WASHINGTON OPERATIONS

BURGLAR ALARM REQUIREMENTS ANALYSIS

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MITRE

THE EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

Following a Congressional mandate* to develop new and improved techniques and equipment to strengthen law enforcement and criminal justice, the National Institute of Law Enforcement and Criminal Justice under the Law Enforcement Assistance Administration of the Department of Justice established the Equipment Systems Improvement Program. The objectives of the Program are to determine the priority needs of the criminal justice community to help in its fight against crime, and to mobilize industry to satisfy these needs. A close working relationship is maintained with operating agencies of the criminal justice community by assigning systems analysts to work directly within the operational departments of police, courts and corrections to conduct studies related to their operational objectives.

This document is a research report from this analytical effort. It is a product of studies performed by systems analysts of the MITRE Corporation, a not-for-profit Federal Contract Research Center retained by the National Institute to assist in the definition of equipment priorities. It is one of a continuing series of reports to support the program decisions of the Institute relative to equipment development, equipment standardization and application guidelines. Comments and recommendations for revision are invited. Suggestions should be addressed to the Director, Advanced Technology Division, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U. S. Department of Justice, Washington, D. C. 20530.

Gerald M. Caplan, Director
National Institute of Law
Enforcement and Criminal Justice

* Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

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ABSTRACT

This report presents the results of an analysis of the false alarm problem associated with burglar alarms. The analysis extends the results of a previously published MITRE report that identified the parameter, Mean-Time-Between-False-Alarms (MTBFA), as the most useful one against which to set performance requirements for alarm systems. The analysis here assumes (or estimates) the percentage of potential burglary targets that will have alarms in the future. Criteria which allow for the determination of the allowable frequency of false alarms are identified, and resultant MTBFA requirements are computed.

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SUMMARY

The purpose of this report is to present the results of an analysis devoted to generating performance requirements for burglar alarms. If met, the number of false alarms would be reduced to an acceptable level. This report attempts to determine quantitatively an acceptable level. The objective of the requirements analysis is to find a compromise between stringent and unrealistic requirements and requirements which would still yield an excess of false alarms.

The results rely strongly on a previously published MITRE study that analyzed parametrically the relationship among:

- The percentage of potential burglary targets that have burglar alarms,
- Various measures of police resources expended in responding to alarms,
- False Alarm Ratio and Rate.

The study concluded that a reduction in the False Alarm Rate must accompany an increase in the percentage of burglar alarm installations. This conclusion was predicated upon the anticipated burden on the responding police forces.

The study identified the Mean-Time-Between-False-Alarms (MTBFA) as a viable performance measure for burglar alarms. Setting requirements on this parameter is the subject of the material presented here.

Once a performance measure had been identified against which to set requirements to reduce false alarms, the basic question that remained was, what criteria should be used to set the requirement?

Whatever feelings individuals have regarding the false alarm problem, the consensus is that it should not be allowed to get any worse. On this basis, it was decided to use the existing conditions as the point upon which to base future requirements. Consequently, as the number of burglar alarm installations increases, the required MTBFA of each system should increase.

The procedure is to postulate future percentages of places with burglar alarms and compute the resulting MTBFA requirements. The results of doing this for residences and nonresidences are presented in this report.

Data indicate that the existing False Alarm Ratio is on the order of 0.95 (i.e., 19 false alarms for every one valid). Data available from several sample cities yield an MTBFA of approximately three to four months.

The results of this analysis indicate that in order to be acceptable to police departments, the systems now being designed should have an MTBFA of about nine months if they are for nonresidential (business) and about two years if they are for residences. The goal for long-term future developmental efforts should be about two years for nonresidential alarms and six years for residential alarms. This requirement is for a complete functional system, including the user or operator.

The different requirements for residential and non-residential alarms were necessitated because of the significantly different number of potential targets in each category, the different burglary rates and the different user habits. These significantly different environments should be recognized.

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1. INTRODUCTION

This is a report of a study performed for The Law Enforcement Assistance Administration (LEAA) under The Equipment Systems Improvement Program (ESIP).(1) The study was to determine the requirements that need to be met for burglar alarm systems to reduce the number of false alarms to an acceptable level as more systems are installed. The study addressed the problem of false alarms to the exclusion of all other problems because of the potential impact of this problem on the effectiveness of alarm systems in combating burglary and because of the high proportion of false alarms presently experienced, typically 95% of all alarms received.

The requirements rely on the concept of Mean-Time-Between-False-Alarms (MTBFA) as a system parameter related to the ability of the system to function for long periods without transmitting a false alarm to the police. The MTBFA is considered to apply to the entire system as a whole, including everything from the burglary sensors at one end of the system to the police "annunciator" at the other end. This includes the user and all the system operators (to the extent that users and operators generate and/or filter alarms) as well as the hardware installations and telephone lines. The MTBFA is considered a basic system performance requirement and is the requirement imposed on the combination of incremental MTBFA's for the system elements.

2. APPROACH AND METHODOLOGY

This section outlines briefly the motivation to focus early attention on burglary in general and burglar alarms in particular. The decision to restrict the problem further to false alarms in burglar alarm systems is also discussed.

