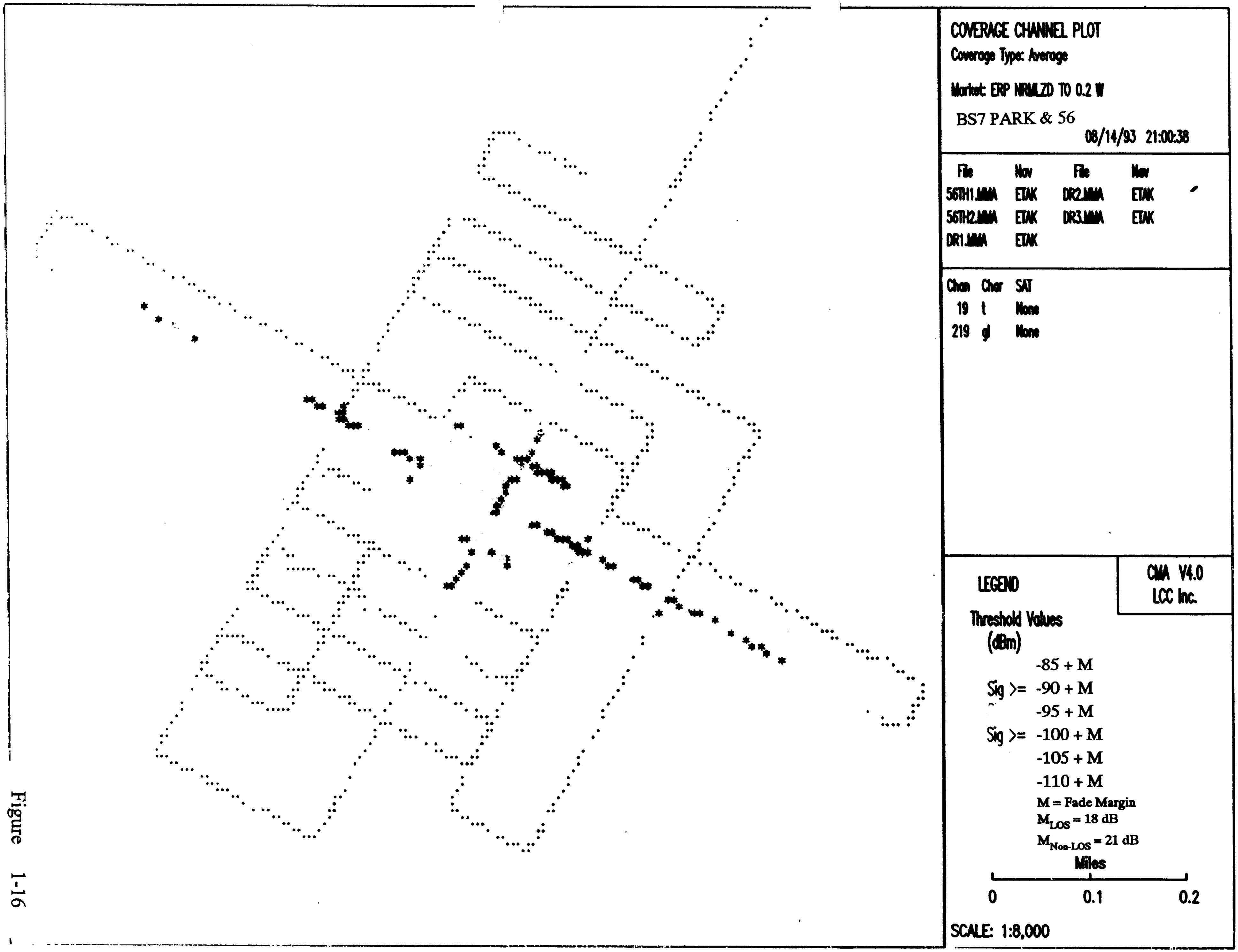
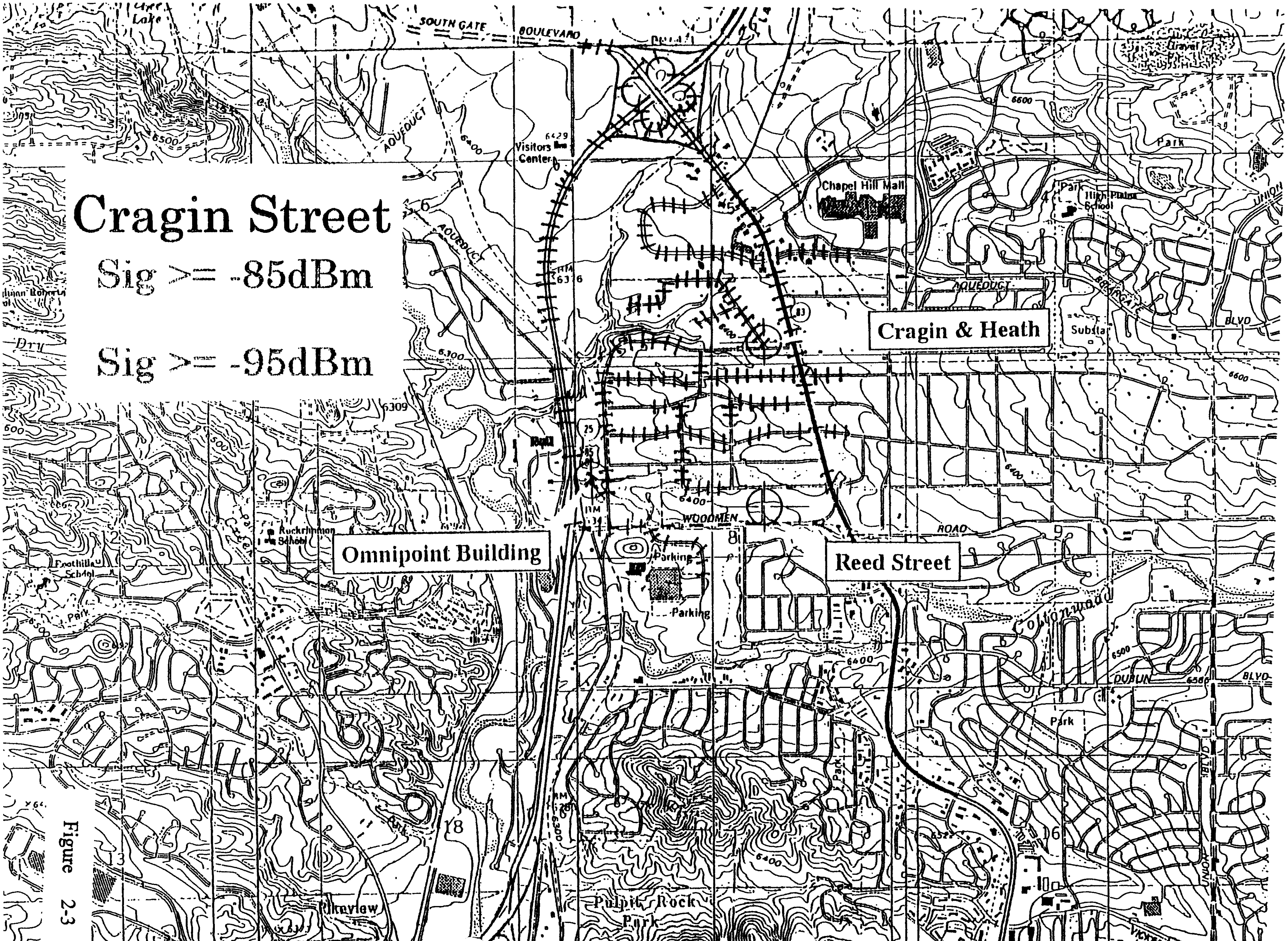

COVERAGE CHANNEL PLOT
Coverage Type: Average
Market: ERP NRMLZD TO 0.2 W
Client: BS-6: 7TH AVE & 56TH ST
08/14/93 23:09:22
File Nav
PCENTRAL.DAT ETAK
Chan Char SAT
107 cd None
LEGEND
CMA V4.0
LCC Inc.
Threshold Values
(dBm)
-85 + M
Sig >= -90 + M
-95 + M
Sig >= -100 + M
-105 + M
-110 + M
M = Fade Margin
M_LOS = 18 dB
M_Non-LOS = 21 dB
Miles
0 0.1 0.2
SCALE: 1:8,000

Figure 1-15



COVERAGE CHANNEL PLOT
Coverage Type: Average
Market: ERP NRMLZD TO 0.2 W
BS7 PARK & 56
08/14/93 21:00:38
File Nav File Nav
56TH1.MMA ETAK DR2.MMA ETAK
56TH2.MMA ETAK DR3.MMA ETAK
DR1.MMA ETAK
Chan Char SAT
19 t None
219 gl None
LEGEND
CMA V4.0
LCC Inc.
Threshold Values
(dBm)
-85 + M
Sig >= -90 + M
-95 + M
Sig >= -100 + M
-105 + M
-110 + M
M = Fade Margin
M_{LOS} = 18 dB
$M_{Non-LOS}$ = 21 dB
Miles
0 0.1 0.2
SCALE: 1:8,000

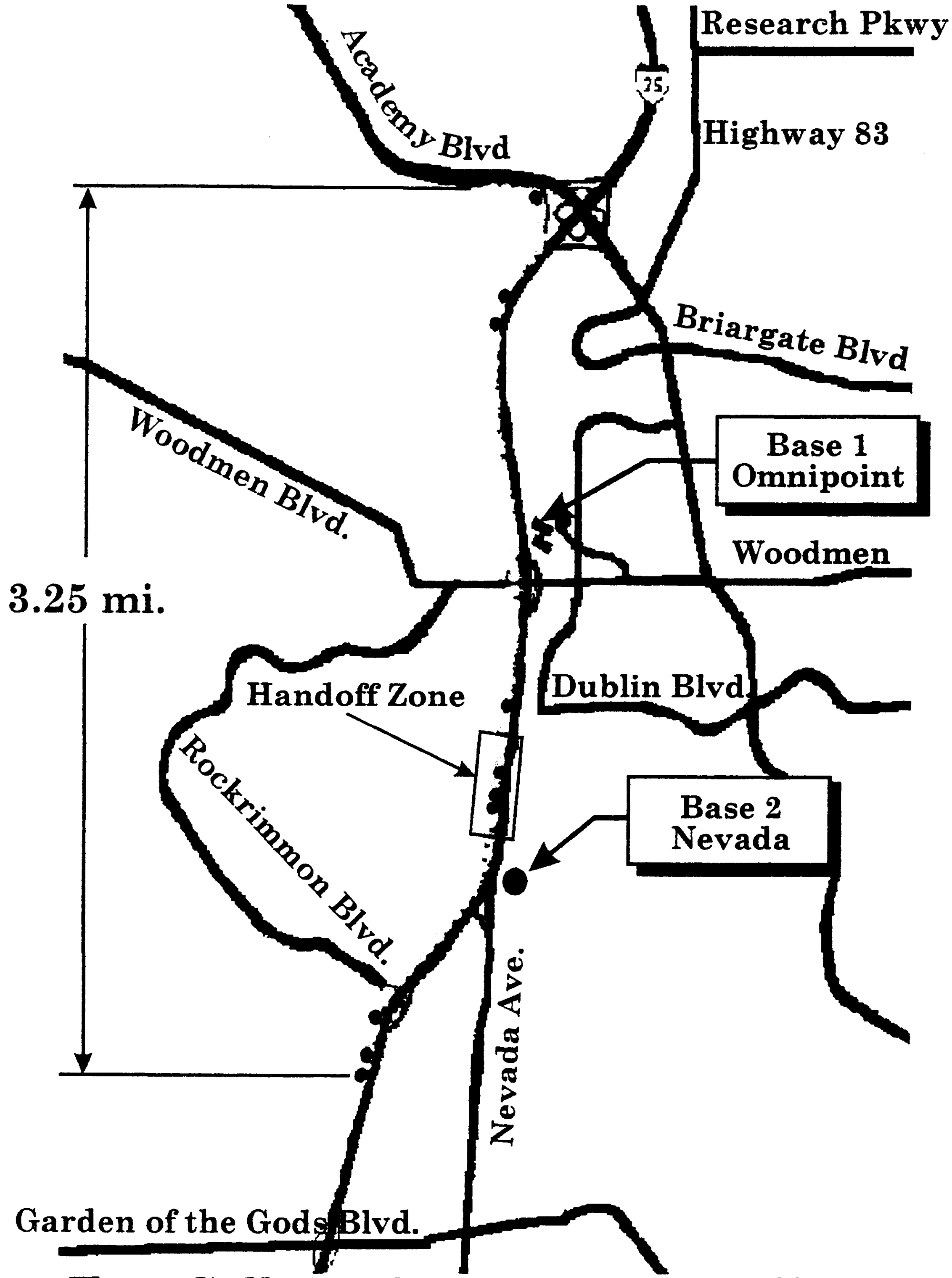
Figure 1-16



Cragin Street
Sig >= -85dBm
Sig >= -95dBm
Cragin & Heath
Omnipoint Building
Reed Street
SOUTH GATE
BOULEVARD
AQUEDUCT
Visitors Center
Chapel Hill Mall
High Plains School
Substa
WOODMEN
ROAD
Parking
Rockrimmon School
Foothills School
Park
Cottonwood
DUBLIN
BLVD
Pulpit Rock Park
Pikeview

