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NON-URBAN MOBILE RADIO MARKET DEMAND FORECAST

FINAL REPORT

JUNE 25, 1982

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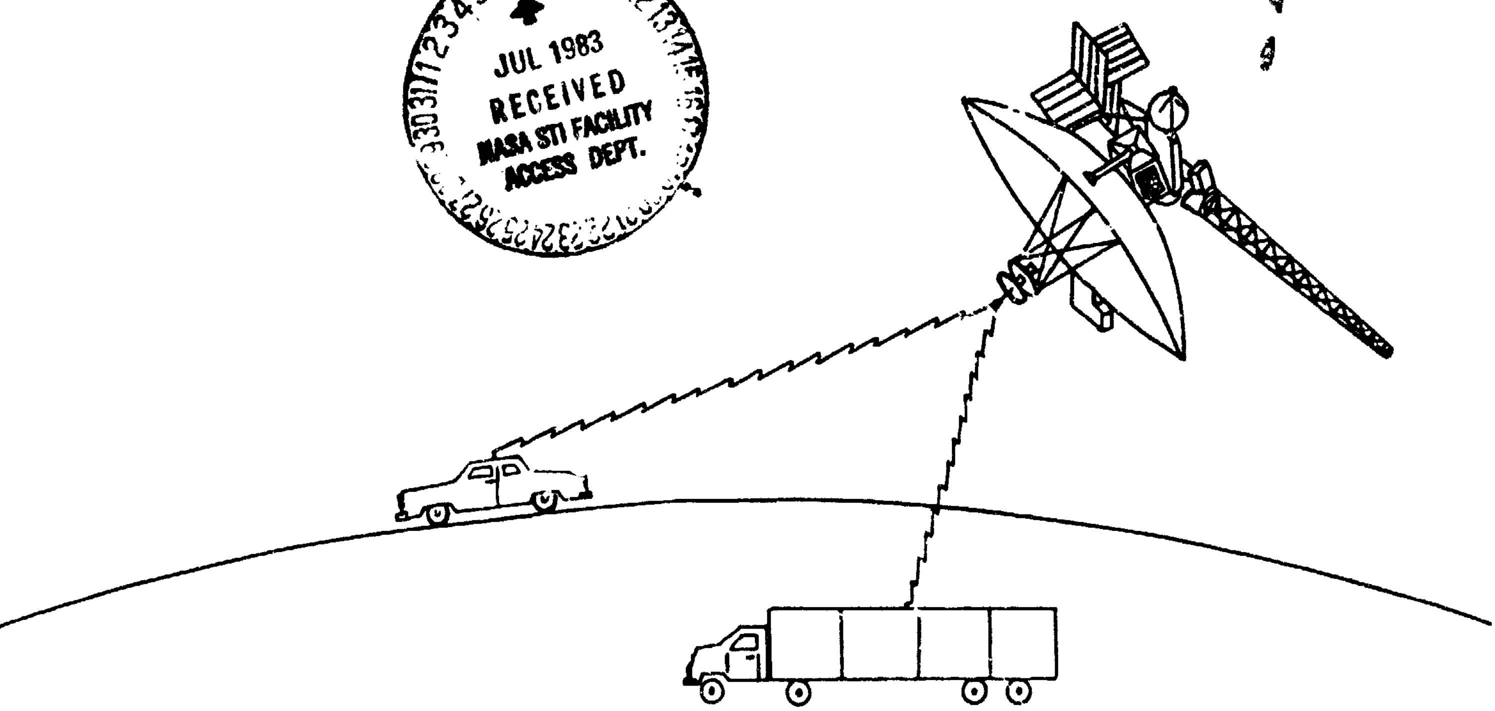

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16. Abstract

A national non-metropolitan land mobile traffic model for 1990-2000 addresses user classes, density classes, traffic mix statistics, distance distribution, geographic distribution, price elasticity, and service quality elasticity. Traffic demands for Business, Special Industrial, and Police were determined on the basis of surveys in 73 randomly selected non-urban counties. The selected services represent 69% of total demand. The results were extrapolated to all services in the non-SMSA areas of the contiguous United States. Radiotelephone services were considered separately. Total non-SMSA mobile radio demand (one way) is estimated to be:

1981 5,904 (6,627 with radiotelephone)
1990 21,969 (23,299 with radiotelephone
2000 108,235 (110,851 with radiotelephone)

General functional requirements include: hand portability, privacy, reduction of blind spots, two-way data transmission, position location, slow scan imagery.

17. Key Words (Suggested by Author(s)) mobile radio, mobile radio traffic, mobile radio traffic prediction, mobile radio functional requirements	18. Distribution Statement

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FOREWORD

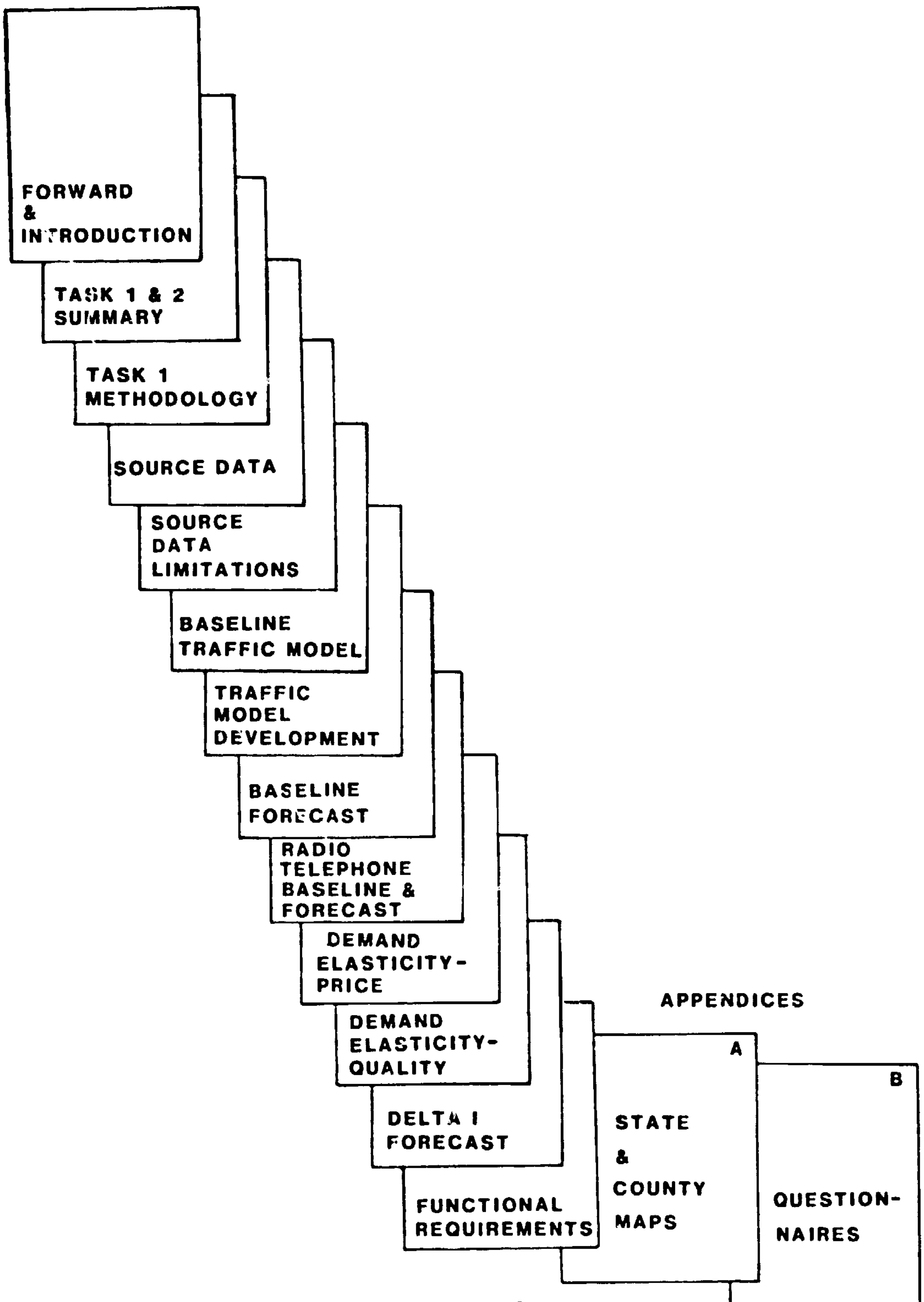
This effort, begun on December 1, 1981, was performed under Subcontract to the General Electric Company's Prime Contract NAS3-23244, "Mobile Radio Alternative Systems Study," for the Lewis Research Center of the National Aeronautics and Space Administration.

The objective of this effort is to define a national nonmetropolitan land mobile traffic model for 1990-2000 and participate in defining the functional and system requirements necessary to support that traffic.

Figure 1 depicts the overall organization of this report.

FIGURE 1

ORGANIZATION OF REPORT



1.0. INTRODUCTION

Land mobile communication in the United States now directly involves two of every 35 members of the civilian labor force on a national average. When pagers are included, the average direct involvement becomes 2 of every 28 workers, or 3% of the total population. Of course, the average varies widely among different enterprises.

Under the eligibility limits and frequency allocations set by the Federal Communications Commission, the nation's land mobile communication has evolved into a widespread pattern of non-integrated separate coverage areas. These separate coverage areas, throughout the country, are set mainly by each user's independent needs and radio propagation constraints. Only modest efficiencies of frequency utilization are achieved by requiring many miles of separation between areas of frequency reuse.

Within this pattern, the user's knowledge of eligibility, and therefore his frequency options, are often limited to the information supplied by the equipment seller. Regardless of their frequency eligibility, customers may be sold frequencies which make them potential subscribers to repeater systems already using those frequencies. While use of a repeater enlarges the coverage area, it also contributes to frequency congestion. This, combined with other factors (the primary factor being extreme population density in metropolitan areas), creates a status of national utilization of assigned frequencies that ranges from zero to complete saturation.

In metropolitan areas, relief for the saturation of two-way radio frequencies is now occurring with the rapid growth of trunked systems. The promise of relief for the saturation of metropolitan radiotelephone frequencies is indicated by the experimental cellular systems of Chicago and Baltimore/Washington. These costly cellular systems and trunked repeaters are expected to be effectively serving major metropolitan areas by the time any alternative large-scale integrated system could be devised and implemented. The remaining question is how best to support the growing land mobile communication requirements generated by the nation's population that lies outside of major metropolitan areas (SMSA's).

The effort includes two Tasks: (1) development of a national nonmetropolitan mobile traffic model for 1990-2000; and (2) definition of the functional requirements needed to support that traffic.

The objects of these two Tasks are presented following.

1.1. TASK 1 SUMMARY

The intent of this Task is to develop a national nonmetropolitan land mobile traffic model for 1990-2000 which addresses user classes, density classes, traffic mix statistics, distance distribution, geographic distribution, price elasticity, and service quality elasticity.

A current baseline model is to be developed and then projected to 1990-2000 using three growth alternatives:

1) Historic user growth rates (Baseline Forecasts)
2) Reduced constraints (blockage, blind spots, interference, range) (Delta I scenario)
3) Potential radical changes in market factors (Delta II scenario)

1.2. TASK 2 SUMMARY

The intent of this Task is to develop initial estimates of functional requirements of the forecast traffic model.

In addition, 25-30% of the total effort will be devoted to participating with the Prime in the further definition of alternative systems.

2.0. TASK 1 MOBILE NATIONAL TRAFFIC MODEL

2.1. METHODOLOGY

The planned methodology employed the following steps:

1. Determine current baseline and historic growth rates of land mobile user classes. (SOURCES: FCC, Common Carriers, Frequency Coordinators, Trade Associations, Market Analysts, Equipment Manufacturers).

2. Determine user characteristics of traffic mix, traffic intensity, distance distribution, price elasticity, service quality elasticity. (SOURCES: User surveys, FCC, Common Carriers, Frequency Coordinators, Trade Associations).

3. Determine correlations between land mobile user characteristics and other statistics readily available in small geographic detail for the entire nation. (SOURCES: Census County and City Data Book, Census 1980 Advance Reports, Statistical Area Supplementary Report, similar.)

4. Apply correlation coefficients for user characteristics and geographic increments to expand the user sample into a national nonmetropolitan geographic distribution of user characteristics (Baseline Land Mobile Traffic Model).

5. Apply historic growth rates, by user class, to Baseline Model to produce the Baseline Forecast Land Mobile Traffic Model for 1990 and 2000.

6. For Delta Case I: Assess the factors which currently constrain the usage of mobile communications, and develop growth coefficients corresponding to the effect of removing such constraints, especially price elasticity and service quality elasticity, in the context of expected evolutions in regulations, technology, demography, economy, and apply to the Baseline Forecast Land Mobile Traffic Model.

7. For Delta Case II: Analyze user characteristics in the context of potential radical changes in market factors and develop growth coefficients for application to the Baseline Forecast Land Mobile Traffic Model.

2.2. SOURCE DATA EMPLOYED IN THE STUDY

Source data for this effort is listed in the table below. For convenient reference throughout this report, each item has been assigned an SD number (F1, etc.) as shown in the table. Also shown in the table is a list of limitations (source data) numbered L1, etc. that correspond to the numbered paragraphs which follow in subsequent pages and which describe the limitations of the source data items.

SD NO.	SOURCE DATA	LIMITATION
F1	FCC Rules & Regulations, Vol. II, V & VII	L1
	FCC OFFICE OF SCIENCE & TECHNOLOGY	
F2	Station classes by service	L2
F3	Station class symbols	L3
F4	Service listing; Admin. & Freq. records	L4
F5	Data base microfiche	L5
F6	Data base terminal	L5
F7	Special data base terminal	L5
	FCC RULES BRANCH	
F8	Data base statistics	
F9	Spectrum occupancy statistics	
	FCC MOBILE SERVICES DIVISION	
F10	RCC/WCC statistics	
	CENSUS BUREAU	
C1	County and City Data Book	L6
C2	1980 Advance Reports for States & Counties	
C3	1980 SMSA Supplementary Report	
C4	New SMSA geographic boundaries	
C5	Special Demographic Analysis (Pop. Deconcentration)	
C6	1980 Per capita income report	
C7	1980 Electronic Products Industrial Report	
C8	U.S. County Maps	L7
	FREQUENCY COORDINATORS/TRADE ASSOCIATIONS	
T1	TELOCATOR (Telocator Network of America)	
T2	NABER (National Association of Business & Educational Radio Inc.)	L8
T3	SIRSA (Special Industrial Radio Service Association)	
	APCO (Association of Public Safety Communication Officers)	L8
T5	Motor Carrier Radio Service statistics	L8
T6	Railroad Radio Service statistics	L8
	EQUIPMENT MANUFACTURERS	
E1	GE, Equip. prices & market estimating factors	
E2	Motorola, Equip. prices	
	DEALERS, REPEATER OPERATORS, RCC'S, WCC'S	
D1	C & P, rates	L9
D2	METROCALL, rates	
D3	Kwik Kall, rates	L10
D4	COECO, prices & rates	
D5	Mobile Radio Comm. Inc., rates	
D6	TEL RAD Comm., rates & statistics	

2.2.1. SOURCE DATA LIMITATIONS

None of the source data presented in the previous section provides a comprehensive picture of the mobile radio situation. Thus, the data need to be compared and integrated. The principal limitations of the source data are presented following.

L1 These regulations describing user eligibility and frequency allocations are not easily obtained or understood by the typical land mobile radio user. This leads to users being licensed in Business Radio Service and corresponding frequencies, regardless of their eligibility for other services and frequencies. This may contribute to frequency congestion and certainly blurs any distinction between Business Radio Service and the other services designed for selected forms of business, primarily the Special Industrial Radio Service.

L2 (a) This computer sort (Sample Page, p. 9) shows the number of each type of station within each radio service. However, due to past data entry inconsistencies, one type of station may be shown by any one of several symbols. This prevents straight forward counting of any one type of station.

L2 (b) Stations with multiple frequencies are counted for each frequency.

L3 This list of station class symbols (Sample Pages, pp. 10 & 11) shows which station class symbols may appear for fixed stations of the Land Mobile Radio services. These symbols are used to solve the limitation discussed in L2 (a) above.

L4 This service listing (Sample Page, p. 12) counts all Administrative and Frequency data base records for each service. The Administrative total includes systems not pertinent to this effort (microwave, etc.). However, FCC personnel indicate that the ratios of administrative records to frequency records for each radio service are practical, derating factors that solve the limitation described in L2 (b). These derating factors are used throughout the report to reduce exaggerated raw station counts to credible count estimates.

L5 The FCC data base is apparently useful for the functions of frequency assignment and compliance. However, for counting and tabulating user characteristics, the data base and its products have the following limitations:

- o Licenses are issued for five years and abandoned operations are often not reported. (Exaggerates counts)

- o Licenses show authorized power and number of radios; the actuals are often less. (Exaggerates counts)

- o Licenses may include an entire system or the base, repeater, and mobiles may be licensed separately, thus making equipment counts difficult to separate. (Blurs counts)

- o Multiple frequency equipment is entered for each frequency. (Exaggerates counts)

- o Expired licenses are not often culled. A renewed license causes automatic removal of the expired license only if certain user data fields are identical, which is frequently not the case after five years. (Exaggerates counts)

- o Applicant misspelling of county or town (or keystroke errors in entering the data) defeats retrieval of that license by county or town sorting. (Diminishes counts)

L6 This massive reference is produced every five years (1972 and 1977 are available, 1982 is not available).

L7 These maps display demographic characteristics by county for the 1970 census; however, 1980 census maps are not yet available.

L8 This frequency coordinator was unable to provide any detailed statistics on user characteristics or spectrum occupancy.

L9 This WCC provided the regulated rates for a radiotelephone system that is completely saturated with a long waiting list. The data is of limited use for price elasticity computations.

L10 This repeater operator has statistics on spectrum occupancy but is reluctant to share them since he is in the process of requesting additional frequencies. (This illustrates the sensitive nature of competing for Government allocation as opposed to buying on an open market.)

(This page is reproduced directly from FCC Document "Station Classes by Service" It is a sample of SD No. F-2 of page 5)

07/01/81 STATION CLASSES BY SERVICE EFS450-01
SERVICE IS

(SPECIAL INDUSTRIAL)

STATION CLASS	NUMBER OF OCCURRENCES
1	1
	206
FAS	1
FB2	5002
FB	54584
FBI	1
FBM	656
FXO	25
FX1	7666
FX2	825
FX3	10
FX	11
FXO	850
IB	54
ME	1
MO	46978
MOP	12
MOR	34
MTE	1
MX	20
PB	79
SA	2
TA	34
TB	2
WBM	1
X1	3
X	1

(This page is reproduced directly from FCC Document "Class of Station Symbols" It is a sample of SD No. F-3 on Page 5)

CLASS OF STATION SYMBOLS

ANT	Antenna Test Station
AT	Amateur Station
ATR	Amateur (Races) Station
AX	Aeronautical Fixed Station
BCFB	FM Booster Station
BCFC	Commercial FM Broadcast Station
BCFE	Non - Commercial FM Broadcast Station
BCFR	FM Translator Station
BCI	International Broadcast Station
BCS	Standard Broadcast Station
BTC	Commercial TV Broadcast Station
BTE	Non - Commercial TV Broadcast Station
BTR	TV Translator Station
BTRB	TV Translator Booster Station
CAR	Cable Antenna Relay Station
CRP	CAR Pickup Station
EA	Amateur - Satellite Space Station
EB	Broadcast - Satellite Space Station (Sound)
EC	Fixed - Satellite Space Station
ED	Space Telecommand Space Station
EE	Standard Frequency - Satellite Space Station
EF	Radiodetermination - Satellite Space Station
EG	Maritime Mobile - Satellite Space Station
EH	Space Research Space Station
EJ	Aeronautical Mobile - Satellite Space Station
EK	Space Tracking Space Station
EM	Meteorological - Satellite Space Station
EN	Radionavigation - Satellite Space Station
EO	Aeronautical Radionavigation - Satellite Space Station
EQ	Maritime Radionavigation - Satellite Space Station
ER	Space Telemetering Space Station
ES	Intersatellite Space Station
EU	Land Mobile - Satellite Space Station
EV	Broadcasting - Satellite Space Station (Television)
EW	Earth Exploration - Satellite Space Station
EX	Experimental Station
EXBC	Experimental Broadcast Station (Sound)
EXBT	Experimental TV Broadcast Station
EY	Time Signal - Satellite Space Station
FA	Aeronautical Enroute Station
FAA	Aeronautical Advisory Station
FAB	Aeronautical Broadcast Station
FAC	Airdrome Control Station
FAM	Aeronautical Metropolitan Station
FAS	Aviation Instructional Station
FAT	Flight Test Station
* FB	Base Station
* FB2	Mobile Relay Station

* Private Land Mobile Radio fixed stations

*FBM	Base & Mobile Station
FBR	Base (Remote Pickup) Station
FBS	Base (Shipyard) Station
FC	Public Coast Station
FCB	Marine Broadcast Station
FCL	Limited Coast Station
FCU	Marine Utility Coast Station
FCX	Coast & Fixed Station
FC2	Relay Station
FD	Dispatch Station
FL	Land Station
FLD	Telecommand Land Station
FLE	Telemetering Land Station
FLEA	Aeronautical Telemetering Land Station
FLEF	Flight Telemetering Land Station
FLES	Surface Telemetering Land Station
FLH	Hydrologic & Meteorological Land Station
FLT	Auxiliary Test Station
FLU	Aeronautical Utility Land Station
FOT	Flight Test Telemetering Station
FSS	Field Strength Survey Station
FX	Fixed Station
FXB	Standard Broadcast STL Station
FXC	Central Office Fixed Station
FXD	Telecommand Fixed Station
FXE	Telemetering Fixed Station
FXF	Aural STL Station
FXG	International Fixed Station (Telegraphy)
FXH	Hydrologic & Meteorological Fixed Station
FXI	International Control Station
FXM	Aural Intercity Relay Station
FXN	TV Intercity Relay Station
FXO	Operational Fixed Station
FXP	International Fixed Station (Telephony)
FXR	Rural Subscriber Fixed Station
FXT	TV STL Station
FXY	Interzone Fixed Station
FXZ	Zone Fixed Station
*FX1	Fixed Control Station
*FX2	Fixed Relay Station
FX3	Fixed Repeater Station
FX4	Inter - Office Fixed Station
ISM	ISM Equipment
ITX	Instructional TV Fixed Station
LMO	Land Mobile Station
LR	Radiolocation Land Station
MA	Aircraft Station
MFL	Aeronautical Multicom Land Station
ML	Land Mobile Station

* Private Land Mobile fixed stations

ORIGINAL PAGE IS OF POOR QUALITY

(This page is reproduced directly from FCC Document "Service Listing". It is a sample of SD No. F-4 of page 5.)

```
SERVICE LISTING AS OF 07/14/81

. . . .  FOR SERVICE IP  . . . .

                     THERE WAS A TOTAL OF    62435 RECORDS
                        OF WHICH     18713 WERE ADMINISTRATIVE RECORDS
                                     18925 WERE GEOGRAPHICAL RECORDS
                                     24797 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IQ  . . . .

                     THERE WAS A TOTAL OF        4 RECORDS
                        OF WHICH         1 WERE ADMINISTRATIVE RECORDS
                                         1 WERE GEOGRAPHICAL RECORDS
                                         2 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IR  . . . .

                     THERE WAS A TOTAL OF    18217 RECORDS
                        OF WHICH      5309 WERE ADMINISTRATIVE RECORDS
                                      5338 WERE GEOGRAPHICAL RECORDS
                                      7570 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IS  . . . .

                     THERE WAS A TOTAL OF   232104 RECORDS
                        OF WHICH     74697 WERE ADMINISTRATIVE RECORDS
                                     76073 WERE GEOGRAPHICAL RECORDS
                                     81334 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IT  . . . .

                     THERE WAS A TOTAL OF    11083 RECORDS
                        OF WHICH      3350 WERE ADMINISTRATIVE RECORDS
                                      3441 WERE GEOGRAPHICAL RECORDS
                                      4292 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IU  . . . .

                     THERE WAS A TOTAL OF        4 RECORDS
                        OF WHICH         1 WERE ADMINISTRATIVE RECORDS
                                         1 WERE GEOGRAPHICAL RECORDS
                                         2 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IW  . . . .

                     THERE WAS A TOTAL OF    89029 RECORDS
                        OF WHICH     24517 WERE ADMINISTRATIVE RECORDS
                                     24958 WERE GEOGRAPHICAL RECORDS
                                     39554 WERE FREQUENCY RECORDS

. . . .  FOR SERVICE IX  . . . .

                     THERE WAS A TOTAL OF    34514 RECORDS
                        OF WHICH      9972 WERE ADMINISTRATIVE RECORDS
                                     10350 WERE GEOGRAPHICAL RECORDS
                                     14192 WERE FREQUENCY RECORDS
```

2.3. BASELINE TRAFFIC MODEL

The concept followed in developing the traffic pattern is based upon quantifying the erlang demand generated by Mobile Services in the nonmetropolitan areas. Direct information on the areal distribution of erlangs generated is scarce and of limited reliability. Instead, the available data sources, see page 6, provide the most reliable quantitative information in terms of Land Mobile fixed stations at the national level and user counts at the county level. Therefore, the baseline model is approached using fixed station counts by User Classes at the national level and user data at the county level. These data are then converted to erlang demand.

2.3.1. User Classes by Fixed Stations

As defined in SD-F1 (FCC Rules and Regulations, Part 90), the Private Land Mobile Radio Services are listed in the first column of Table 1. Column A of this table shows the record count of fixed stations of each service derived from SD-F2, using the station symbols of SD-F3. Column B shows the ratio of frequency to records as developed from SD-F4. Using this ratio as a derating factor to eliminate frequency compounding, Column C shows the estimated number of fixed stations for each service ranked in descending order. Column D shows the percent of total estimated stations for each service. Column E shows the cumulative percent of the total estimated stations. Also included in the tabulation is General Mobile Radio Service (FCC Rules and Regulations, Part 95) which is available to anyone for business or personal use (Table 1, Service No. 8).

One other user class as defined in SD-F1 (FCC Rules and Regulations, Part 22) is Domestic Public Land Mobile Radio Service (radiotelephone). This service is analyzed separately later in the report.

Together, Parts 90 and 22 encompass the entire population of Land Mobile Radio Services or User Classes with FCC eligibility requirements based on type of enterprise.

2.3.2. Selection of User Classes for Investigation

As shown in Table 1, the top four services comprise three-quarters of the total estimated stations pertaining to Private Land Mobile Radio. The first two services (Business and Special Industrial) represent the principal shares of the total; the third (Local Government) and fourth (Police) are approximately equal at 5% each.

TABLE 1

PRIVATE LAND MOBILE RADIO SERVICES

A = Fixed Station "Occurrences" (SD-F2)
B = Ratio of frequency records to administrative records
<u>DERATING FACTORS</u> (SD-F4)
C = Estimated fixed stations
D = Percent of total fixed stations
E = Cumulative percent of total fixed stations

SERVICE	A	B	C	D	E
Business	341286	1.26	270862	52.28	52.28
Special Industrial	68744	1.09	63068	12.17	64.45
Local Government	36278	1.31	27693	5.35	69.80
Police	54275	2.1	25845	4.99	74.79
Special Emergency	48277	2.7	17880	3.45	78.24
Fire	29789	1.68	17732	3.42	81.66
Power	26022	1.61	16163	3.12	84.78
Gen'l Mob(Part 95)	17950	1.36	13199	2.55	87.33
Petroleum	12602	1.33	9475	1.83	89.16
Highway Maint	14437	1.59	9080	1.75	90.91
Railroad	18104	2.04	8875	1.71	92.62
Forestry Conserv	14523	1.96	7410	1.43	94.05
Manufacturers	9072	1.42	6389	1.23	95.28
Auto Emergency	5345	1.03	5189	1.00	96.29
Forest Products	5936	1.31	4531	0.87	97.16
Telephone Maint	4536	1.28	3544	0.68	97.84
Urban Property	3285	1.11	2959	0.57	98.42
Taxicab	4838	1.88	2573	0.50	98.91
Interurban Prop	2942	1.15	2558	0.49	99.41
Miscellaneous	7224	Various	3077	0.59	100.00
TOTALS	725465		518102	100	

After the largest four services, each of the remaining services is individually of lesser significance, ranging from about 3% downward. Since FCC spectrum occupancy monitoring has shown that Business, Special Industrial, and Police, in addition to comprising a cumulative 69.5% of the total station count, tend to be heavy users of the spectrum, these three services were selected for survey as shown in Table 2. Police service was preferred to Local Government service for survey efficiency since state and county police organizations generally possess knowledgeable single points of contact. By contrast, Local Government radio services are fragmented among diverse organizations, thus requiring separate surveys for each.

It is obvious that the number of stations is not necessarily proportional to the level of erlangs generated by the systems of which such stations are a part. For this reason, the national station counts are not used in any direct calculation of erlangs for the surveyed services. The erlang demand is computed from actual surveys of users.