By any measure, burglary is of major concern to the criminal justice community. Appendix I contains a collection of some of the more interesting and relevant statistics on burglary in the United States. For example: burglary ranks highest in rate per 100,000 population of the seven Crime Index Offenses;[2] estimates vary of the total property stolen by burglars but one billion dollars per year appears likely;[3][4] and only 19 percent of reported burglaries are cleared.[4]

Recent studies have addressed the effectiveness of various burglary prevention procedures. These studies indicate that:

- better locks, stronger doors, reinforced glass windows ("hardening" in general) deter burglars;[5]
- good lighting deters burglars;[6] and
- burglar alarms are effective.[7]

With regard to the last point, data from Reference 7 further indicate that for businesses with burglar alarms:

- arrests at the scene are more likely;
- clearance rates are higher;
- losses are less; and
- fewer places are burglarized.

As the effectiveness of burglar alarms becomes recognized, their increasing widespread use is anticipated. Unfortunately, the above salutary effects notwithstanding, one existing problem could possibly negate the apparent significant advantages. This problem is the extraordinary prevalence of false alarms.[1]

[1] The definition of "false alarm" is not universal, and at best is controversial. The analysis presented here defines a false alarm as an alarm received by the police and not set off by an illegal or unwarranted entry or attempted entry.

The False Alarm Ratio is one measure of this prevalence and is the ratio of the number of false alarms to the total number of alarms. Most jurisdictions are experiencing False Alarm Ratios of around 0.95. That is, approximately 20 false alarms for every valid alarm.

Appendix II discusses burglar alarms briefly, defines false alarms and other measures of their prevalence, and cites results of investigations to determine the frequency of false alarms.

This excess of false alarms causes many problems. To mention a few:

- police attitude is one of complacency;[10]
- police responses to false alarms take manpower away from other duties.

Furthermore, extrapolating to a widespread proliferation of alarm systems, police resources may be in danger of saturation.[8]

The ramifications of the latter point have been explored[8] and a methodology developed to express the minimum allowable MTBFA in terms of various measures of police resource dissipation. This is summarized in Appendix III. These results constitute a major input to the analysis which is the subject of this report.

Having decided to focus the analysis on requirements to reduce false alarms to a tolerable level, two primary questions were to be answered:

1) What parameter or parameters describing burglar alarm performance should be chosen against which to set requirements?

2) Once the parameter(s) is chosen what criteria should be used to set the requirement?

Several parameters were considered as candidates to give the most meaningful and useful measure of false alarms. Most common parameters are usually ratios and rates. These are usually chosen on an ad hoc basis and serve the needs of the particular analysis in which they are introduced.

The most common definition of false alarm ratio was given above. The most common definition of false alarm rate is the number of false alarms in a jurisdiction per unit time (usually a month). Neither of these parameters is believed to be an appropriate measure of performance upon which to place requirements. A combination of rate and ratio such as was used by the Cedar Rapids Police Department[2] is more descriptive and was adequate for their purposes and approaches what is needed for the objective here.

The above measures rely on the number of burglaries or the burglary rate per unit time or the number of alarms installed. The performance of a given burglar alarm system, as determined by these measures, would vary dramatically as a function of external factors such as burglary rate and the number of alarm systems installed. These factors are beyond the control of the designer. Moreover, the designer would have to be cognizant of these factors before equipment specifications could be generated, which is impractical.

That is to say those measures are determined not only by the characteristics of the burglar alarm but also by external characteristics which are not under the control of the alarm manufacturer. What is needed is a measure with the following characteristics:

- The measure is a characteristic only of the burglar alarm.
- The measure can be applied during the manufacturing and operation of the system.
- Other, more common, measures can be related directly.

The analysis of Reference 8 makes use of a measure which meets these needs. The analysis introduces and defines the parameter MTBFA from which most other common performance measures can be derived when combined with factors such as burglary rate or number of installed systems. MTBFA is defined as the reciprocal of the average number of false alarms per unit time (usually years for purposes here). This parameter is analogous to Mean-Time-Between-Failure commonly used by reliability engineers to specify dependable performance of complex equipment. Reference 8 developed extensive parametric relationships among MTBFA and other variables such as "false dispatch radio," "coverage ratio," and "number-of-targets to number-of-burglaries ratio."[3]

[2] i.e., number of false alarms per month divided by the number of alarm systems. c.f. Reference 7.

[3] These parameters are defined in Appendix III.

The analysis established quantitatively that, "a significant increase in the number of burglar alarm installations, without a corresponding reduction in the false alarm ratio, may impose a burden on the large urban police forces which they may not be willing or able to carry."(8)

The number of burglar alarm installations is measured by "Coverage Ratio" (i.e., the number of installations divided by the number of potential burglary targets). As this parameter increases, the number of police dispatches to false alarms also increases. Presumably, without an increase (improvement) in MTBFA, this will eventually become intolerable. Reference 8 defines the parameter "False Dispatch Ratio" as the ratio of false to legitimate police dispatches and provides a mechanism for converting arbitrary combinations of Coverage Ratios and False Dispatch Ratios into MTBFA.

Now that the parametric relationships among the variables have been developed and a measure of burglar alarm performance has been defined which has the characteristics identified on Page 4, the procedure is as follows:

- First, assume (or estimate) reasonable future Coverage Ratios.
- Second, identify a criterion which will allow setting a tolerable False Dispatch Ratio.
- Third, determine the tolerable False Dispatch Ratio.
- Fourth, compute the resultant MTBFA.

3. MTBFA REQUIREMENTS

Figures 1, 2, and 3 of Appendix III provide the mechanism for converting either False Alarm Ratio or False Dispatch Ratio into MTBFA. Now that these parameters can be related to MTBFA, the question to address is the choice of a defendable level of false alarm ratio or false dispatch ratio so that a requirement on MTBFA can be set.