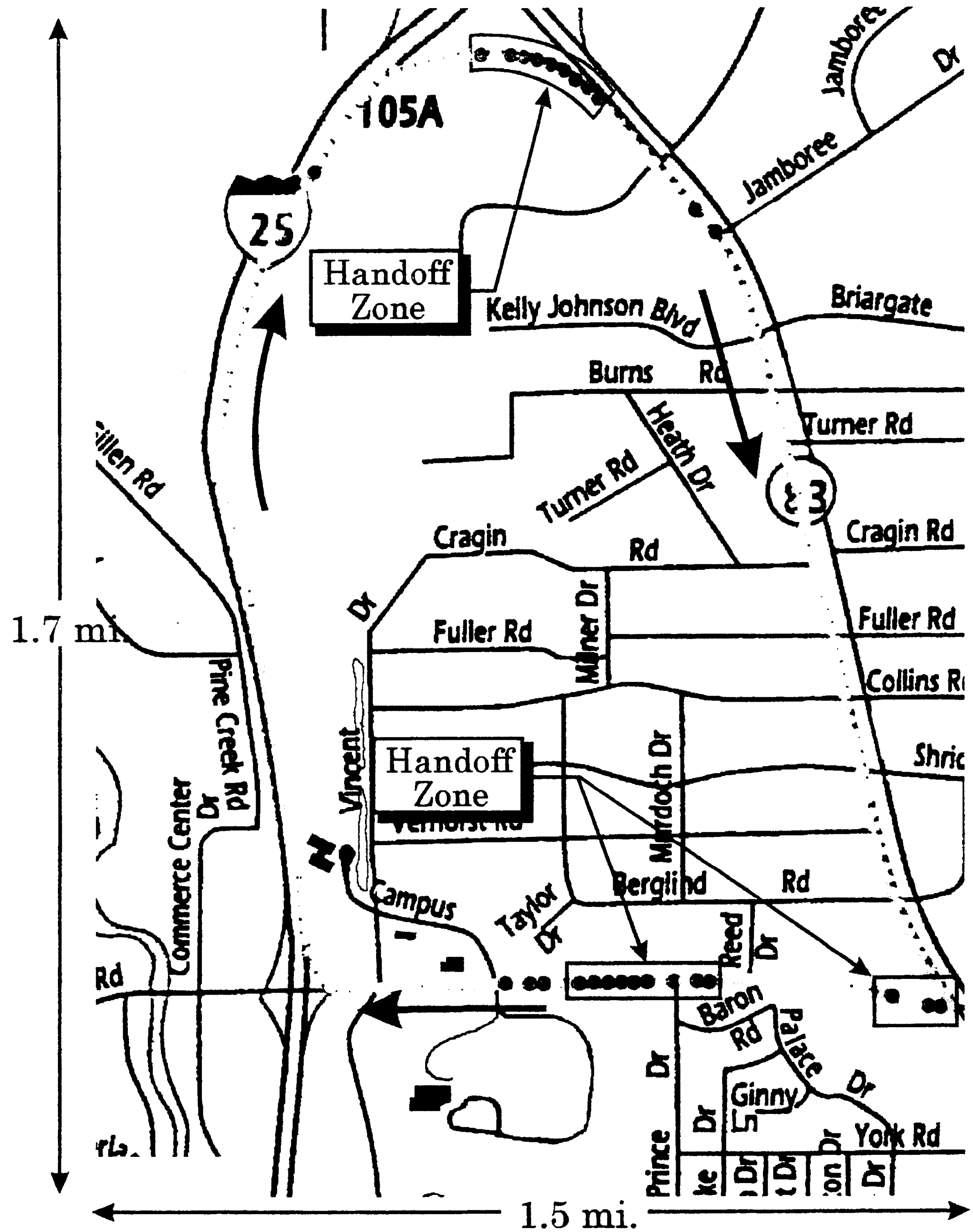
Figure 2-3

Omnipoint CORPORATION



Two Cell, High Speed Hand-off Test

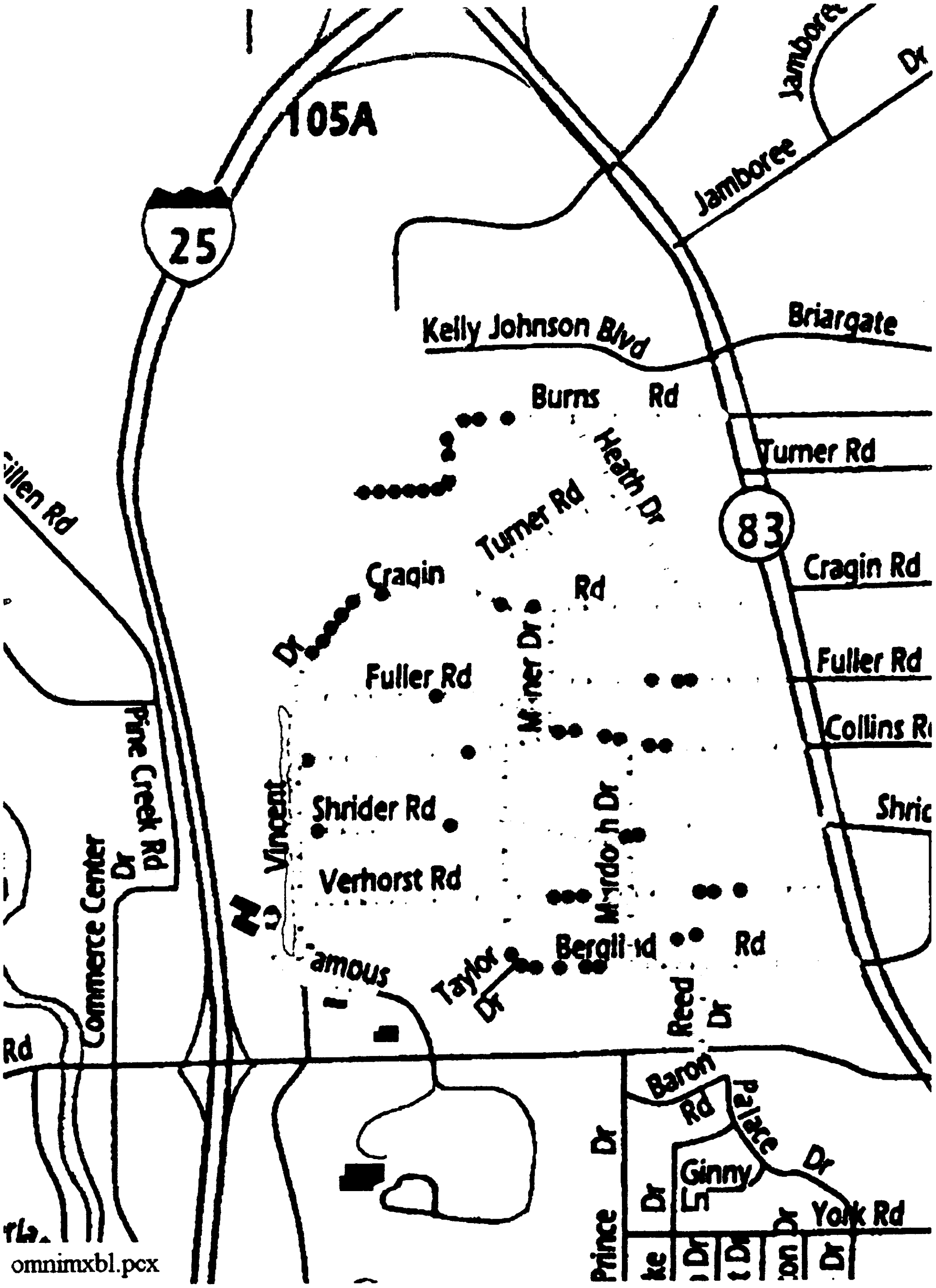
coslx01c.cdr



Northeast Residential Quadrant Perimeter High Speed Test

coslp03.cdr

Omnipoint
CORPORATION



Northeast Residential Quadrant Neighborhood Low Speed Test

cosnb01.cdr

Experimental License Progress Report - August 1993

Figure 2-7

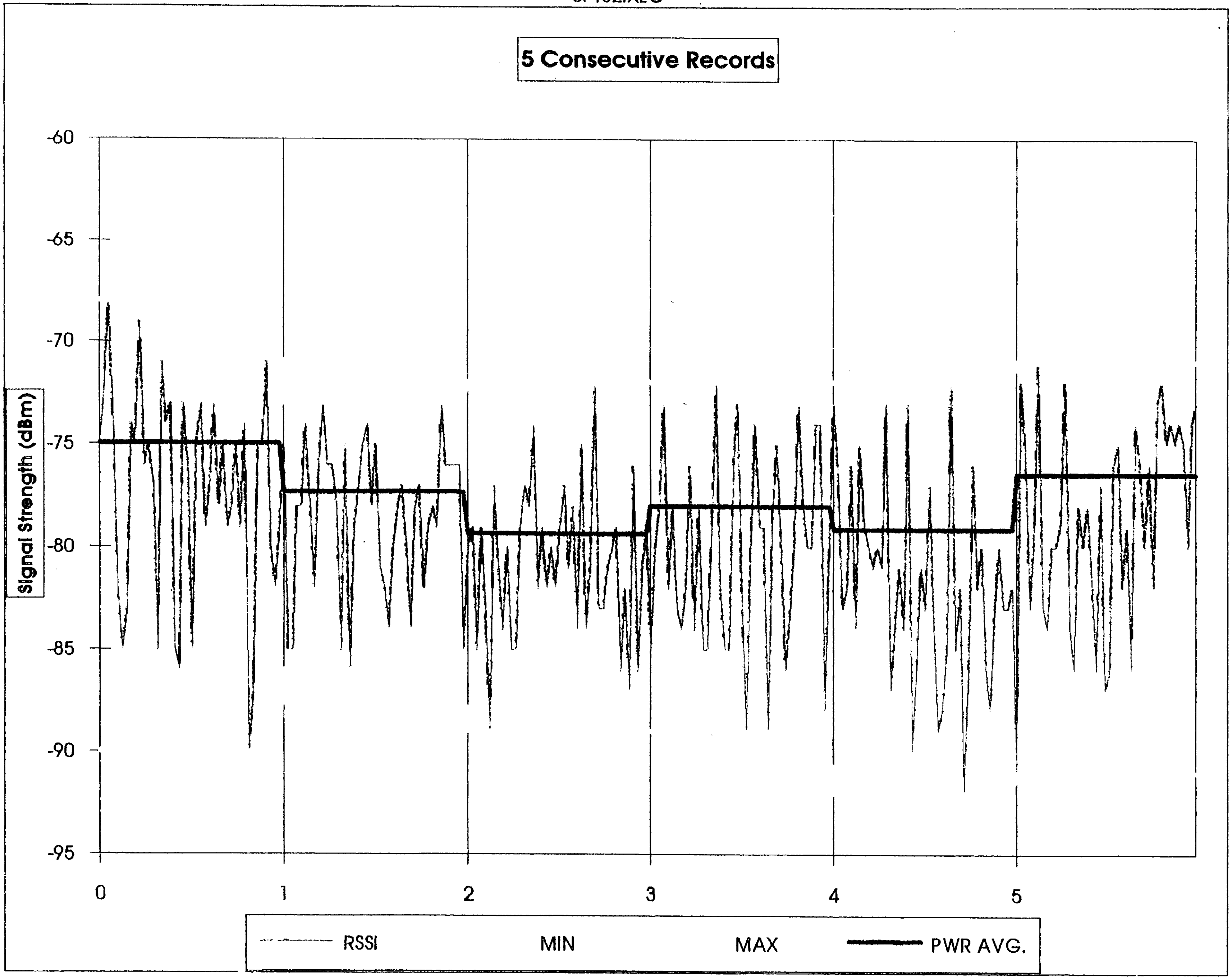

5 Consecutive Records
Signal Strength (dBm)
-60
-65
-70
-75
-80
-85
-90
-95
0
1
2
3
4
5
RSSI
MIN
MAX
PWR AVG.

Figure 2-8

COVERAGE CHANNEL PLOT
Coverage Type: Average

Market: ERP NRMLZD TO 0.2 W
Client: BS-8: PARK & 50TH
08/14/93 23:06:59

File	Nav
PARK.MMA	ETAK
WD1.MMA	ETAK

Chan	Char	SAT
27	B	None
227	gt	None

LEGEND

CMA V4.0
LCC Inc.

Threshold Values
(dBm)

-85 + M
Sig >= -90 + M
-95 + M
Sig >= -100 + M
-105 + M
-110 + M

M = Fade Margin
M_{LOS} = 18 dB
$M_{Non\text{-}LOS}$ = 21 dB

Miles
0 0.1 0.2

SCALE: 1:8,000

Figure 1-17

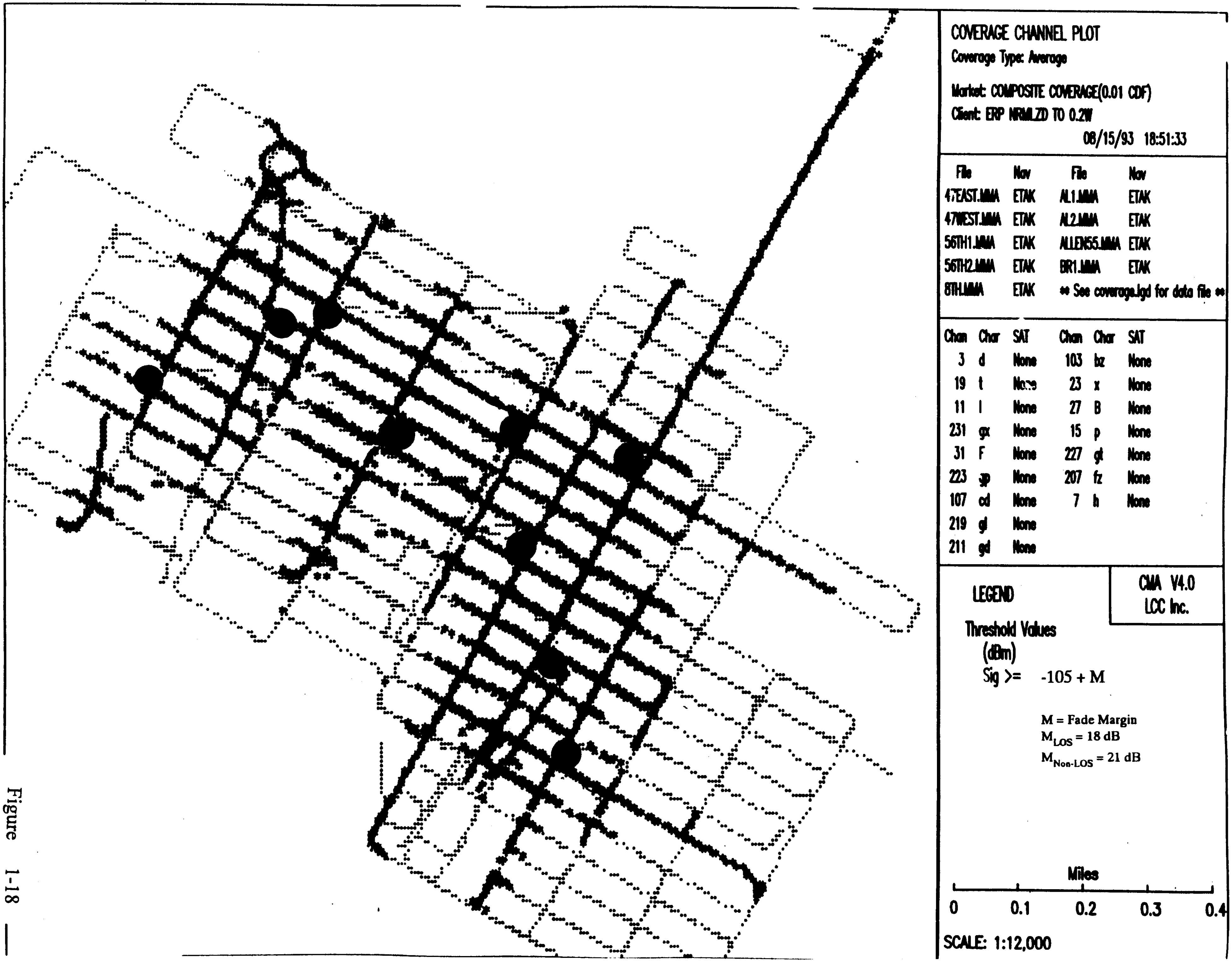

COVERAGE CHANNEL PLOT
Coverage Type: Average
Market: COMPOSITE COVERAGE(0.01 CDF)
Client: ERP NRMLZD TO 0.2W
08/15/93 18:51:33
File Nav File Nav
47EAST.MMA ETAK AL1.MMA ETAK
47WEST.MMA ETAK AL2.MMA ETAK
56TH1.MMA ETAK ALLEN55.MMA ETAK
56TH2.MMA ETAK BR1.MMA ETAK
8TH.MMA ETAK ** See coverage.lgd for data file **
Chan Char SAT Chan Char SAT
3 d None 103 bz None
19 t None 23 x None
11 l None 27 B None
231 gx None 15 p None
31 F None 227 gt None
223 gp None 207 fz None
107 cd None 7 h None
219 gl None
211 gd None
LEGEND
CMA V4.0
LCC Inc.
Threshold Values
(dBm)
Sig >= -105 + M
M = Fade Margin
M_{LOS} = 18 dB
$M_{Non-LOS}$ = 21 dB
Miles
0 0.1 0.2 0.3 0.4
SCALE: 1:12,000