The estimated national station counts are used to assess the relative significance of User Classes in order to select the radio services for detailed investigation. The national station counts are also used later to impute erlang ratio of surveyed/ non-surveyed services and national averages of service users per 1000 population. As detailed later, these national averages are used in calculations to divide national growth rates into metropolitan/nonmetropolitan components.

TABLE 2

RADIO SERVICES SELECTED FOR INVESTIGATION
(*ESTIMATED FIXED STATION)

SERVICE	PERCENT OF TOTAL*	CUMULATIVE PERCENT OF TOTAL*
BUSINESS	52.28	52.28
SPECIAL INDUSTRIAL	12.17	64.45
POLICE	4.99	69.44
(REMAINING SERVICES TO BE ESTIMATED)		
LOCAL GOVERNMENT	5.35	5.35
OTHERS	25.21	30.56

2.4. METHOD FOR DEVELOPING THE TRAFFIC MODEL

2.4.1 Principal Requirements

The principal requirements for the traffic model are:

(1) Its geographic granularity should be smaller than the postulated satellite footprint, which is of order 100,000 square kilometers;

(2) Its accuracy should be commensurate with satellite conceptual design specification, i.e., of order 10%;

(3) It should identify as quantitatively as possible those parameters which measure the quality of the service currently offered: (a) level of service, i.e., line blockage or waiting time; (b) completeness of the geographic coverage achieved versus that sought by users, i.e., extent of "blind spots"; (c) quality of reception, i.e., intelligibility—whether constrained by terrain roughness or limited by interference from extraneous signals.

No prior efforts appear to have been made by any of the available sources, shown on page 6, at the level of granularity required by (1) above.

On the other hand, the data which are conveniently available for constructing local traffic models—e.g. number of users and corresponding fixed stations—possess a granularity corresponding to the geographic jurisdiction of counties.

Therefore, the approach followed was to sample the selected radio services at county levels. A Summary of The Counties Samples Is Shown In Table 3.

To this effect, an initial set of 20 nonmetropolitan counties was randomly selected throughout the United States. The objective was to determine: (1) the traffic profile of Police, Special Industrial, and Business radio users within the 20 selected counties; and (2) the existence of potential correlations between the characteristics of these users and demographic variables available from census, e.g., area, population, gross and disposable income, number of establishments, similar. The purpose of seeking such correlations was that of further expanding the sample without having to engage in additional direct surveys beyond the initial 20.

TABLE 3

COUNTIES SELECTED FOR SURVEY

	COUNTY	STATE	CODE		COUNTY	STATE	CODE
1	Jackson	AL	X1	39	Grafton	NH	X1
2	Washington	AL	X1	40	Catron	NM	X1
3	Lawrence	AR	X1	41	Lea	NM	X1
4	Union	AR	X1	42	Lincoln	NM	O2
5	Coconino	AZ	O2	43	Taos	NM	X1
6	Gila	AZ	X1	44	Churchill	NV	X1
7	Inyo	CA	O2	45	Elko	NV	X1
8	Bent	CO	X1	46	Lewis	NY	X1
9	Eagle	CO	X1	47	Holmes	OH	X1
10	Windham	CT	X1	48	Adair	OK	X1
11	Sussex	DE	X1	49	Greer	OK	X1
12	Dixie	FL	X1	50	Douglas	OR	X1
13	Hendry	FL	X1	51	Gilliam	OR	X1
14	Dodge	GA	O2	52	Harney	OR	O1
15	Kossuth	IA	O2	53	Tioga	PA	O2
16	Lucas	IA	X1	54	Williamsburg	SC	O1
17	Clark	ID	X1	55	Clay	SD	X1
18	Clearwater	ID	X1	56	Dewey	SD	X1
19	Lee	IL	X1	57	Greene	TN	X1
20	Shelby	IL	X1	58	Haskell	TX	X1
21	Randolph	IN	X1	59	Hunt	TX	X1
22	Harper	KS	X1	60	Jackson	TX	X1
23	Logan	KS	O2	61	Kerr	TX	X1
24	Lyon	KS	X1	62	Leon	TX	X1
25	Hart	KY	O2	63	Oldham	TX	X1
26	Allen	LA	X1	64	Reagan	TX	O1
27	Garrett	MD	O2	65	Cache	UT	X1
28	Allegan	MI	X1	66	Wayne	UT	X1
29	Oscoda	MI	O1	67	Madison	VA	O1
30	Camden	MO	O2	68	Lewis	WA	X1
31	Attala	MS	O1	69	Whitman	WA	X1
32	Jefferson	MT	X1	70	Marinette	WI	X1
33	Rosebud	MT	X1	71	Greenbrier	WV	O2
34	Pitt	NC	X1	72	Fremont	WY	O1
35	Oliver	ND	X1	73	Weston	WY	X1
36	Richland	ND	X1		Penobscot	ME	OZ2
37	Franklin	NE	O2				
38	Keith	NE	X1				

KEY

O = Original 20 nonmetropolitan counties selected to explore correlations.

X = Expanded selection of nonmetropolitan counties to allow plotting of traffic isopleths.

1 = License count data.

2 = License count data and user survey data for business and special industrial.

Z = Original county discarded for traffic isopleths due to containing new SMSA.

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2.4.2 County Police

The results for the 20 County Police departments sampled are summarized in Table 4.

It turned out that the County Police Radio Service did correlate with the demographic datum of "county population," to a sufficient degree of confidence.

The best-fit correlation between County Police radio traffic and county population was found to be the following:

$$\log E_p = -2.68 + 0.96 \log P$$

where:

E_p = Peak milli-erlang demand (during busy hours)

P = Population

Valid for P- 616 persons

R2 = 0.62

The equivalent equation for milli-erlang demand of County Police is:

$$E_p = 0.002\ P^{0.96}$$

2.4.3 State Police

Of the 20 State Police organizations originally queried, only 13 did supply information as of the date of this writing. The corresponding results are summarized in ..le 5. State Police peak traffic demand appears quite similar among the states: ..or ..ximately 1 + 0.3 (one sigma) peak erlangs per state. Since State Police erlang turned out to be remarkably uniform for the states sampled, which represent 25% ... US no additional correlations were sought. In view of the large sample, this average demand was assumed to be the same for all states within CONUS.

TABLE 4

COUNTY POLICE

COUNTY/STATE	ANNUAL MESSAGES FROM BASE	AVERAGE MESSAGE LENGTH (Seconds)	MILLI-ERLANGS	PEAK TO AVERAGE RATIO	PEAK MILLI-ERLANGS	POPULATION
GARRETT, MD	95,000	7	21.1	1.3	27.	23,700
DODGE, GA	20,800	5	3.3	1.5	4.9	16,500
TIOGA, PA	600,000	5	95.1	1.55	147.	42,000
MADISON, VA	36,000	5	5.7	1.5	90.	10,000
GREENBRIER, WV	500,000	6	95.1	1.3	123.	33,000
HART, KY	12,000	4	1.5	1.2	1.8	15,000
PENOBSCOT, ME	1,000,000	4	126.8	1.65	210.	134,000
WILLIAMSBURG, SC	52,000	22.5	37.1	1.1	40.8	35,000
ATTALA, MI	40,000	5	6.3	1.3	8.2	19,000
REAGAN, TX	45,000	5	7.1	1.3	9.2	3,500
FRANKLIN, NE	50,000	5	7.9	1.35	10.	4,700
LOGAN, KS	1,600	5	2.5	1.8	.4	3,800
COCONINO, AZ	127,500	5	20.2	1.7	34.	68,000
FREMONT, WY	168,000	5	26.6	1.2	32.	31,500
HARNEY, OR	7,000	18.5	4.1	1.1	4.5	7,350
INYO, CA	850,000	5	134.8	1.3	175.	17,500
LINCOLN, NM	68,000	5	10.8	1.3	13.	9,710
CAMDEN, MO	45,600	5	7.2	1.3	9.4	16,419
OSCODA, MI	27,400	5	4.3	1.5	6.5	6,200
KOSSUTH, IO	728,000	12	277.0	1.3	360.	23,000

TABLE 5

STATE POLICE

STATE	ANNUAL MESSAGES FROM BASE	AVERAGE MESSAGE LENGTH (Seconds)	MILLI-ERLANGS	PEAK TO AVERAGE RATIO	PEAK ERLANGS
MARYLAND	3,500,000	5	554.9	1.3	.72
NEBRASKA	5,500,000	5	872.0	1.3	1.13
KANSAS	2,900,000	6.5	597.7	3.	1.79
WYOMING	2,500,000	5	396.4	1.5	.59
MISSOURI	5,800,000	5	919.9	1.3	1.20
MICHIGAN	5,700,000	5	903.7	1.4	1.27
MISSISSIPPI	5,500,000	5	872.0	1.3	1.13
GEORGIA	5,000,000	5	792.7	1.4	1.11
VIRGINIA	5,000,000	5	792.7	1.3	1.03
TEXAS	4,000,000	5	634.2	1.25	.79
ARIZONA	5,500,000	2.3	401.1	1.5	.60
IOWA	5,000,000	5	792.7	1.3	1.03
NEW MEXICO	5,000,000	5	792.7	1.35	1.07

Maps supplied by County and State Police Departments, depicting the blind areas existing within their respective territories, are contained in Appendix A. Samples of police survey questionnaires are shown in Appendix B.

2.4.4. Business and Special Industrial

After direct survey of 109 Business and Special Industrial users in 13 of the original 20 counties, no significant correlations were found betwen erlang demand and available demographic data. Due to time and resource constraints, the direct user surveys and the search for demographic correlations had to be abandoned. However, user characteristics (especially average erlang demand per user) had been sufficiently determined to allow an alternate method of developing the traffic model. The alternate method was accomplished by actually counting, from the FCC data base, the individual users licensed within 73 random sample counties (including the original 20 counties), then attributing to each user the average erlang demand derived from the direct surveys of 109 users. (Construction of the traffic model is detailed in section 2.5).

The results for 77 Business radio users sampled directly are summarized in Table 6.

Similarly, the results for 32 Special Industrial radio users sampled directly are shown in Table 7.

It must be emphasized here that the erlang demands shown in Tables 4,5,6, and 7 are computed per user, regardless of number of base or repeater stations. It must also be emphasized that these erlangs per user are one-way only, having been calculated from the survey of total traffic characteristics of the total base radios of each user.

Business and Special Industrial license counts for the 73 sampled counties are shown in Table 8.

Samples of Business and Special Industrial survey questionnaires are shown in Appendix B.

TABLE 6
BUSINESS USER TRAFFIC SURVEY RESULTS

USER	BASES	MOBILES	MSG PER DAY	AVG MSG LENGTH	WORK HOURS	MILLI-ERLANGS
#1	1	3	15	150	9	69.44
#2	2	4	15	8	11.5	2.89
#3	1	3	5	12	9	1.85
#4	1	2	10	60	9	18.51
#5	1	2	12	35	9	12.96
#6	1	9	125	35	9	135.03
#7	1	4	27	15	9.5	11.84
#8	2	30	45	45	10	56.25
#9	1	7	27	20	9.5	15.78
#10	1	6	30	20	13	12.82
#11	1	6	200	9	24	20.83
#12	1	15	30	60	11.5	43.47
#13	1	6	10	35	9	10.80
#14	5	200	1000	45	24	520.83
#15	1	2	20	5	24	1.15
#16	1	6	30	15	9	13.88
#17	1	5	10	17	11	4.29
#18	1	1	10	35	9	10.80
#19	1	6	30	20	9	18.51
#20	5	16	375	30	14	223.21
#21	1	2	10	10	9	3.08
#22	1	8	12	12	9.5	4.21
#23	1	4	50	10	10	13.88
#24	1	6	22	20	9	13.58
#25	1	3	75	17	9	39.35
#26	1	5	50	17	10	23.61
#27	2	13	75	150	11	284.09
#28	1	2	15	15	9	6.94
#29	2	20	55	7	24	4.45
#30	1	2	15	1	9	.46
#31	1	3	62	15	9	28.70
#32	1	3	10	7	10	1.94
#33	1	6	100	10	10	27.77
#34	3	3	16	10	10	4.44
#35	2	8	50	30	10	41.66
#36	1	5	20	30	10	16.66
#37	1	5	20	30	10	16.66
#38	1	12	160	15	16	41.66
#39	1	1	10	20	10	5.55

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TABLE 6 CONTINUED
BUSINESS USER TRAFFIC SURVEY RESULTS

USER	BASES	MOBILES	MSG PER DAY	AVG MSG LENGTH	WORK HOURS	MILLI-ERLANGS
#40	1	1	6	30	10	5.00
#41	1	10	30	20	10	16.66
#42	1	3	NA	NA	NA	0.00
#43	1	3	100	7	10	19.44
#44	1	4	20	20	12	9.25
#45	5	3	50	10	10	13.88
#46	1	3	50	5	11	6.31
#47	2	4	11	10	9	3.39
#48	1	3	20	7	9	4.32
#49	1	9	10	15	16	2.60
#50	1	2	10	4	15	.74
#51	1	3	7	8	13	1.19
#52	2	5	100	30	16	52.08
#53	1	2	6	7	8	1.45
#54	1	3	2	30	9	1.85
#55	1	1	12	10	10	3.33
#56	1	6	80	7	24	6.48
#57	2	5	50	10	13	10.68
#58	1	3	15	30	9	13.88
#59	1	2	8	20	17.5	2.53
#60	1	4	18	20	20	5.00
#61	1	3	90	150	12	312.5
#62	2	4	50	20	8.5	32.67
#63	1	1	13	13	8	5.86
#64	1	6	7	10	9	2.16
#65	1	12	70	13	11	22.97
#66	2	4	20	10	8	6.94
#67	1	6	10	12	10.5	3.17
#68	1	6	30	17	10	14.16
#69	4	3	50	12	10	16.66
#70	2	9	25	10	10	6.94
#71	1	2	20	17	12	7.87
#72	2	4	30	45	8	46.87
#73	1	3	20	12	9.5	7.01
#74	1	5	7	17	8	4.13
#75	1	1	5	22	9	3.39
#76	1	6	15	32	8	16.66
#77	1	2	4	12	24	.55
TOTALS:	106	600				2474.4

TABLE 7
SPECIAL INDUSTRIAL USER TRAFFIC SURVEY RESULTS

USER	BASES	MOBILES	MSG'S PER DAY	AVG MSG LENGTH	WORK HOURS	MILLI-ERLANGS
#1	1	3	10	30	10	8.33
#2	1	2	7	12	11	2.12
#3	1	4	12	35	13	8.97
#4	2	15	27	12	11	8.18
#5	1	3	35	12	11	10.60
#6	6	25	250	10	24	28.93
#7	2	15	125	15	24	21.70
#8	1	2	80	40	10	88.88
#9	2	8	100	7.5	24	8.68
#10	1	5	50	10	8	17.36
#11	1	8	100	15	24	17.36
#12	1	2	25	20	9	15.43
#13	1	4	50	18	9	27.77
#14	2	45	250	20	12.5	111.11
#15	1	4	12	7	10	2.33
#16	2	6	8	20	11	4.04
#17	1	6	20	5	9	3.08
#18	1	6	20	30	10	16.66
#19	1	4	5	7	16	.60
#20	1	7	150	30	9	138.88
#21	1	3	20	10	12.5	4.44
#22	1	14	100	7	9	21.60
#23	2	6	10	10	12	2.31
#24	2	7	50	7	10	9.72
#25	3	20	75	60	12	104.16
#26	1	4	55	4	10	6.11
#27	1	5	50	10	10	13.88
#28	5	20	275	10	24	31.82
#29	1	7	35	27	9	29.16
#30	1	4	20	7	13	2.99
#31	1	2	15	10	11	3.78
#32	2	25	70	12	8	29.16
	51	291				800.14

TABLE 8

BUSINESS AND SPECIAL INDUSTRIAL LICENSE COUNTS

COUNTY	STATE	BUSINESS	DERATED BUSINESS	SPECIAL INDUSTRIAL	DERATED SPECIAL INDUSTRIAL	POPULATION (000)
JACKSON	AL	19	15	9	8	51.4
WASHINGTON	AL	7	6	3	3	16.8
LAWRENCE	AR	26	21	16	15	18.45
UNION	AR	53	42	24	22	49.99
COCONINO	AZ	154	122	11	10	74.95
GILA	AZ	104	83	20	18	37.00
INYO	CA	32	25	8	7	17.9
BENT	CO	3	2	4	4	5.95
EAGLE	CO	107	85	6	6	13.17
WINDHAM	CT	36	29	18	17	92.31
SUSSEX	DE	133	106	32	29	98.00
DIXIE	FL	4	3	2	2	7.75
HENDRY	FL	34	27	19	17	18.6
DODGE	GA	8	6	6	6	16.96
KOSSUTH	IA	90	71	9	8	21.89
LUCAS	IA	32	25	6	6	10.31
CLARK	ID	1	1	0	0	.8.
CLEARWATER	ID	98	78	4	4	10.39
LEE	IL	133	106	64	59	36.33
SHELBY	IL	47	37	26	24	23.92
RANDOLPH	IN	48	38	18	17	30.00
HARPER	KS	55	44	31	28	7.78
LOGAN	KS	17	13	21	19	3.40
LYON	KS	48	38	4	4	35.11
HART	KY	3	2	3	3	15.4
ALLEN	LA	13	10	15	14	21.39
GARRETT	MD	12	10	13	12	26.5
ALLEGAN	MI	52	41	30	28	81.56
OSCODA	MI	11	9	1	1	6.86
CAMDEN	MO	66	52	5	5	19.96
ATTALA	MS	11	9	4	4	19.87
JEFFERSON	MT	6	5	4	4	7.03
ROSEBUD	MT	12	10	24	22	9.9
PITT	NC	102	81	33	30	83.65
OLIVER	ND	3	2	7	6	2.5
RICHLAND	ND	112	89	48	44	19.21
FRANKLIN	NE	16	13	15	14	4.38
KEITH	NE	65	52	28	26	9.36
GRAFTON	NH	59	47	14	13	65.81
CATRON	NM	6	5	1	1	2.72
LEA	NM	351	279	104	95	55.63
LINCOLN	NM	71	56	62	57	11.00
TAOS	NM	31	25	9	8	18.06
CHURCHILL	NV	11	9	1	1	13.92
ELKO	NV	22	17	18	17	17.27
LEWIS	NY	22	17	8	7	25.04
HOLMES	OH	26	21	14	13	29.42
ADAIR	OK	7	6	6	6	18.58
GREER	OK	17	13	21	19	6.80
DOUGLAS	OR	90	71	5	5	93.75
GILLIAM	OR	3	2	7	6	2.06
HARNEY	OR	11	9	3	3	8.31
TIOGA	PA	30	24	5	5	40.97
WILLIAMSBURG	SC	38	30	12	11	38.23
CLAY	SD	7	6	5	5	13.14
DEWEY	SD	18	14	10	9	5.37
GREENE	TN	17	13	3	3	54.41
HASKELL	TX	24	19	17	16	7.73
HUNT	TX	39	31	11	10	55.25
JACKSON	TX	39	31	28	26	13.35
KERR	TX	60	48	9	8	28.78
LEON	TX	16	13	8	7	9.59
OLDHAM	TX	6	5	8	7	2.20
REAGAN	TX	28	22	24	22	4.14
CACHE	UT	59	47	7	6	57.18
WAYNE	UT	3	2	0	0	1.91
MADISON	VA	29	23	6	6	10.23
LEWIS	WA	140	111	11	10	55.28
WHITMAN	WA	88	70	89	82	40.1
MARINETTE	WI	59	47	9	8	39.31
GREENBRIER	WV	7	6	19	17	37.67
FREMONT	WY	59	47	46	42	40.25
WESTON	WY	24	19	20	18	7.11
TOTALS:		3290	2613	1211	1115	1958.42

2.5 BASELINE TRAFFIC MODEL FOR THE 73 COUNTIES SAMPLED

The 1981 Baseline Traffic Model For The 73 counties sampled was constructed as follows:

2.5.1 County Police Radio

Using each county's population and the equation of correlation between County Police erlang demand and population, the peak milli-erlang traffic demand for each of the 73 counties sampled was computed.

These values are shown in Table 9 under the heading "COUNTY POLICE".

2.5.2 State Police Radio

Using the previously derived State Police average traffic of one erlang of peak demand, and a corresponding state/county area ratio for each of the 73 counties, State Police milli-erlangs per sample county were calculated.

These are shown in Table 9 under the heading "STATE POLICE."

2.5.3 Business and Special Industrial Radio

From the data presented in Table 6, the weighted average traffic demand per Business user was calculated to be 32.1 milli-erlangs peak. From Table 7, the weighted average demand per Special Industrial user was calculated to be 25 milli-erlangs peak. Figures 2 and 3 show the similarity between the user demand profiles of Special Industrial and Business Radio. In fact, 84% or more of the sampled users in each of these two services exhibit traffic demands between zero and forty milli-erlangs. The similarity between distributions reinforces the use of weighted averages as representative of most of the users in these two services.

These average demands multiplied by the derated license counts for these servies (Table 8), yielded the traffic demands for these services for each county.

These are shown in Table 9 under IB (Business) and IS (Special Industrial)

FIGURE 2

DISTRIBUTION OF BUSINESS RADIO SERVICE USERS' ERLANG DEMAND WITHIN THE SAMPLE (77 USERS)

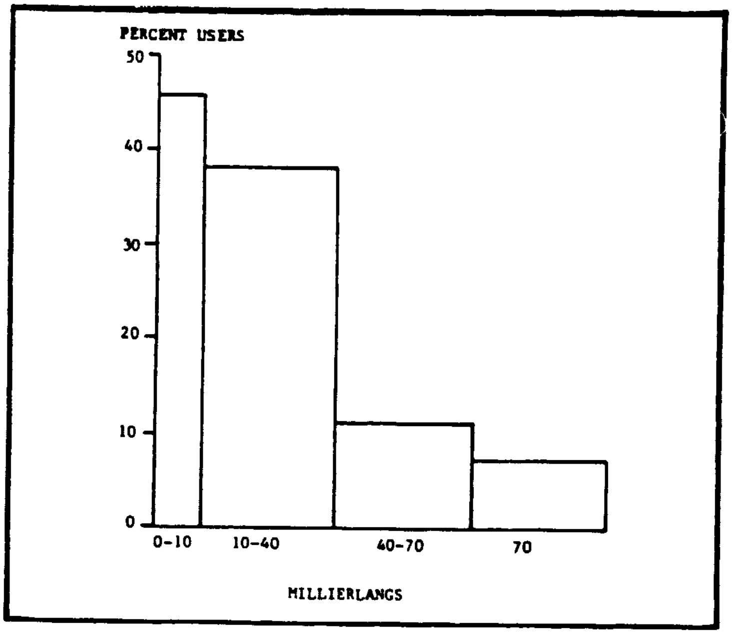
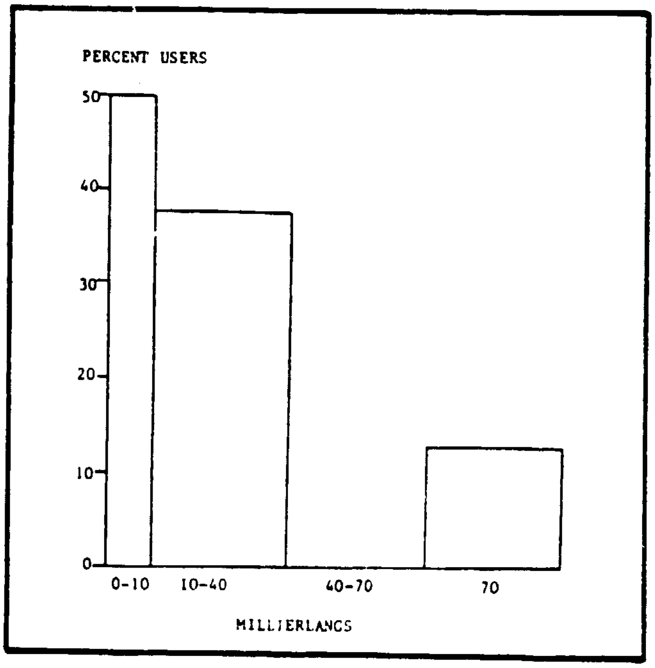


FIGURE 3

DISTRIBUTION OF SPECIAL INDUSTRIAL RADIO SERVICE USERS' ERLANG DEMAND WITHIN THE SAMPLE (32 USERS)



The first four columns of Table 9 were summed for each county data point, as shown in the column labeled "TOTAL." This total is representative of 69.44% of the fixed stations from all Land Mobile Radio Services (see Table 2). The demand originating from the remaining unsurveyed services were estimated by the ratio of the respective fixed installations, which is 30.56% of the total for all services. This amounts to a multiplier factor of 0.44 of the surveyed services. This estimated demand, in milli-erlangs peak for each county data point, is shown in Table 9 under "OTHER" (estimated). The "TOTAL" and "OTHER" columns are then summed as shown under "TOTAL ALL SERVICES" in Table 9.

TABLE 9
1981 BASELINE
MILLI-ERLANGS/COUNTY - 73 COUNTIES

FILE NAME-DATA

COUNTY	STATE	CO. POLICE	ST. POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
JACKSON	AL	70	21	484	206	781	343	1124
WASHINGTON	AL	24	21	178	68	291	128	419
LAWRENCE	AR	26	11	662	366	1065	468	1533
UNION	AR	68	20	1350	550	1988	874	2862
COCONINO	AZ	99	161	3923	252	4435	1951	6386
GILA	AZ	51	41	2649	458	3199	1407	4606
INYO	CA	25	64	815	183	1087	478	1565
BENT	CO	8	14	76	91	189	83	272
EAGLE	CO	18	16	2725	137	2896	1274	4170
WINDHAM	CT	122	105	917	412	1556	684	2240
SUSSEX	DE	130	479	3388	733	4730	2081	6811
DIXIE	FL	11	12	101	45	169	74	243
HENDRY	FL	26	21	866	435	1348	593	1941
DODGE	GA	24	8	203	137	372	163	535
KOSSUTH	IA	30	17	2292	206	2545	1119	3664
LUCAS	IA	14	7	815	137	973	428	1401
CLARK	ID	1	21	25	0	47	20	67
CLEARWATER	ID	14	30	2496	91	2631	1157	3788
LEE	IL	50	13	3388	1467	4918	2163	7081
SHELBY	IL	33	13	1197	596	1839	809	2648
RANDOLPH	IN	41	12	1222	412	1687	742	2429
HARPER	KS	11	9	1401	711	2132	938	3070
LOGAN	KS	5	13	433	481	932	410	1342
LYON	KS	48	10	1222	91	1371	603	1974
HART	KY	22	15	76	68	176	77	253
ALLEN	LA	30	17	331	344	722	317	1039
GARRETT	MD	37	66	305	298	706	310	1016
ALLEGAN	MI	109	14	1324	688	2135	939	3074
OSCODA	MI	10	9	280	22	321	141	462
CAMDEN	MO	28	9	1681	114	1832	806	2638
ATTALA	MS	28	15	280	91	414	182	596
JEFFERSON	MT	10	11	152	91	264	116	380
ROSEBUD	MT	14	34	305	550	903	397	1300
PITT	NC	111	13	259	756	3478	1530	5008
OLIVER	ND	3	10	76	160	249	109	358
RICHLAND	ND	27	20	2853	1100	4000	1760	5760
FRANKLIN	NE	6	7	407	344	764	336	1100
KEITH	NE	13	13	1655	642	2323	1022	3345

TABLE 9 CONTINUED

1981 BASELINE

MILLI-ERLANGS/COUNTY - 73 COUNTIES

COUNTY	STATE	CO. POLICE	ST. POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
GRAFTON	NH	88	230	1503	321	2142	942	3084
CATRON	NM	3	56	152	22	233	102	335
LEA	NM	75	35	8942	2385	11437	5032	16469
LINCOLN	NM	16	39	1808	1422	3285	1445	4730
TAOS	NM	26	18	789	206	1039	457	1496
CHURCHILL	NV	20	45	280	22	367	161	528
ELKO	NV	26	158	560	412	1156	508	1664
LEWIS	NY	35	27	560	183	805	354	1159
HOLMES	OH	41	10	662	321	1034	454	1488
ADAIR	OK	26	8	178	137	349	153	502
GREER	OK	10	9	433	481	933	410	1343
DOUGLAS	OR	124	53	2292	114	2583	1136	3719
GILLIAM	OR	3	12	76	160	251	110	361
HARNEY	OR	13	106	280	68	467	205	672
TIOGA	PA	56	25	764	114	959	421	1380
WILLIAMSBURG	SC	52	30	968	275	1325	583	1908
CLAY	SD	18	5	178	114	315	138	453
DEWEY	SD	7	30	458	229	724	318	1042
GREENE	TN	74	14	433	68	589	259	848
HASKELL	TX	11	3	611	389	1014	446	1460
HUNT	TX	75	3	993	252	1323	582	1905
JACKSON	TX	19	3	993	642	1657	729	2386
KERR	TX	40	4	1528	206	1778	782	2560
LYNN	TX	14	4	407	183	608	267	875
OLDHAM	TX	3	5	152	183	343	150	493
REAGAN	TX	6	4	713	550	1273	560	1833
CACHE	UT	77	14	1503	160	1754	771	2525
WAYNE	UT	3	30	76	0	109	47	156
MADISON	VA	14	8	738	137	897	394	1291
LEWIS	WA	75	36	3566	252	3929	1728	5657
WHITMAN	WA	55	32	2241	2041	4369	1922	6291
MARINETTE	WI	54	25	1503	206	1788	786	2574
GREENBRIER	WV	52	42	178	435	707	311	1018
FREMONT	WY	56	94	1503	1055	2708	1191	3899
WESTON	WY	10	24	611	458	1103	485	1588

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2.5.4. Key Elements of the Statistical Analysis

The key elements of the statistical analysis are itemized as follows:

(1) 20 counties were selected ramdomly for the initial sampling. If the county selected fell in a metropolitan area, the adjoining nonmetropolitan county was selected.