There are indications(3)(10)(14) that whatever feelings individuals have regarding the false alarm problem, the consensus is that it should not be allowed to get any worse. An attitude of police complacency is developing in their response to alarms.(10) Many cities are proposing ordinances which would fine or charge owners of alarm systems.(10)(14) There is a growing inclination of police departments to downgrade response priorities.(3) On this basis, it was decided to use the existing False Dispatch Ratio as the point upon which to base future requirements.

In order to determine existing False Dispatch Ratios, data were obtained on selected cities throughout the United States. These were: Washington, D. C.; Seattle, Washington; Los Angeles, California; Columbus, Georgia; San Francisco, California; Jackson, Mississippi; and Cedar Rapids, Iowa. These cities were chosen on the basis of being geographically representative, having available data or having recently performed studies or experiments regarding burglary. The data consisted of population, number of police officers, number of targets (residential and nonresidential), number of burglaries (residential and nonresidential), and number of burglar alarms (residential and nonresidential).

Under the assumption that burglary rate for large cities (say greater than 100,000 population) will remain roughly constant for the next several years, holding the False Dispatch Ratio constant is equivalent to holding constant the total number of police dispatches to burglary indications. This includes the number of dispatches to false alarms, the number of dispatches to valid alarms, and the remaining number of reported burglaries. The goal is then to increase the MTBFA of burglar alarm systems so that as Coverage Ratios increase, the total number of police responses remains constant. Holding the total number of police responses constant represents an equivalent criterion for determining allowable MTBFA's.

In some cases, the data were incomplete and to fill the blanks, the following rules of thumb were used:[4]

[4] These approximations were based upon existing information where data were complete.

- 15 percent of nonresidential targets are burglarized per year;
- 5 percent of residential targets are burglarized per year;
- 20 percent of nonresidential targets have burglar alarms;
- A negligible number of residential targets have burglar alarms.

The need to differentiate between residential and nonresidential alarm systems was identified early in the study. The reason for the differentiation was based upon the supposition that reasonable extrapolations of the percentages of targets which have burglar alarms vary greatly from residences to nonresidences. Currently the percentage of residences which have burglar alarms is negligible (less than 0.1% for most large cities) while some cities already have 30 or 40 percent coverage for nonresidential targets.

The different requirements for residential and nonresidential alarms were necessitated because of the significantly different number of potential targets in each category, the different burglary rates and the different user habits. These significantly different environments should be recognized.

Table I presents the data from which the existing MTBFA's were computed. The computation of False Dispatch Ratio assumes a false alarm ratio of 0.95.

As the Table indicates the maximum and minimum False Dispatch Ratio vary from the average by about 40%. A False Dispatch Ratio of 1.5 was chosen to be representative and to serve as the baseline upon which to base future MTBFA requirements. By keeping the False Dispatch Ratio constant at 1.5 and increasing the Coverage Ratio by reasonable amounts, it is possible to determine future requirements on MTBFA. This is presented in Table II for three sets of Coverage Ratio extrapolations.

The three sets of requirements can be thought of as representing intermediate points on a multi-year chronology. The near term is the least stringent and should be the goal of current developments. The intermediate term represents the goal for the next generation of alarm systems. The far-term requirements are the most stringent and represent about a 10-year extrapolation.

TABLE I

BURGLARY STATISTICS

	Population		Burglary		No. of Targets (,000)		No. of Burglaries		No. of	No. of	F.D.R.[4]		Nonresidential
	(,000)	Ranking	Rate Per 100,000	Ranking[1]	Residential	Nonresidential	Residential	Nonresidential	Burglar Alarms[2] (,000)	Responses[3] (,000)	All	Nonresidential	MTBFA[5]
Washington, D. C.	757	9	2,486	12	250	50	13,300	5,500	20	60	2.23	7.6	0.48
Seattle	531	22	2,346	15	150	30	7,500*	4,500*	6	30	1.37	3.8	0.35
Los Angeles	2,816	3	2,657	9	800	150	48,000	27,000	50	246	2.28	6.3	0.29
Columbus, Ga.	170	88	1,058	127	73	7	1,000	800	1	4	1.20	2.7	0.46
San Francisco	716	13	2,551	11	200	40	12,000	6,000*	8*	41	1.27	3.8	0.35
Cedar Rapids, Io.	111	133	615	151	30	6	409	274	2	2	1.52	6.3	1.15

1. For cities with population greater than 100,000.
2. Negligible percentage are residential.
3. Number of burglaries plus number of false alarms. (Assumes F.A.R. = 0.95).
4. False Dispatch Ratio equals number of false alarms divided by number of burglaries.
5. MTBFA can be computed from either: (see Appendix III for nomenclature).

$$MTBFA = \frac{T}{B}\left(\frac{1-F}{F}\right)$$

$$\text{or } MTBFA = \left(\frac{T}{B}\right)\left(\frac{C}{D}\right)$$

6.* Indicates rule of thumb was used. (c.f. pages 6 and 7)

TABLE II

MTBFA REQUIREMENTS[a]

	Existing Conditions[b]	Required[c] (Near Term)	Desired[d] (Intermediate Term)	Goal[e] (Far Term)
False Dispatch Ratio	1.5	1.5	1.5	1.5
False Alarm Ratio	0.95	0.91	0.83	0.77
MTFBA (Overall)	f	1.5 years	3.0 years	4.5 years
MTFBA (Residential)	f	2.0 years	4.0 years	6.0 years
MTBFA (Nonresidential)	0.25 years	0.75 years	1.5 years	2.0 years

a. All values assume 5% of residential targets (c.f Reference 2 and 15) and 15% of Nonresidential targets (c.f Reference 3) are burglarized each year. MTBFA requirements are rounded off to the nearest quarter of a year.

b. 20 percent Nonresidential Coverage; negligible Residential Coverage.

c. 40 percent Nonresidential Coverage; one percent Residential Coverage.

d. 75 percent Nonresidential Coverage; five percent Residential Coverage.

e. 100 percent Nonresidential Coverage; ten percent Residential Coverage.

f. Insufficient data.