Figure 1-18

STF11_93.XLS Chart 6

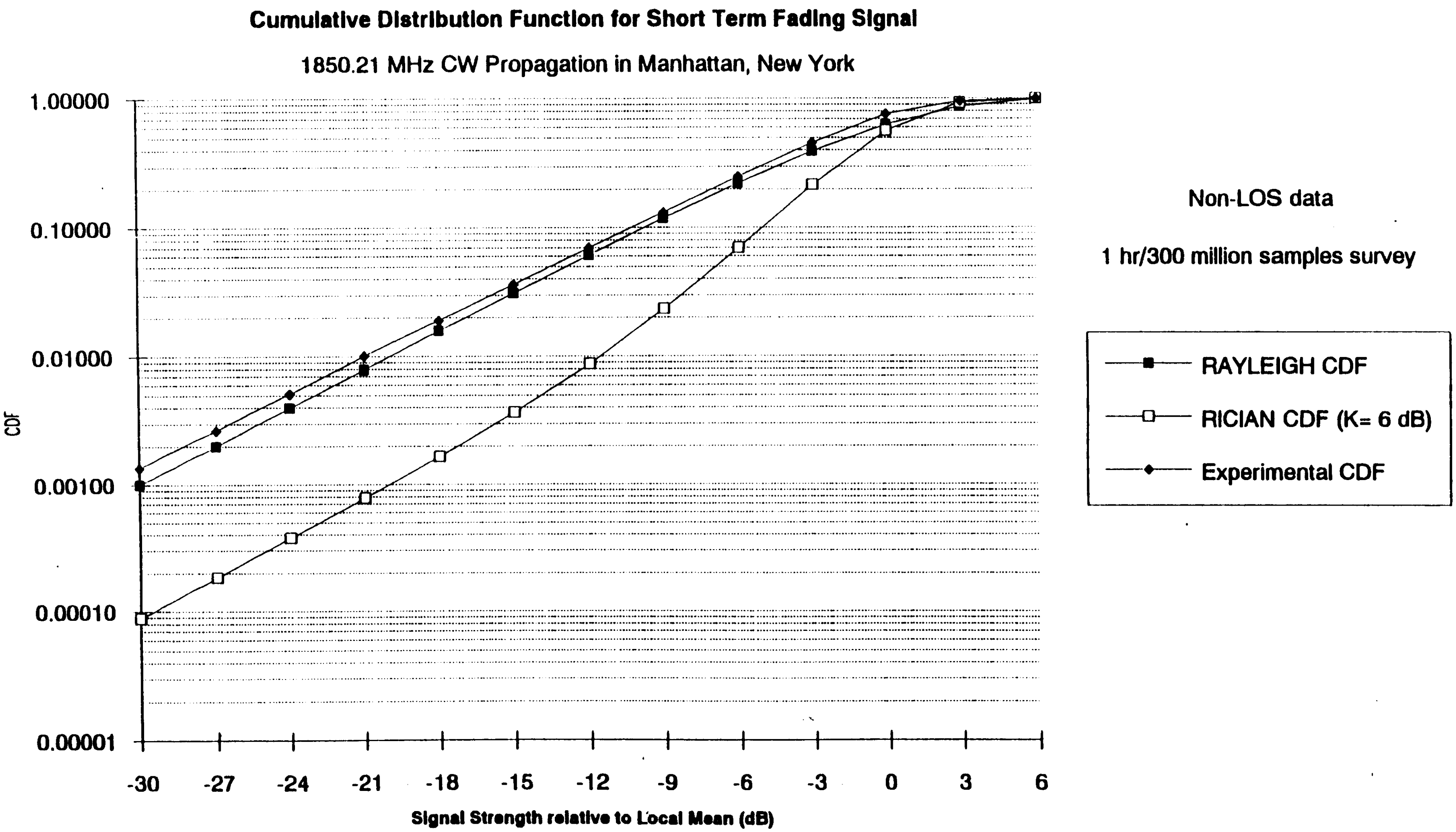


Figure 1-19

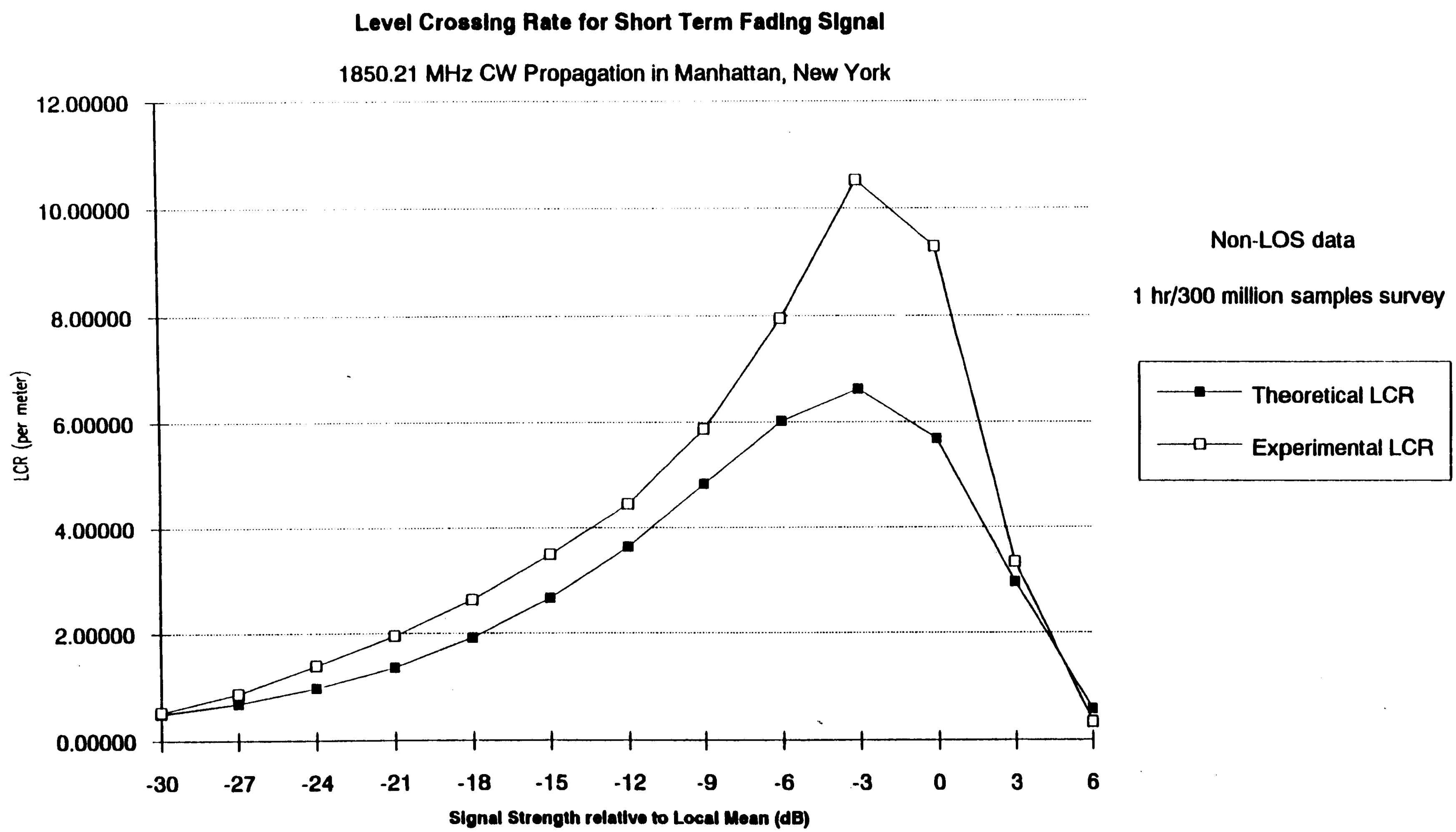

Level Crossing Rate for Short Term Fading Signal
1850.21 MHz CW Propagation in Manhattan, New York
12.00000
10.00000
8.00000
6.00000
4.00000
2.00000
0.00000
LCR (per meter)
-30
-27
-24
-21
-18
-15
-12
-9
-6
-3
0
3
6
Signal Strength relative to Local Mean (dB)
Non-LOS data
1 hr/300 million samples survey
Theoretical LCR
Experimental LCR

Figure 1-20

STF11_93.XLS Chart 8

Average Duration of Fades for Short Term Fading Signal

1850.21 MHz CW Propagation in Manhattan, New York

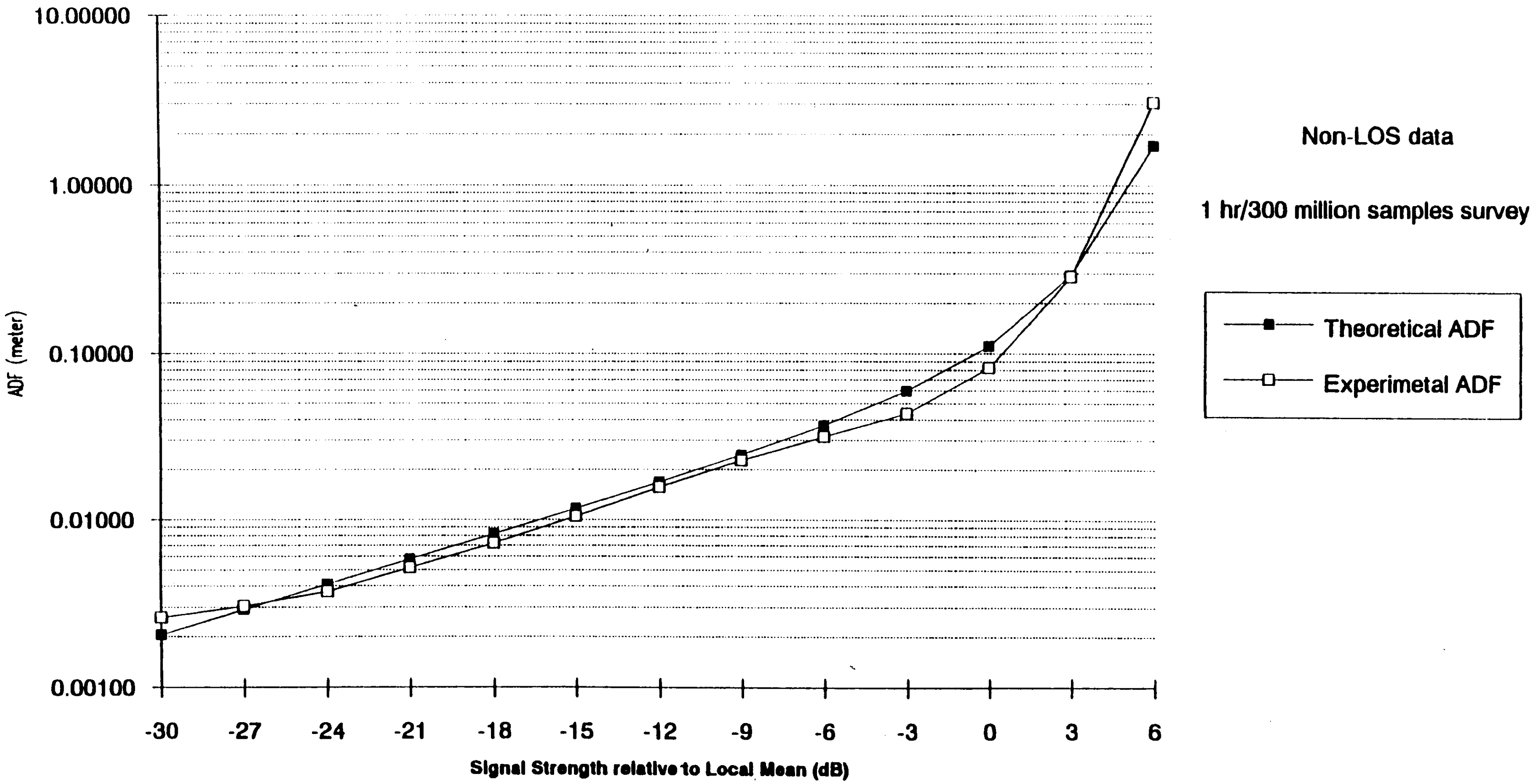


Figure 1-21

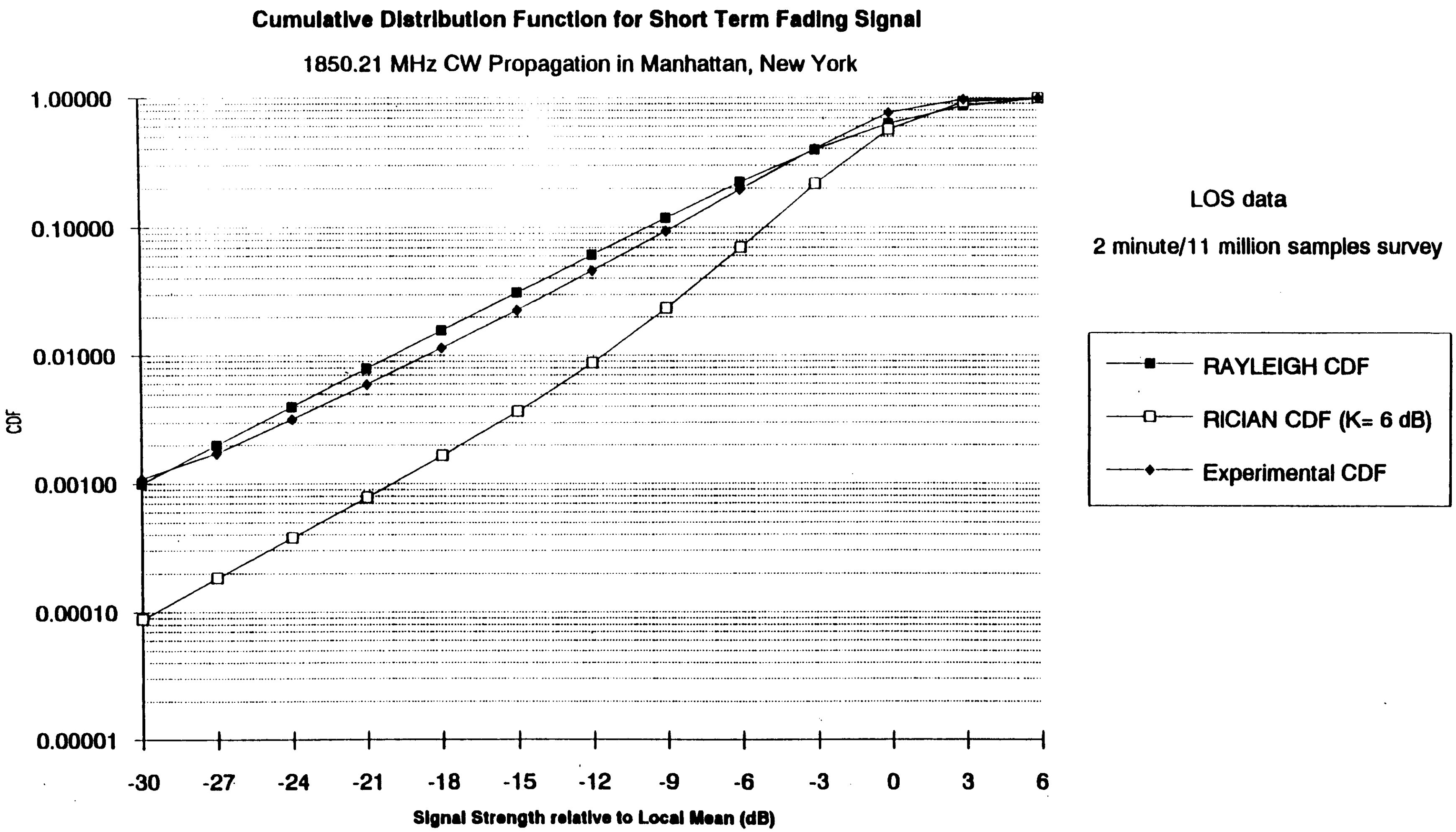

Cumulative Distribution Function for Short Term Fading Signal
1850.21 MHz CW Propagation in Manhattan, New York
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
CDF
-30
-27
-24
-21
-18
-15
-12
-9
-6
-3
0
3
6
Signal Strength relative to Local Mean (dB)
LOS data
2 minute/11 million samples survey
RAYLEIGH CDF
RICIAN CDF (K= 6 dB)
Experimental CDF