(2) For these 20 counties, direct user surveys were initiated for the following services:

(a) County Police (20 counties cooperated)
(b) State Police (13 states cooperated)
(c) Business (stopped at 13 counties)
(d) Special Industrial (stopped at 13 counties)

(3) The data of County Police showed a correlation with the population of the counties. This correlation was used to expand the sample to a subsequent larger sample of 73 counties, also randomly chosen.

(4) State Police data did not show much variation between erlang demand among states. An average value of one erlang for each state was thus assumed. The computed c.v. was $\pm$ 30%.

(5) The survey was initiated to all the users for Special Industrial and Business in the selected 20 counties. 77 Business and 32 Special Industrial users were contacted in 13 of the 20 counties.

(6) The Special Industrial and Business data derived from the survey are presented as histograms in Figures 2 and 3.

(7) The profiles obtained for the Special Industrial and Business user's erlang demand showed a substantial departure from normal distribution. However, the sample is sufficiently large as to enable neglecting corrections for non-normality in estimating population means.* Note that these profiles display

* Cockran, W.G., 1963. "Sampling Techniques." John Wiley and Sons, Inc., New York.

Hoel, P.G., 1971. "Introduction to Mathematical Statistics." John Wiley and a substantially similar probability distribution function (pdf); this pdf is also similar to that derived from the SIRSA survey for a larger sample of users (approximately 2800).

(8) The mean, standard deviation, and confidence interval for the average erlang demand for Special Industrial and Business Radio service are as listed in Paragraph 2.5.5.

(9) No significant correlation was found between Special Industrial and Business user's erlang demand and available county statistics (population, area, number of establishments, size of farms, per capita income, etc.). There exists a trend of larger traffic with greater county populations. The fluctuations in the trend were found however to be too high for confident extrapolation among counties (R2 = 0.3).

(10) Because of the weakness of the correlations, the original 20-county random sample was expanded by an additional 53 nonmetropolitan counties, also randomly chosen, for a total of 73 nonmetropolitan counties.

(11) This second-stage sampling included a total count, from the FCC data base, of Special Industrial and Business Radio users in each of the 73 counties.

(12) This total number of users per each of the 73 counties was multiplied by the average erlang demand computed from first-stage sample. This provided 73 data points, or approximately a 3% sample of nonmetropolitan counties.

2.5.5. Estimation of Mean, Standard Deviation, and Confidence Interval for Business and Special Industrial Radio Service

Busine

Mean	=	0.032 erlangs
Standard Deviation	=	0.0788 erlangs
Sample Size	=	76
Student t Value	=	1.295 (degrees of freedom = 75 level of confidence = 80%)
Confidence Interval	=	$0.032 \pm (1.295)(0.0788)/\sqrt{73}$ 0.032 ± 0.011

Confidence limits are 0.021 and 0.043 erlangs per user.

Special Industrial

Mean	=	0.025 erlangs
Standard Deviation	=	0.035 erlangs
Sample Size	=	32
Student t Value	=	0.32 (degrees of freedom = 31; level of confidence = 80%)
Confidence Interval	=	$0.025 \pm (1.32)(0.035)/\sqrt{32}$
	=	0.025 ± 0.008

Confidence limits are 0.017 and 0.033 erlangs per user

2.6 BASELINE FORECAST OF THE TRAFFIC MODEL (HISTORIC GROWTH RATES)

As discussed earlier, the method of entering their data base employed by the FCC obfuscates the accurate count of the elements of mobile radio systems, necessitating the use of appropriate derating factors drawn from the comparative analysis and integration of several additional data.

Historical growth rates drawn directly from the FCC data base are subject to similar ambiguities, particularly as regards the separation between metropolitan and nonmetropolitan growths.

To circumvent this problem, statistics from FCC, SIRSA, Census, and market forecasters were separately analyzed and integrated, to generate the following forecasts of the traffic pattern to 1990 and 2000. (Further details of the growth rate calculations are provided in Paragraph 2.8.6.)

2.6.1 Police Radio Service

Statistics by FCC and market analysts cite the annual nationwide growth of this service's fixed bases as 5%.

The FCC statistics for fixed stations in all radio services show that the ratio of nationwide growth to growth in the metropolitan areas is 8:5. Apportionment of this ratio among the 700 metropolitan and 2,300 nonmetropolitan counties yields a nonmetropolitan growth rate of fixed base count of 5.6% per annum.

Responses from the direct survey of those Police respondents who were equipped with message counters indicate erlang demand growth rates of 10 to 15% per annum at constant fixed base count for both County and State Police radio services.

Additionally, the County Police Radio service was shown to correlate with county population: Census data indicate that the growth rate of nonmetropolitan population exceeds that of the national population by a factor of 1.3.

Integration of these data leads to the estimation of 10% annual peak erlang traffic growth for nonmetropolitan Police Radio services.

2.6.2 Special Industrial Radio Service

SIRSA statistics show an average annual user system growth rate of 10% since 1976. Statistics from FCC and market analysts confirm this rate.

A decline of the historical growth rate has been observed in the early months of 1982. This is, however, attributed by SIRSA to temporary economic conditions, and was not therefore taken into account.

The 73 county survey shows that the nonmetropolitan county users for this service (Table 8) are slightly over twice as numerous per 1000 population as the national average.

Using the Census ratio of 25% (nonmetropolitan population) to 75% (metropolitan population), it can be computed that 52% of SIRSA users are nonmetropolitan.

Using the FCC's 8:5 national-to-metropolitan growth ratio for all services, it can be calculated that the 10% national annual growth of Special Industrial is composed of 13.5% nonmetropolitan and 6.25% metropolitan. Special Industrial annual nonmetropolitan traffic growth is therefore forecast at 13.5%.

2.6.3. Business Radio Service

Conflicting FCC and market analyst data show Business Radio user annual growth rates as low as 6% and as high as 25%.

One firm statistic offered by the National Association of Business and Educational Radio (NABER) was a recent annual new license growth rate of 10%.

The 73-county survey (Table 8) shows the nonmetropolitan users per 1000 population to be only slightly higher than the national average for this service. Using the same calculation process applied to Special Industrial, the forecast for Business nonmetropolitan annual growth is 19.6%.

2.6.4. Other Radio Services

Services such as Fire and Taxicab are concentrated in metropolitan areas; others, e.g., Forest Products and Conservation, are heavier in nonmetropolitan areas. There is thus a tendency for these services to offset each other. Consequently, the rate of users per 1000 population for Other Radio Services is assumed to be constant throughout the U.S.

Using the FCC's annual growth rate of 8% for all services, and the same calculation process applied to Business and Special Industrial, the forecasted annual growth for nonmetropolitan Other Radio Services is 8.9%.

2.6.5. Total Traffic

The individual annual growth rates for Police, Business, Special Industrial and Other Radio Services have been compounded to 1990 and 2000 and applied to their respective columns of Table 9 (1981 Baseline) to produce Tables 10 and 11, the Baseline Forecasts for 1990 and 2000.

Again, it is emphasized that the milli-erlang values represent one-way traffic and should be doubled to evaluate channel requirements for any system designed to handle both legs of two-way communications.

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TABLE 10
1990 BASELINE
MILLI-ERLANGS/COUNTY - 73 COUNTIES

FILE NAME-MERLS/COUNTY-1990

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
JACKSON	AL	214	2423	643	3280	738	4018
WASHINGTON	AL	106	891	212	1209	275	1484
LAWRENCE	AR	87	3314	1144	4545	1008	5553
UNION	AR	207	6759	1719	8685	1882	10567
COCONINO	AZ	613	19642	787	21042	4202	25244
GILA	AZ	216	13263	1431	14910	3030	17940
INYO	CA	209	4080	572	4861	1029	5890
BENT	CO	51	380	284	715	178	893
EAGLE	CO	80	13644	428	14152	2744	16896
WINDHAM	CT	535	4591	1287	6413	1473	7886
SUSSEX	DE	1435	16963	2291	20689	4482	25171
DIXIE	FL	54	505	140	699	159	858
HENDRY	FL	110	4336	1359	5805	1277	7082
DODGE	GA	75	1016	428	1519	351	1870
KOSSUTH	IA	110	11476	643	12229	2410	14639
LUCAS	IA	49	4080	428	4557	921	5478
CLARK	ID	51	125	0	176	43	219
CLEARWATER	ID	103	12497	284	12884	2492	15376
LEE	IL	148	16963	4585	21696	4659	26355
SHELBY	IL	108	5993	1862	7963	1742	9705
RANDOLPH	IN	124	6118	1287	7529	1598	9127
HARPER	KS	47	7014	2222	9283	2020	11303
LOGAN	KS	42	2168	1503	3713	883	4596
LYON	KS	136	6118	284	6538	1298	7836
HART	KY	75	380	212	667	165	832
ALLEN	LA	110	1657	1075	2842	682	3524
GARRETT	MD	242	1527	931	2700	667	3367
ALLEGAN	MI	290	6629	2150	9069	2022	11091
OSCODA	MI	44	1401	68	1513	303	1816
CAMDEN	MO	87	8416	356	8859	1736	10595
ATTALA	MS	101	1401	284	1786	392	2178
JEFFERSON	MT	49	761	284	1094	249	1343
ROSEBUD	MT	113	1527	1719	3359	855	4214
PITT	NC	292	13008	2363	15663	3295	18958
OLIVER	ND	30	380	500	910	234	1144
RICHLAND	ND	110	14285	3438	17833	3791	21624
FRANKLIN	NE	30	2037	1075	3142	723	3865
KEITH	NE	61	8286	2006	10353	2201	12554

TABLE 10 CONTINUED
1990 BASELINE
MILLI-ERLANGS/COUNTY - 73 COUNTIES

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
GRAFTON	NH	749	7525	1003	9277	2029	11306
CATRON	NM	135	761	68	968	219	1187
LEA	NM	259	44772	7455	52486	10839	63325
LINCOLN	NM	129	9052	4444	13625	3112	16737
TAOS	NM	103	3950	643	4696	984	5680
CHURCHILL	NV	153	1401	68	1622	346	1968
ELKO	NV	433	2803	1287	4523	1094	5617
LEWIS	NY	146	2803	572	3521	762	4283
HOLMES	OH	120	3314	1003	4437	977	5414
ADAIR	OK	80	891	428	1399	329	1728
GREER	OK	44	2168	1503	3715	883	4598
DOUGLAS	OR	417	11476	356	12249	2446	14695
GILLIAM	OR	35	380	500	915	236	1151
HARNEY	OR	280	1401	212	1893	441	2334
TIOGA	PA	190	3825	356	4371	906	5277
WILLIAMSBURG	SC	193	4846	859	5898	1255	7153
CLAY	SD	54	891	356	1301	297	1598
DEWEY	SD	87	2293	715	3095	684	3779
GREENE	TN	207	2168	212	2587	557	3144
HASKELL	TX	33	3059	1215	4307	960	5267
HUNT	TX	183	4971	787	5941	1253	7194
JACKSON	TX	51	4971	2006	7028	1570	8598
KERR	TX	103	7650	643	8396	1684	10080
LEON	TX	42	2037	572	2651	575	3226
OLDHAM	TX	18	761	572	1351	323	1674
REAGAN	TX	23	3570	1719	5312	1206	6518
CACHE	UT	214	7525	500	8239	1660	9899
WAYNE	UT	77	380	0	457	101	558
MADISON	VA	51	3695	428	4174	848	5022
LEWIS	WA	261	17855	787	18903	3722	22625
WHITMAN	WA	205	11220	6379	17804	4140	21944
MARQUETTE	WI	186	7525	643	8354	1693	10047
GREENBRIER	WV	221	891	1359	2471	669	3140
FREMONT	WY	353	7525	3297	11175	2565	13740
WESTON	WY	80	3059	1431	4570	1044	5614

TABLE 11
2000 BASELINE
MILLI-ERLANGS/COUNTY - 73 COUNTIES

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FILE NAME-MERLS/COUNTY-2000

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
JACKSON	AL	555	14509	2281	17345	1731	19076
WASHINGTON	AL	274	5335	752	6361	645	7006
LAWRENCE	AR	225	19845	4058	24128	2364	26492
UNION	AR	536	40475	6098	47109	4414	51523
COCONINO	AZ	1589	117624	2792	122005	9856	13186[illegible]
GILA	AZ	560	79424	5076	85060	7107	92167
INYO	CA	542	244[illegible]2	2029	27003	2413	29416
BENT	CO	132	2275	1007	3414	417	3831
EAGLE	CO	207	81705	1518	83430	6436	89866
WINDHAM	CT	1387	27492	4566	33445	3455	36900
SUSSEX	DE	3722	101581	8128	113431	10513	123944
DIXIE	FL	140	3024	496	3660	372	4032
HENDRY	FL	285	25965	4821	31071	2995	34066
DODGE	GA	194	6084	1518	7796	823	8619
KOSSUTH	IA	285	68723	2281	71289	5653	76942
LUCAS	IA	127	24432	1518	26077	2160	28237
CLARK	ID	132	748	0	880	100	980
CLEARWATER	ID	267	74837	1007	76111	5845	81956
LEE	IL	383	101581	16266	118230	10928	129158
SHELBY	IL	280	35888	6605	42773	4086	46859
RANDOLPH	IN	321	36637	4566	41524	3748	45272
HARPER	KS	121	42002	7883	50006	4738	54744
LOGAN	KS	108	12982	5332	18422	2071	20493
LYON	KS	352	36637	1007	37996	3044	41040
HART	KY	194	2275	752	3221	387	3608
ALLEN	LA	285	9922	3813	14020	1599	1561[illegible]
GARRETT	MD	627	9144	3302	13073	1564	140[illegible]
ALLEGAN	MI	752	39697	7627	48076	4743	52[illegible]
OSCODA	MI	114	8389	241	8744	710	94[illegible]
CAMDEN	MO	225	50398	1263	51886	4072	55[illegible]
ATTALA	MS	261	8389	1007	9657	919	[illegible]
JEFFERSON	MT	127	4557	1007	5691	584	6[illegible]
ROSEBUD	MT	293	9144	6098	15535	2005	17[illegible]
PITT	NC	757	77897	8383	87037	7729	947[illegible]
OLIVER	ND	77	2275	1773	4125	548	4673
RICHLAND	ND	285	85544	12197	98026	8892	106918
FRANKLIN	NE	77	12198	3813	16088	1695	17783
KEITH	NE	158	49619	7116	56093	5162	62055

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TABLE 11 CONTINUED
2000 BASELINE
MILLI-ERLANGS/COUNTY - 73 COUNTIES

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
GRAFTON	NH	1942	45062	3558	50562	4759	55321
CATRON	NM	360	4557	241	5158	513	5671
LEA	NM	671	268113	26448	295232	25425	320657
LINCOLN	NM	334	54207	15766	70307	7299	77606
TAOS	NM	267	23654	2281	26202	2308	28510
CHURCHILL	NV	396	8389	241	9026	811	9837
ELKO	NV	1123	16785	4566	22474	2566	25040
LEWIS	NY	378	16785	2029	19192	1787	20979
HOLMES	OH	311	19845	3558	23714	2291	26005
ADAIR	OK	207	5335	1518	7060	771	7831
GREER	OK	114	12982	5332	18428	2071	20499
DOUGLAS	OR	1081	68723	1263	71067	5737	76804
GILLIAM	OR	90	2275	1773	4138	553	4691
HARNEY	OR	726	8389	752	9867	1034	10901
TIOGA	PA	492	22905	1263	24660	2125	26785
WILLIAMSBURG	SC	500	29019	3047	32566	2943	35509
CLAY	SD	140	5335	1263	6738	696	7434
DEWEY	SD	225	13731	2536	16492	1604	18096
GREENE	TN	536	12982	752	14270	1306	15576
HASKELL	TX	85	18318	4310	22713	2251	24964
HUNT	TX	474	29768	2792	33034	2939	35973
JACKSON	TX	132	29768	7116	37016	3682	40698
KERR	TX	267	45811	2281	48359	3950	52309
LEON	TX	108	12198	2029	14335	1348	15683
OLDHAM	TX	46	4557	2029	6632	757	7389
REAGAN	TX	59	21378	6098	27535	2828	30363
CACHE	UT	555	45062	1773	47390	3893	51283
WAYNE	UT	199	2275	0	2474	236	2710
MADISON	VA	132	22127	1518	23777	1989	25766
LEWIS	WA	676	106923	2792	110391	8730	119121
WHITMAN	WA	531	67190	22631	90352	9711	100063
MARINETTE	WI	482	45062	2281	47825	3971	51796
GREENBRIER	WV	573	5335	4821	10729	1569	12298
FREMONT	WY	915	45062	11697	57674	6016	63690
WESTON	WY	207	18318	5076	23601	2448	26049

2.6.6 Explanation of Growth Rate Calculations

The following page (P.43) shows the detailed calculations of non-SMSA growth rates for Police, Special Industrial, Business and the "Other" radio services. The upper portion of page 43 summarizes the reference values which are applied in the equations for individual service growth rates shown on the lower portion of the page.

Note that after calculating the police non-SMSA annual growth at 5.6%, Paragraph 2.6.1 increases this estimate to 10%. This increase is based on judgemental evaluation of two factors: (1) survey findings that police message traffic is growing above and beyond base unit growth; and (2) the correlation, found in the analysis, of county police traffic to population, combined with the continuing trend for non-SMSA population to grow at 1.3 times the national average. The 10% growth rate estimate for non-SMSA police traffic is considered to be conservative.

DETAILED CALCULATIONS OF GROWTH RATES

FROM CENSUS:

	POPULATION (1000's)	ANNUAL GROWTH PER 1000	COUNTIES
U.S.:	226505	10.9	3042
SMSA:	169405	9.8	696
NON-SMSA:	57100	14.2	2346

FROM FCC:

BASE STATION GROWTH RATES (ALL SERVICES)
URBAN (ANNUAL): 5%
NATIONAL (ANNUAL): 8%

FROM REPORT:

SECTION 2.6 NATIONAL GROWTH RATES (ANNUAL)

POLICE	BUSINESS	SPEC. IND.
5%	10%	10%

TABLE 1 DERATED NAT'L STATION COUNTS

POLICE	BUSINESS	SP.IND.	OTHER	TOTAL
25845	270862	63068	158327	518102

TABLE 8 NON-SMSA LICENSE COUNTS (PER 1000 POP)
BUSINESS: 1.33 SP.IND.: 0.57

TO COMPUTE NAT'L GROWTH RATE OF "OTHER" SERVICES (X%):

X%(OTHER)+5%(POLICE)+10%(BUSINESS)+10%(SP.IND.)=8%(NAT'L)
X%(158327)+5%(25845)+10%(270862)+10%(63068)=8%(518102)
X=4.3%

TO COMPUTE URBAN (SMSA) GROWTH RATES USE 5/8 OF NAT'L RATES:

	POLICE	BUSINESS	SP.IND.	OTHER
NAT'L	5%	10%	10%	4.3%
SMSA(5/8)	3.13%	6.25%	6.25%	2.7%

TO COMPUTE NON-SMSA POLICE GROWTH RATE (X%):

X%(NON-SMSA COUNTIES)+3.13%(SMSA COUNTIES)=5%(NAT'L C'NTIES)
X%(2346)+3.13(696)=5%(3042)
X=5.6%

TO COMPUTE NON-SMSA SP.IND. GROWTH RATE (X%):

FIRST COMPUTE NON-SMSA USERS:
0.57 LIC/1000 x 57100 NON-SMSA 1000's = 32547

THEN:
X%(NON-SMSA)+6.25%(SMSA)=10%(NAT'L)
X%(32547)+6.25%(30521)=10%(63068)
X=13.5%

TO COMPUTE NON-SMSA BUSINESS GROWTH RATE (X%):

FIRST COMPUTE NON-SMSA USERS:
1.33 LIC/1000 x 57100 NON-SMSA 1000's = 75943

THEN:
X%(NON-SMSA)+6.25%(SMSA)=10%(NAT'L)
X%(75943)+6.25%(194919)=10%(270862)
X=19.6%

TO COMPUTE NON-SMSA "OTHER" GROWTH RATE (X%):

X%(NON-SMSA)+2.7%(SMSA)=4.3%(NAT'L)
(assuming licenses/1000 are uniform)
X%(57100)+2.7%(169405)=4.3%(226505)
X=9%

2.6.7. Alternative Tabulation (Milli-erlangs Per 10,000 Sq. Km.)

The preceeding tabulations of milli-erlangs per sample county treat each county as a point source of erlang demand within the US land area.

An alternative method is to use each county's area to convert the point source data to milli-erlangs per 10,000 sq. km. This conversion process has been applied to Tables 9, 10 and 11 to produce Tables 9A, 10A and 11A. Obviously, this process increases the erlangs associated with small counties (less than 10,000 sq. km.) and decreases the erlangs associated with large counties (larger than 10,000 sq. km.)

The significance of these two tabulation alternatives is their potential use as data points in a contour mapping program. Such a program could produce two sets of U.S. - wide contour maps reflecting: (1) the traffic demand in peak erlangs per county and (2) peak erlangs per 10,000 Sq. Km. Of course the contour sets resulting from these two sets of tables would be fundamentally different in shape and magnitude and each contour set would require a different interpretation or "reading" technique.

The "reading" technique in the case of the first contour set (Tables 9, 10 and 11: Milli-erlangs per County) would consist of imputing to any counties of interest, the erlang value of whichever contour passes through the center of the county.

The "reading" technique in the case of the second contour set (Tables 9A, 10A and 11A: Milli-erlangs per 10,000 sq. km.) would consist of imputing to any 10,000 sq. km of interest, the erlang value derived by standard linear interpolation of the subareas between contours.

2.6.8 Contour Mapping Interval Selection

Contour mapping of either of the preceeding sets of tables would require a method of selecting the specific values of the contour intervals. The following method is based upon a "constant accuracy" policy. By this is meant that beach contour line, regardless of the erlang level which it represents, is affected by the same proportional error as all other contours. This is accomplished by subdividing the erlang range pertaining to each plot in accordance with the expression:

$$e_{min} (1 + i)^n = e_{max}$$

or, equivalently:

$$i = \left(\frac{e_{max}}{e_{min}}\right)^{\frac{1}{n}} - 1$$

where:

e_{min}	=	minimum erlang value
e_{max}	=	maximum erlang value
i	=	fractional increment
n	=	number of contour levels

To illustrate, assume a contour mapping program, possessing a maximum n of 20, were used to plot contours from the data of Table 9A.

Thus, for example, with reference to County Police traffic, (see Table 9A):

e_{min}	=	2 milli-erlangs peak
e_{max}	=	667 milli-erlangs peak
i	=	0.34

This means that each erlang interval would be accurate to ± 34%.

Because the isolines would represent traffic per 10,000 Km^2, if the satellite's footprint area were of order 100,000 Km^2, it can be expected that the average error in the estimation of erlang demand per footprint (and thus in assessing the number of channels per footprint) would be reduced by approximately $\left(\frac{100,000 \text{ Km}^2}{10,000 \text{ Km}^2}\right)^{1/2}$, i.e., by a factor of order 3:1.

This would lead to an average error of estimation of the number of satellite channels per beam of approximately $\frac{34\%}{3} = 11\%$.

During the course of this project, contour maps, as described above, were attempted using a program of Boeing Computer Services, Vienna, VA. Representative products were obtained but their full potential, usefulness was not achieved due primarily to a programming feature that was not fully operational (the ability to specify variable increments between contours). Time and resource limits prevented further exploration of contour mapping as a useful means of displaying and analyzing the geographic distribution of erlang demand data.

2.6.9. Total Non-SMSA Erlangs

From Tables 9A, 10A, and 11A, the values in the column "TOT. ALL SERV." have been summed and divided by the number of data points (73) to produce "Average Non-SMSA Millierlangs Per 10,000 Sq. Km." for 1981, 1990, and 2000. These averages are 7,677; 28,568; and 140,748 respectively. Adding the values for radiotelephone of Figure 4 (Section 2.7), dividing by 1,000 to convert to erlangs, and multiplying by the number of nonmetropolitan 10,000 sq. Km. blocks in the U.S. (769), produces the following Total Non-SMSA Erlangs:

1981	5,904	(6,627 with radiotelephone)
1990	21,969	(23,299 with radiotelephone)
2000	108,235	(110,851 with radiotelephone)

TABLE 9A
1981 BASELINE MILLI-ERLANGS PER 10,000 SQUARE KILOMETERS - 73 COUNTIES

FILE NAME-MERLS/10000SQKM

COUNTY	STATE	CO. POLICE	ST. POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
JACKSON	AL	250	75	1731	737	2794	1227	4022
WASHINGTON	AL	86	76	644	246	1053	463	1517
LAWRENCE	AR	170	71	4332	2395	6969	3062	10032
UNION	AR	250	73	4964	2022	7310	3213	10523
COCONINO	AZ	20	33	816	52	923	406	1329
GILA	AZ	41	33	2154	372	2601	1144	3745
INYO	CA	9	23	305	68	407	179	586
BENT	CO	20	35	193	231	480	210	691
EAGLE	CO	41	36	6258	314	6651	2926	9577
WINDHAM	CT	916	788	6888	3094	11688	5137	16826
SUSSEX	DE	528	1946	13769	2979	19223	8457	27681
DIXIE	FL	61	66	563	251	942	412	1355
HENDRY	FL	84	68	2816	1414	4384	1928	6313
DODGE	GA	186	62	1573	1062	2884	1263	4147
KOSSUTH	IA	118	67	9039	812	10037	4413	14450
LUCAS	IA	124	62	7250	1218	8656	3807	12463
CLARK	ID	2	46	55	0	103	44	147
CLEARWATER	ID	21	45	3822	139	4029	1771	5801
LEE	IL	265	68	17968	7780	26082	11471	37554
SHELBY	IL	169	66	6145	3060	9442	4153	13595
RANDOLPH	IN	346	101	10324	3480	14252	6268	20521
HARPER	KS	53	43	6753	3427	10276	4521	14798
LOGAN	KS	17	46	1558	1730	3353	1475	4828
LYON	KS	220	45	5610	417	6294	2768	9062
HART	KY	202	91	698	625	1617	707	2325
ALLEN	LA	149	84	1651	1716	3601	1581	5182
GARRETT	MD	216	386	1786	1745	4136	1816	5952
ALLEGAN	MI	509	65	6188	3215	9979	4389	14368
OSCODA	MI	68	61	1920	150	2201	966	3168
CAMDEN	MO	168	54	10141	687	11052	4862	15914
ATTALA	MS	149	79	1493	485	2207	970	3179
JEFFERSON	MT	23	25	355	212	617	271	888
ROSEBUD	MT	10	26	233	421	692	304	996
PITT	NC	654	76	15314	4456	20501	9018	29520
OLIVER	ND	16	53	406	856	1333	583	1917
RICHLAND	ND	71	53	7602	2931	10658	4689	15348
FRANKLIN	NE	40	46	2718	2297	5103	2244	7347
KEITH	NE	48	48	6191	2401	8690	3823	12514

TABLE 9A CONTINUED
1981 BASELINE MILLI-ERLANGS PER 10,000 SQUARE KILOMETERS - 73 COUNTIES

COUNTY	STATE	CO. POLICE	ST. POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
GRAFTON	NH	196	512	3350	715	4774	2099	6874
CATRON	NM	1	31	85	12	130	57	187
LEA	NM	65	30	7859	2096	10051	4422	14474
LINCOLN	NM	12	30	1436	1130	2610	1148	3759
TAOS	NM	44	30	1350	352	1778	782	2560
CHURCHILL	NV	15	35	221	17	290	127	417
ELKO	NV	5	35	125	92	260	114	374
LEWIS	NY	104	80	1674	547	2407	1058	3466
HOLMES	OH	373	91	6028	2923	9415	4134	13549
ADAIR	OK	176	54	1205	927	2364	1036	3400
GREER	OK	60	54	2641	2933	5690	2500	8191
DOUGLAS	OR	94	40	1747	86	1969	866	2836
GILLIAM	OR	9	38	242	511	802	351	1153
HARNEY	OR	4	40	106	25	177	77	255
TIOGA	PA	188	84	2574	384	3230	1418	4649
WILLIAMSBURG	SC	214	123	3997	1135	5471	2407	7878
CLAY	SD	171	47	1696	1086	3003	1315	4318
DEWEY	SD	11	49	752	376	1189	522	1711
GREENE	TN	466	88	2727	428	3709	1631	5341
HASKELL	TX	48	13	2689	1712	4464	1963	6427
HUNT	TX	350	14	4641	1177	6184	2720	8904
JACKSON	TX	86	13	4510	2916	7526	3311	10838
KERR	TX	140	14	5358	722	6235	2742	8977
LEON	TX	49	14	1425	641	2130	935	3065
OLDHAM	TX	7	12	394	475	890	389	1280
[illegible]	TX	20	13	2431	1875	4341	1910	6251
CACHE	UT	253	46	4943	526	5768	2535	8304
WAYNE	UT	4	46	118	0	169	72	242
MADISON	VA	165	94	8713	1617	10591	4652	15243
LEWIS	WA	119	57	5661	400	6237	2743	8980
WHITMAN	WA	98	57	4018	3660	7834	3446	11281
MARINETTE	WI	151	70	4211		5009	2202	7212
GREENBRIER	WV	195	158	669		2660	1170	3830
FREMONT	WY	23	39	631		1136	500	1637
WESTON	WY	16	38	980	14	1769	777	2547