4. DISCUSSION

Examination of the numbers in Table II points out one aspect of the difficulty encountered in setting performance requirements for burglar alarms. Intuitively, the false alarm ratios appear inordinately high and something that could and should be significantly reduced. On the other hand, the corresponding MTBFA's are very stringent. For example, for an arbitrary apportionment of one half false alarms for user-caused and one half for equipment-caused, the MTBFA for the equipment in the intermediate term for residential targets is about eight years. The reason that long MTBFA's still result in high false alarm ratios is that burglaries (UCR statistics notwithstanding) are probabilistically a very rare occurrence. In order to achieve a 0.5 false alarm ratio, the mean-time-between-burglaries must be equal to the MTBFA. Even for a high burglary rate as found in Washington, D.C., the mean-time-between-burglaries for a randomly selected residential or business target is roughly 16 years.

The difficulty in reducing the false alarm ratio is highlighted by the analysis in Appendix III. For a particular jurisdiction with a given number of targets and a given burglary rate, the MTBFA is dependent only on the false alarm ratio. In order to achieve apparently modest improvements in the False Alarm Ratio, large improvements in the MTBFA must be achieved. For example, for the case where 5% of the potential targets are burglarized each year, improving the False Alarm Ratio from 0.95 to 0.85 requires a greater than threefold increase in the MTBFA (one year to 3.5 years).

The intent here is not to indicate the hopelessness of the situation but rather to put in perspective the severity of the problem in order to stimulate the intense effort required to ameliorate it. In order to accomplish this a completely new approach to burglar alarm system design is required. This system should have no equipment caused false alarms during the life of the installation. The user caused false alarm rate should be reduced by a factor of five. This would yield a false alarm ratio of 0.75 which meets the long term goal of Table II.

APPENDIX I

BURGLARY STATISTICS

The nature and extent of the crime of burglary has been well documented.(2)(3)(4)(9) Some of the more interesting and appropriate aspects will be highlighted in this Appendix.

Although certain criticisms may be justified,(3)(4) The Uniform Crime Reports published by the FBI are usually the most widely used as a statistical basis for the seven major offenses: homicide, rape, robbery, assault, burglary, larceny and auto theft. Table III summarizes the statistics associated with each. The intent is to show burglary in perspective, and the importance is easily seen.

Since 1964, two significant trends in the nature of burglary have been identified. Residential burglary now accounts for 60% of the reported cases as opposed to 47% in 1964. In the same period, the predominence of residential burglaries has shifted from nighttime to daytime. The average value of the goods stolen from residences has remained roughly constant from 1964 to 1971 when the effect of inflation is considered. Interestingly, this is not the case for nonresidences. Table IV summarizes the comparison.

The average value of the goods stolen substantiates the contention that burglars in general are unsophisticated and that the predominance of burglaries are crimes of opportunity. This is further evidenced by the fact that 74% of those arrested for burglary are under 21 years old.

The nonprofessional nature of burglary is consistent with the observation that burglar alarms are effective in deterring and capturing burglars. Table V summarizes data from a study(7) which compared alarmed and unalarmed business.

In 1971, the nationwide burglary rate per 100,000 population was 1,148. For the ten largest standard metropolitan statistical areas it was 1,576 and for cities over 250,000 in population it was 2,042. The larger burglary rate for larger jurisdictions suggests that burglary rate and population are correlated. However, for cities over 250,000 population this apparently is not the case. Figure 1 is a scatter design in which the cities were ranked according to population and burglary rate. As is evident, no correlation is present. Chicago and Philadelphia are the second and fourth largest cities, but rank near the bottom in burglary rate. Alburqueque is the smallest city in the sample but ranks tenth in burglary rate.

TABLE III[a]

SERIOUS CRIME STATISTICS

	Rate Per 100,000	Percent Increase Since 1966	Rate Cities Over 250,000	Clearance Rate
Homicide	8.5	52%	19	84%
Rape	20.3	55%	--[b]	55%
Robbery	187.1	133%	633	27%
Assault	176.8	49%	351	66%
Burglary	1148.3	62%	2,042	19%
Larceny	909.2	99%	1,241	19%
Auto Theft	456.5	60%	1,099	16%

[a]Uniform Crime Report for 1971

[b]Not available

TABLE IV

BURGLARIES BY STRUCTURE

	Percent		Average Value Taken (Dollars)	
	1964	1971	1964	1971
Residence	47.0	60.2		
Night	24.5	28.1	240	310
Day	22.5	32.1	275	331
Nonresidence	53.0	39.8		
Night	47.7	34.2	189	307
Day	5.3	5.6	248	250

Source: Uniform Crime Reports for 1964 and 1971

TABLE V

COMPARISON OF ALARMED AND UNALARMED BUSINESSES

	Alarmed	Unalarmed
Percentage of Places Burglarized		
1970	23%	77%
1971	24%	76%
Percentage of Arrests at Scene		
1970	26%	3%
1971	36%	9%
Clearance Rate[a]		
1970	33%	17%
1971	28%	22%
Percent With No Loss[b]	63%	31%

[a] Exclusive of confessions and arrests at scene.