Figure 1-22

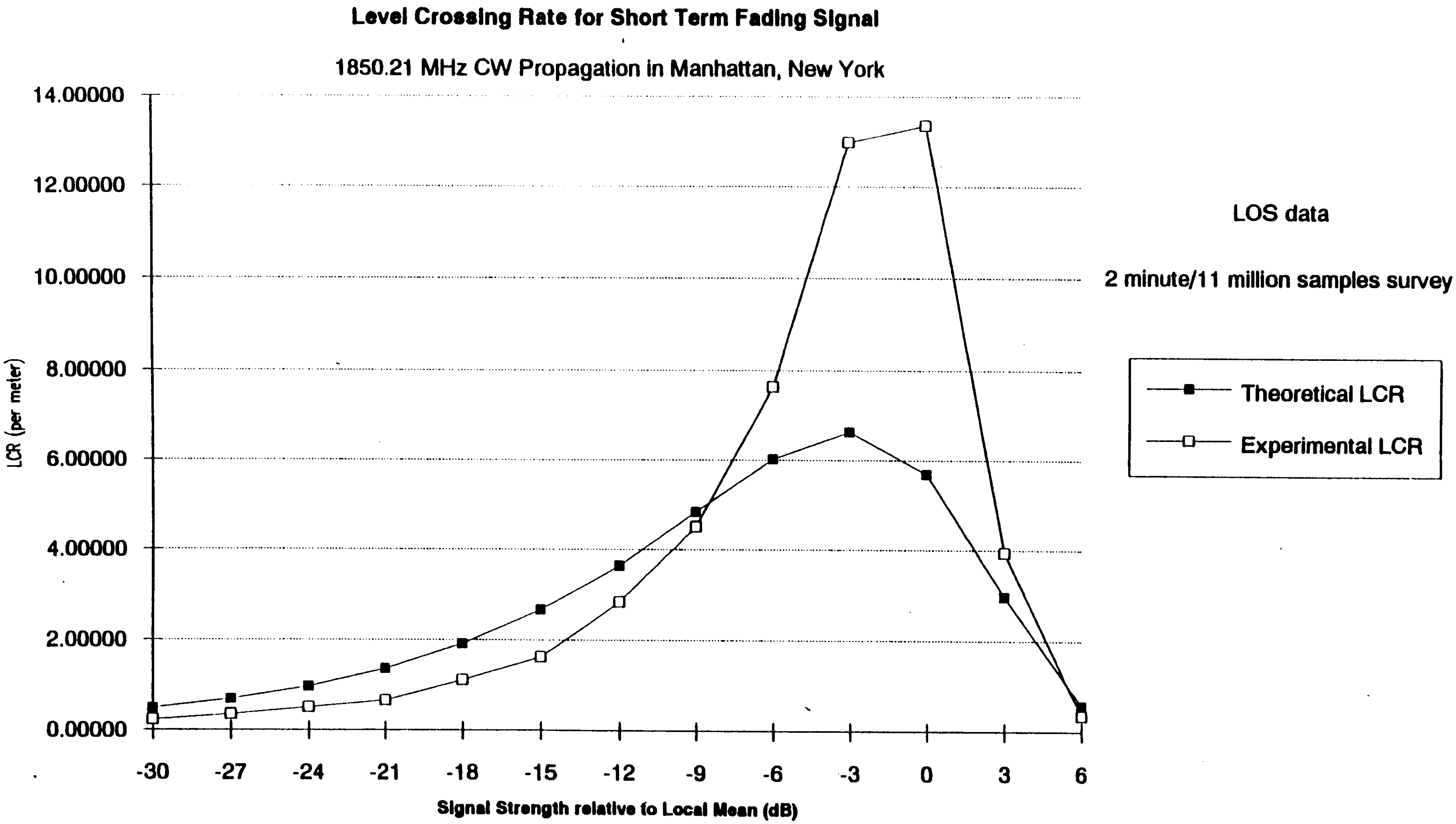

Level Crossing Rate for Short Term Fading Signal
1850.21 MHz CW Propagation in Manhattan, New York
14.00000
12.00000
10.00000
8.00000
6.00000
4.00000
2.00000
0.00000
LCR (per meter)
-30
-27
-24
-21
-18
-15
-12
-9
-6
-3
0
3
6
Signal Strength relative to Local Mean (dB)
LOS data
2 minute/11 million samples survey
Theoretical LCR
Experimental LCR

Figure 1-23

STF99_00.XLS Chart 8

Average Duration of Fades for Short Term Fading Signal

1850.21 MHz CW Propagation in Manhattan, New York

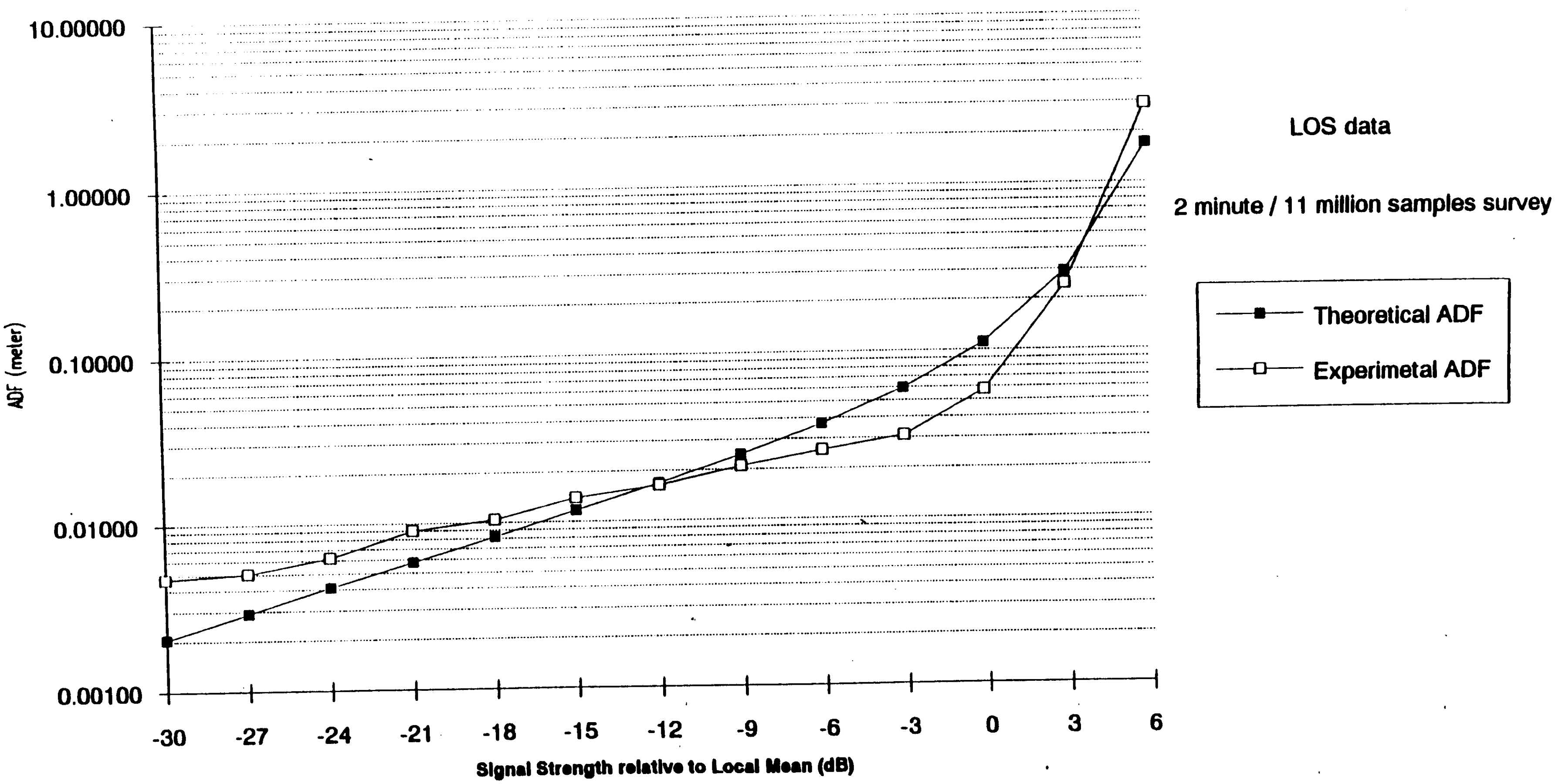
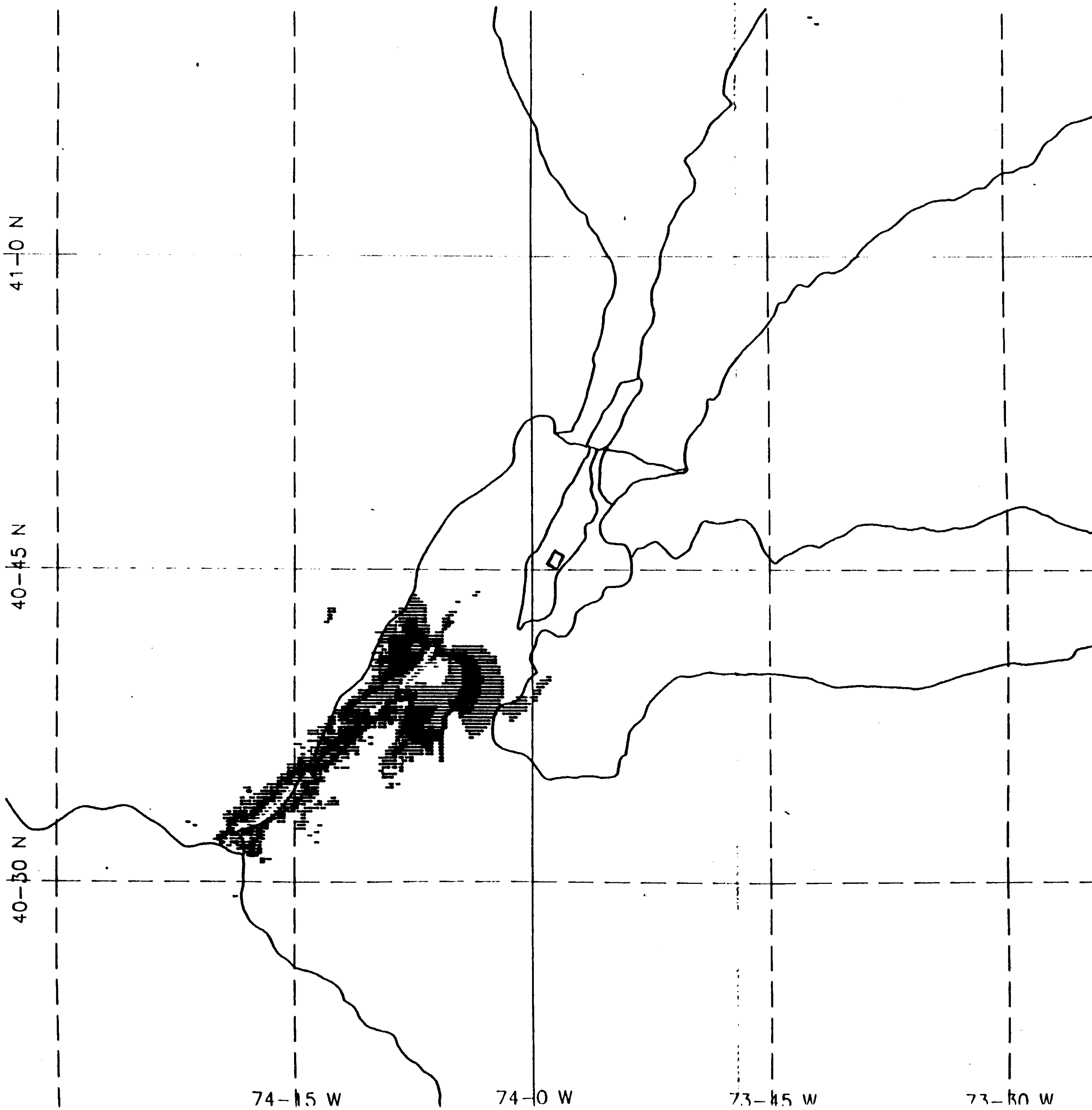


Figure 1-



DEMO MARKET
BEST SERVER (LINE COLOR = dBm)
Test 1910-1930
DEMO MARKET
Wed Aug 4 10:42:32 1993
Group : 500 1910-1930 Test
L:\PLOT\00FE

SITE: BAYONNE M-0023-12 ST: AAW
LAT: 40-40-59 N LNG: 74- 5-58 W STN: V6 AW
ANT: ANFCCANTENNA ORTN: 227°TN ERP: 147.910 W
CF: 0.0dB DT: 0° GE: 16.0m TXHT: 30.0m

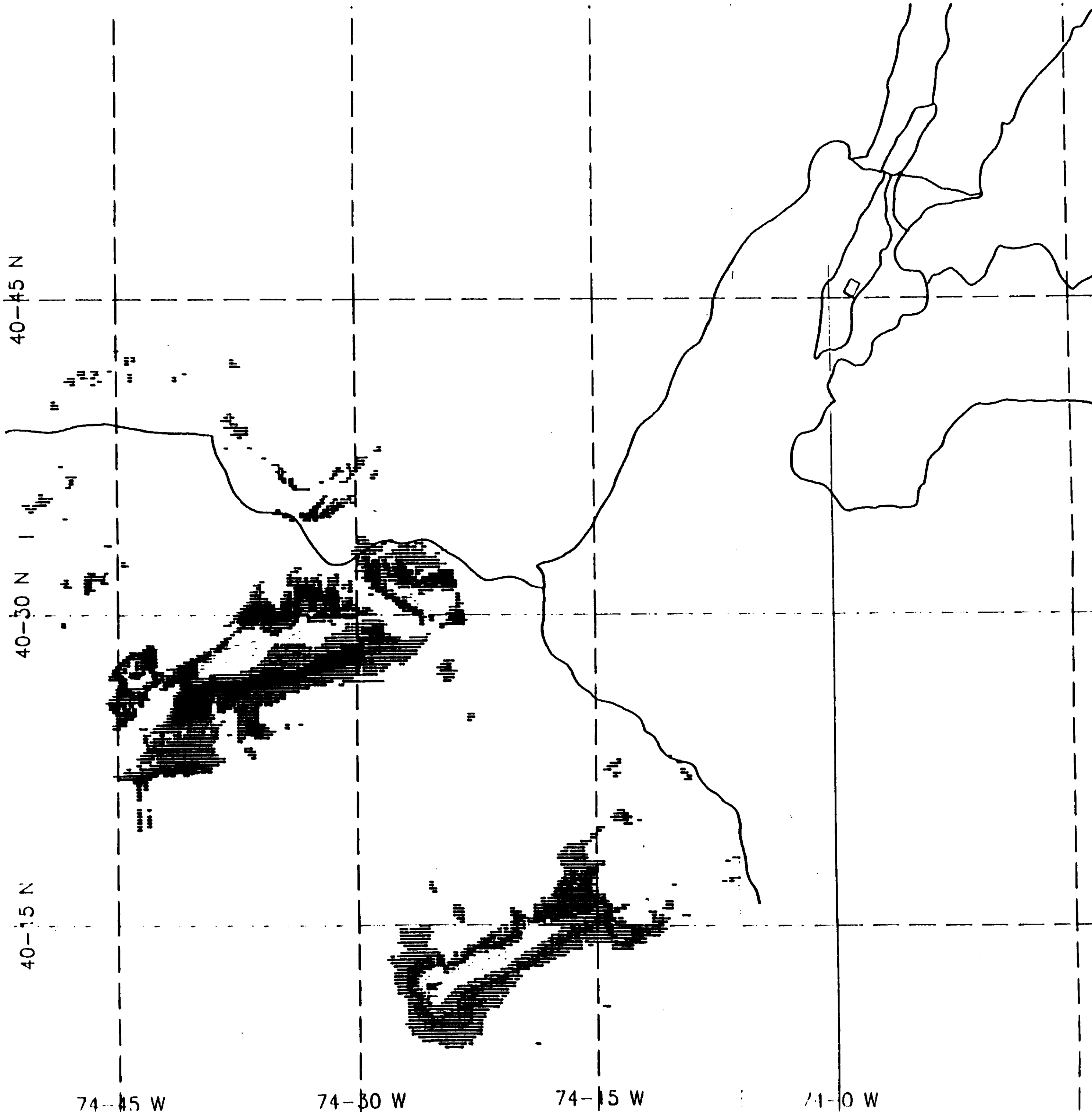
SITE: WOODBRIDGE M-0023-21 ST: MMW
LAT: 40-32-20 N LNG: 74-18- 1 W STN: V6 MW
ANT: ANFCCANTENNA ORTN: 47°TN ERP: 131.830 W
CF: 0.0dB DT: 0° GE: 30.0m TXHT: 32.0m