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TABLE 10A
1990 BASELINE MILLI-ERLANGS PER 10,COO SQUARE KILOMETERS - 73 COUNTIES

FILE NAME-MERLS/10KSQKM-1990

COUNTY	STATE	VOICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVIC
JACKSON	AL	766	8667	2303	11736	2642	14378
WASHINGTON	AL	[illegible]81	3224	768	4373	997	5370
LAWRENCE	AR	5[illegible]	21690	7486	29744	6595	36339
UNION	AR	761	24854	6320	31935	6920	38855
COCONINO	AZ	124	4085	162	4371	874	5245
GILA	AZ	174	10785	1162	12121	2464	14585
INYO	CA	75	1527	212	1814	385	2199
BENT	CO	129	966	722	1817	452	2269
EAGLE	CO	181	31334	981	32496	6302	38798
WINDHAM	CT	4017	34488	9671	48176	11065	59241
SUSSEX	DE	5833	68941	9311	84085	18216	102301
DIXIE	FL	299	2818	784	3901	887	4788
HENDRY	FL	358	14099	4419	18876	4152	23028
DODGE	GA	584	7876	3319	11779	2720	14499
KOSSUTH	IA	436	45258	2538	48232	9505	57737
LUCAS	IA	438	36301	3807	40546	8200	48746
CLARK	ID	113	275	0	388	94	482
CLEARWATER	ID	155	19136	434	19725	3814	23539
LEE	IL	785	89966	24318	115069	24708	139777
SHELBY	IL	554	30768	9564	40086	8945	49831
RANDOLPH	IN	1054	51692	10877	63623	13501	77124
HARPER	KS	225	33812	10712	44750	9738	54488
LOGAN	KS	148	7800	5407	13355	3177	16532
LYON	KS	624	28089	1303	30016	5962	35978
HART	KY	690	3494	1953	6137	1522	7659
ALLEN	LA	549	8266	5363	14178	3405	17583
GARRETT	MD	1419	8942	5454	15815	3911	19726
ALLEGAN	MI	1353	30983	10049	42385	9454	51839
OSCODA	MI	304	9613	468	10385	2080	12465
CAMDEN	MO	523	50776	2147	53446	10472	63918
ATTALA	MS	537	7475	1516	9528	[illegible]89	11617
JEFFERSON	MT	113	1777	662	2552	583	3135
ROSEBUD	MT	84	1166	1315	2565	654	3219
PITT	NC	1721	76677	13928	92326	19425	111751
OLIVER	ND	162	2032	267[illegible]	4069	1255	6124
RICHLAND	ND	292	38063	9161	47516	10100	57616
FRANKLIN	NE	202	13609	7179	20990	4833	25823
KEITH	NE	226	30998	7505	38729	8234	46963

10A CONTINUED
1990 BASELINE MILLI-ERLANGS PER 10,000 SQUARE KILOMETERS - 73 COUNTIES

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
GRAFTON	NH	1669	16773	2234	20676	4521	25197
CATRON	NM	75	425	37	537	122	659
LEA	NM	224	39350	6551	46125	9525	55650
LINCOLN	NM	99	7190	3532	10821	2472	13293
TAOS	NM	174	6759	1100	8033	1684	9717
CHURCHILL	NV	117	1106	53	1276	273	1549
ELKO	NV	94	625	287	1006	245	1251
LEWIS	NY	433	8381	1709	10523	2278	12801
HOLMES	OH	1094	30182	9136	40412	8904	49316
ADAIR	OK	542	6033	2897	9472	2231	11703
GREER	OK	268	13223	9168	22659	5385	28044
DOUGLAS	OR	315	8747	268	9330	1865	11195
GILLIAM	OR	110	1211	1597	2918	756	3674
HARNEY	OR	103	530	78	711	165	876
TIOGA	PA	641	12888	1200	14729	3054	17783
WILLIAMSBURG	SC	794	20013	3547	24354	5184	29538
CLAY	SD	514	8491	3394	12399	2832	15231
DEWEY	SD	141	3765	1175	5081	1124	6205
GREENE	TN	1306	13654	1337	16297	3513	19810
HASKELL	TX	143	13463	5351	18957	4228	23185
HUNT	TX	856	23237	3679	27774	5858	33632
JACKSON	TX	233	22581	9114	31928	7131	39059
KERR	TX	363	26827	2256	29446	5906	35352
LEON	TX	148	7135	2003	9286	2014	11300
OLDHAM	TX	44	1972	1484	3500	837	4337
REAGAN	TX	77	12172	5860	18109	4114	22223
CACHE	UT	705	24749	1644	27098	5460	32558
WAYNE	UT	117	590	0	707	155	862
MADISON	VA	610	43626	5054	49290	10020	59310
LEWIS	WA	414	28344	1250	30008	5908	35916
WHITMAN	WA	365	20118	11440	31923	7422	39345
MARINETTE	WI	521	21084	1803	23408	4743	28151
GREENBRIER	WV	832	3349	5113	9294	2520	11814
FREMONT	WY	146	3159	1381	4686	1077	5763
WESTON	WY	127	4906	2294	7327	1673	9000

TABLE 11A
2000 BASELINE MILLI-ERLANGS PER 10,000 SQUARE KILOMETERS - 73 COUNTIES

FILE NAME-MERLS/10KSQKM-2000

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
JACKSON	AL	1986	51901	8170	62057	6197	68254
WASHINGTON	AL	988	19306	2724	23018	2338	25356
LAWRENCE	AR	1473	129888	26558	157919	15470	173389
UNION	AR	1973	148836	22422	173231	16232	189463
COCONINO	AZ	321	24462	574	25357	2050	27407
GILA	AZ	451	64585	4122	69158	5779	74937
INYO	CA	194	9144	752	10090	903	10993
BENT	CO	334	5784	2561	8679	1060	9739
EAGLE	CO	469	187640	3480	191589	14782	206371
WINDHAM	CT	10419	206528	34310	251257	25955	277212
SUSSEX	DE	15129	412847	33033	461009	42729	503738
DIXIE	FL	775	16875	2781	20431	2080	22511
HENDRY	FL	928	84430	15677	101035	9739	110774
DODGE	GA	1514	47164	11775	60453	6380	66833
KOSSUTH	IA	1130	271023	9004	281157	22296	303453
LUCAS	IA	1136	217385	13506	232027	19235	251262
CLARK	ID	293	1646	0	1939	220	2159
CLEARWATER	ID	402	114594	1539	116535	8946	125481
LEE	IL	2036	538753	86275	627064	57958	685022
SHELBY	IL	1436	184251	33931	219618	20982	240600
RANDOLPH	IN	2733	309553	38589	350875	31669	382544
HARPER	KS	586	202480	38003	241069	22842	263911
LOGAN	KS	383	46709	19182	66274	7452	73726
LYON	KS	1618	168208	4622	174448	13985	188433
HART	KY	1789	20923	6928	29640	3570	33210
ALLEN	LA	1423	49500	19026	69949	7987	77936
GARRETT	MD	3680	53548	19349	76577	9174	85751
ALLEGAN	MI	3509	185539	35651	224699	22176	246875
OSCODA	MI	788	57566	1660	60014	4879	64893
CAMDEN	MO	1356	304067	7617	313040	24564	337604
ATTALA	MS	1392	44763	5378	51533	4900	56433
JEFFERSON	MT	293	10641	2348	13282	1367	14649
ROSEBUD	MT	217	6982	4665	11864	1534	13398
PITT	NC	4463	459173	49413	513049	45565	558614
OLIVER	ND	420	12168	9490	22078	2943	25021
RICHLAND	ND	757	227936	32501	261194	23691	284885
FRANKLIN	NE	523	81496	25469	107488	11336	118824
KEITH	NE	586	185628	26626	212840	19314	232154

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TABLE 11A CONTINUED
2000 BASELINE MILLI-ERLANGS PER 10,000 SQUARE KILOMETERS - 73 COUNTIES

COUNTY	STATE	POLICE	IB'S	IS'S	TOTAL	OTHER(EST)	TOT. ALL SERVICE
GRAFTON	NH	4328	100443	7925	112696	10605	123301
CATRON	NM	194	2545	131	2870	286	3156
LEA	NM	580	235644	23241	259465	22343	281808
LINCOLN	NM	256	43056	12530	55842	5798	61640
TAOS	NM	451	40475	3902	44828	3950	48778
CHURCHILL	NV	303	6623	188	7114	640	7754
ELKO	NV	243	3742	1018	5003	574	5577
LEWIS	NY	1123	50188	6063	57374	5343	62717
HOLMES	OH	2837	180742	32412	215991	20886	236877
ADAIR	OK	1405	36128	10277	47810	5233	53043
GREER	OK	695	79184	32526	112405	12631	125036
DOUGLAS	OR	817	52380	950	54147	4374	58521
GILLIAM	OR	285	7251	5665	13201	1773	14974
HARNEY	OR	267	3173	276	3716	387	4103
TIOGA	PA	1662	77178	4257	83097	7163	90260
WILLIAMSBURG	SC	2059	119846	12584	134489	12160	146649
CLAY	SD	1333	50847	12041	64221	6643	70864
DEWEY	SD	365	22546	4168	27079	2636	29715
GREENE	TN	3387	81765	4743	89895	8240	98135
HASKELL	TX	370	80622	18984	99976	9917	109893
HUNT	TX	2225	139152	13052	154429	13741	168170
JACKSON	TX	604	135224	32334	168162	16727	184889
KERR	TX	941	160651	8003	169595	13853	183448
LEON	TX	383	42727	7106	50216	4724	54940
OLDHAM	TX	114	11809	5264	17187	1963	19150
REAGAN	TX	199	72890	20790	93879	9650	103529
CACHE	UT	1828	148207	5832	155867	12807	168674
WAYNE	UT	303	3533	0	3836	363	4199
MADISON	VA	1562	261250	17930	280762	23504	304266
LEWIS	WA	1073	169735	4434	175242	13858	189100
WHITMAN	WA	946	120474	40586	162006	17410	179416
MARINETTE	WI	1351	126259	6396	134006	11125	145131
GREENBRIER	WV	2157	20055	18139	40351	5911	46262
FREMONT	WY	378	18917	4899	24194	2526	26720
WESTON	WY	32[illegible]	29379	8138	37846	3924	41770

2.7 BASELINE AND FORECAST FOR RADIOTELEPHONE

Current FCC statistics, which sample some 50 Common Carriers widely distributed through the U.S. and the 5,062 mobile units they serve, show a weighted average of 14 milli-erlangs per mobile. Combining this average with data on nonmetropolitan radiotelephones per state from prior ECOsystems' research produces the Radiotelephone Baseline shown in Figure 4. The established 7% annual growth rate for this service, when compounded to 1990 and 2000, produces the following forecasting coefficients:

1990	Multiply values in Figure 4 by 1.84
2000	Multiply values in Figure 4 by 3.62

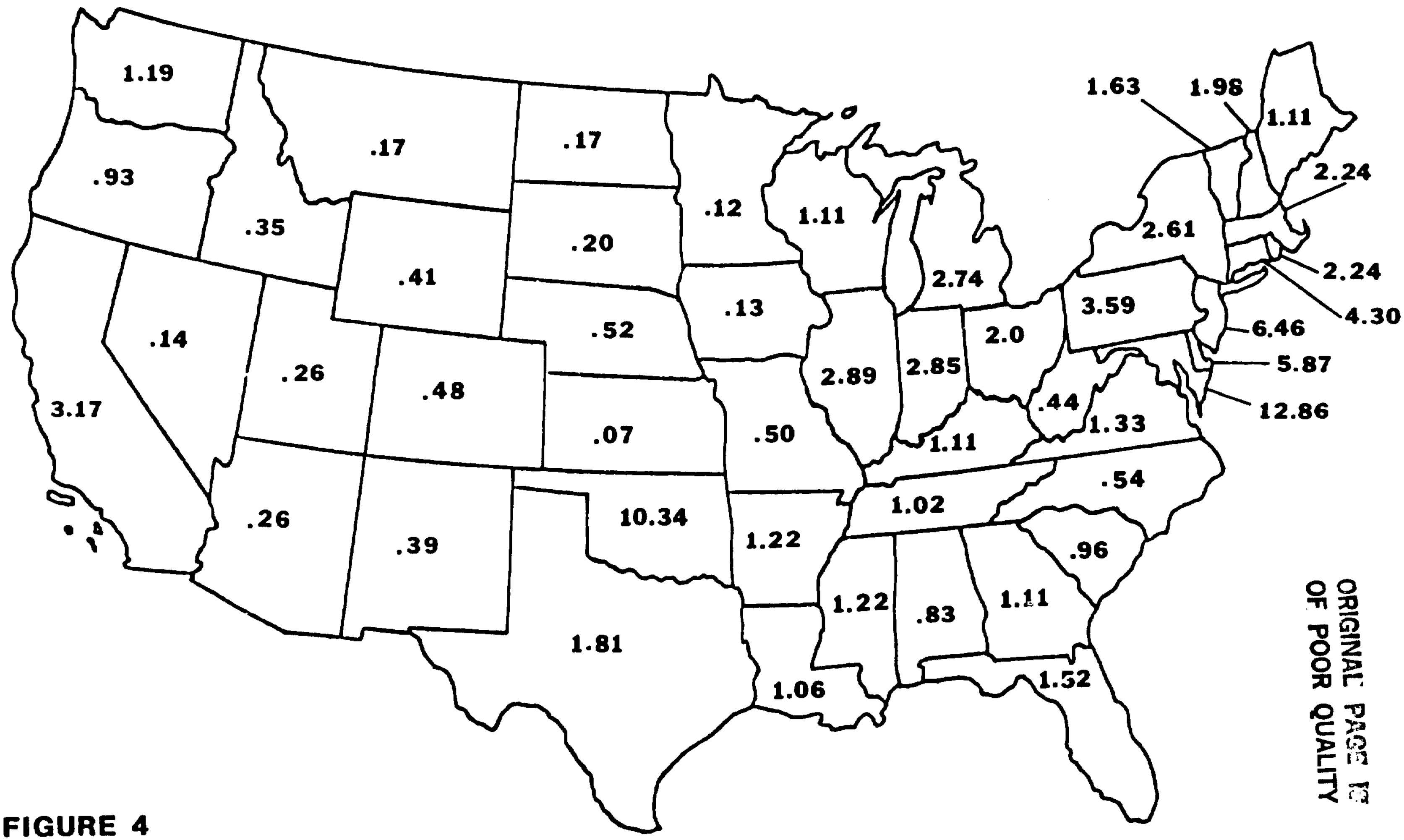

FIGURE 4

NONMETROPOLITAN RADIOTELEPHONE TWO-WAY ERLANGS PER 10,000 KM^2 BY STATE (1981)

2.8 ASSESSMENT OF PRICE ELASTICTY

2.8.1. Methodology

The intent of computing price elasticity—or, equivalently, the market demand profile—is twofold:

(1) To assess what fraction of the market could be captured by the alternative system, at what price;

(2) To assess whether the market could be expanded as a function of appropriate price policies.

The contemplated radio alternative system is expected to impact the structure, and therefore, the price to the users, of the fixed portions of terrestrial radio systems (impact upon the mobile segments is expected to be indirect).

The concept of the approach is thus to assess the market demand induced by the differential between current user costs and the new, lower costs potentially accruing from the advent of the alternative system.

The hypotheses used are: (1) the introduction of the new alternative system displaces the fixed station costs, e.g., those pertaining to bases and repeaters; (2) the yearly costs attributable to the presence of fixed stations are their yearly maintenance and amortization expenditures; (3) the alternative system would not affect the costs pertaining to the mobile units.

It is noted that hypothesis (1) establishes a maximum cost ceiling against which a hypothetical alternative system must compete. Eventual additional costs incurred in restructuring the terrestrial system for compatibility with the alternative system—e.g., provision of gateways, additional hard-wire services—must eventually be deducted from this ceiling to achieve a final estimate.

2.8.2. Displaceable Costs for Police Radio Services

One-half of the County Police and one-third of the State Police Departments surveyed supplied cost data of sufficient completeness and reliability to warrant their inclusion in the assessment. These data reflect the yearly expenditures incurred to maintain the fixed portions of their systems. These costs were then applied to the erlang demand generated by each user.

The results are presented in Tables 12 and 13 and in Figures 5 and 6.

Reliable data on fixed equipment amortization was not available to the Police respondents. This is because most Police Departments queried update their equipment internally, thus the assessment of equipment amortization or updating costs would require the analysis of each Department's capital budget. This procedure requires time and effort in excess of that available for this writing.

An alternate procedure is to impute an experiential ratio between maintenance and amortization to the data of Tables 12 and 13 and Figures 5 and 6. For typical electronic equipment, this ratio is currently of order 1:1. Thus the curves of Figures 5 and 6 are conservative by a factor approaching 2.

The above curves define the yearly burden which the Police services are currently sustaining for their fixed equipment. Equivalently, they could be considered as the costs that these Departments would save by converting to alternative service. In other words, the curves can be considered as representing the Police service's market demand for service.

2.8.3. Displaceable Costs for Special Industrial and Business Radio Services—User-Owned Systems

The method employed to assess these elements of costs is conceptually similar to that used for the Police services. The significant difference is that, whereas Police Departments in general possess good data on annual maintenance and limited data on capital expenditure amortization, the reverse was found to be true in the case of the businessmen-owned systems.

The average fixed base acquisition prices paid by the users as a function of the key parameters of frequency and transmitted power are synthesized in Figure 7.

The Business and Special Industrial users queried indicated 10 years as their average equipment replacement time.

The amortization data presented in Tables 14 and 15, and Figures 8 and 9 thus reflect the price of the fixed equipment divided by 10. This cost per erlang is doubled by adding consideration of maintenance costs.

2.8.4. Displaceable Costs for Special Industrial and Business Radio Services—Leased Systems

Twenty Business and Special Industrial users of the 109 surveyed (approximately 18%), used leased repeaters in addition to fixed base installations. The costs of the repeaters per two-way erlang-year are detailed in Table 16 and Figure 10. Note that the costs are additional to those applicable to the base installations only.

TABLE 12

RURAL COUNTY POLICE COST PER ERLANG (USING FIXED EQUIPMENT ANNUAL MAINTENANCE COSTS AND ERLANGS FOR 10 SAMPLE COUNTIES)

COUNTY/STATE	ERLANGS	COST PER ERLANG
MADISON, VA	0.006	$ 933,167
REAGAN, TX	0.007	430,000
COCONINO, AZ	0.020	365,500
ATTALA, MS	0.006	358,333
OSCODA, MI	0.004	322,500
CAMDEN, MO	0.007	184,286
FREMONT, WY	0.027	127,407
FRANKLIN, NE	0.008	107,500
INYO, CA	0.135	55,422
HARNEY, OR	0.004	32,250

TABLE 13

STATE POLICE COST PER ERLANG
(USING FIXED EQUIPMENT ANNUAL MAINTENANCE COSTS AND ERLANGS
FOR 6 SAMPLE STATES)

STATE	ERLANGS	COST PER ERLANG
MARYLAND	0.555	$ 774,852
MICHIGAN	0.904	285,398
KANSAS	0.598	259,821
GEORGIA	0.793	162,673
MISSISSIPPI	0.872	19,725
MISSOURI	0.920	18,228

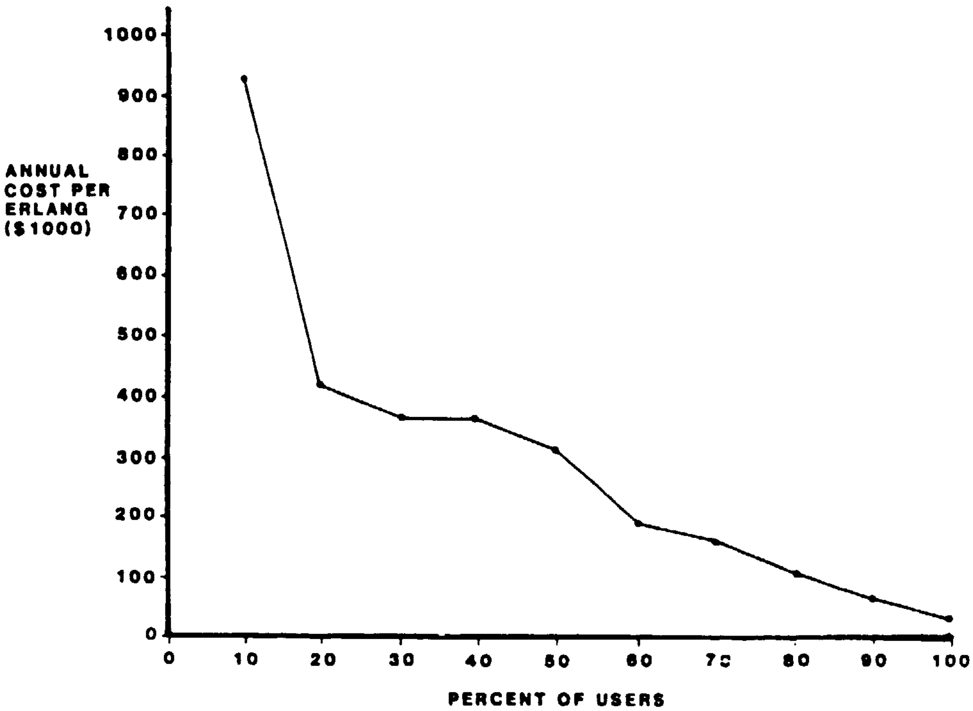

FIGURE 5

RURAL COUNTY POLICE ANNUAL ERLANG COSTS (USING FIXED EQUIPMENT ANNUAL MAINTENANCE COSTS & ERLANGS FOR 10 SAMPLE COUNTIES)

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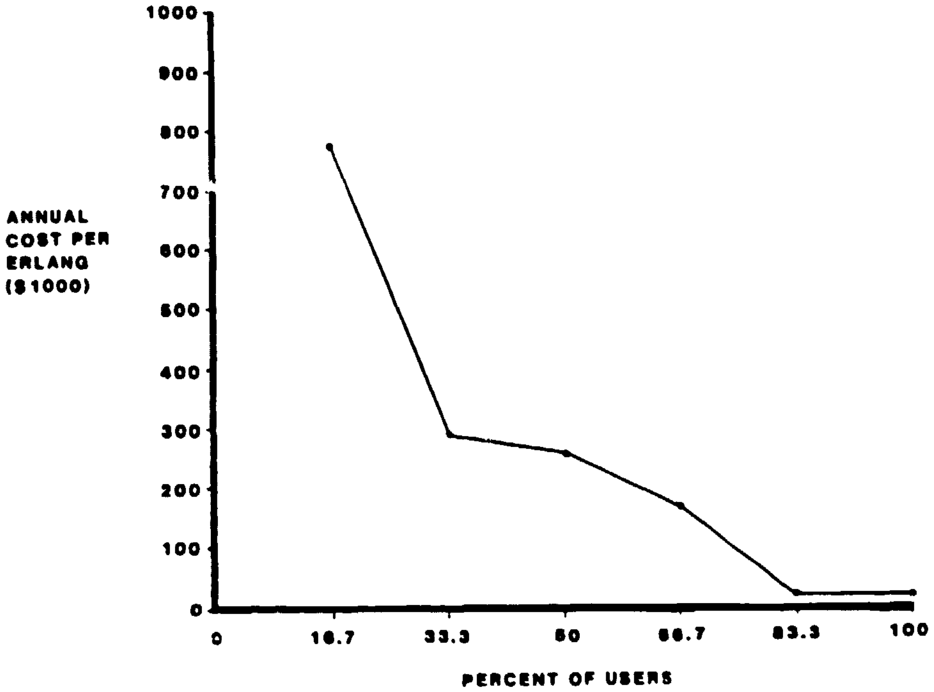

FIGURE 6

STATE POLICE ANNUAL ERLANG COSTS
(USING FIXED EQUIPMENT ANNUAL MAINTENANCE COSTS
& ERLANGS FOR SIX SAMPLE STATES)

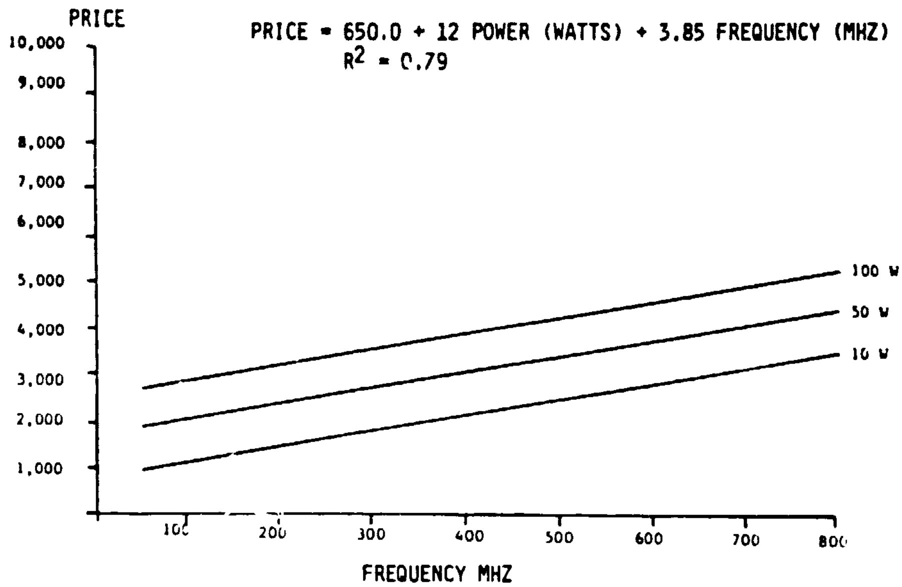

FIGURE 7

PRICE OF BASE STATION AS A FUNCTION OF FREQUENCY AND TRANSMITTED POWER (FEBRUARY 1982)

TABLE 14

BUSINESS USERS' BASE STATION COST PER ERLANG

USER	COST PER ERLANG	USER	COST PER ERLANG
#1	1940	#29	28971
#2	100953	#30	89984
#3	95445	#31	40905
#4	9545	#32	56352
#5	14098	#33	443138
#6	1620	#34	214152
#7	15374	#35	10301
#8	8196	#36	138375
#9	6170	#37	40425
#10	16917	#38	23567
#11	25794	#39	78296
#12	13015	#40	17470
#13	2522	#41	25750
#14	49860	#42	858
#15	221274	#43	16784
#16	329940	#44	106804
#17	8457	#45	15590
#18	72206	#46	76466
#19	5499	#47	18088
#20	163856	#48	85920
#21	9619	#49	73800
#22	22215	#50	31796
#23	12024	#51	7797
#24	4306	#52	39936
#25	62325	#53	36968
#26	40080	#54	71501
#27	5544	#55	18615
#28	10306	#56	536850

TABLE 15

SPECIAL INDUSTRIAL USERS' BASE STATION COST PER ERLANG

USER	COST PER ERLANG
#1	46590
#2	168889
#3	59339
#4	13836
#5	23478
#6	2255
#7	46172
#8	12234
#9	13755
#10	10899
#11	109821
#12	72641
#13	78651
#14	14565
#15	211886
#16	2612
#17	77906
#18	13805
#19	309528
#20	5772
#21	39723
#22	15293
#23	51565
#24	8323
#25	68278
#26	40326
#27	13742