[b] Where there was no apprehension at scene.

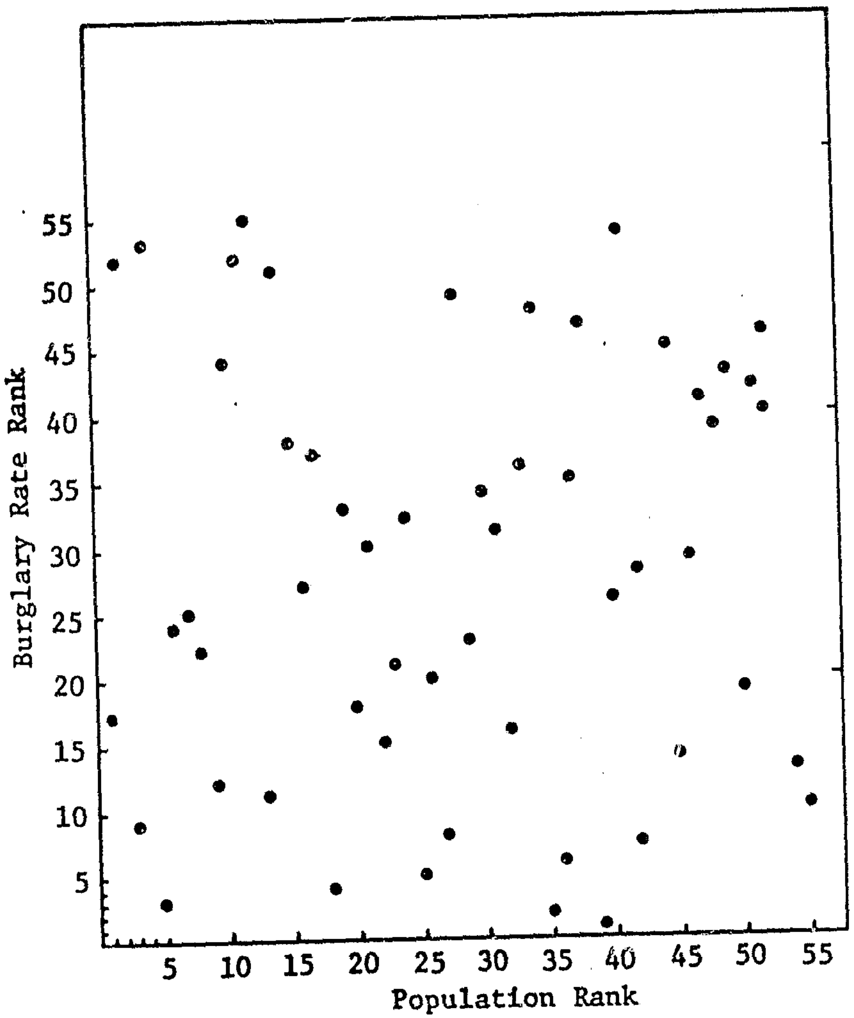

FIGURE 1
SCATTER DIAGRAM BURGLARY RATE VS. CITY SIZE FOR CITIES OVER 250,000

APPENDIX II

BURGLAR ALARMS

Burglar alarms are classified according to how they sense the intrusion or intruder and how they reveal (or to whom they reveal) that their sensor has been activated. There are three basic types of sensors:

Intrusion Sensors - protection of doors, windows and other accessible openings

Space Sensors - protection of the enclosed space. Senses the presence of an intruder usually through RF, sonic doppler or infrared techniques.

Periphery - protection of the perimeter of a structure.

There are four basic types of communication:

Local - protective circuits are connected to a klaxon in or on the building

Central Station - protective circuits are connected to an alarm panel in a centrally located receiving station

Proprietary - protective circuits are connected to an alarm panel located in a guard room on the premises

Police Connection - protective circuits are connected to a police station alarm panel or are connected to an automatic telephone dialer.

False alarms are alarms not set off by an intruder. Unfortunately, even though the definition is simple, determining when an alarm is false is difficult. A false alarm is characterized by the absence of evidence of an attempted intrusion.

The prevalence of false alarms is usually measured by a rate, a ratio or a combination of both. Rate is a measure of the number of false alarms per unit time and, hence, is an indication of the number of alarm systems and their tendency to false. Ratio is a measure of the number of false alarms but also of the number of burglaries. The number of false alarms per unit time per number of systems is a good indication of the quality of the alarm systems.

Recent studies indicate that false alarms outnumber real alarms by ten-to-twenty to one. The results of some exemplars are given:

- AICCC:[11] FAR = 0.92 (Central Stations),
- SBA:[3] FAR >0.90,
- Rand Corporation:[12] FAR = 0.95 (Private Police),
- London:[13] FAR = 0.98.

APPENDIX III

PARAMETRIC ANALYSIS

This Appendix defines and discusses the interrelationship of the parameters used in the body of the report. The basis for most of the material is Reference 8.

Parameters:

Burglary Rate (B) - The number of burglaries in a jurisdiction per year.

False Alarm Ratio (F) - The number of false alarms (from burglar alarm systems) divided by the total number of alarms (from burglar alarm systems), legitimate plus false.

Number of Targets (T) - Number of potential places which could be burglarized.

Coverage Ratio (C) - The fraction of targets which have burglar alarms.

Mean-Time-Between-False-Alarms (Ensemble) - Reciprocal of the number of false alarms per unit time.