THRESHOLDS:
Signal >= -93 dBm
Signal >= -103 dBm
Signal >= -108 dBm
Signal >= -113 dBm

ANET v1.5
V1.51ML
LCC Inc.
DNLK

Kilometers
0.00 12.0 24.0

SCALE: 1:500,000 USER :



DEMO MARKET
BEST SERVER (LINE COLOR = dBm)
Test 1970 Transmitters
NEW YORK CITY
Wed Aug 4 10:25:43 1993
Group : 131 Group 1970
L:\PLOT\00EF

SITE: SCHOOLHSE L M-0012-21 ST: MML
LAT: 40-12- 2 N LNG: 74-25-29 W STN: V6 ML
ANT: ANFCCANTENNA ORTN: 65°TN ERP: 831.760 W
CF: 0.0dB DT: 0° GE: 75.0m TXHT: 46.0m

SITE: SOURLAND MT M-0019-21 ST: MMS
LAT: 40-27- 6 N LNG: 74-43-57 W STN: V6 MS
ANT: ANFCCANTENNA ORTN: 75°TN ERP: 537.030 W
CF: 0.0dB DT: 0° GE: 152.0m TXHT: 37.0m

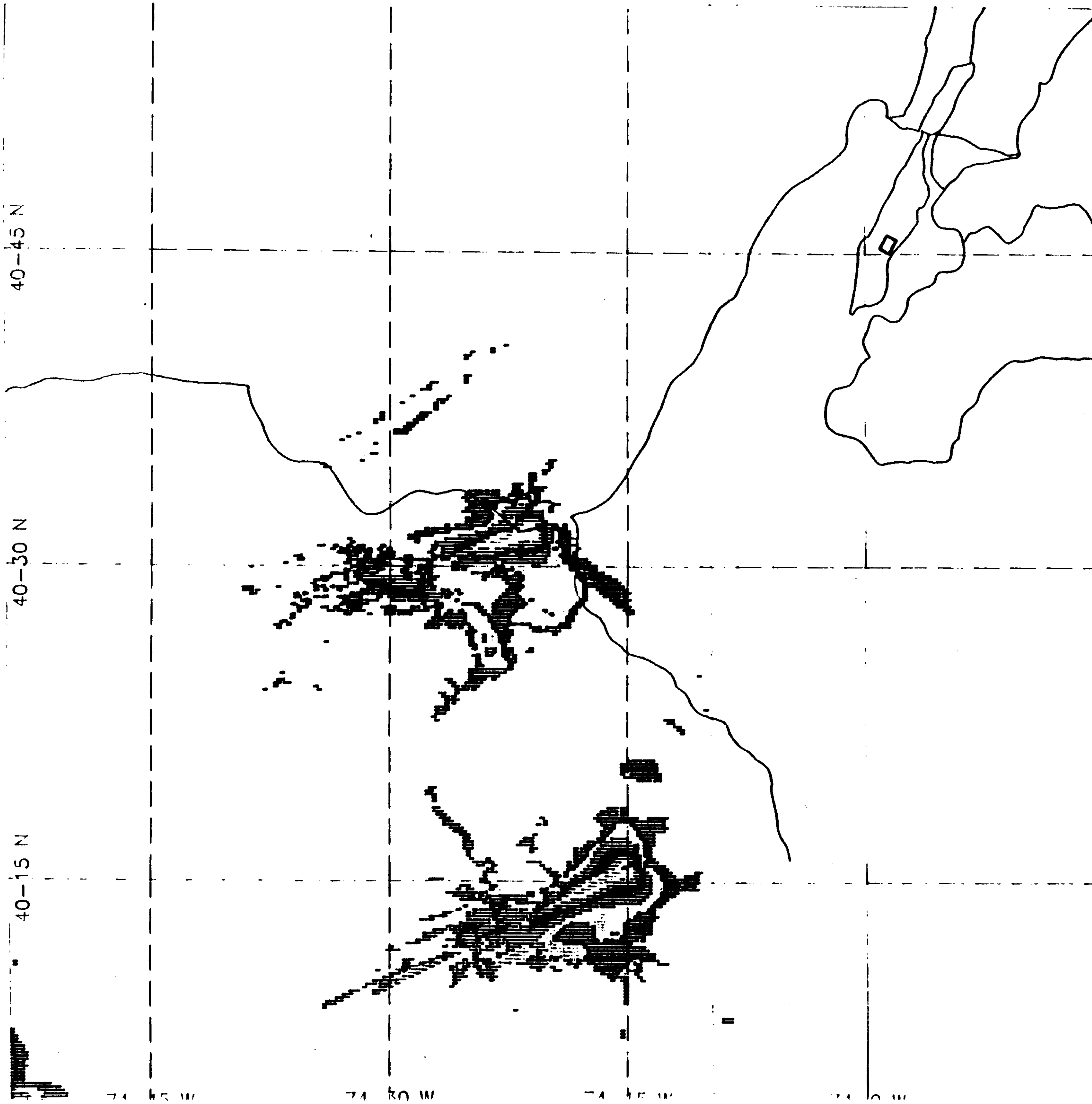
THRESHOLDS:

Signal >= -91 dBm
Signal >= -101 dBm
Signal >= -106 dBm
Signal >= -111 dBm

ANET v1.5
V1.51ML
LCC Inc.
DNLK

Kilometers
0.00 12.0 24.0

SCALE: 1:500,000 USER : MLAVIN



DEMO MARKET
BEST SERVER (LINE COLOR = dBm)
Test 1970 Receivers
NEW YORK CITY
Wed Aug 4 10:29:07 1993
Group : 223 Rec 1970
L:\PLOT\00B8

SITE: POLICE M-0012-12 ST: AAL
LAT: 40-15-51 N LNG: 74-14-46 W STN: V6 AL
ANT: ANFCCANTENNA ORTN: 245°TN ERP: 831.760 W
CF: -8.0dB DT: 0° GE: 58.0m TXHT: 41.0m

SITE: PIERSON ST M-0019-12 ST: AAS
LAT: 40-31-51 N LNG: 74-20-36 W STN: V6 AS
ANT: ANFCCANTENNA ORTN: 255°TN ERP: 426.580 W
CF: -6.0dB DT: 0° GE: 29.0m TXHT: 40.0m

THRESHOLDS:
--- Signal >= -93 dBm
--- Signal >= -103 dBm
---- **Signal >= -108 dBm**
--- Signal >= -113 dBm
· Signal >= -118 dBm
·-· Signal >= -123 dBm

ANET v1.5
V1.51ML
LCC Inc.