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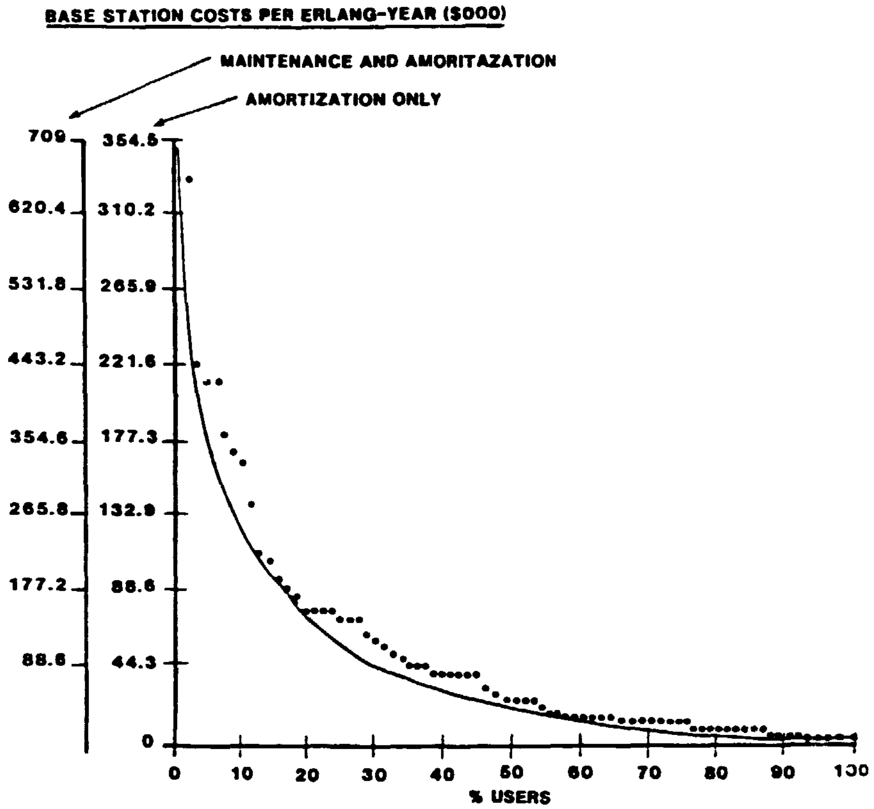

FIGURE 8

BUSINESS RADIO USERS' BASE STATION AMORTIZATION AND MAINTENANCE COSTS PER ERLANG-YEAR

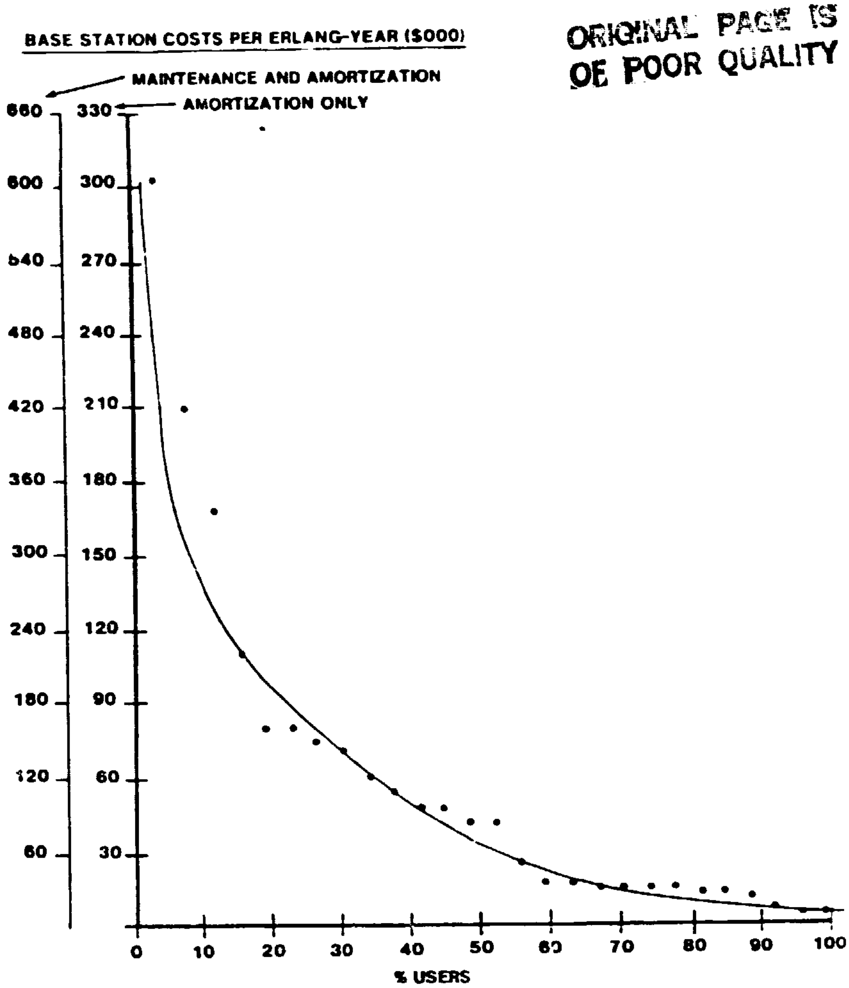

FIGURE 9

SPECIAL INDUSTRIAL USERS' BASE STATION AMORTIZATION AND MAINTENANCE COSTS PER ERLANG - YEAR

TABLE 16

BUSINESS & SPECIAL INDUSTRIAL USER COSTS PER ERLANG FOR REPEATER SERVICE

USERS	TOTAL BASES & MOBILES	$ PER MONTH	$ PER YEAR	TX PER DAY	AVG TX (SEC)	HRS PER DAY	MILLI ERL. 2-WAY	$/YEAR PER ERLANG
1	32	100	1200	45	45	10	112.50	10667
2	8	30	360	27	20	9.5	31.58	11400
3	7	40	480	30	20	13	25.64	18720
4	16	100	1200	30	60	11.5	86.96	13800
5	7	33	396	30	15	9	27.78	14256
6	6	15	180	10	17	11	8.59	20965
7	7	14	168	30	20	9	37.04	4536
8	3	25	300	20	17	12	15.74	19059
9	4	25	300	20	12	9.5	14.04	21375
10	11	45	540	25	10	10	13.89	38880
11	7	25	300	15	32	8	33.33	9000
12	3	20	240	15	10	11	7.58	31680
13	4	14	168	90	150	12	625.00	269
14	6	24	288	50	20	8.5	65.36	4406
15	15	130	1560	75	150	11	568.18	2746
16	3	30	360	15	15	9	13.89	25920
17	4	67	804	20	10	12.5	8.89	90450
18	3	41	492	10	4	15	1.48	332100
19	4	23	276	2	52	12	4.81	57323
20	25	37.5	450	275	10	24	63.66	7069

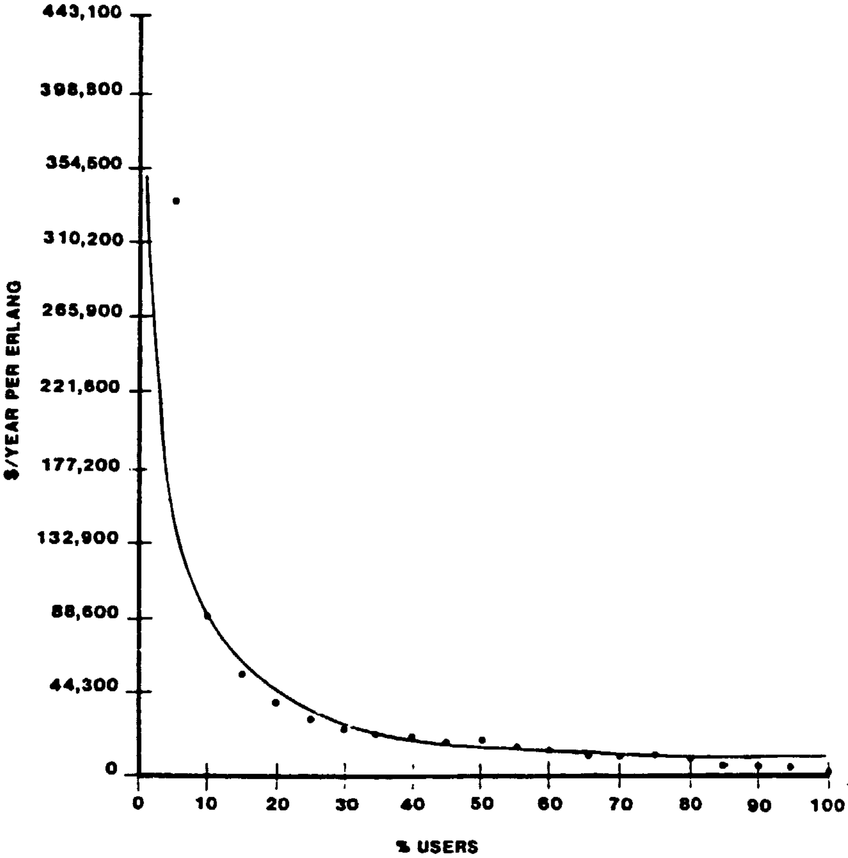

FIGURE 10

BUSINESS AND SPECIAL INDUSTRIAL USER COSTS PER ERLANG FOR REPEATER SERVICE

2.9 ASSESSMENT OF ELASTICITY OF DEMAND VERSUS SERVICE QUALITY

By quality elasticity is meant the additional price which users are willing to pay in order to upgrade the performance of their systems from current to predetermined levels of improvement. The purpose of calculating this quantity is to assess the magnitude of the eventual "premium" for performance which could be incorporated in the tariff structure of an eventual high-performance alternative system.

The most reliable data to the effect of computing such premium were found to be those furnished by SIRSA.

With Special Industrial Radio Service having a nationwide growth rate in excess of 9% per year since 1977, SIRSA surveys showed a general decline in system satisfaction with 6.6% fewer users (primarily metropolitan users) willing to rate their communication system "excellent" in 1979 as compared to 1977. In January 1979, SIRSA forwarded to its membership a survey designed to obtain reliable statistical information about this trend.

For the purpose of classifying the survey data, SIRSA designated a system as "rural" if its principal radio operations took place in a township, city, or county with less than 100,000 population. There were 1489 rural survey returns. System satisfaction indicated by rural users is shown in the following table.

Rural System Satisfaction

RATING	PERCENT
Excellent	22.9
Good	48.6
Average	19.2
Fair	6.8
Poor	2.5
100.0	

The question, asked by SIRSA to its users, of interest in evaluating service quality elasticity was:

Assuming your radio system satisfaction was average or below, how much would you be willing to pay to upgrade your system satisfaction to excellent?

The returns from the approximately 1300 rural SIRSA respondents to this question were as shown in the following table.

Willingness to Pay to Upgrade System Satisfaction to Excellent

WILLINGNESS TO PAY, $	CUMULATIVE PERCENT USERS	AVERAGE WILL- PERCENT USERS	INGNESS TO PAY PER USER	CUMULATIVE AVERAGE
$ 0	39.6	39.6	0	0
100	23.2	62.8	$ 23.20	23.20
500	22.1	84.9	110.50	133.70
2,500	12.6	97.5	315.00	448.70
10,000	2.5	100	250.00	698.70

Figure 11 shows the amount that rural users are willing to pay in order to upgrade the quality of their system satisfaction to excellent.

Figure 12 shows the prices which users actually pay for their base equipment. (Note that Special Industrial and Business Radio users are combined, because of their high degree of similarity.)

Comparison of Figures 11 and 12 shows that the user's willingness to pay a "premium for quality" is of order 7%.

This figure is consistent with an experiential expression, much used in the DP industry, "top quality is worth 10% more."

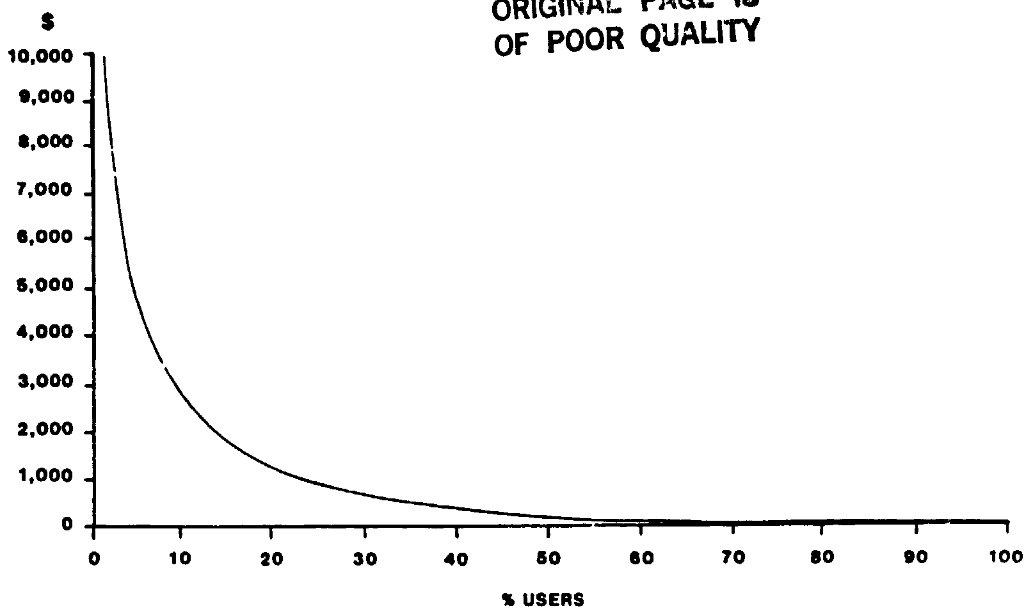

FIGURE II

USERS' WILLINGNESS TO PAY TO UPGRADE SYSTEM SATISFACTION TO EXCELLENT (CUMULATIVE BY % OF RURAL USERS)

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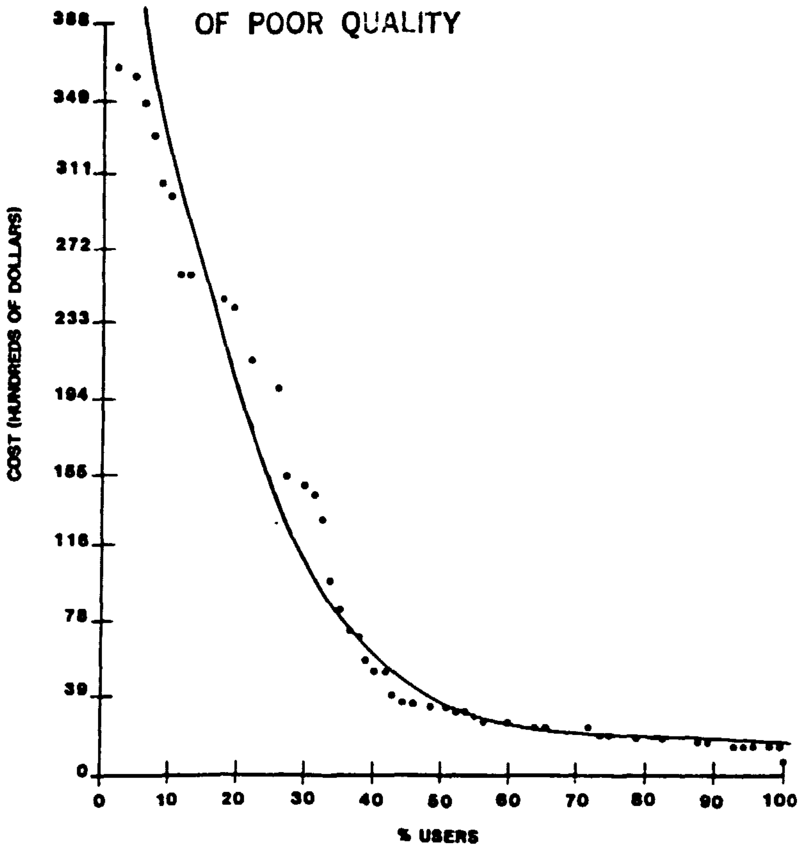


FIGURE 12

BUSINESS & SPECIAL INDUSTRIAL USERS' BASE RADIO COSTS (FEB 1982)

2.10. DISTANCE DISTRIBUTION OF MOBILE RADIO TRAFFIC

The results of the ECOsystems survey indicate that the distance requirements of Police mobile radio traffic range from very low (a few kilometers) up to the maximum distance subtended by the corresponding political boundaries. Only minimal traffic (of order 1% or less) is required to go beyond these boundaries.

The maximum ranges compute out as follows:

TERRITORIAL AREA (COUNTY OR STATE	AVERAGE MAXIMUM RANGE, Km	ABSOLUTE MAXIMUM RANGE, Km
Average Eastern County	20 - 30	40 - 60
Average Western County	50 - 70	100 - 140
Median State	150 - 200	300 - 400

By average maximum range is meant the radius of coverage from geographic center to the furthermost territorial boundary.

Absolute maximum range designates the longest distance between the furthest territorial boundaries.

The communication ranges for Special Industrial radio can be derived from SIRSA survey data as follows.

SIRSA queried users as to the range required by them and as to the range achieved by their mobile systems. The results of the survey appear as indicated in the table which follows.

Range Required Versus Achieved by Users

INDUSTRY	NUMBER OF RESPONDENTS	PERCENT	COMMUNICATION RANGE, WEIGHTED AVERAGE MILES REQUIRED	ACHIEVED
Agriculture	862	33.9	33.9	31.3
Heavy/Utility Contractor	455	17.9	44.4	38.1
Full Delivery	398	15.7	29.1	26.2
Concrete/Asphalt Placement	371	14.6	35.4	30.8
Agricultural Services	208	8.2	38.5	35.6
Mining	151	5.9	42.8	40.1
Petroleum Services	98	3.8	53.2	45.9
	2,543	100.0		
All Industry Weighted Average			36.9	33.1

It can be seen that the average differential between range achieved and range required is of order 10%. The premium which users are willing to pay to upgrade their range is included in the computation of quality elasticity, given in the previous section.

2.11. DELTA I FORECAST

The original intent of this portion of the effort was to assess the mobile radio traffic which would arise, above and beyond the baseline historic projection traffic, if the conditions which currently constrain the growth of the erlang demand were to be relaxed. (Constraints assumed initially were blockage, blind areas, interference, range.)

The results of the user survey, integrated with the analysis of available data, lead to the following conclusions as regards the nonmetropolitan user's view of the current constraints:

1. The presence of "blind spots," i.e., of areas of especially poor or missed communication, is acknowledged by the users. However, they do not feel that their filling is economically worthwhile with current technology costs.

2. Likewise, the existence of "fringe areas," i.e., zones of poor intelligibility, is recognized. Especially annoying are skip interferences from other signals in the western portions of CONUS. However, this factor is generally not considered by users to represent a significant problem.

3. Achievement of the desired communications ranges is satisfactory for Police Radio (by extensive use of relays) and appears essentially adequate for Special Industrial Services (see Section 2.10 dealing with Distance Distribution of Traffic). This finding does not imply that, if the possibility of increased range were offered by an alternative system at the appropriate price, users would not avail themselves of the opportunity. The finding merely indicates that users are by and large satisfied with current systems performance, within the horizon of their current perception of what current systems can accomplish technically and economically.

4. There exists an evolutionary trend of gradual increase of the lengths and numbers of messages. No major user demand appears to exist for "revolutionary," drastic increases of these parameters. However, if an alternative system to handle increased traffic were available, users would, in all probability avail themselves of it, providing that the price was within acceptable limits.

5. The user's willingness to pay additional moneys to upgrade their systems is relatively modest, of order of 7% of their current expenditures, see Figures 11 and 12. Systems upgrading from current performance to "excellent" includes the elimination of "blind spots," elimination of spurious interference, achievement of full desired range, elimination of waiting times.

6. Two principal factors were found to constrain the growth of users of mobile radio systems. The most significant of these is price; the next is "ease of usage."

   By the latter is meant the essentially unanimous desire on the part of users to do away with bases, repeaters, and the requirement for high-power car-mounted mobiles; and to have available, instead, small hand-portable units, usable anywhere and capable of communicating in uncomplicated wavs with all the transceivers comprising the user's system.

Since the anticipated constraints did not materialize and since the baseline historic projection traffic becomes extremely optimistic after several years of compounding growth rates it became necessary to alter the purpose of the Delta I forecast. Rather than search for amplifying growth coefficients, the Delta I forecast provides the following practical (albeit judgemental) limit to the baseline historic projection traffic.

Using the current land mobile frequency spectrum (allocated and reserve), the following computation produces the total number of nonmetropolitan systems that will saturate this spectrum.

SPECTRUM SATURATION

$U = N\ C/F \qquad A/\ \pi R^2$ = 616,000 SYSTEMS

U = MAXIMUM NON-METRO SYSTEMS
C = TOTAL NO. CHANNELS AVAILABLE
F = FREQUENCY RE-USE MULTIPLIER
A = TOTAL NONMETRO AREA SERVED
R = AVERAGE RADIUS OF COMMUNICATION (CELL)
N = NO. SYSTEMS PER CHANNEL/CELL

FOR CONUS:

A Z 7 X 106 km2

R Z 50 km

F = 7

C = 4850

N = 1 (CURRENT SYSTEM LOAD 0.03E = 1 CHANNEL QUALITY OF 0.03)

The 1981 baseline total nonmetropolitan erlangs indicate a total of 196,800 nonmetropolitan systems (at an average of 30 milli-erlangs per system). The 1990 historic projection of total nonmetropolitan erlangs indicates an aggregate annual growth rate of 15.7%. Applying this annual growth rate to the current 196,800 nonmetropolitan systems indicates that the spectrum saturation number of systems (616,000) will be achieved in just over eight years.

The Delta I forecast, therefore, concludes that the baseline historic projection is valid to the 1990 era; however, the arithmetical compounding of erlang growth rates (baseline historic projection for 2000) beyond 1990 is not reasonably useful.

2.12. DELTA II FORECAST

As a result of findings and developments after the start of this effort, the Delta II forecast originally envisioned was eliminated from this report.

3.0. TASK 2 FUNCTIONAL REQUIREMENTS

The extensive user interface, and the information collected from user organizations such as SIRSA during the Task 1 effort, lead to the initial definition of the following functional requirements for the mobile radio alternative system.

3.1. General Functional Requirements

1. The forecast for 2000 at current growth rates, shows that the U.S. nonmetropolitan total Land Mobile traffic demand will exceed 100,000 erlangs (one-way). If the capture rates of the alternative system should exceed 10 to 15% of the market, the implementation currently contemplated for the alternative system's space segment may require significant re-thinking to serve this demand. An obvious option is to set the initial price for alternative system service at a sufficiently high level so as to constrain the number of subscribers to within the system's initial capacity (the so-called strategy of the luxury market).

2. Current mobile radio systems have evolved gradually, since approximately 1925, without clearly defined prior guidelines or policies; rather, the evolution has occurred substantially as a reaction to the market demand. As a consequence, the current implementation of mobile radio has been characterized by some students as a "hodge-podge" of dispersed entities, with limited compatibility between each other. Nevertheless, the user surveys by agencies such as SIRSA, and the responses obtained during the survey conducted under Task 1, indicate that users are generally content with current performance. It is not therefore absolutely essential that the alternative system be totally compatible with all other systems emplaced prior to its advent. Specifically, full compatibility with the 30, 150, 450 MHz installations may be very difficult and costly to achieve. It is however highly desirable that the alternative system be compatible with all then-existing Land Mobile frequency allocations and trunking, routing and control systems (including metropolitan area cellular systems), in the 800 MHz band. In particular, an important feature of the future alternative system should be the development of policies which would allow orderly expansion of subscriber's population well beyond its era of implementation.

3. Land Mobile radio users unanimously desire hand held portability. This requires resolution of tradeoffs among radiation safety, power supply burden, and range.

4. Several users desire improved privacy, both to shield proprietary data from competitive business traffic, and to prevent unwanted interactions by suspects or the general public in public safety traffic.

5. Users desire mobile-to-mobile capabilities at least equal to, or better than, existing capabilities.

6. Users desire the shrinking or elimination of blind spots.

7. Users desire service quality (line blockage) equal to, or less than, 1%.

8. Users desire range capabilities equal to, or somewhat greater than, current range requirements (see Section 2.10 for details).

9. In cases where footprint boundaries are exceeded, invisible handover is required.

10. A segment of the user population is expected to acquire, at the appropriate price, two-way data transmission (e.g., data on equipment status, position location, navigation, slow-scan imagery, etc.).

11. Prices for service are the key determinant of the market. They will need to be competitive with baseline costs. (See Figures 5 , 6 , 8 , & 9.). Premiums for upgraded quality are not expected to command more than 10% (see Figure 11).

12. Mode of billing. With the exception of radiotelephone, current Land Mobile Radio users' costs are essentially insensitive to the number and duration of their transmissions (erlangs). This has conditioned the respective users to fixed costs regardless of traffic quantity. The alternative system may incorporate individual user traffic measurement capability thus enabling charges proportional to use. It is desirable to explore a hybrid billing mode (similar to radiotelephone), e.g., a base fixed price proportional to the number of units served, plus additional charges proportional to usage beyond standard levels for peak and nonpeak times.

3.2. Special Requirements for Police Mobile Radio

1. State and County Police traffic must access the limits of their geographic jurisdictions, often well in excess of 100 miles (see Section 2.10). Invisible handover across footprint boundaries crossing these jurisdictions is required.

2. A small amount (approximately 1%) of police traffic requires message routing outside of their jurisdictions for such activities as "hot pursuit", coordination or routine information exchange with neighboring and Federal elements (FBI), etc.

   During large scale gatherings/demonstrations/marches or motorcades, even greater cross-jurisdiction traffic will be required.

   In the event of large scale emergencies or disasters, additional external routing to neighboring counties, states, and to Federal elements such as the FEMA Regional Center, DOD, is required.

3. The two preceding requirements make it highly desirable to assure compatibility between Land Mobile and other Police systems, e.g., Aviation, Coastal Zone Monitoring, Inland Waters Patrolling.

4. Mobile-to-mobile capabilities are desired equal to, or greater than, current capabilities. Particularly important are the so-called State Police "point-to-point" systems, involving 300 Watt, 30 MHz, statewide car-to-car exchanges.

5. Police requirements involve operations inside buildings or otherwise radiation-absorbent areas.

6. Future Police radio traffic peak-to-average ratios are expected to range from 1.2 to 1.5.

7. Due to the nonprofit nature and the "public perceived need" of Police communication budgeting, the margin of willingness to pay for upgraded services is probably substantially greater than for Business or Industrial users.

8. Pricing of service "by the channel" may be more responsive to Police needs and practices than pricing in proportion to usage.

3.3. Special Requirements for Business, Special Industrial and "Other" Mobile Radio

The General Functional Requirements of Section 3.1 are a composite of requirements generated from the direct survey of Business and Special Industrial users and previous ECOsystems analysis of selected other mobile radio users. With the exception of Police special requirements, the remaining users demonstrate considerable operational uniformity. Therefore, no additional special requirements, beyond those for police, are indicated at this time.

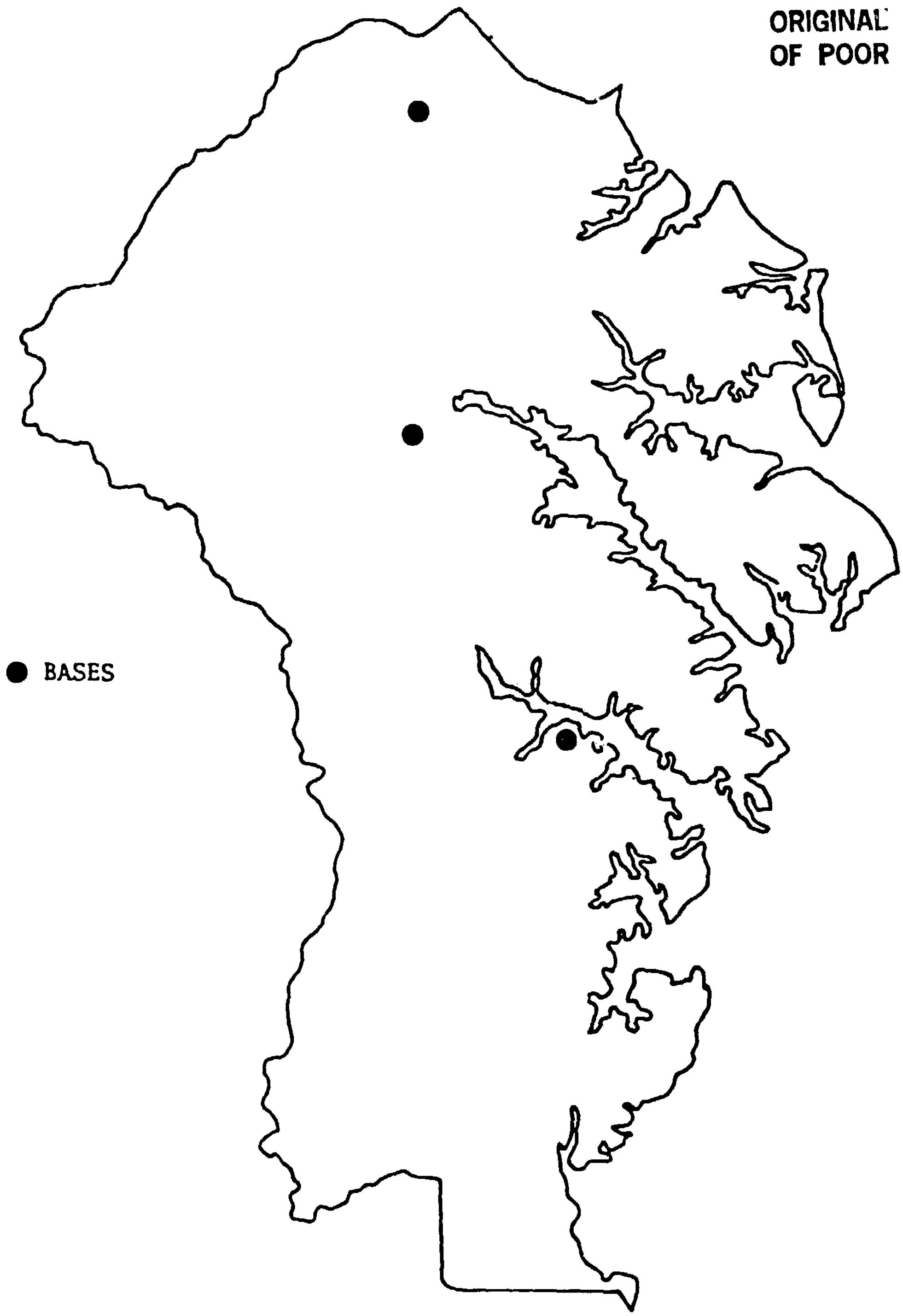
APPENDIX A

MAPS OF MOBILE RADIO SERVICE BASE LOCATIONS AND OF "BLIND" AREAS OF COUNTY AND STATE POLICE ORGANIZATIONS

This Appendix contains the geographical locations of base stations and of areas of poor reception, supplied by the Police Departments sampled as of the date of this writing.