Mean-Time-Between-False-Alarms (for a unit) - MTBFA for ensemble times the number of units.

False Dispatch Ratio (D) - Number of false alarms divided by the number of burglaries.

The model developed in Reference 8 assumes all targets have equal likelihood of being burglarized, and the burglar alarms are randomly installed. For the model used in this paper, residential and nonresidential targets were considered separately, so care must be taken in using the curves given in Reference 8.

The calculation procedures for Table II (MTBFA Requirements) are illustrated below for the intermediate term (5% residential coverage and 75% nonresidential coverage).

By definition,

$$D = \frac{\text{number of false alarms}}{\text{number of burglaries}}$$

A value of D=1.5 was chosen as the number required to remain constant. Also the burglary rate was assumed to remain constant. Therefore, if T_R represents the number of residential targets, $T_R/5$ is the number of nonresidential targets (see page 8), and if 5% and 15% of the residences and nonresidences are burglarized each year, then

$$\text{number of burglaries} = (0.05\ T_R) + (0.15)\ \frac{T_R}{5} = 0.08\ T_R$$

Therefore,

$$\text{number of false alarms} = (1.5)\ (0.08\ T_R) = 0.12\ T_R$$

At this point, three alternatives are available: (1) hold D constant at 1.5 for both residential and nonresidential cases and compute different MTBFA's and different False Alarm Ratios, (2) hold MTBFA constant for both residential and nonresidential targets and have different False Dispatch Ratios (but an overall D=1.5) and different False Alarm Ratios, and (3) hold the overall False Dispatch Ratio constant at 1.5, compute an overall False Alarm Ratio (hold it constant for both) and calculate different MTBFA requirements for residences and nonresidences.

The last course of action was chosen. All alternatives were computed for all time periods but the last gave the most reasonable combination of numbers and requirements.

The number of legitimate residential alarms is

$$(\text{coverage ratio})\ (\text{number of burglaries}) = (0.05)(0.05\ T_R) = 0.0025\ T_R$$

Similarly, the number of legitimate nonresidential alarms is

$$(0.75)\ (0.15)\left(\frac{T_R}{5}\right) = 0.0225\ T_R$$

By definition

$$F = \frac{\text{number of false alarms}}{(\text{number of false alarms}) + (\text{number of legitimate alarms})}$$

Therefore,

$$F = \frac{0.12\ T_R}{0.12\ T_R + (0.0025\ T_R + 0.0225\ T_R)} = 0.8276$$

The required MTBFA's can be computed from Equation 10, Reference 7,

$$MTBFA = \left(\frac{T}{B}\right)\left(\frac{1-F}{F}\right)$$

For residences, since B=0.05T,

$$MTBFA = (20)\left(\frac{1-0.8276}{0.8276}\right) = 4.17 \text{ years.}$$

For nonresidences, since B = 0.15T

$$MTBFA = (6.67)\left(\frac{1-0.8276}{0.8276}\right) = 1.39 \text{ years.}$$

The overall MTBFA is of academic interest only, but can be computed as follows:

The total number of targets, T, is given by

$$T = T_R + \frac{T_R}{5} = 1.2T_R$$

The total number of burglaries, B, is given by

$$B = 0.05T_R + (0.15)\left(\frac{T_R}{5}\right) = 0.08T_R$$

Therefore, the overall MTBFA is

$$\left(\frac{1.2T_R}{0.08T_R}\right)\left(\frac{1-0.8276}{0.8276}\right) = 3.12 \text{ years}$$

The corresponding False Dispatch Ratios are of only academic interest so long as the overall ratio is 1.5. However, they can be calculated from Equation 11, Reference 7,

$$D = \frac{CF}{1-F}.$$

For residences,

$$D = \frac{(0.05)\ (0.8276)}{1-0.8276} = 0.24$$

For non residences

$$D = \frac{(0.75)\ (0.8276)}{1-0.8276} = 3.6$$

The graphical representation of the equation

$$MTBFA = \left(\frac{T}{B}\right)\left(\frac{1-F}{F}\right)$$

is given in Figure 2 and points out two interesting observations. First, for a given $\frac{T}{B}$ ratio and false alarm ratio, the MTBFA is independent of the coverage ratio. This is to say, for a particular jurisdiction with a fairly constant ratio of targets to burglary rate, the required MTBFA is dependent only on the false alarm ratio. Secondly, modest improvements in the false alarm ratio can only be achieved through very large increases in the MTBFA for alarm systems (e.g., improving the false alarm ratio from 0.95 to 0.85 requires increasing the MTBFA by more than a factor of three).

The graphical representation of the equation

$$MTBFA = \left(\frac{C}{D}\right)\left(\frac{T}{B}\right)$$

is given in Figures 3 and 4 for the two cases considered in this report (i.e., T/B = 20 for residences, T/B = 6.67 for nonresidences and D = 1.5).