DNLK

Kilometers

0.00 12.0 24.0


Public Microcell

STF11_93.XLS Chart 8

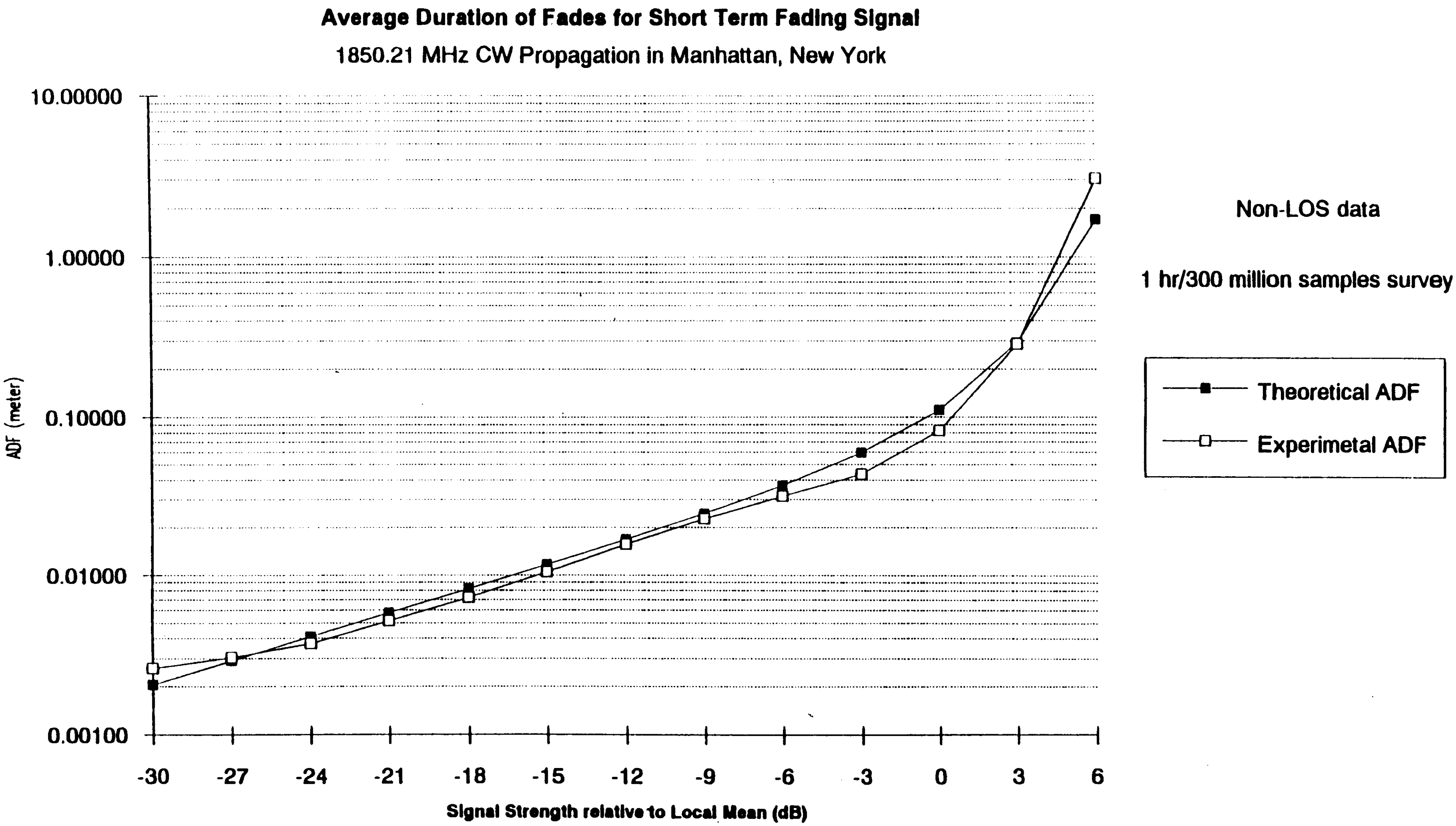


Figure 1-21

STF99_00.XLS Chart 6

Cumulative Distribution Function for Short Term Fading Signal

1850.21 MHz CW Propagation in Manhattan, New York

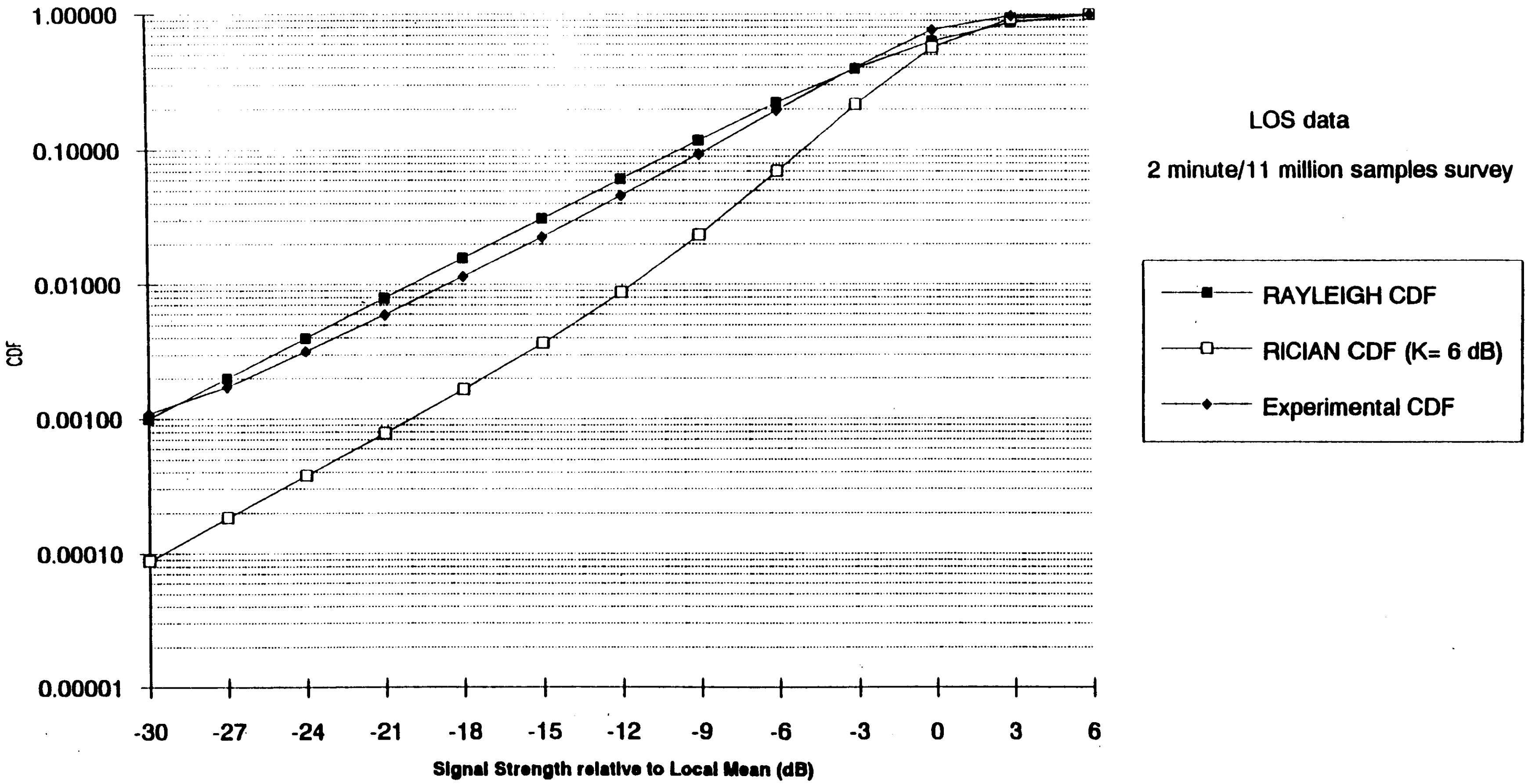


Figure 1-22

STF99_00.XLS Chart 7

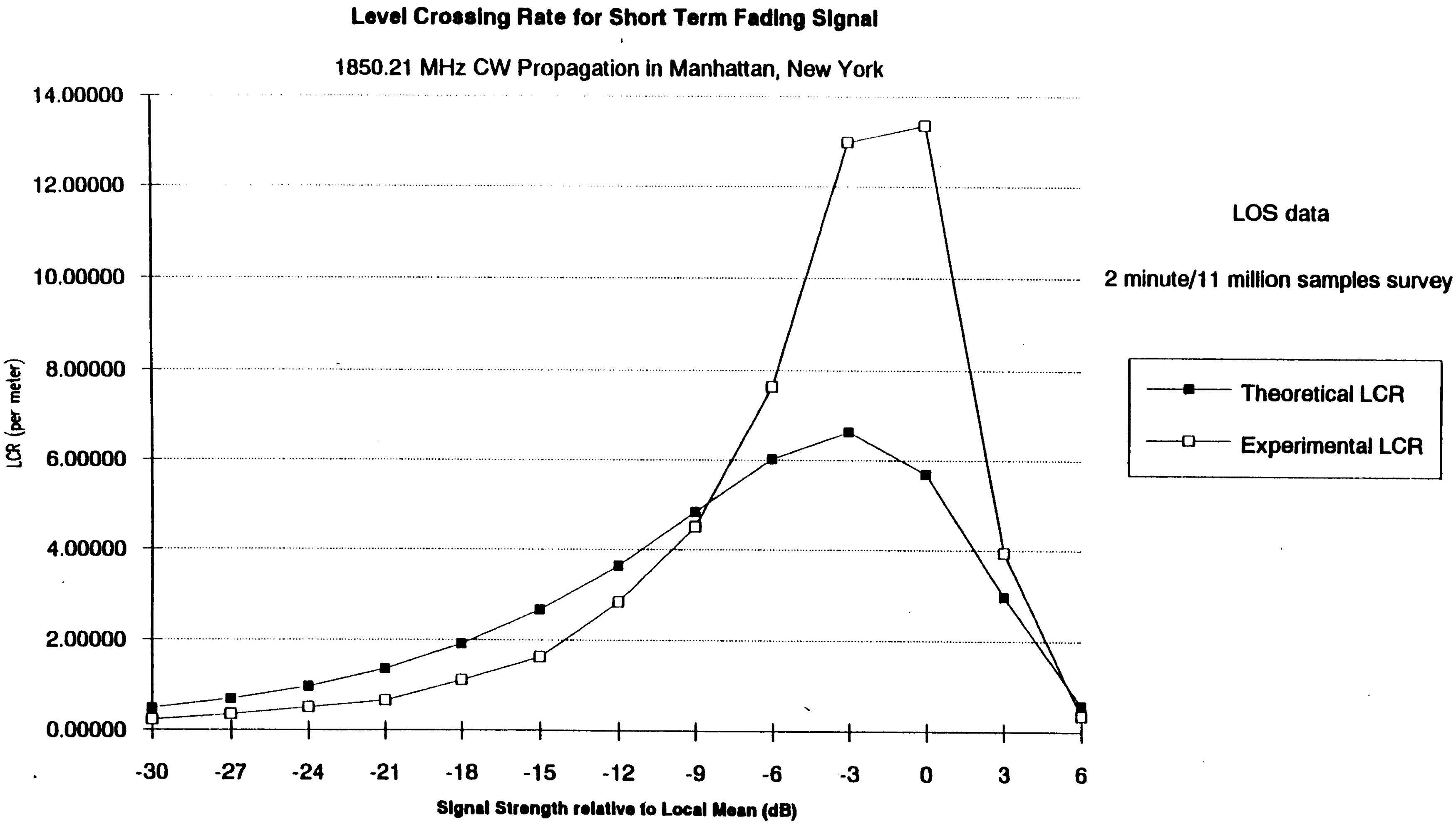


Figure 1-23

STF99_00.XLS Chart 8

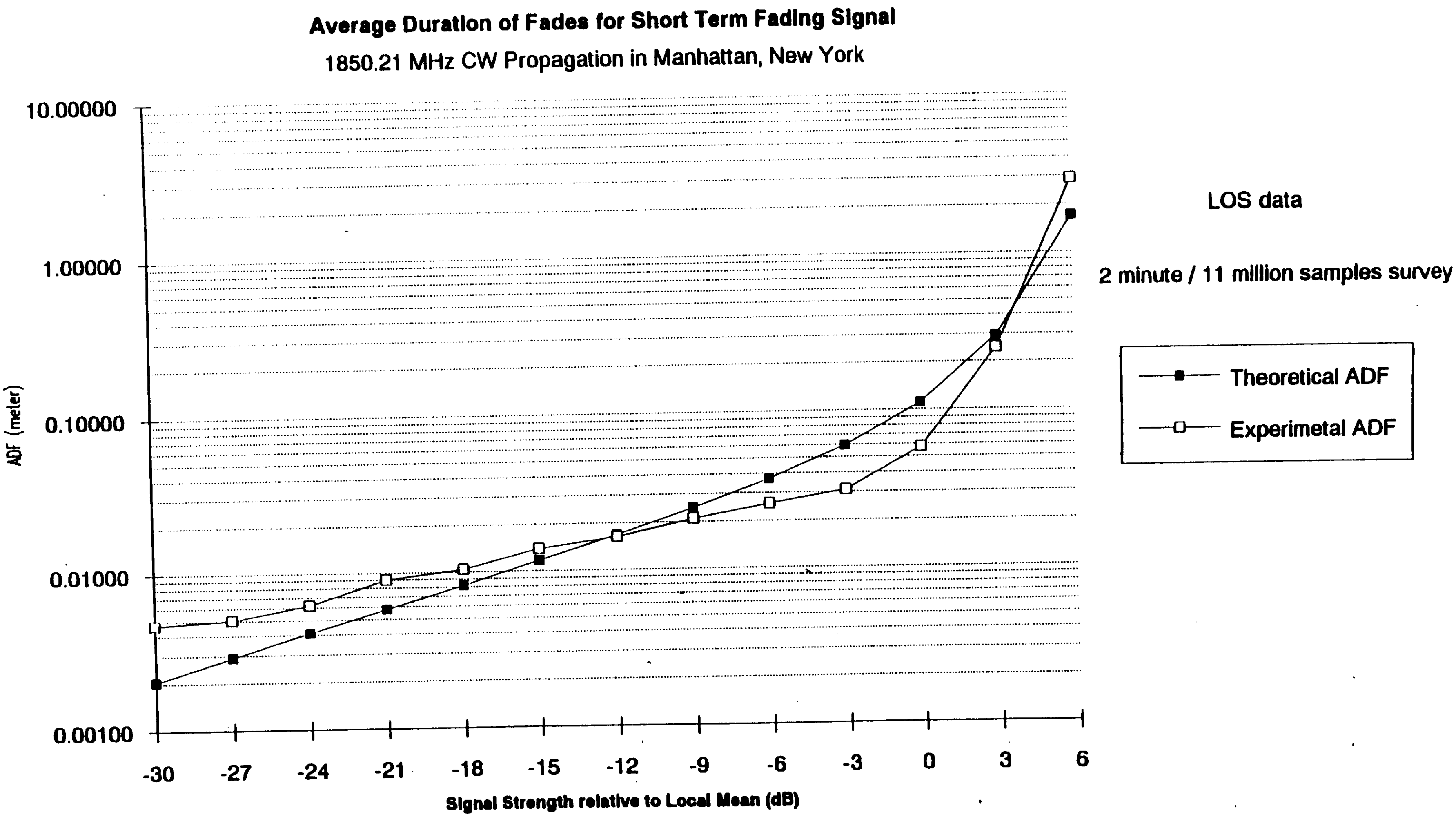
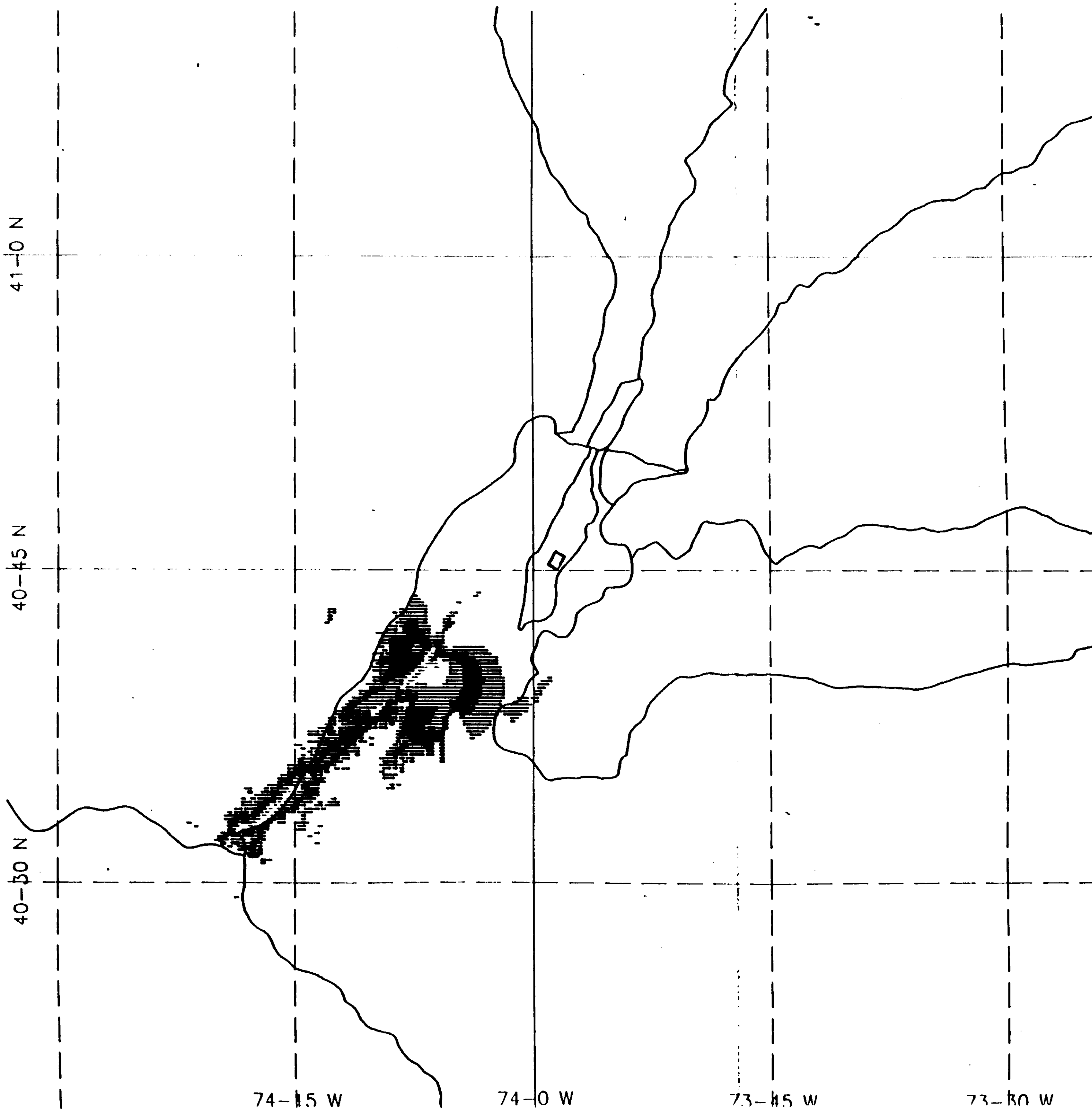


Figure 1-



DEMO MARKET
BEST SERVER (LINE COLOR = dBm)
Test 1910-1930
DEMO MARKET
Wed Aug 4 10:42:32 1993
Group : 500 1910-1930 Test
L:\PLOT\00FE

SITE: BAYONNE M-0023-12 ST: AAW
LAT: 40-40-59 N LNG: 74- 5-58 W STN: V6 AW
ANT: ANFCCANTENNA ORTN: 227°TN ERP: 147.910 W
CF: 0.0dB DT: 0° GE: 16.0m TXHT: 30.0m

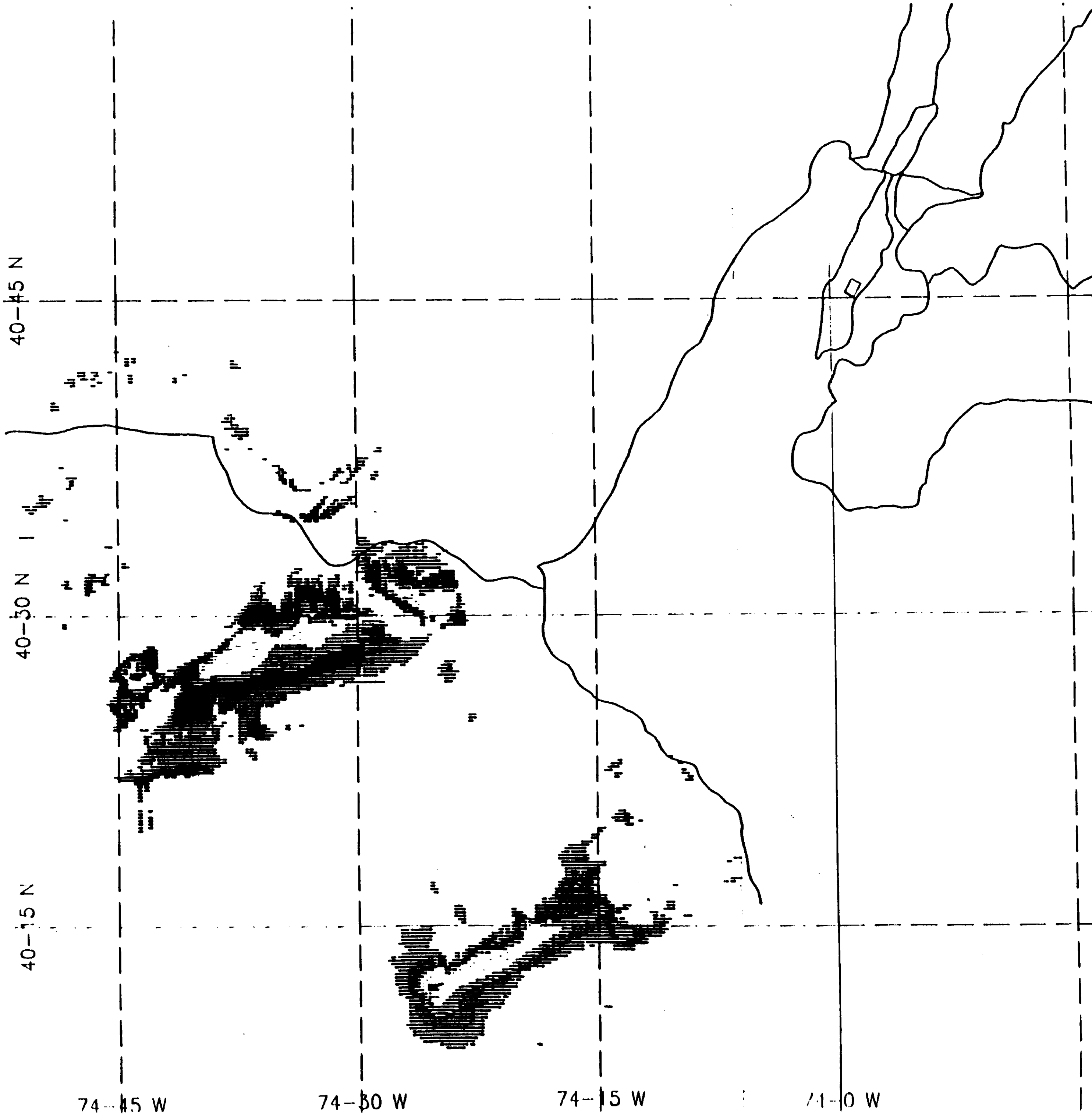
SITE: WOODBRIDGE M-0023-21 ST: MMW
LAT: 40-32-20 N LNG: 74-18- 1 W STN: V6 MW
ANT: ANFCCANTENNA ORTN: 47°TN ERP: 131.830 W
CF: 0.0dB DT: 0° GE: 30.0m TXHT: 32.0m