In addition, maps pertaining to, and supplied by, selected Local Government organizations are included as follows:

Maryland Department of Forests and Parks
Maryland State Highway Administration



ANNE ARUNDEL COUNTY
MARYLAND

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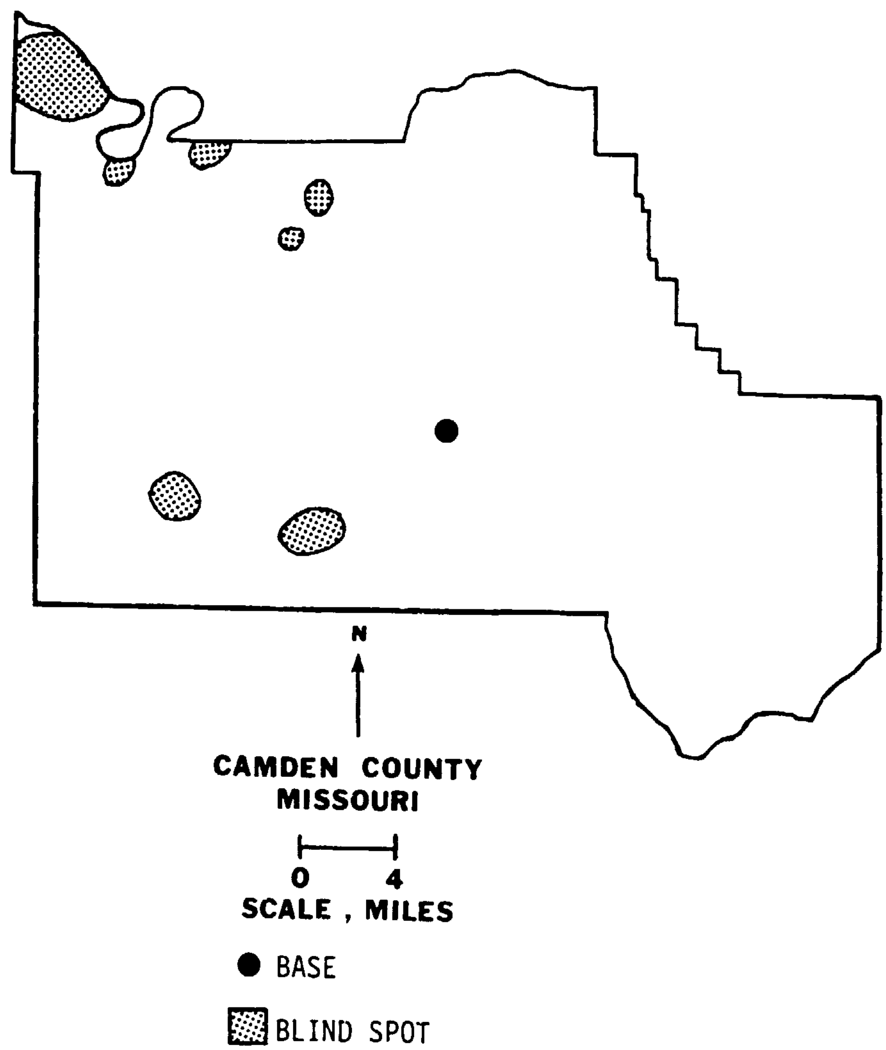
SCALE, MILES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CAMDEN COUNTY
MISSOURI
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BASE
BLIND SPOT

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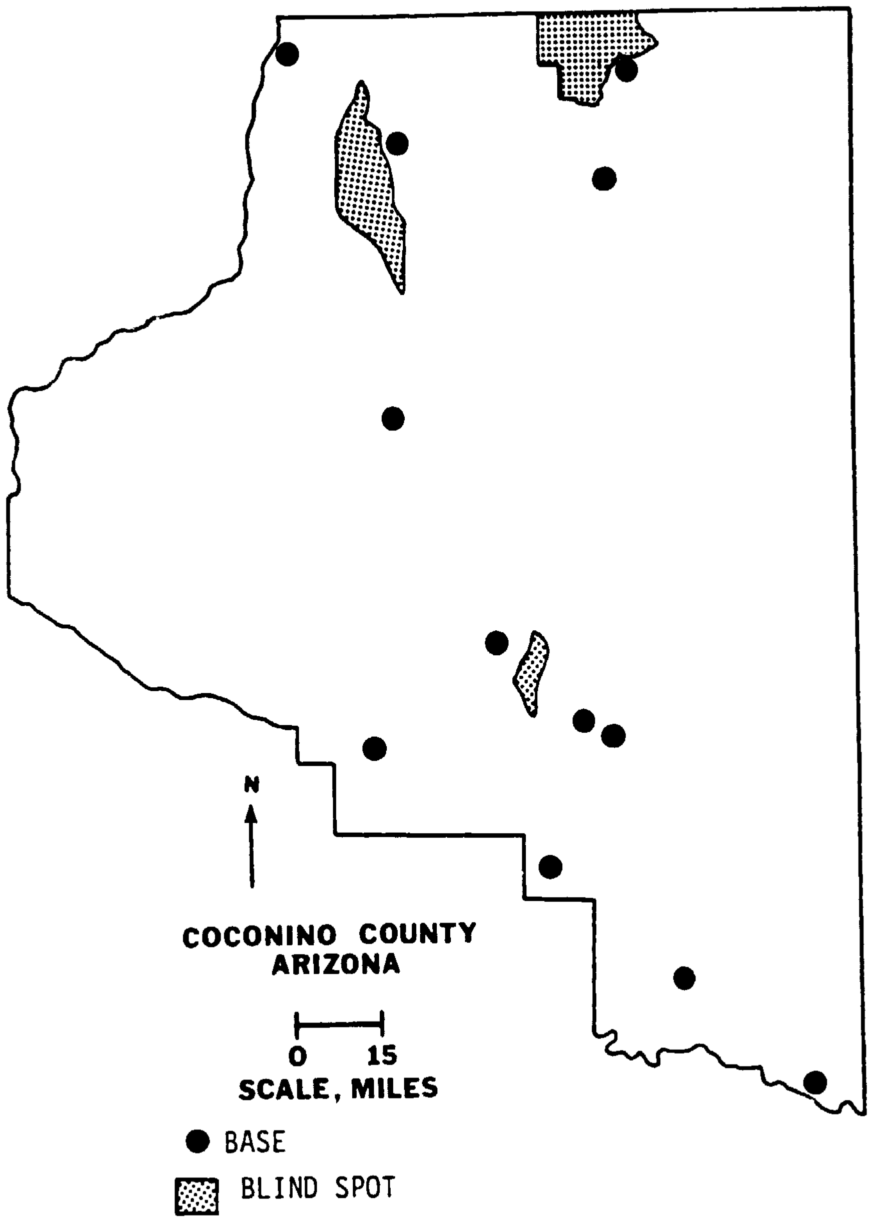

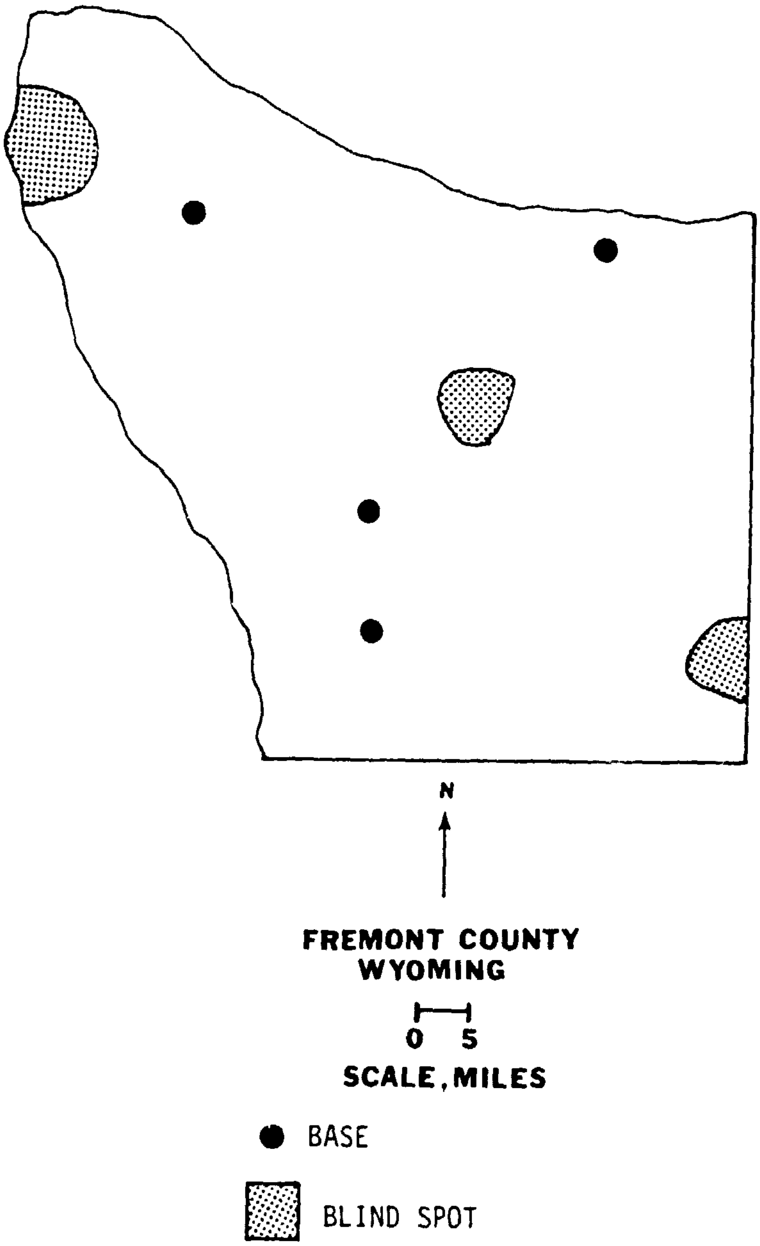
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FREMONT COUNTY
WYOMING
0 5
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BASE
BLIND SPOT

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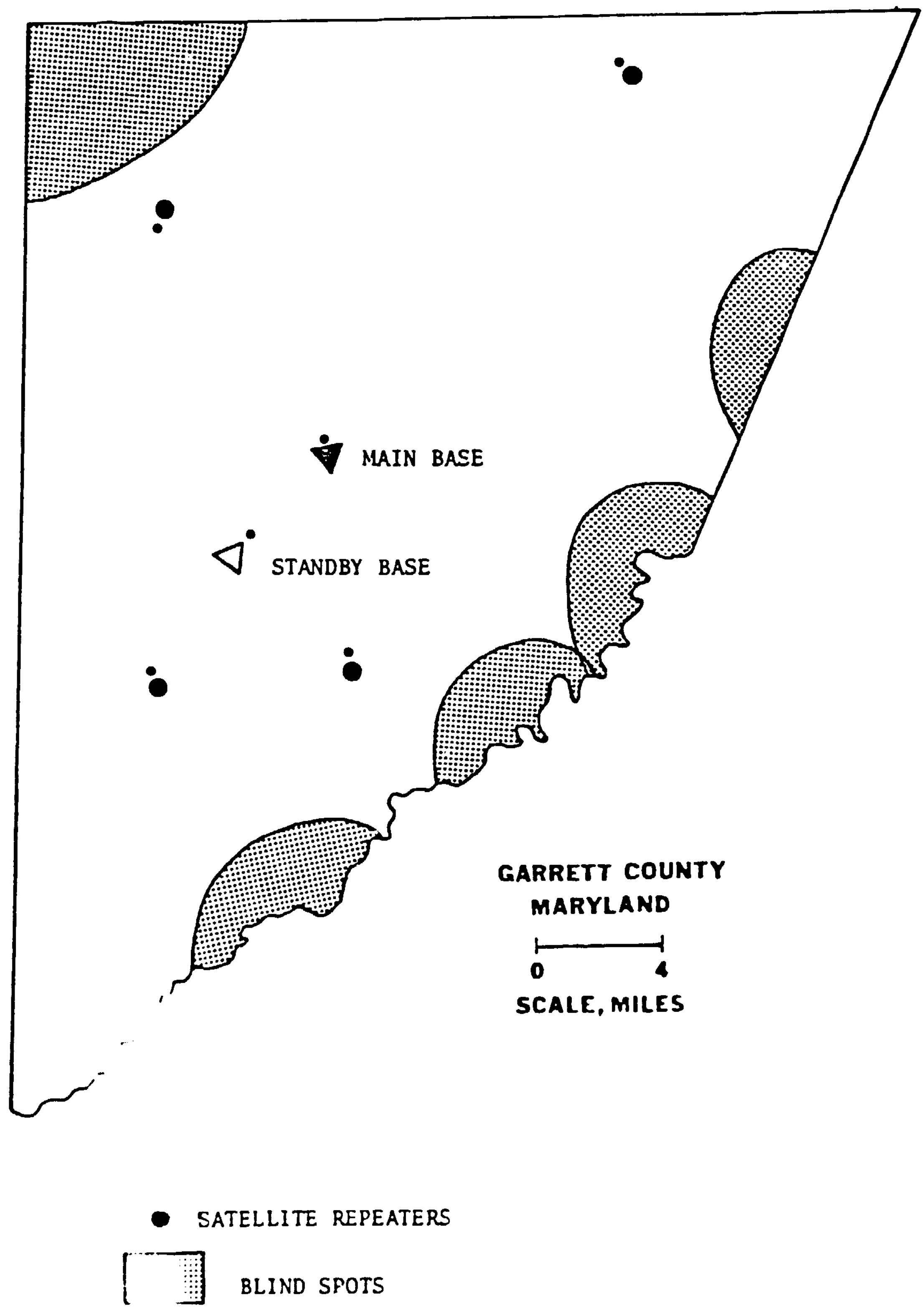

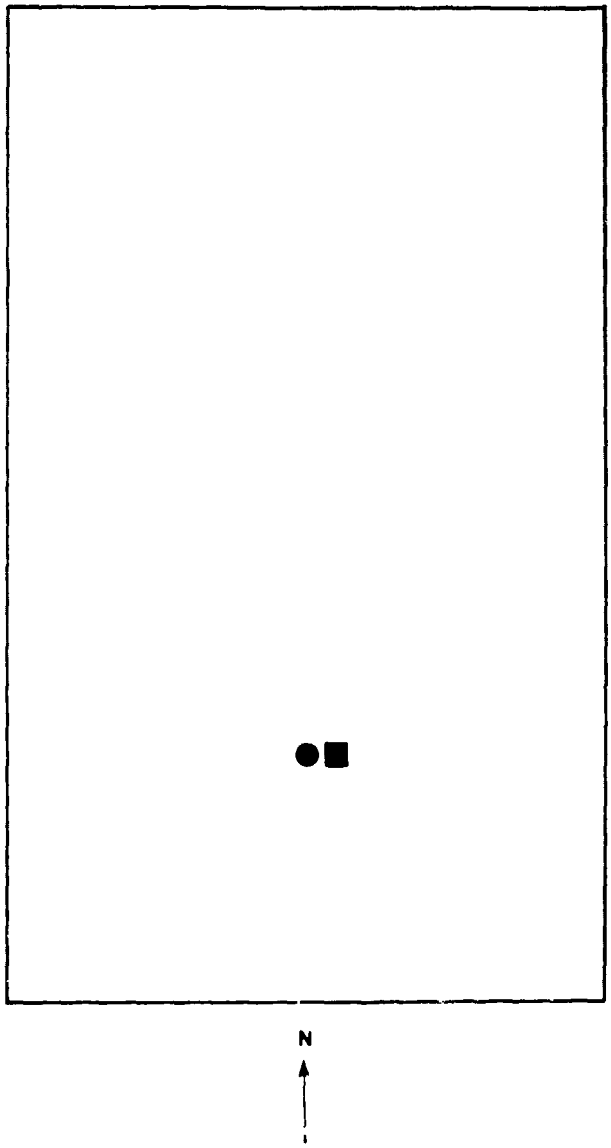

**KOSSUTH COUNTY
IOWA**

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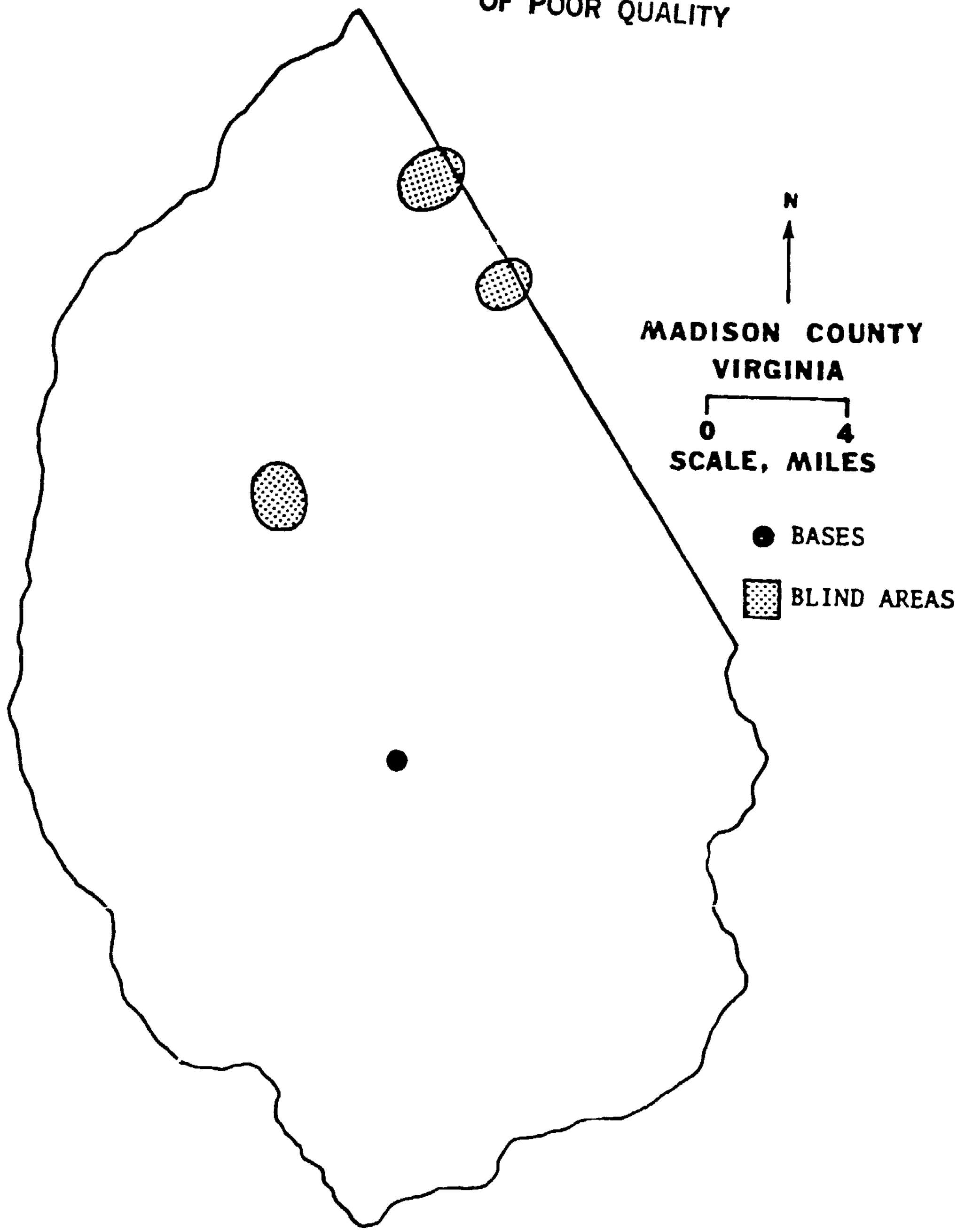
SCALE, MILES