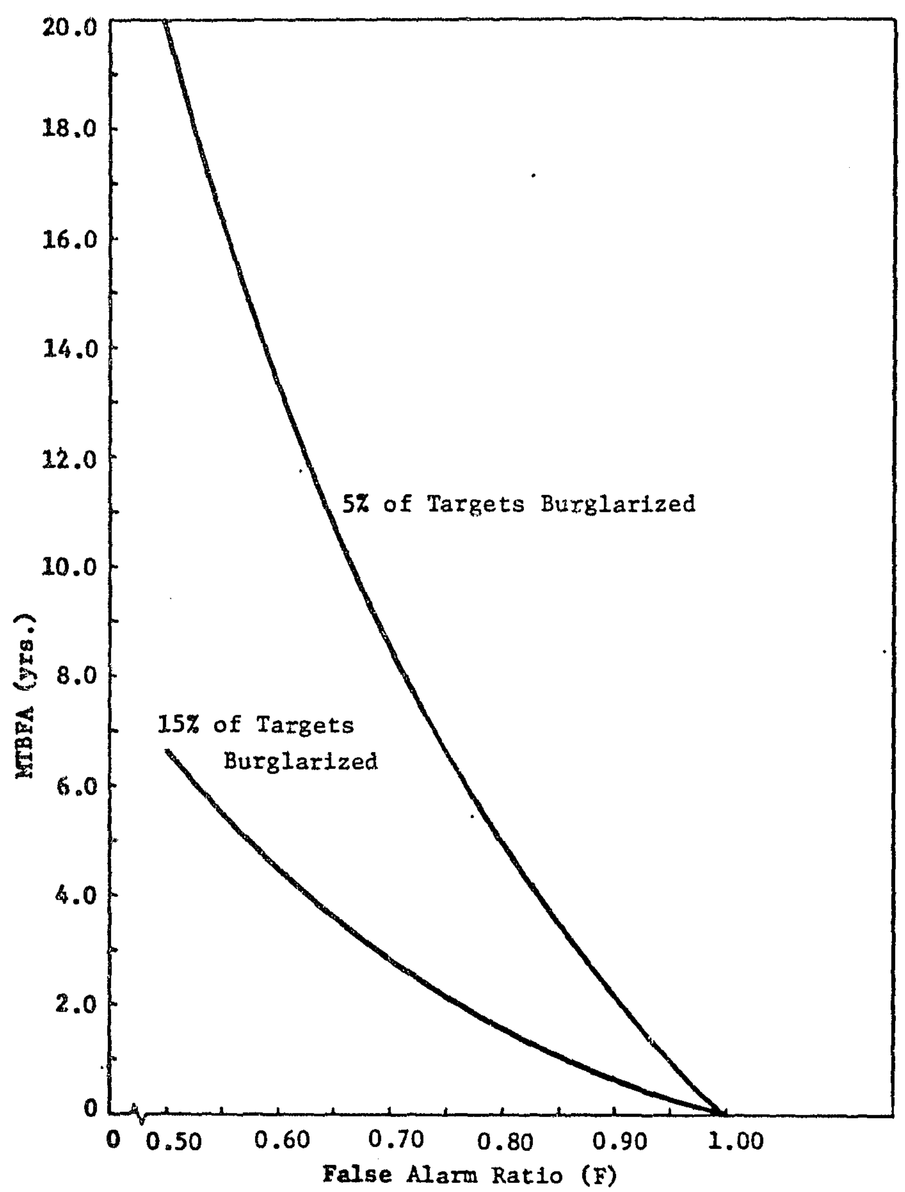

FIGURE 2

MTBFA VERSUS FALSE ALARM RATIO

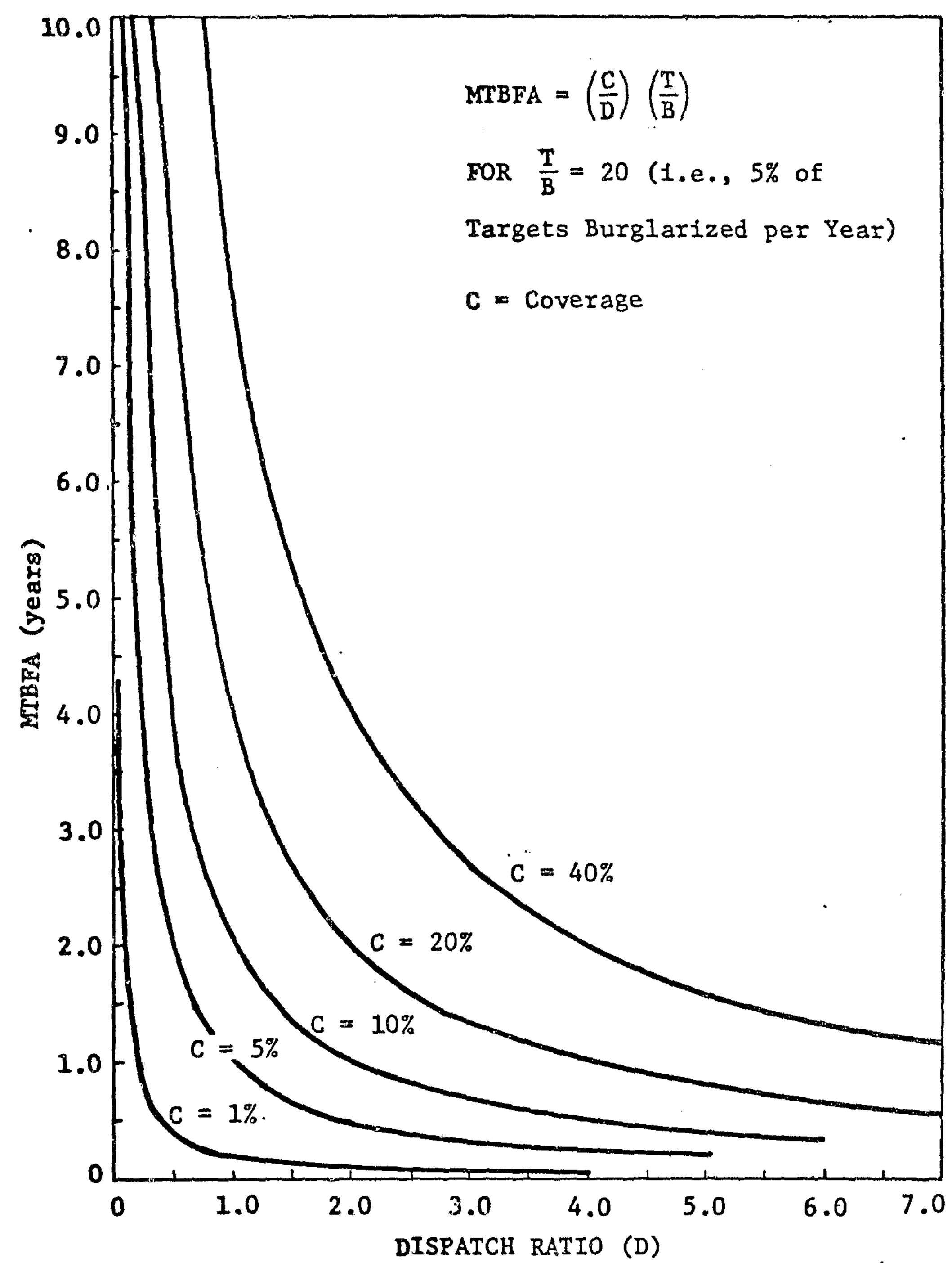

FIGURE 3
MTBFA VS. DISPATCH RATIO FOR RESIDENTIAL BURGLARIES