THRESHOLDS:
Signal >= -93 dBm
Signal >= -103 dBm
Signal >= -108 dBm
Signal >= -113 dBm

ANET v1.5
V1.51ML
LCC Inc.
DNLK

Kilometers
0.00 12.0 24.0

SCALE: 1:500,000 USER: MLAWN



DEMO MARKET
BEST SERVER (LINE COLOR = dBm)
Test 1970 Transmitters
NEW YORK CITY
Wed Aug 4 10:25:43 1993
Group : 131 Group 1970
L:\PLOT\00EF

SITE: SCHOOLHSE L M-0012-21 ST: MML
LAT: 40-12- 2 N LNG: 74-25-29 W STN: V6 ML
ANT: ANFCCANTENNA ORTN: 65°TN ERP: 831.760 W
CF: 0.0dB DT: 0° GE: 75.0m TXHT: 46.0m

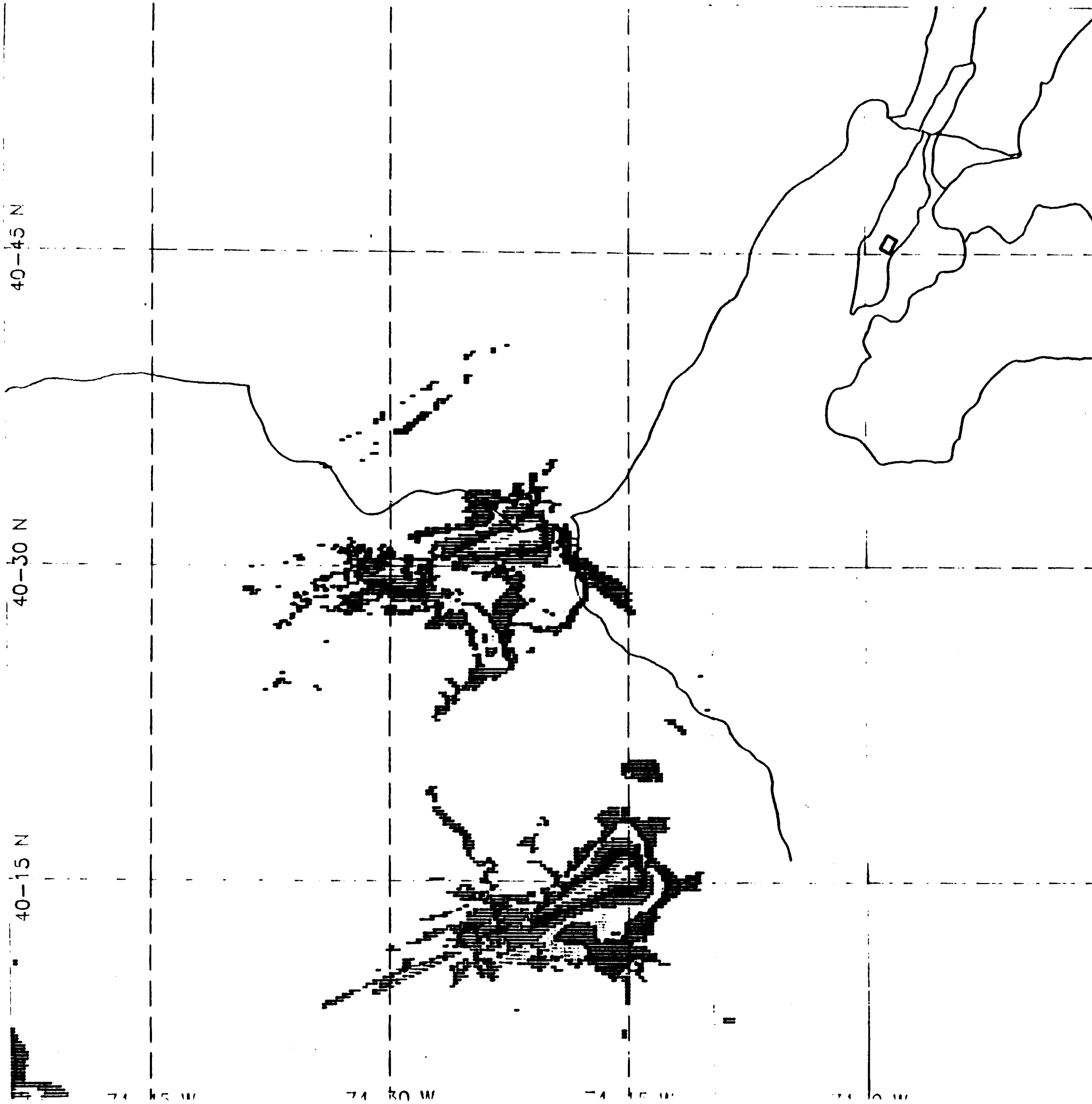
SITE: SOURLAND MT M-0019-21 ST: MMS
LAT: 40-27- 6 N LNG: 74-43-57 W STN: V6 MS
ANT: ANFCCANTENNA ORTN: 75°TN ERP: 537.030 W
CF: 0.0dB DT: 0° GE: 152.0m TXHT: 37.0m

THRESHOLDS:
Signal >= -91 dBm
Signal >= -101 dBm
Signal >= -106 dBm
Signal >= -111 dBm

ANET v1.5
V1.51ML
LCC Inc.
DNLK

Kilometers
0.00 12.0 24.0

SCALE: 1:500,000 USER : MLAVIN



DEMO MARKET
BEST SERVER (LINE COLOR = dBm)
Test 1970 Receivers
NEW YORK CITY
Wed Aug 4 10:29:07 1993
Group : 223 Rec 1970
L:\PLOT\00B8

SITE: POLICE M-0012-12 ST: AAL
LAT: 40-15-51 N LNG: 74-14-46 W STN: V6 AL
ANT: ANFCCANTENNA ORTN: 245'TN ERP: 831.760 W
CF: -8.0dB DT: 0' GE: 58.0m TXHT: 41.0m

SITE: PIERSON ST M-0019-12 ST: AAS
LAT: 40-31-51 N LNG: 74-20-36 W STN: V6 AS
ANT: ANFCCANTENNA ORTN: 255'TN ERP: 426.580 W
CF: -6.0dB DT: 0' GE: 29.0m TXHT: 40.0m

THRESHOLDS:
--- Signal >= -93 dBm
--- Signal >= -103 dBm
—— Signal >= -108 dBm
--- Signal >= -113 dBm
· Signal >= -118 dBm
-·- Signal >= -123 dBm

ANET v1.5
V1.51ML
LCC Inc.
DNLK

Kilometers
0.00 12.0 24.0

LCC Incorporated

August 17, 1993

To whom it may concern:

LCC has participated in tests with Omnipoint over the last several months including tests for New York City and Colorado Springs. The purpose of the tests is to verify various design assumptions and create valid design rules for constructing a personal communications network using the Omnipoint system. The tests involved set up of test transmitters, extensive data collection on streets and in buildings, and data processing and analysis to allow support of test conclusions. The data collected, analysis, and conclusions are contained in this report. Further, LCC personnel verified and replicated the performance of the Omnipoint system in Manhattan with respect to the coverage plots and drive tests. I validate that all data, analysis, and conclusions are correct and accurately reflect the characteristics found for personal communications.

Louis Olsen

Louis Olsen
Director of Engineering

Arlington Courthouse Plaza II 2300 Clarendon Boulevard, Suite 800 Arlington, Va. 22201 (703) 351-6666 Fax (703) 516-4950

Attachment
OFS Sharing Revisited (Again)

Five months after the Reply deadline, Qualcomm requested a "Motion for Leave to File Supplemental Comments", in which they attached an 8 page Appendix A presenting their views on the OFS sharing problem. However, in Qualcomm's comparison of interference potential between Omnipoint's system and theirs, Qualcomm loads their cells with only one user, ignores disparities between FDD and TDD systems regarding frequency availability, and demonstrates an insensitivity to how a FDM-FM OFS receiver actually operates. At the same time, they make inaccurate claims about the architecture and performance of Omnipoints system. Further, they portray Omnipoint as distorting the American Personal Communications (APC) results,[1] denying the validity of Omnipoint's analysis by simply saying it isn't so while offering no corroborating experimental evidence.

Qualcomm's OFS Sharing Analysis is Severely Flawed in Several Ways

> *"Of course, because the narrowband signal occupies one one hundredth the bandwidth of the Omnipoint signal, it will cause interference to far fewer OFS users."* Qualcomm, Page 4 of Appendix A

Such a statement shows a lack of knowledge of the typical FDM-FM radio's signal structure and basic OFS operational characteristics. As an example, analog FDM-FM OFS transmissions universally use different but specific OFS narrowband frequencies for:

[1]Re: American Personal Communications KC2XDM, FCC File No. 2056-EX-ML-91, Tenth Progress Report. dated January 26,1993.

- AGC functions
- Space diversity combiner control
- Squelch control
- Link continuity monitoring
- Baseband SSB demodulation

Interference with any of these functions generally causes catastrophic OFS link failure. Even a single narrowband interferer can concentrate essentially all of it's energy in the spectral region of one of these control frequencies and thus drop the link with substantially less radiated power than a wideband system. A narrowband CDMA-only PCS system has the further problem that it layers the power of each user on top of the same OFS frequencies. **These control frequencies vary from vender to vender andequipment type to equipment type and are also dependent on FDM baseband groupings.** Qualcomm's statement that narrowband interferers harm a relative few channels, is quite simply, wrong and is just the type of assumption that will lead to damaging interference to incumbent OFS users.

As another example of how wrong Qualcomm is, many OFS users employ fixed FDM channel allocations and group routings to support required functions. For example, FDM channel 22 for one OFS link might be allocated to modem modulated data for control and monitoring of a particular pipeline valve, FDM channel 912 to another, and so on. Undetected disruption of any channel could lead to obvious problems. OFS provisioning doctrine is very different from common carrier doctrine because of the large number of "semi-permanent" connections and relative few alternate routings.

Qualcomm's Comparison of Omnipoint's System with CT-2 is Invalid

In their original January 29, 1993 comments on Omnipoint's system Qualcomm argues that:

> *"there is no significant difference in exclusion zone radius between Omnipoint's system and the generic narrowband system"*[2]

They base this on the following statement

> *"If Omnipoint's system transmits the same number of speech bits over the same RF channel using the same antenna as the CT-2 system, its average power would be comparable to that of the CT-2 system. Thus for example, an Omnipoint mobile transmitting 1 watt peak power is equivalent to the CT-2 system transmitting 40 milliwatts (50%/2% x 40 mW = 1 Watt)"*[3]

In their most recent attack they repeat this argument almost verbatim saying

> *"Clearly, both a narrowband system (say, the 100 kHz bandwidth) and a wideband system (Omnipoint's 10 MHz bandwidth) must transmit the same energy per bit to achieve the same link performance..."*[4]

There are several fundamental flaws in Qualcomm's argument. First, the notion that Omnipoint uses average power in our interference calculations is wrong; we do not and never have.

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[2]Page 20, Qualcomm 29 January 1993 filing

[3]ibid.

[4]page 1, Appendix A

Qualcomm then makes a rather lengthy argument about "temporal concentration" but the fact is, from the OFS user's perspective peak power is the important parameter. Qualcomm agrees with this statement:

"victim microwave receivers are sensitive to the peak power of the interfering waveform, not the average power."[5]

Note that Qualcomm's temporal concentration arguments based on range and bits per PCS channel of different PCS systems are irrelevant to the OFS user concerned about interference. The factor that is very relevant to the OFS user is aggregate peak PCS power, ie what is the peak power of each PCS transmitter and how many PCS transmitters are active simultaneously, regardless of the efficiency of the PCS system or the PCS operator's service goals with respect to range, data raate, or contiguous coverage. Qualcomm's starting premise that PCS systems must be equal is actually only relevant to PCS debates on the performance characteristics of different PCS systems. Whether a PCS system uses small cells, efficient modulation formats, or even islands of coverage is a function of the PCS operators service definition.

However, let us consider Qualcomm's assumption that the PCS services should be identical in performance, as based on range and bits, and then consider the sharing problem. First, a narrowband PCS signal experiences more propagation impairments than a wideband PCS system. Narrowband systems are subject to deep, "notch like" fading and consequently must transmit at much higher powers to overcome these fades. A typical narrowband system requires a 5 - 13.5 dB higher transmit power relative to a wideband system to obtain the same bit rate in Rayleigh fading (depending on delay spread). Qualcomm recognizes this effect[6] and even notes that we take advantage of it (although they give us no credit for it in their sharing analysis).

[5] page 2, Appendix A.

[6] Price&Green also recognized this in their 1958 paper: "A Communication Technique for Multipath Channels", Proc. IRE vol.46, pp 555-570, March

Second, regarding sharing, a major difference is that multiple CT-2 transmitters will be active simultaneously in a cell whereas in the Omnipoint system, only one transmitter is active at a given time, thus less interference is seen by the OFS receiver.

In actuality, the disparity is even greater since Omnipoint uses a much more efficient modulation format than CT-2. Among the many advantages associated with Omnipoint's direct sequence spread spectrum format is an ability to employ higher order orthogonal[7] spreading functions thereby allowing an Omnipoint system to increase the data rate without increasing the symbol rate and without having to increase RF carrier bandwidth. By providing for operation at significantly lower Eb/No than a CT-2 like modulation, transmit powers can be further reduced relative to other PCS systems with the same data rate. At the same time, the lower symbol rates improves resistance to intersymbol interference effects caused by multipath.

The use of Omnipoint's higher order modulation format can improve Omnipoint's performance an additional 5 - 6.5 dB at a BER of 10^{-3} relative to the CT-2 format. Thus, from the above two factors alone, to obtain the same data rate as a CT-2 type modulated system, the Omnipoint system could operate with well over 10 dB less transmitted power. Indeed Omnipoint systems are currently operating over distances far in excess of 1.9 GHz CT2 systems while transmitting seven times the data rate with only 2 - 2.5 times the transmit power.[8].

As we have repeatedly demonstrated[9], in a one transmitter to one transmitter comparison of different PCS technologies with respect to interference potential, direct sequence spread spectrum modulation helps greatly by spreading the energy over the OFS receive bandwidth.

[7]In the context of this discussion, we actually mean "sufficiently orthogonal". Perfectly orthogonal code exist only in a mathematical sense; after modulator and channel impairments, complete orthogonality ceases to exist.

[8]Note also that differences in transmission data rates per user, such as those due to different vocoder requirements, will also result in different transmit energies per user.

[9]Omnipoint May 4, 1992, June 25, 1992, and March 1 , 1993 filings

However, in comparison with a Qualcomm style spread spectrum CDMA-only system, we must consider the many transmitters versus one transmitter interference scenario.

In summary, Qualcomm's comparison of Omnipoint's system to CT2 is based only on duty factor and bit rate and is grossly incomplete when calculating interference to an OFS user. The wider bandwidth waveforms that Omnipoint uses exploits environmental features and technical design options in ways that are simply not available to the narrowband waveform designer. Major reductions in transmitter power requirements are made possible through the use of implicit diversity structures within the waveform design itself. Omnipoint's spread spectrum TDMA implementation employs a higher order modulation technique and couples this with lower spectral density. This means that Omnipoint's system truly causes less interference to OFS incumbents at high data rates, and this is what has been tested in the field by multiple parties. The overly simplistic analysis that Qualcomm uses does not consider these aspects of the design process, choosing instead to simply ignore the above benefits of the Omnipoint techniques.