● BASE ■ REPEATER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VIRGINIA
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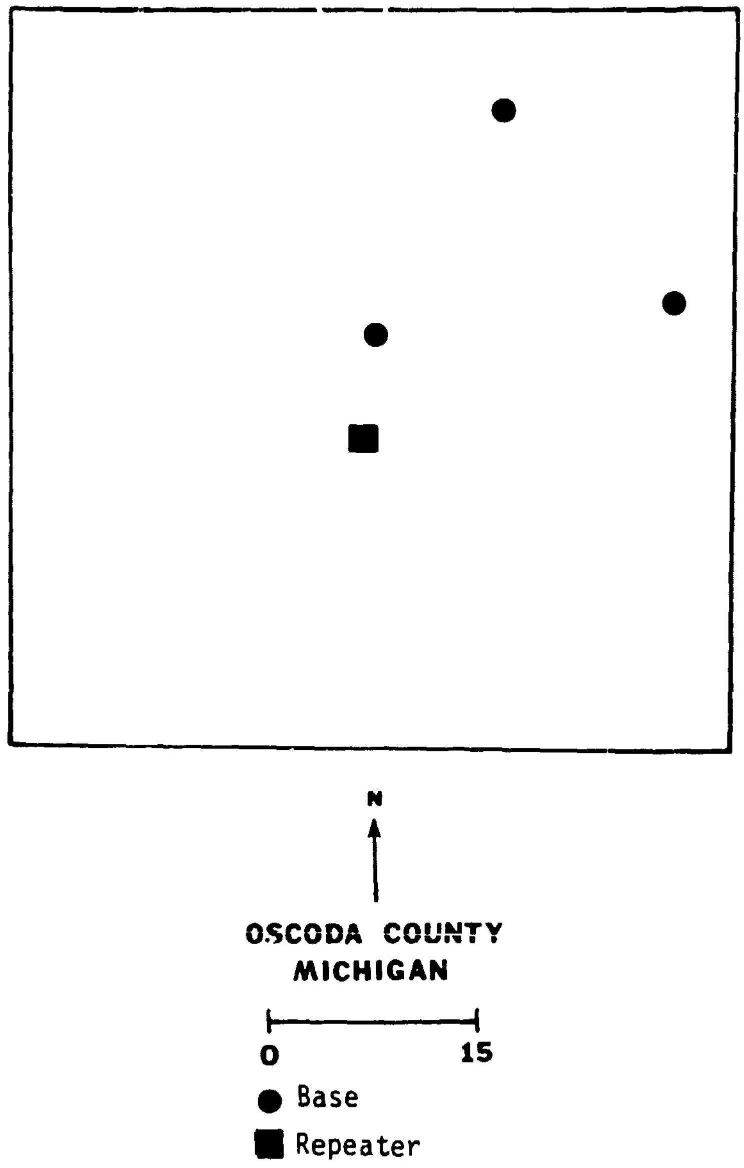
4
SCALE, MILES
BASES
BLIND AREAS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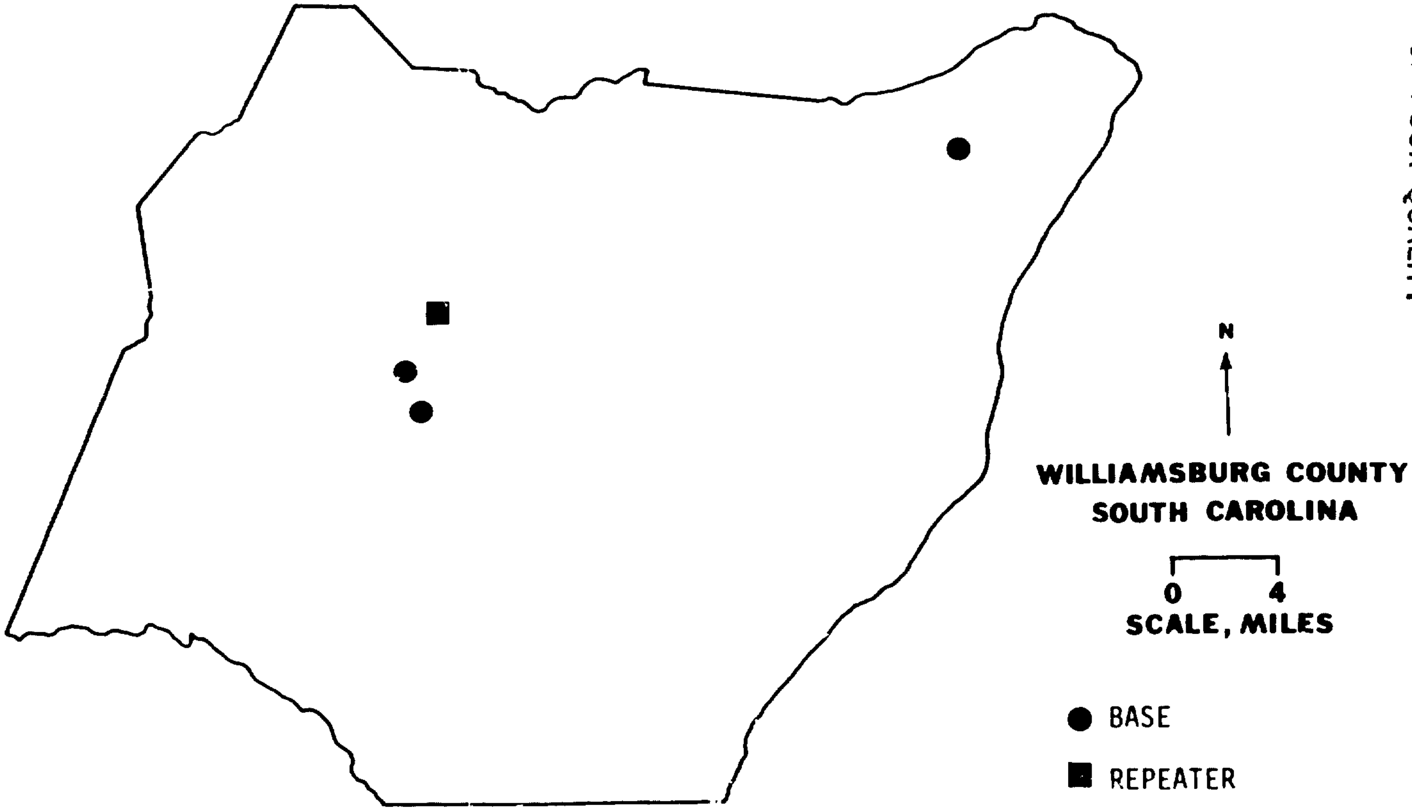
OSCODA COUNTY
MICHIGAN
0
15
Base
Repeater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WILLIAMSBURG COUNTY
SOUTH CAROLINA
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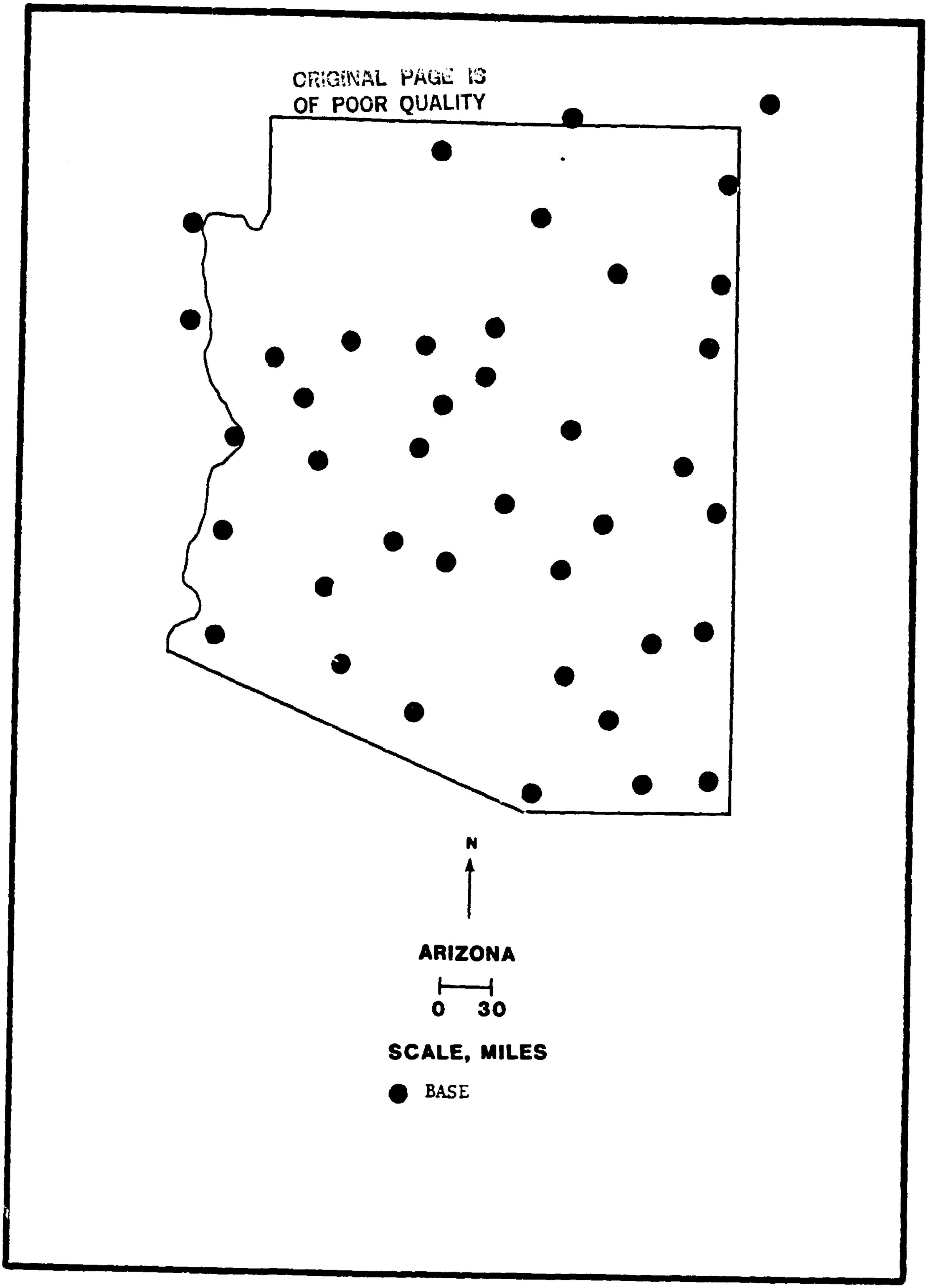
BASE
REPEATER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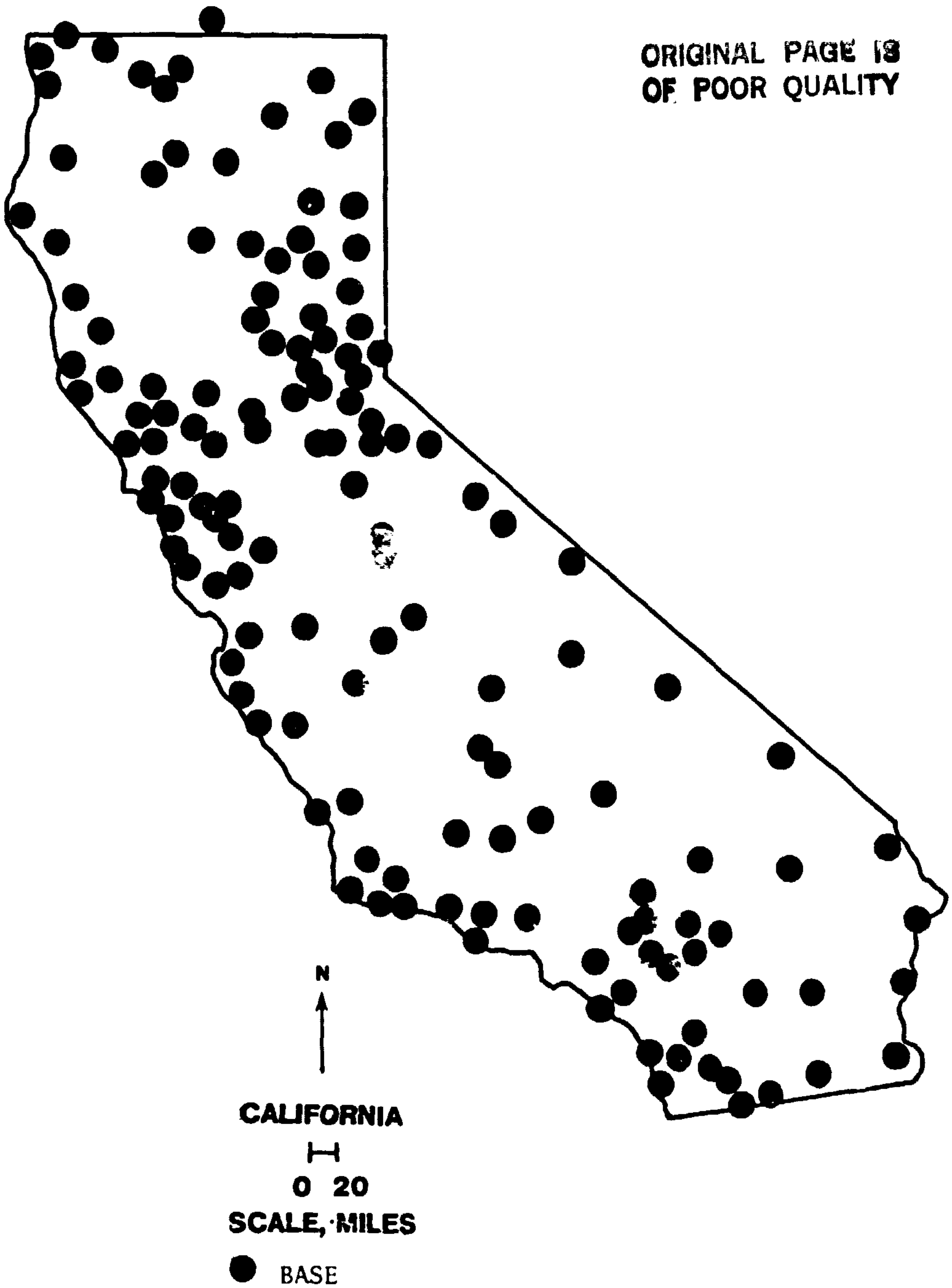
SCALE, MILES
BASE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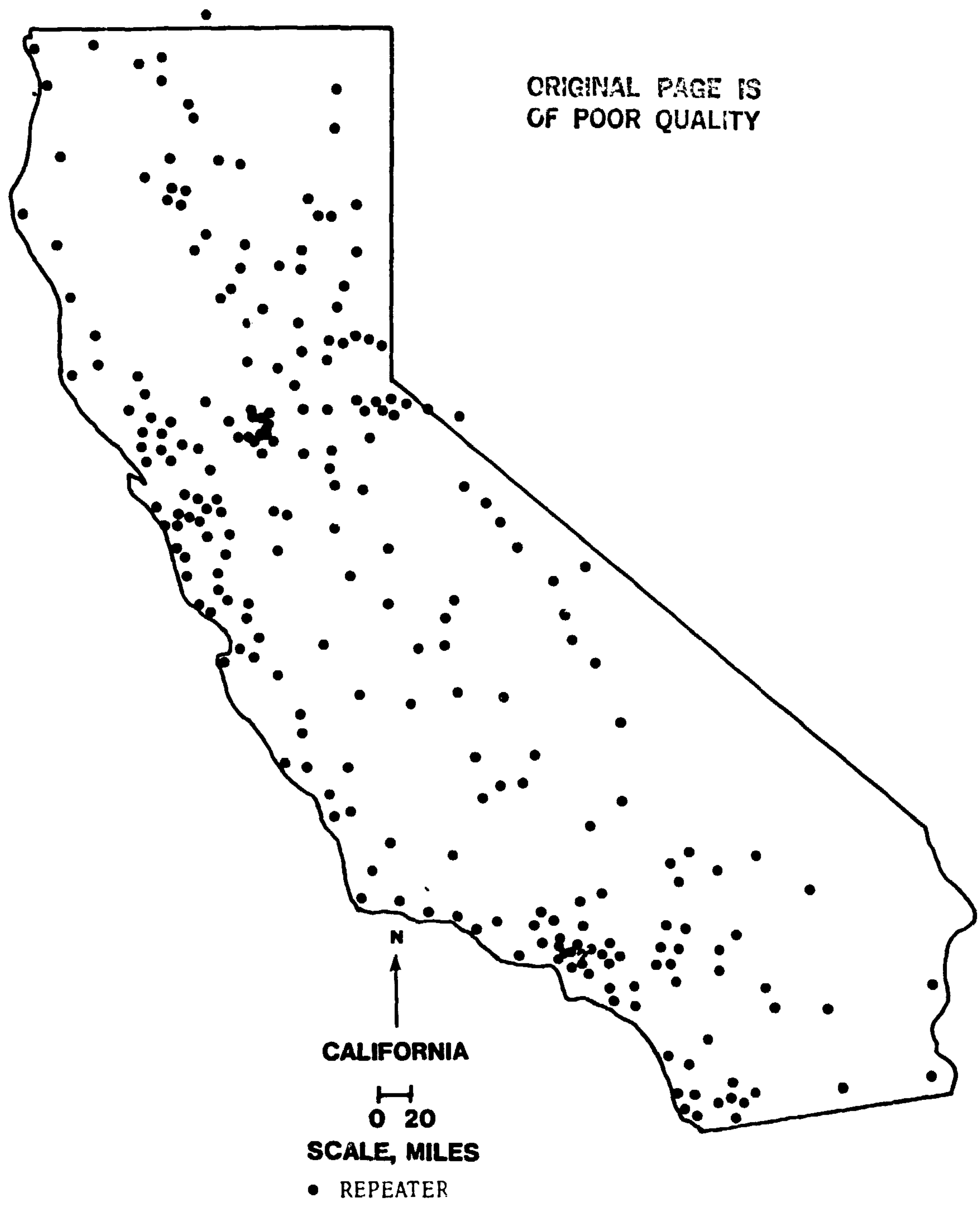
BASE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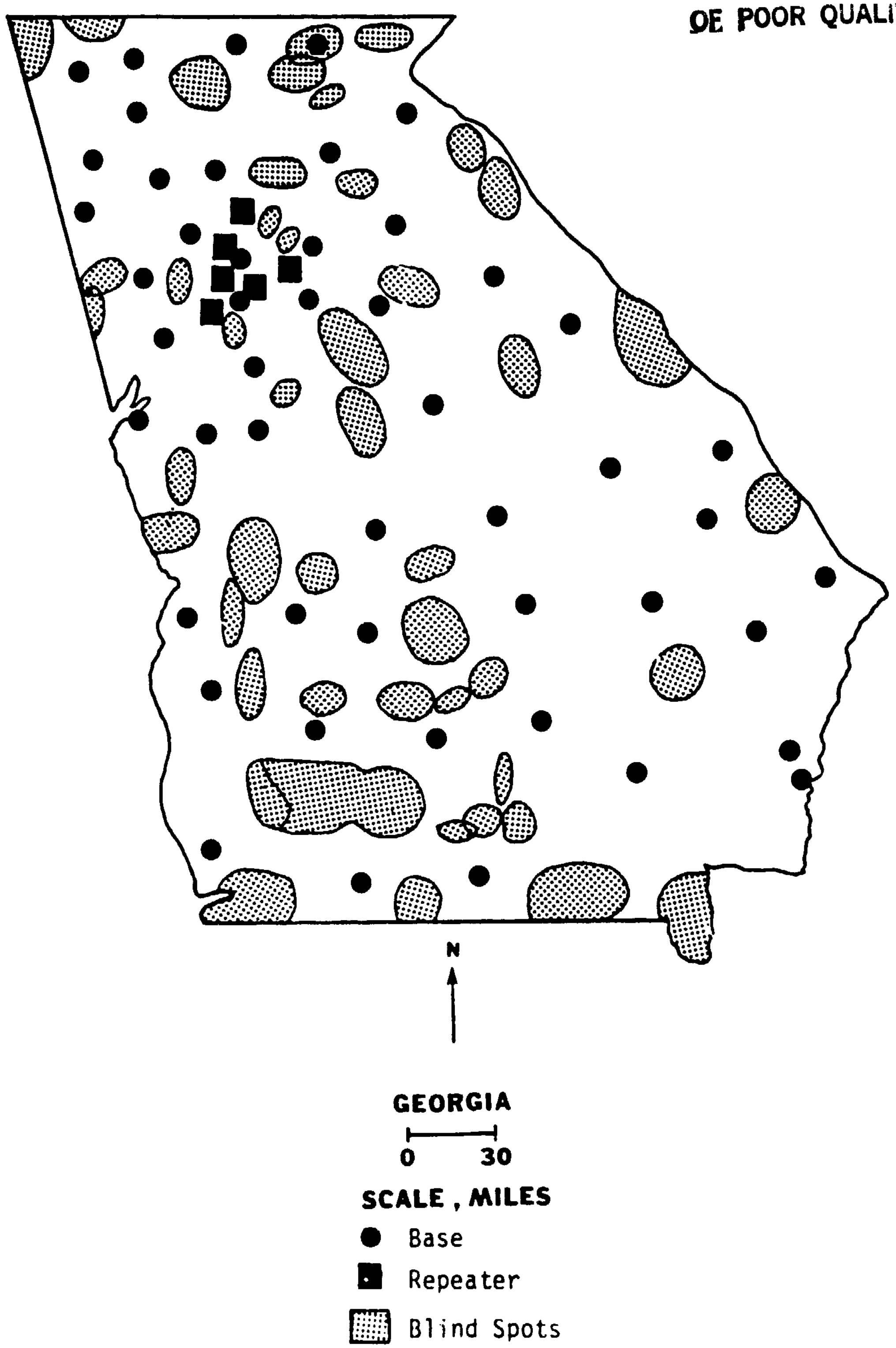
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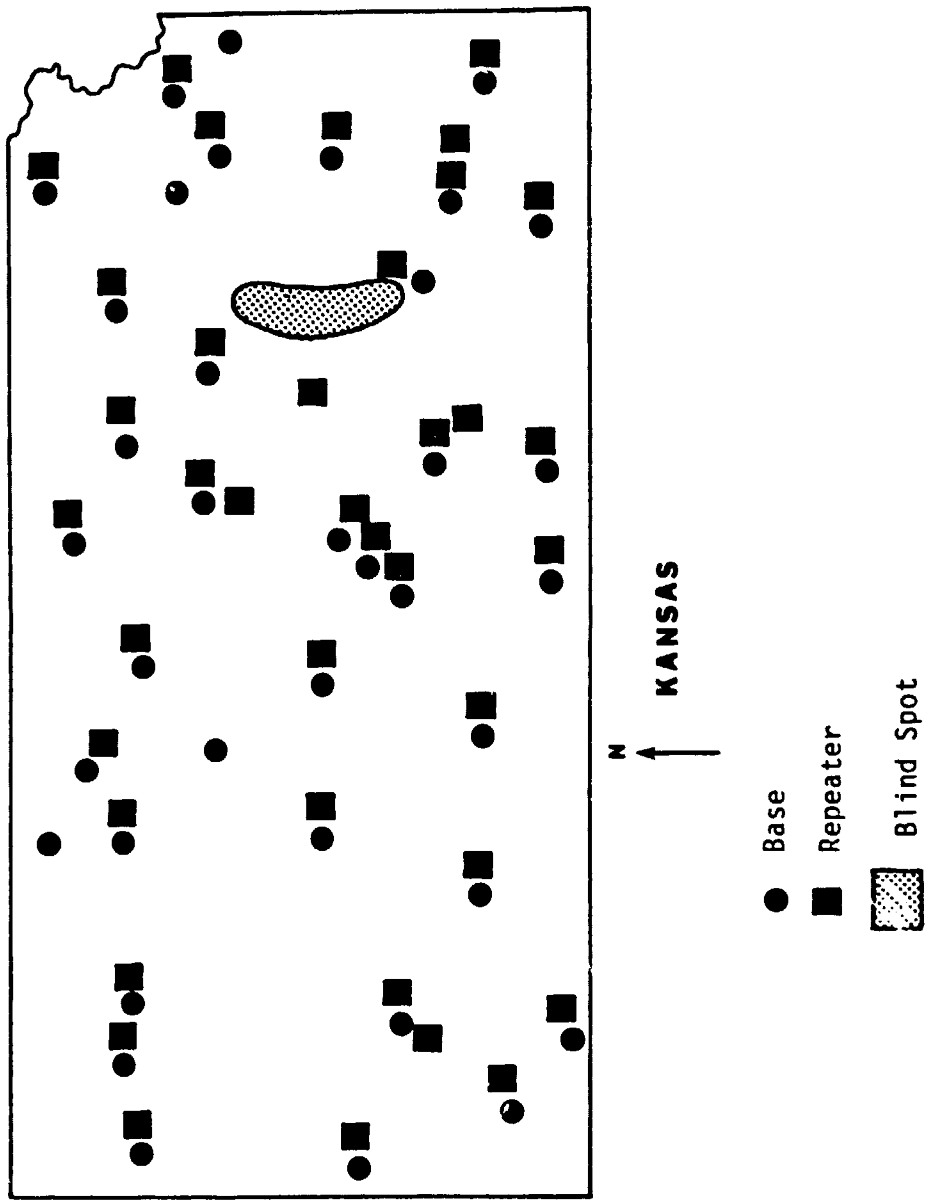
30
SCALE , MILES
Base
Repeater
Blind Spots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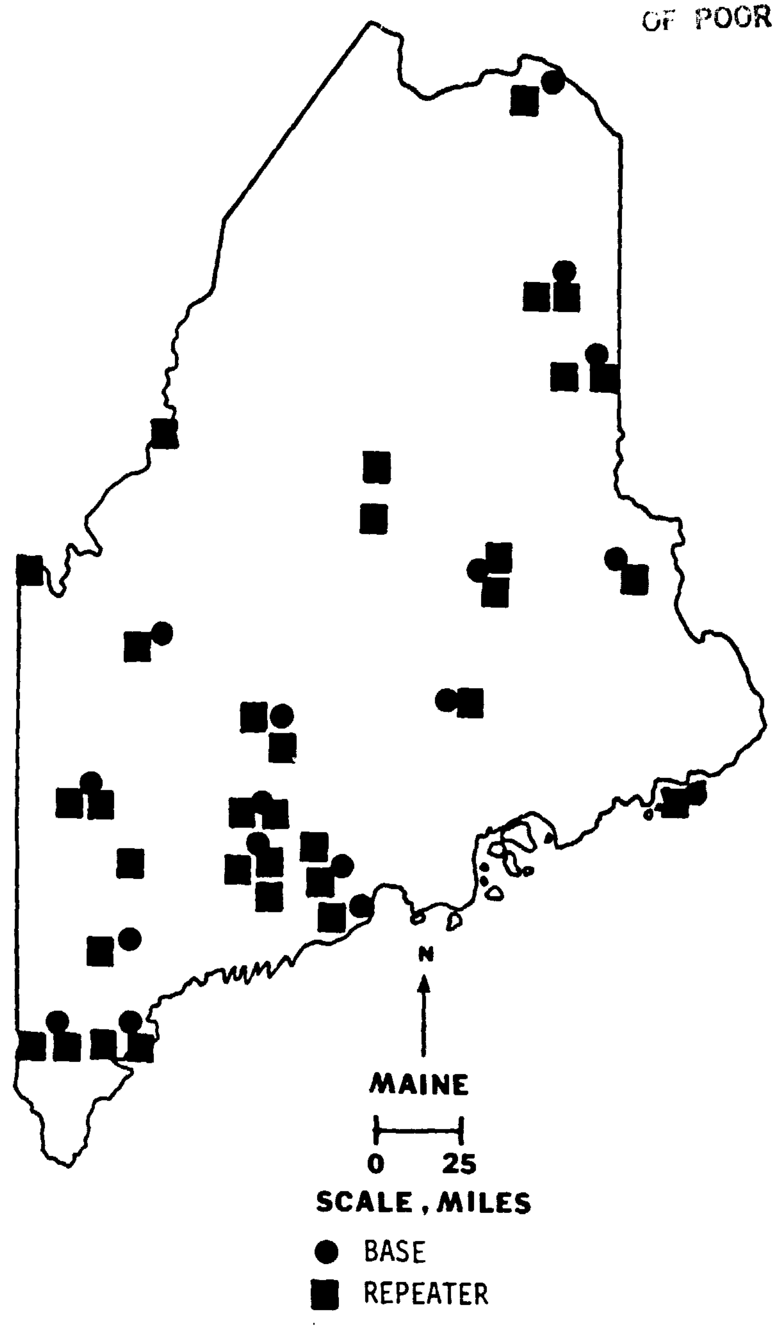
Base
Repeater
Blind Spot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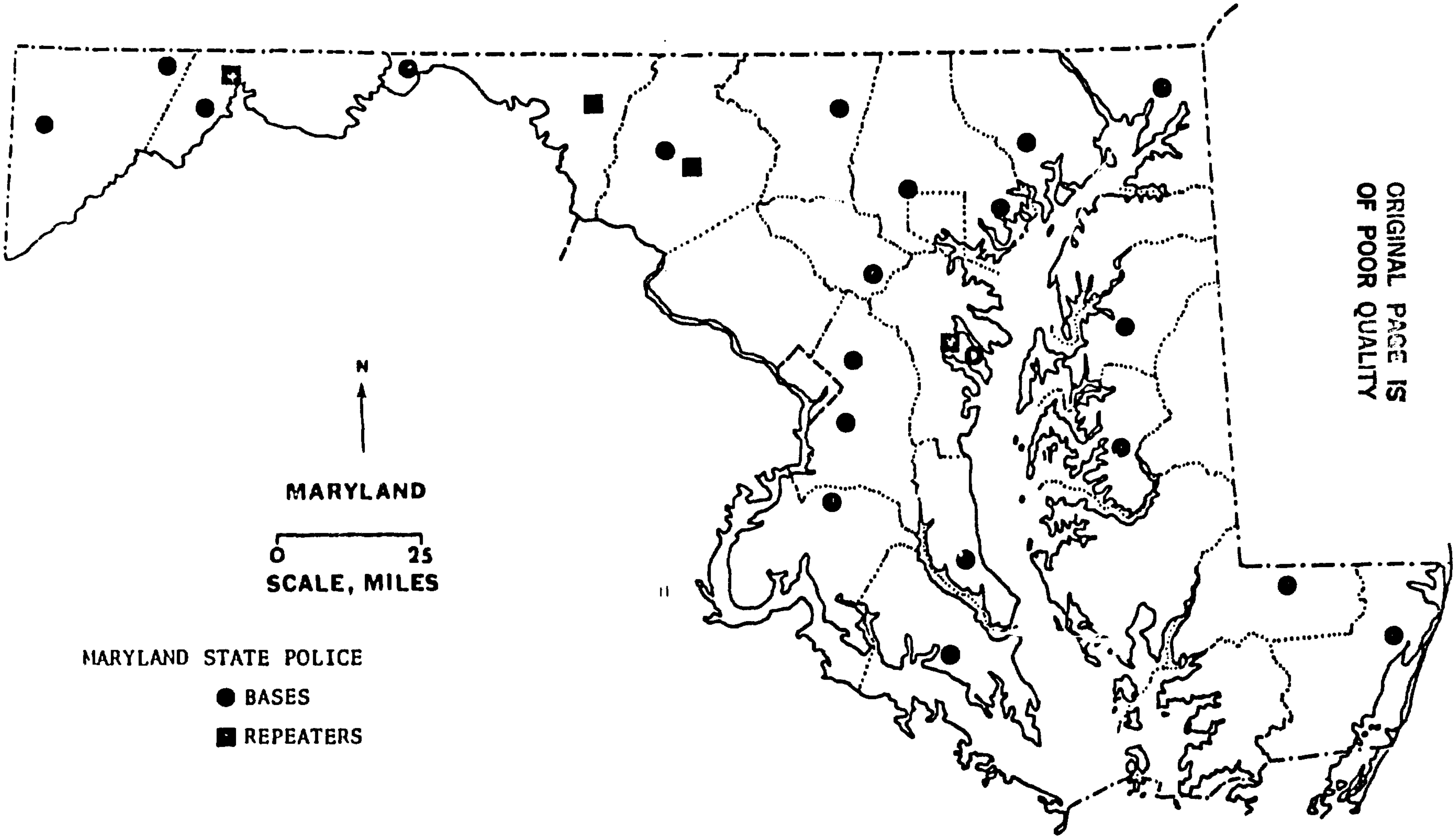
MAINE
0 25
SCALE, MILES
BASE
REPEATER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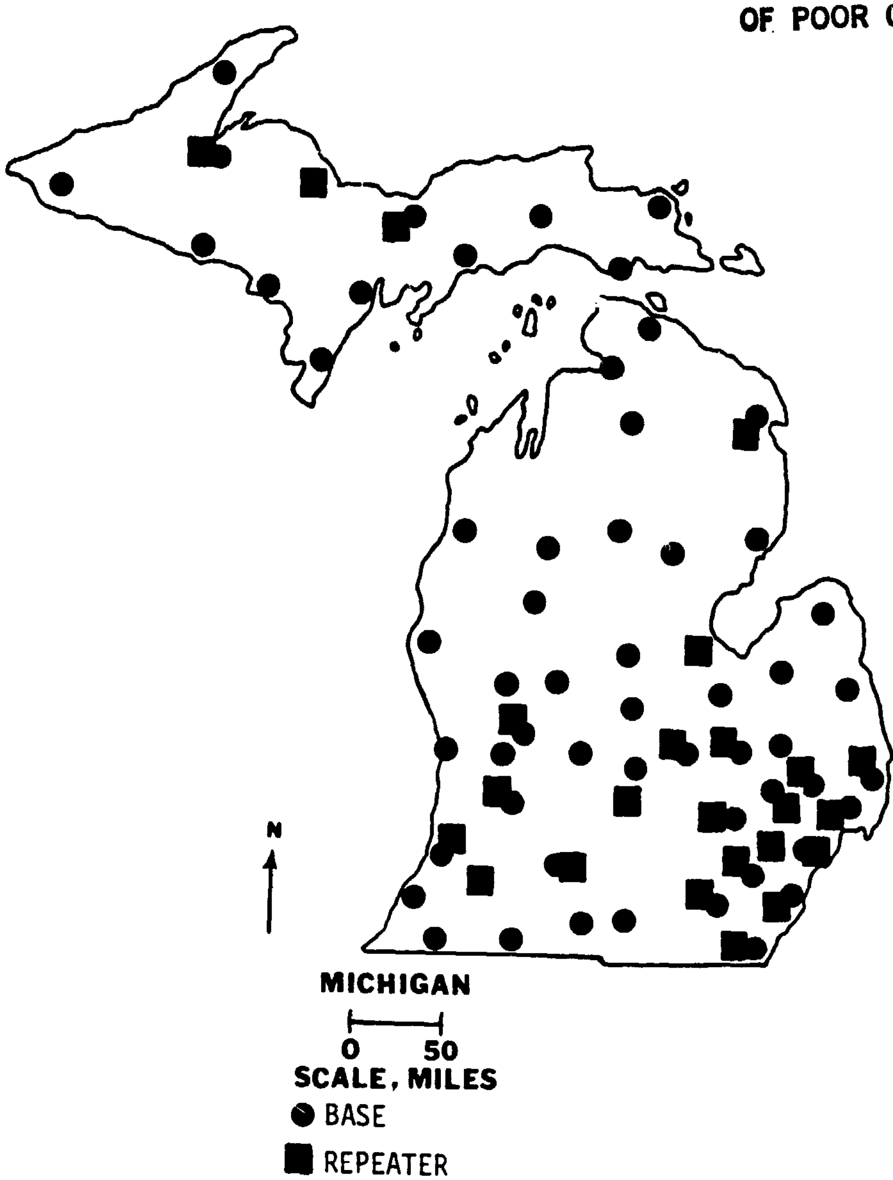
SCALE, MILES
MARYLAND STATE POLICE
BASES
REPEATERS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MICHIGAN
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SCALE, MILES
BASE
REPEATER