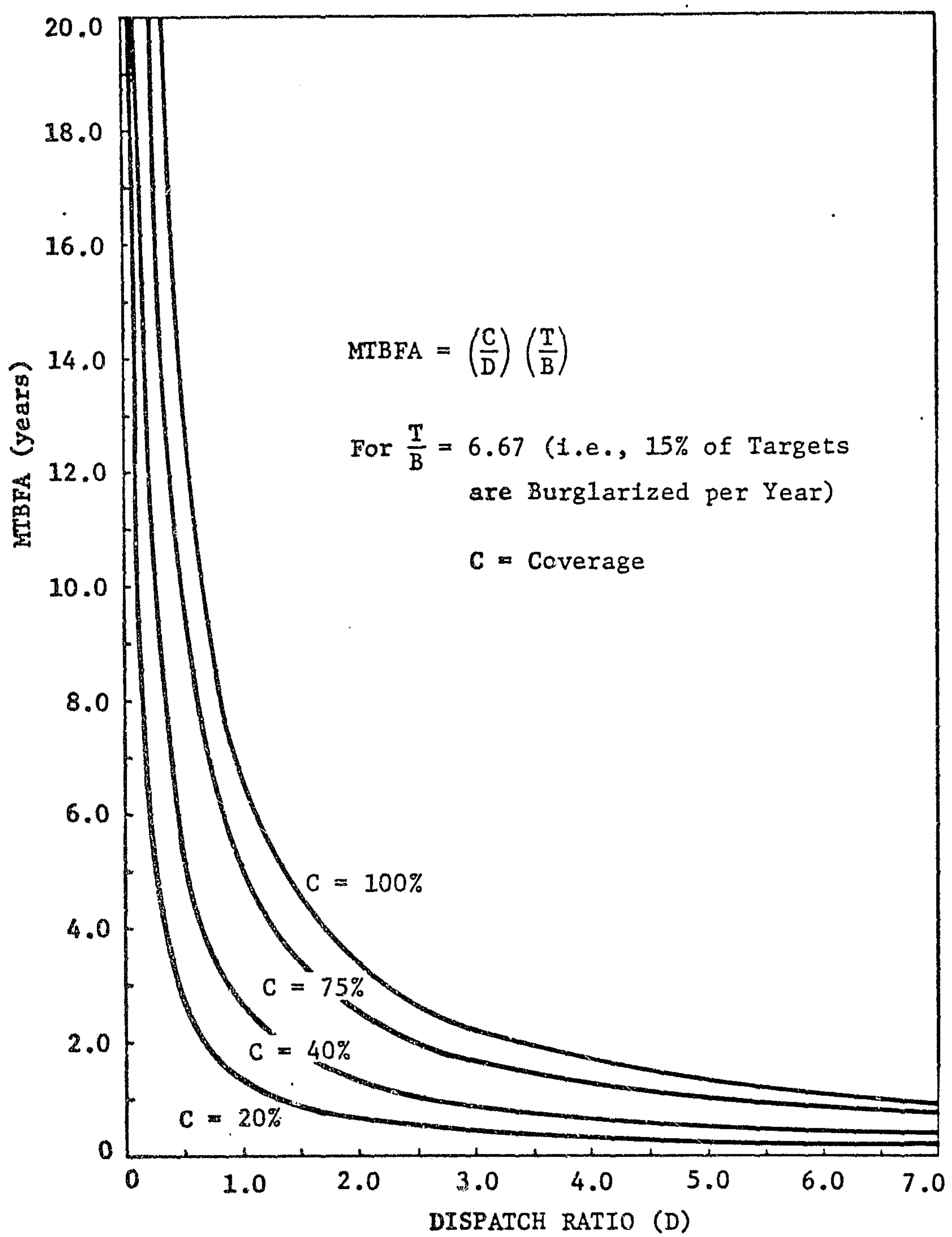

FIGURE 4
MTBFA VS. DISPATCH RATIO FOR NONRESIDENTIAL BURGLARIES

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