Qualcomm's Sharing Comparison Claims are Also Flawed

In their requested Supplemental Comment's appendix A, Qualcomm claims *"the Qualcomm system has an advantage of 42 dB in interference potential over the Omnipoint system ..."*[10] Taken at face value, Qualcomm is saying they can broadcast with an effective radiated power of 1.585 kilowatts without causing interference to an OPS receiver from the same location that an Omnipoint system transmitting at 100mW will cause interference.

To start with, Qualcomm ignores a key distinction between Omnipoint's TDMA system and their CDMA-only system. CDMA-only systems have multiple transmitters active simultaneously within a cell that contribute to the overall interference picture. Omnipoint's system only has one transmitter on at a time.

[10] page 7 of Appendix A

Next, Qualcomm makes a major issue of the so called "temporal concentration of energy" associated with other TDMA systems and proceeds to give themselves 17 dB of credit because they operate with 100% duty cycle. However, they did not consider the benefits which Omnipoint has from employing the higher order modulation as noted above, and they neglect to mention the radically different interference environments the two systems operate in. In a single cell environment, Omnipoint's TDMA system must only transmit enough energy to overcome thermal noise power since only one transmitter is on at a given time even when fully loaded. In a fully loaded Qualcomm CDMA single cell, there are the equivalent of 18 other transmitters on at the same time, on the same frequency. This has the effect of increasing interference potential into an OFS receiver since the CDMA transmission powers sum up in the OFS receiver.

In the multiple cell environment, the situation becomes even more complex since competing cochannel cells now contribute to the interference picture within the cellular system. In Omnipoint's TDMA system, an allocation must be made for collisions between transmissions from other cochannel cells. However, one of the reasons Omnipoint uses direct sequence spread spectrum is to permit operation at lower C/I ratios (more interference). The exact allocations necessary depend on exact spreading ratios employed, reuse patterns, and most especially, propagation characteristics. Interestingly, the capacity of N=1, pure CDMA systems such as Qualcomm's are extremely sensitive to transitions in propagation characteristic.

Qualcomm's general capacity claims[11] are based on the assumption that signal strength falls off as $1/R^4$. However, at shorter ranges, signals tend to fall off with a $1/R^2$ characteristic. This has

[11] K.S.Gilhousen,"On the Capacity of a Cellular CDMA System", IEEE Transactions on Vehicular Technology, May 1991

been confirmed by a myriad of researchers[12] [13] [14] [15] as well as Omnipoint's own experimental data. In a sense, there is a breakpoint in propagation coefficient. Rappaport and Milstein[16] have conducted theoretical studies to establish the impact of propagation variations on pure CDMA only systems using a two-ray model. Of particular interest, they found that **by changing CDMA cell radius from 10 km to 2 km, CDMA capacity drops by a factor of 6**. Discussing a 2 km cell radius case, Rappaport and Milstein observe:

> *"This is more than six times (8 dB) lower than the frequency reuse obtained using the exact same channel model except with d = 10 km"*

Interference from nearby cells leaks into adjacent cells much more readily in an N=1 system such as Qualcomm's and effectively reduces capacity. Compared with an N=3 reuse pattern, the nearest cochannel basestation neighbors are a factor of 1.73 closer and nearest cochannel handset neighbors are a factor of 2.31 closer[17]. Moreover, all of the CDMA-only transmitters and receivers are on the same frequency in every cell, whereas in Omnipoint's system in addition to

[12] Telesis Technologies Laboratory, "Experimental License Progress Report", August, 1991

[13] Henrik Borjeson, "Outdoor Microcell Measurements at 1700 MHz", IEEE VT-92 Proceedings pp. 927-931

[14] Bell Atlantic Mobile Systems, "Experimental Report", 1 Feb, 1993

[15] Vinko Erceg et al. "Urban/Suburban Out-of-Sight Propagation Modeling", IEEE Communications Magazine, June 1992

[16] T.S. Rappaport & L.B. Milstein, "Effects of Radio Propagation Path Loss on DS-CDMA Cellular Frequency Reuse Efficiency for the Reverse Channel", IEEE Transactions on Vehicular Technology, August 1992

[17] Ratios were obtained using idealized hexagonal cell structures. In actuality cell structure is controlled by specific environmental factors but the trend remains the same; N=1 systems have closer cochannel neighbors.

the N=3 advantage only one user in each cell is on at any instant in time. These effects will dominate performance in the 1.9GHz PCS environment where small cells are the norm.

Returning to the OFS interference question, Qualcomm argues *"a wideband system (Omnipoint's 10 MHz bandwidth) must transmit the same energy per bit to achieve the same link performance, all other things being equal..."* As we have just shown, all other things are not equal; e.g., higher order modulation, the fact that CDMA-only systems must deal with much greater interference, etc. all contribute to the overall picture. Additionally, one of the primary reasons for using spread spectrum is to avoid deep multipath fading and the consequent requirements for large fade margins (i.e. high transmit powers). Qualcomm certainly claims this benefit for their system while denying any gains to our system, even though our signal is of wider bandwidth and less subject to frequency selective fading.

TDD is Better Than FDD for Sharing

Another of Qualcomm's claims which reflects a lack of knowledge regarding the existing OFS users within the 1850-1990 MHz band is Qualcomm's assertion that FDD actually helps by 3 dB in sharing with OFS[18]. However, Qualcomm's FDD system will need to find two frequencies.whereas Omnipoint's TDD system will need to find only one non-interfering frequency at a given location. Exacerbating this disadvantage of FDD is the fact that OFS licensees follow 80 MHz pair spacing only some of the time; actual pairings range from 40 to 120 MHz within the OFS band. In high OFS density regions, non-standard OFS duplex spacings approach 50% in many MSAs. Consequently, FDD air interfaces will be forced to use variable duplex spacing in order to coexist in these areas, and still may not avoid the OFS receivers depending on the geographic pattern of the OFS frequencies. Variable duplex spacing would necessitate extremely complex hardware architectures in contrast with a TDD air interface.

In figure 1 we plot the probability that a PCS operator can find suitable frequencies to commence operations as a function of a single frequency OFS necessitated exclusion probability using a Bernoulli trial analysis for any given 2x10 = 20 MHz block. Even with only 50% of the frequencies occupied by OFS at any given cell site, the FDD system is unable to begin operation in 75% of the geographic areas while the TDD system is excluded less than 25% of the time. Stated another way; even with a random distribution of OFS the TDD PCS system is 3 times more likely to find a frequency allocation compared with an FDD system.

To gain some understanding of the magnitude of the initial sharing problem; COMSEARCH performed a study of the Detroit MSA (32 microwave paths) and presented these results to Telocator on April 13, 1993[19]. In their study, COMSEARCH assumed a TDD PCS system and

[18]page 4/5 of Appendix A: "... the difference between duty cycles improves (for Qualcomm) from 14 dB to 17 dB because the Qualcomm system uses frequency division duplexing (FDD)."

[19]"Spectrum Allocations and Their Impact on Microwave User Relocations: A Case Study.", COMSEARCH, March 12, 1993, Telocator Doc. Number TE/93-4-13/239

still found a requirement to relocate as many as nine OFS operators within the initial PCS deployment time frame assuming even a 30 MHz allocation. Imagine how much worse the situation would be with an FDD air interface.

The Proof is In The Experimental Reports

Omnipoint's approach to OFS sharing has been the subject of hundreds of pages of experimental data. Omnipoint's techniques have been tested or studied specifically for their sharing capabilities by many companies including:

- Southwestern Bell
- McCaw
- Oracle
- APCN
- LCC
- Alcatel
- Westinghouse

In every case, Omnipoint's system was verified to perform as predicted in its pioneer's preference claims.

In contrast, Qualcomm's sharing claims are based on a few paragraphs of a relatively simplistic analysis. Further, the only experiment we are aware of is the January 1993 APC test.

In Omnipoint's last experimental reports (attached to its reply comments dated March 1, 1993) we pointed out that while APC is developing methodologies for avoiding OFS frequencies in use in a given area, the tests of Qualcomm's system shows substantial interference to OFS receiving equipment from Qualcomm upbanded basestations operating at normal radiated power levels of 4.1 to 6.6 Watts. Using the clearly labeled data tables in APC's report, we simply plotted the data to show that upwards of 25 dB of degradation was occurring to the OFS receiver. Qualcomm has objected to the interpretation of these findings by implying that 5 watts is not their normal transmit power, even though this is the number given for their coverage/capacity numbers.

However, consider the effects of turning down Qualcomm's power. In APC's experimental program they reduced Qualcomm ERP until interference effects became relatively benign in accordance with TSB-10E definitions. Specifically, APC found that when received Qualcomm signal strength is -101 dBm into the OFS receiver, it does not cause harmful interference[20]. However, Qualcomm never states what the EIRP must be when it finally becomes benign under the same test conditions.

In APC's test program, the victim OFS receiving antenna (Garfield) is at 480' AMSL[21] while the Qualcomm base station sites are located between 150' and 495' AMSL. Exhibits 3 and 4 in APC's report show unobstructed line of sight paths between the Garfield site and Qualcomm basestations designated DC1 and VA1. Exhibit 2 shows a 25' obstruction near the DC2 site location. For all intents, we can assume free space propagation exists between the Qualcomm sites and the victim OFS receiver. Measured interference power going into the victim OFS receiver is described by:

$$\mathbf{P_{received} = EIRP + G_r - PL}$$

where:

$P_{received}$ = Receive Power Level (dBm)
EIRP = Transmitted Isotropic Power Level (dBmi)

[20] 45-th page of Appendix V in APC report.

[21] Above Mean Sea Level

G_r = OFS Receiving Antenna Gain in Direction of Interfering Transmitter (dBi)
PL = Propagation Path Loss (dB)

At 1970 MHz, free space propagation path loss is described by:

PL = 102.46 + 20 log R

where:

R is slant range (miles)

Solving for EIRP and assuming -5 dBi OFS antenna gain in the direction of the Qualcomm site we obtain Table 1.

Table 1: Allowable Qualcomm Basestation EIRP to meet Interference Objective

Site Name	Range to Victim OFS Receiver	Allowable Basestation Transmit EIRP to Generate –101 dBm Into -5 dBi OFS Receiver
DC2	0.45 Miles	1.39 milliWatts
DC1	2.61 Miles	30.16 milliWatts
VA1	4.56 Miles	92.08 milliWatts

Qualcomm base stations do not provide significant coverage at these power levels because of their CDMA nature. In fact, in APC's coverage testing, actual base station pilot power levels alone were 1.53 Watts, 1.85 Watts, and 2.15 Watts[22]. This is the transmitted power level in the absence of traffic. APC indicates that the base station will need to transmit an additional 0.198 to 0.226 Watts per user in order to carry traffic[23]. Base station transmitted powers of 4 to 6 Watts are typical in the APC configuration. In both their March and July 1993 reports, APC notes that the base stations transmit 5 Watts.

[22] Page 8 of APC report.

[23] Pages 9 and 10 of the APC report.

For example, in their July 27, 1993 filing, APC confirms this in describing some of their microcell testing in the Washington D.C. area:

> *"This microcell employs a 5 watt power amplifier, which is the same power as the base stations."*[24]

Thus the APC tables used in demonstrating 25 dB of OFS degradation due to Qualcomm basestation interference are representative of typical Qualcomm operating conditions.

Note that 5 Watt power levels are not particularly high for the Qualcomm system. In Qualcomm's November 4, 1992 filing with the FCC, they indicate a base station ERP of 100 Watts for their 800 MHz testing and 39.7 Watts for their 1700 MHz testing. Also see MCI's July 1993 report which describes the two base station transmit powers as being 20 Watts and 16 Watts.

In conclusion the experimental evidence stands on its own.

[24]Re: American Personal Communications KC2XDM, FCC File No. 2056-EX-R-92, Twelfth Progress Report. dated July 27,1993.

Time Division Duplex Helps Ensure Ability to Find a Frequency in Each Geographic Location

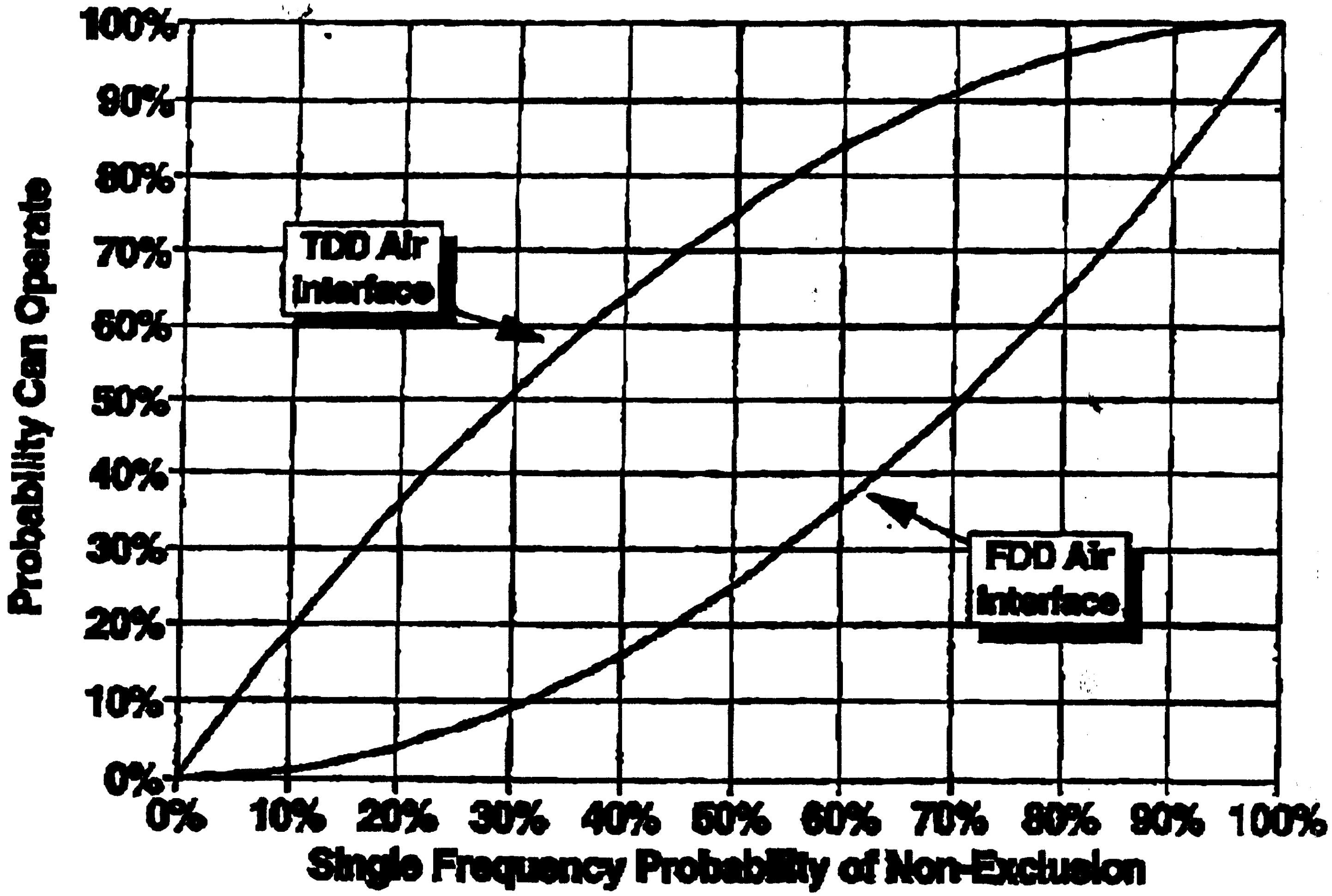

Figure 1