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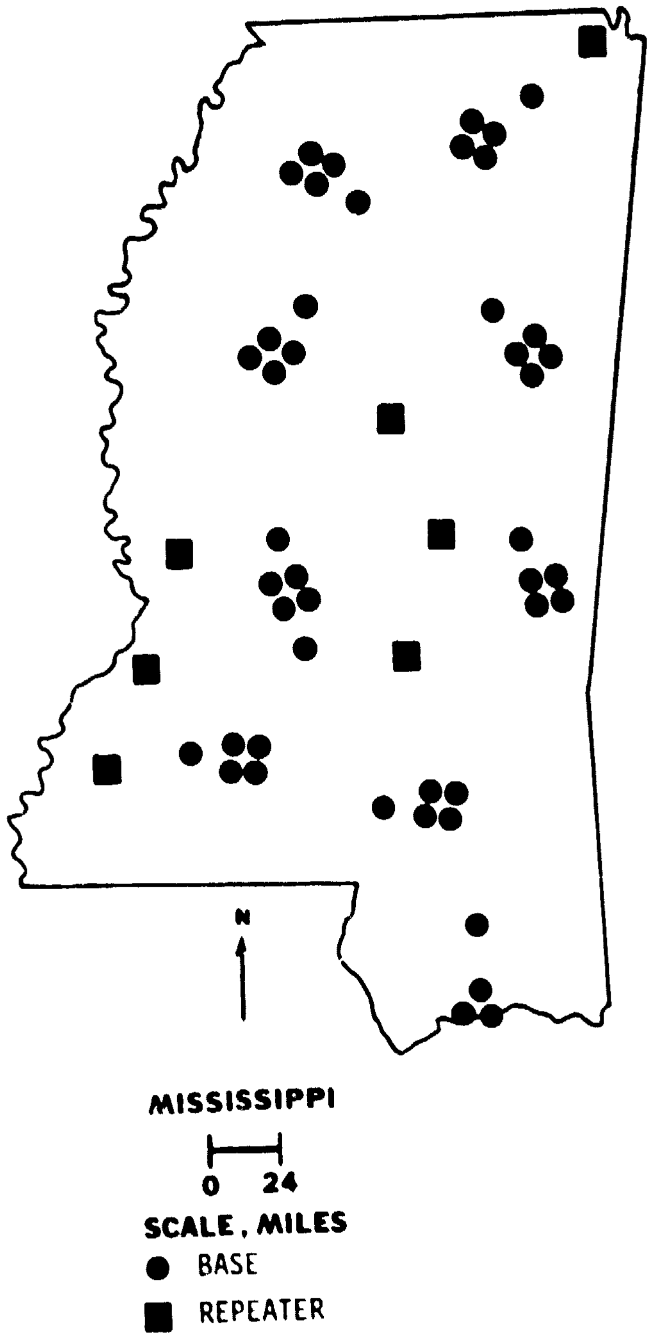

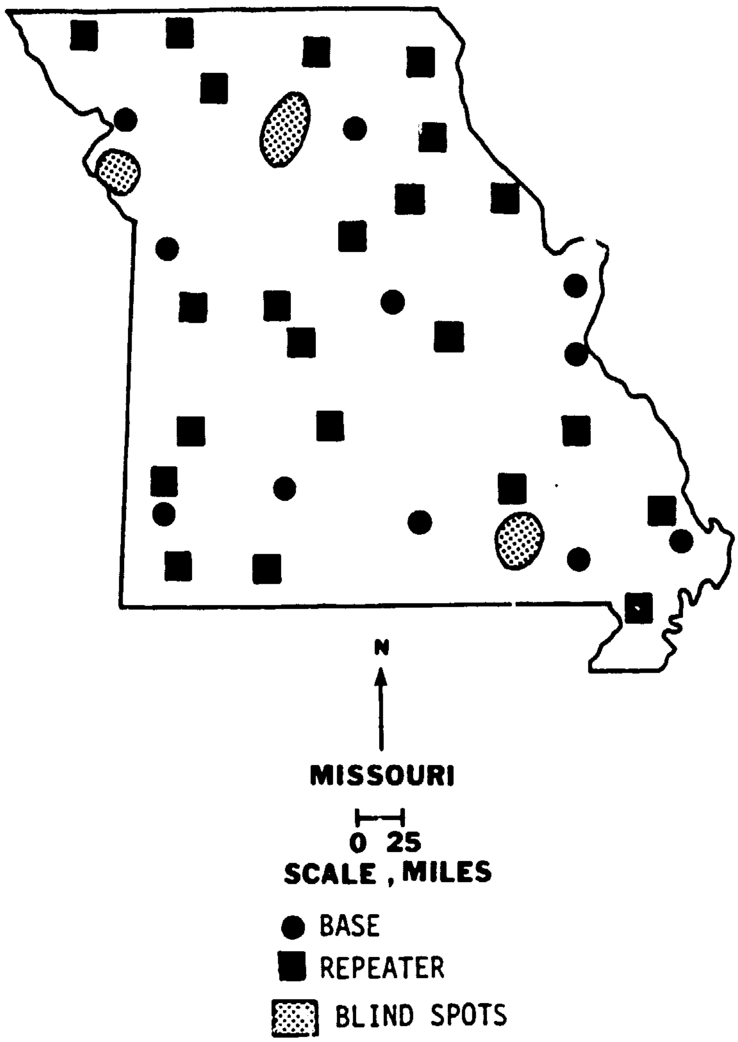
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SCALE, MILES
BASE
REPEATER
BLIND SPOTS

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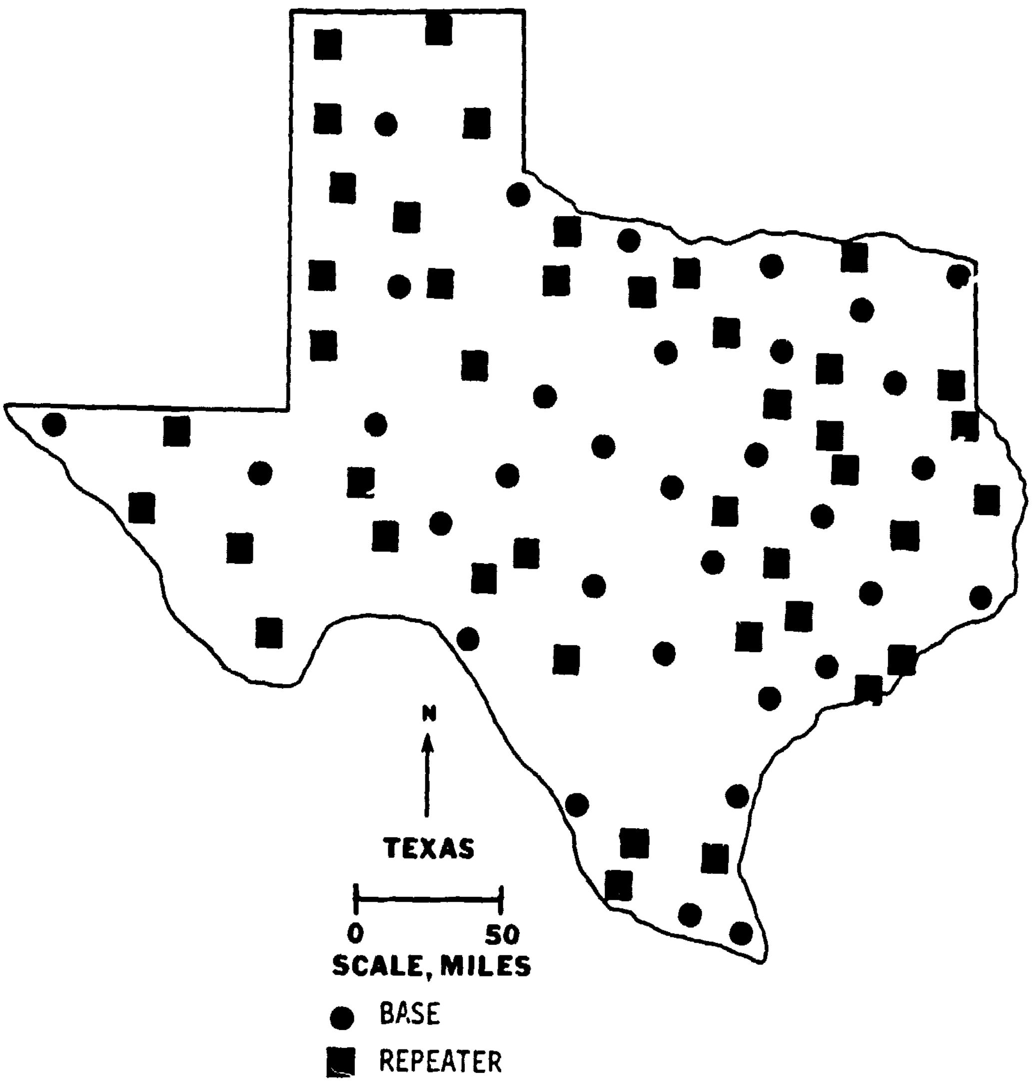

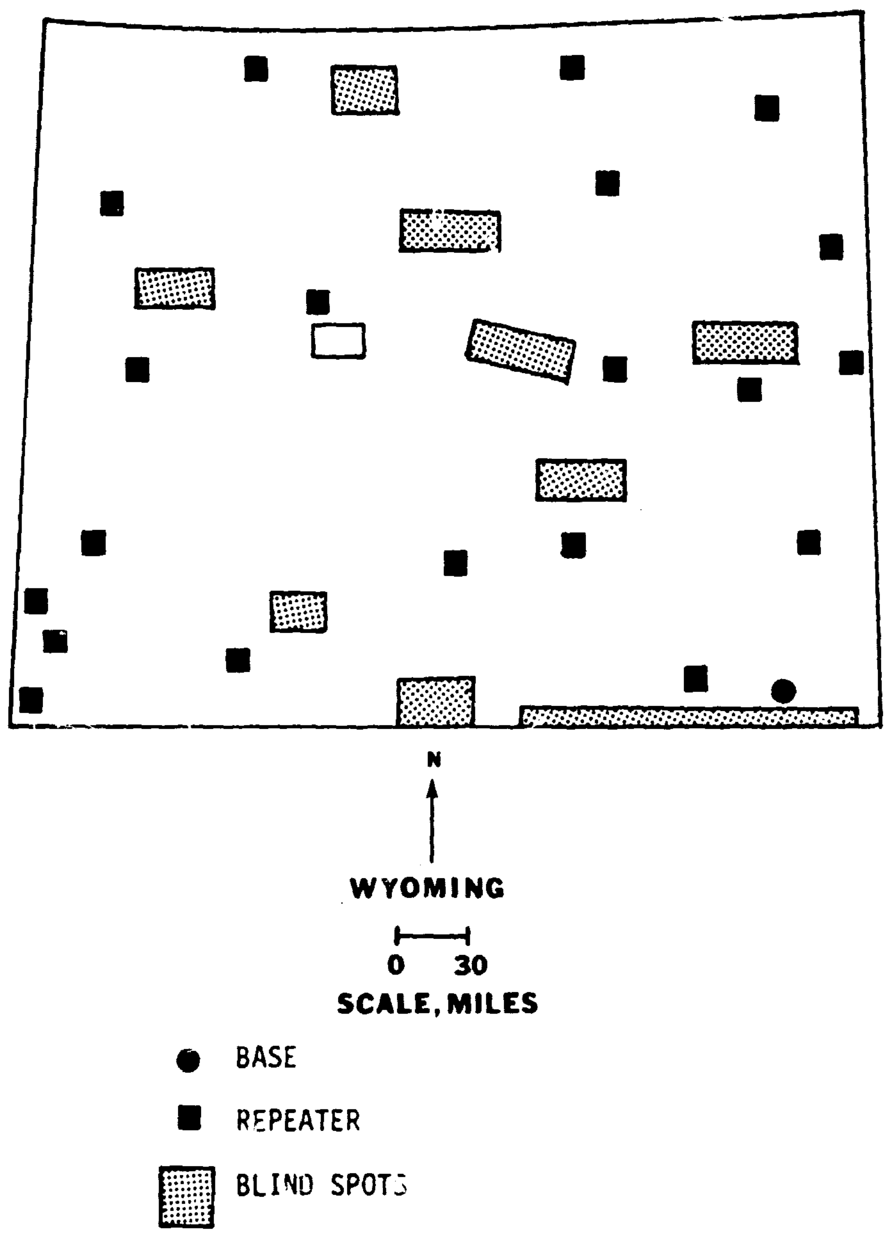
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WYOMING
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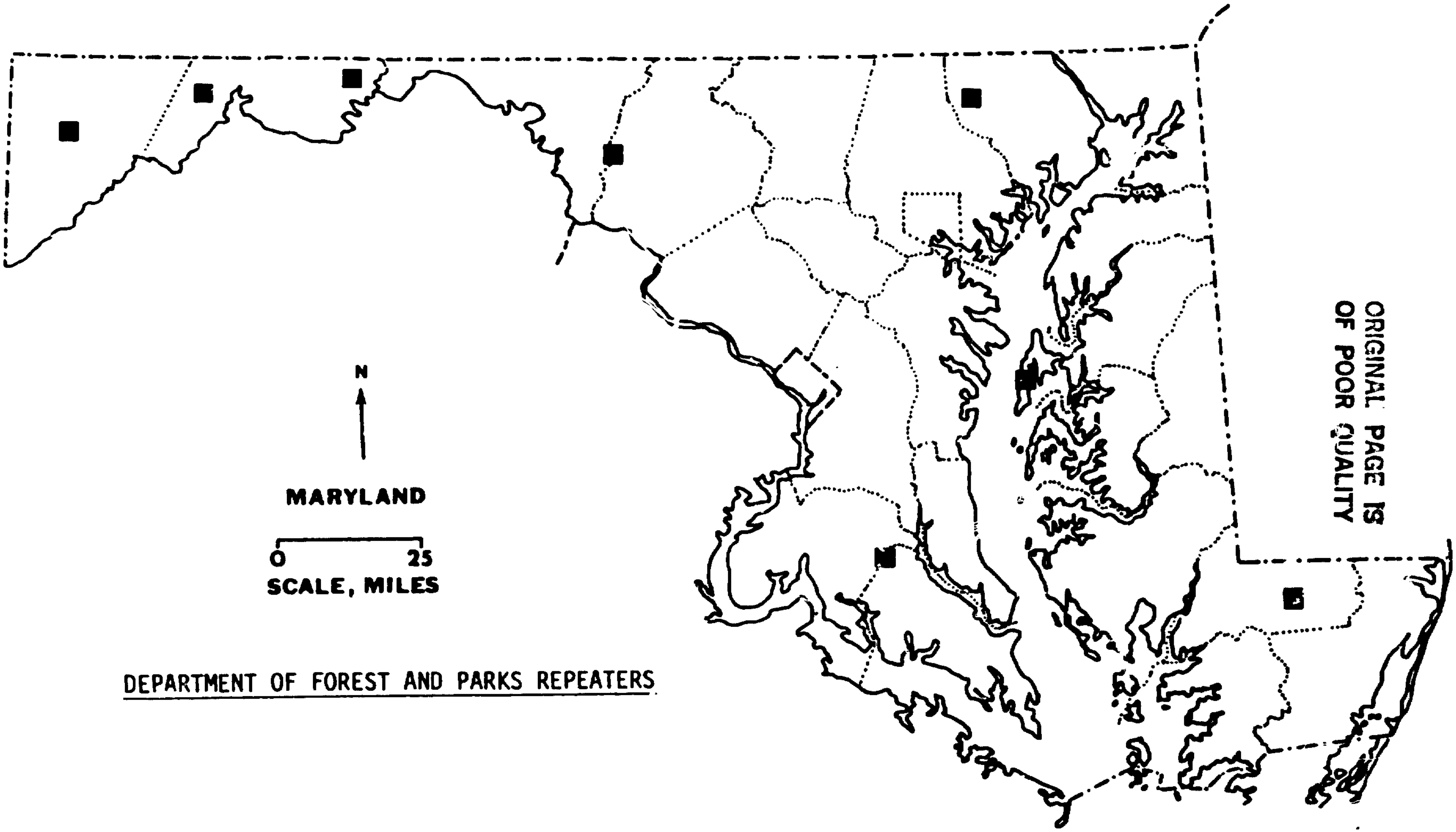
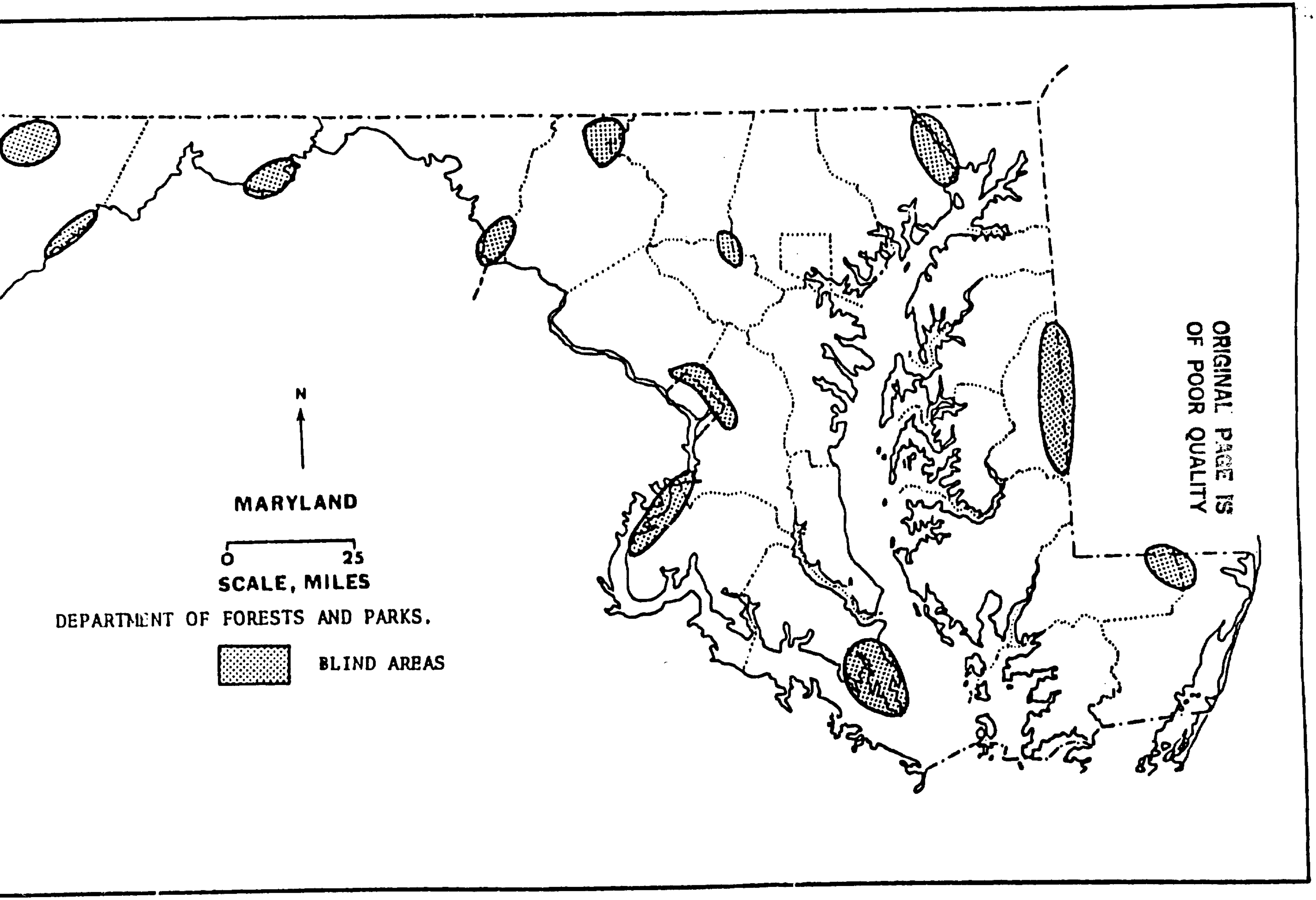
SCALE, MILES
BASE
REPEATER
BLIND SPOTS



DEPARTMENT OF FOREST AND PARKS REPEATERS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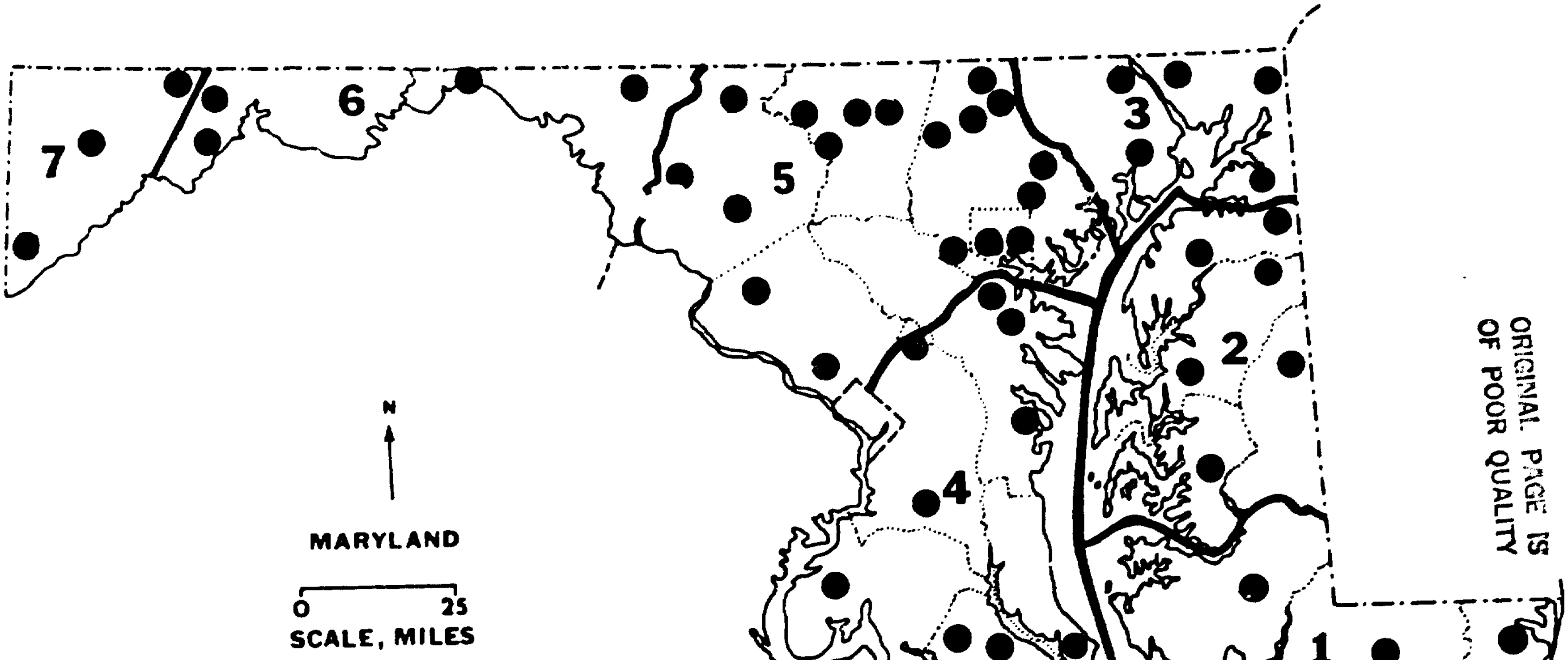
DEPARTMENT OF FORESTS AND PARKS.
BLIND AREAS



STATE HWY. ADMINISTRATION

DISTRICT	NO. BASES
1	5
2	10
3	5
4	8
5	7
6	7
7	4

APPENDIX B

SAMPLE QUESTIONNAIRES USED IN THE SURVEY

The questionnaires shown among those collected pertain each to: one County Police; one State Police; one Special Industrial; and one Business Radio respondent.

REVISION DATE: JANUARY 14. 1982

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1. General Information:

   A. Date of Interview: January 26, 1982

   B. Person Contacted: Larry Whitten

   C. Location/Address: P.O. Box 507
      Carbenton 65020
      Camden County

   D. Telephone Number: 1-314-346-2243

   E. Organization: Camden County MO Sheriff Dept.

2. Primary Information:

   A. Geographic Area Covered (e.g. County, State, Square Miles): 670 sq. miles

   B. Service type (e.g. Business, Police, etc.): Police

   C. Description of service offered (e.g. police only, combines fire and police single business or several etc.) Police and Fire

   D. No. of messages handled per year: 45,600 per year

   E. Length of messages: 3 to 7 seconds

   F. No. of messages out of area: Yes point, 10 per day

      Does system patch into telephone: No

      What are busiest hours: 7 a.m. to 10 p.m.

   H. How many more messages then the average happen during the busy hours: 30%

   I. How many messages between mobiles without passing through bases: 20%

3. Quality of Service

   A. Channel Blockage: Not serious

   B. Blind Spots: Creek, Piney Grove

      Map if Possible:

4. Equipment and Costs

   A. Type of system (e.g. single, trunking, Simplex): Simplex

   B. Bases 2

   C. Mobiles and Portables: 13 mobiles, 4 portables, pagers none.

   D. Antennas: 2

   E. Repeaters/Satellites: None

G. Maintenance: $1,500

H. Ownership (e.g leased, owned telephone co., independent Rec., etc.):
Owned

REVISION DATE: JANUARY 14, 1982

ORIGINAL PAGE IS OF POOR QUALITY

1. General Information:
   - A. Date of Interview: January 28, 1982
   - B. Person Contacted: Marion J. Brent
   - C. Location/Address: P.O. Box 568
     Jefferson City 65102
   - D. Telephone Number: 1-315-751-3313
   - E. Organization: MO Highway Patrol
2. Primary Information:
   - A. Geographic Area Covered (e.g. County, State, Square Miles): 69,886 sq. mile
   - B. Service type (e.g. Business, Police, etc.): Police
   - C. Description of service offered (e.g. police only, combines fire and police single business or several etc.) Police only
   - D. No. of messages handled per year: 5,777,330
   - E. Length of messages: 3 to 7 seconds
   - F. No. of messages out of area: 100 times per month. 1,200 per year

     Does system patch into telephone: No

     What are busiest hours: 8 a.m. to 10 a.m. 3 p.m. to 6 p.m.
   - H. How many more messages then the average happen during the busy hours: 30%
   - I. How many messages between mobiles without passing through bases: 10%
3. Quality of Service
   - A. Channel Blockage: Skip interference
   - B. Blind Spots: 3

     Map if Possible
4. Equipment and Cost
   - A. Type of system (e.g. single, trunking, Simplex): Simplex
   - B. Bases 9
   - C. Mobiles and Portables: 560 mobiles 560 portables
   - D. Antennas: 9 base 560 mobiles
   - E. Repeaters/Satellites: Repeaters 21

G. Maintenance: $39,000

H. Ownership (e.g leased, owned telephone co., independent Rec., etc.):
Owned

F C C D A T A	RADIO SERVICE: 1B

STATE: Arizona COUNTY: Coconino TOWN: Flagstaff	FREQUENCIES 464.95	CALL SIGNS WRF 374	NAME OF LICENSEE Reliance Plumbing

BASE UNITS	BASE POWER	RELAY UNITS	RELAY POWER	MOBILE UNITS	MOBILE POWER

S U R V E Y

PHONE NUMBER	NAME OF CONTACT	TYPE OF BUSINESS
602-774-4678	Ray Harshman	Plumbing

BASE UNITS	BASE POWER	RELAY UNITS	RELAY POWER	MOBILE UNITS	MOBILE POWER
1	25W			15	25 W

RANGE	RANGE NEEDED	BLIND SPOTS (%)	BLOCKAGE (%, WAIT TIME, ETC)	INTERFERENCE (SKIP, FADE, ETC)
80-100 Miles	OK	Some	None	Some Skip

AVG. MSG'S PER DAY	AVG. MSG LENGTH	AVG. WORK DAY	RATIO PEAK/AVG MSG'S/DAY	PEAK TIMES
30	60 sec.	11.5 hours	Even	

MOBILE TO MOBILE MSGS (%)	MOBILE CALLS OUT OF AREA	REPEATER SERVICE (NAME, ADDRESS, PHONE, COSTS)
15%	None	$100/Moneht

SPECIFIC COMPLAINTS ON ANY PART OF TOTAL SYSTEM

None

ANTENNA SYSTEM DEDICATED COSTS EXCLUDING ANTENNA (BASE & RELAY UNITS)

REAL ESTATE
STRUCTURE
BLDG LEASE
WIRES/PHONE LINES
TESTING
LIGHTING

NONE

ORIGINAL PAGE IS
OF POOR QUALITY

REMARKS (SYSTEM COMPONENT COST DATA)

Approx $10,000: Regency Base & Mobiles

F C C D A T A	RADIO SERVICE: 1S

STATE: Kentucky COUNTY: Hart TOWN: Mumfordville	FREQUENCIES 152.990	CALL SIGNS WSS 306	NAME OF LICENSEE Bobby Smith Ashland Oil Distributer

BASE UNITS	BASE POWER	RELAY UNITS	RELAY POWER	MOBILE UNITS	MOBILE POWER

S U R V E Y

PHONE NUMBER	NAME OF CONTACT	TYPE OF BUSINESS
502-524-5224	S. Smith	Bulk Fuel Delivery

BASE UNITS	BASE POWER	RELAY UNITS	RELAY POWER	MOBILE UNITS	MOBILE POWER
1	25W			2	25W

RANGE	RANGE NEEDED	BLIND SPOTS (%)	BLOCKAGE (%, WAIT TIME, ETC)	INTERFERENCE (SKIP, FADE, ETC)
25 Miles	OK	Some	None	None

AVG. MSG'S PER DAY	AVG. MSG LENGTH	AVG. WORK DAY	RATIO PEAK/AVG MSG'S/DAY	PEAK TIMES
15	10 sec.	11 hours	even	

MOBILE TO MOBILE MSGS (%)	MOBILE CALLS OUT OF AREA	REPEATER SERVICE (NAME, ADDRESS, PHONE, COSTS)
Some	None	$20/Month

SPECIFIC COMPLAINTS ON ANY PART OF TOTAL SYSTEM

Good Service

ANTENNA SYSTEM DEDICATED COSTS EXCLUDING ANTENNA (BASE & RELAY UNITS)

REAL ESTATE
STRUCTURE
BLDG LEASE
WIRES/PHONE LINES
TESTING
LIGHTING

NONE

REMARKS (SYSTEM COMPONENT COST DATA)

Approx. $3,000: Regency Base & Mobiles