X

THE MITRE CORPORATION

WASHINGTON OPERATIONS

~~WORKING PAPER~~

WP. 10274 ___ ___ ___ ___ ___
No. Vol. Series Rev. Supp. Corr.

~~CONTROLLED DISTRIBUTION~~

Subject: WIDESPREAD BURGLAR ALARM USE - IMPLICATION FOR THE POLICE COMMUNITY AND THE ALARM INDUSTRY

To: W. E. Holden

From: W. F. de Dufour

Dept.: D-38

Contract No.: F19628-73-C-0001

Sponsor: LEAA

Project No.: 8160

Page 1 of 39 Pages

Date: 30 April 1973

Approved for MITRE Distribution: M. J. Gordon
M. J. Gordon

ABSTRACT:

This paper explores the preliminary structure of a burglar alarm response model that may be used to describe the changes in police response requirements that occur as additional burglar alarms are installed in a community. The concept of a mean-time-between-false-alarms is introduced as a potential approach to establishing maximum false alarm goals for burglar alarm installations.

The concepts discussed in this paper were developed under a contract with the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration.

28487

LOAN

~~THIS INFORMAL PAPER PRESENTS TENTATIVE INFORMATION FOR LIMITED DISTRIBUTION.~~

EXECUTIVE SUMMARY

The high percentage of false alarms associated with most present burglar alarm installations is beginning to cause concern in some police departments. Only about 5% of the alarms that involve a police response are caused by a criminal intruder; the remainder are false alarms. At the same time, existing burglar alarm installations seldom provide coverage for more than a few percent of the potential burglary targets. This situation has allowed police departments to tolerate high false alarm rates in order to obtain the deterrent and alerting potential of burglar alarms. With more widespread use of burglar alarms being advocated as a means of reducing the criminal act of burglary, an increase in the number of false alarms can be expected. If the police workload due to false alarms becomes excessive, their tolerance to them may disappear.

The work reported on in this paper was performed in an attempt to identify the magnitude of the false alarm problem as the number of burglar alarm installations increased. The parameters that affect the number of police dispatches generated by burglaries and burglar alarms are identified, defined and assembled into the algebraic identities that form the burglar alarm response (BAR) model. An example is provided that shows how the BAR model might be used to estimate future police burglary dispatch requirements.

An effort was also made to identify any parameters that might be useful in establishing meaningful false alarm related performance requirements for burglar alarms. To this end, the concept of a mean-time-between-false-alarms (MTBFA) for individual burglar alarm installations is developed. The parameters that determine the MTBFA requirements are identified and incorporated into the MTBFA model. An example is provided combining the BAR model and the MTBFA model that permits determination of the average false alarm requirements for each burglar alarm installation in a future burglar alarm network.

The paper concludes that:

- A need exists to quantify police false alarm tolerance levels
- MTBFA requirement goals can be generated using alarm network performance as a criteria
- Small improvements in the MTBFA of some existing alarm installations may have a significant payoff.

ACKNOWLEDGEMENT

The author wishes to acknowledge the encouragement and assistance provided by Warner Eliot and Norman Mines, during the many discussions and suggestions that helped to define the concepts presented here.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1. INTRODUCTION

1.1 Background

The burglar alarms available today are generally effective in deterring burglary where they are installed. The sharp increase in the burglary rate in the last decade[1] suggests a need for more burglar alarms. Yet widespread use of these systems appears to be limited by their relatively high cost and their tendency to generate false alarms.[2, 3, 4]

In an effort to reduce the incidence of burglary, the National Institute for Law Enforcement and Criminal Justice (NILECJ) of the Law Enforcement Assistance Administration (LEAA) is supporting the development of low cost security alarm systems for residences and small businesses. The objective of this effort, which is being performed under the Equipment Systems Improvement Program (ESIP), is to develop alarm systems that are low in cost, reliable, and reduce the incidence of false alarms. The MITRE Corporation, under contract to NILECJ, is performing the functions of the ESIP Analysis Group, and is investigating the demand these false alarms place on police resources and the factors that affect this demand. One of the goals of this investigation is to develop a methodology by which quantitative false alarm requirements may be established for burglar alarm systems.

1.2 Scope

This paper explores the preliminary concepts that evolved during the development of a burglar alarm response (BAR) model. It reviews the distribution of false alarms by cause then introduces the concept of using the ratio of dispatches to false alarms compared to dispatches to legitimate alarms as a method of assessing police response to burglar alarms. The parameters used in the BAR model are those that affect the magnitude of the police resources required to service burglary-related calls in a community where burglar alarms are installed. The relationship among these parameters is expressed in the BAR model as a set of algebraic equations that may be combined to evaluate a selected parameter in terms of two or more of the other variables. An example is provided to show how the model may be developed to evaluate a selected parameter.

The paper introduces the concept of utilizing the mean-time-between-false-alarms (MTBFA) of the individual burglar alarm installations as a method of quantifying the false alarm requirements of a large alarm network. The parameters that determine the network false alarm rate are discussed in the MTBFA model. An example is provided to illustrate how the MTBFA model may be developed to evaluate a selected parameter.

A sample calculation utilizing both the BAR model and the MTBFA model is provided to demonstrate a methodology that may be used to obtain a quantitative false alarm requirement for each alarm installed in a given alarm network.

2. THE FALSE ALARM PROBLEM

2.1 Police Response

An alarm caused by other than a criminal intruder can be classified as a false alarm. A police dispatch in response to a false alarm commits resources that might be needed elsewhere (this dispatch cannot result in a capture related to the alarm). Today many small police jurisdictions are tolerant of these false alarms, probably because the frequency of occurence of the alarms does not disrupt normal police functions or create an excessive safety risk for the police and the general public. However, the number of false alarms received each day in many of the large urban police departments has increased to the point that the police are no longer willing to service all burglar alarm calls with high-priority dispatches. The police in these areas are having to re-evaluate their procedures with regard to burglar alarm dispatches. Many have downgraded burglar alarm responses from a high priority to a routine dispatch; by this alteration they have also, of course, reduced their chances to capture a burglar when the alarm is legitimate.

Today, burglar alarms are installed in only a small fraction of potential burglary targets. As the installed cost of burglar alarms comes down and as the need generated by the increase in the burglary rate goes up, more installations can be anticipated. If the number of installed alarms rises significantly and if the tendency of these installations to generate false alarms is not reduced, the new installations may impose an additional burden on the large urban police forces that they may be either unwilling or unable to carry.

2.2 Characteristics of Alarm Systems

Burglar alarm systems as configured today have a tendency to generate alarms that are not caused by an intruder. A survey of the alarms received by 178 burglar alarm central station operators [4] indicates the distribution by cause of almost 39,000 alarms received during a one-month interval from more than 152,000 individual burglar alarm installations. A summary of the distribution of these alarms is shown in Table I.

It is not unreasonable to distribute the Unknown Alarms shown in Table I among the other categories on a proportional basis. If this is done, and the number of Property Damage alarms is assumed to be very small, the alarms caused by intruders would increase from 8% to about 10% of the total. The other 90% can be considered false alarms. Alarms can seldom be classified definitively as false or legitimate at the time they are received at the central station. Of the alarms cited in Table I, those that were reported to the police with a request for a police dispatch probably had the same false-to-legitimate ratio as those that were received at the central station.

The term false alarm ratio--the ratio of false alarms to the total alarms received--is frequently used when discussing an alarm network. The false alarm ratio is commonly expressed as a percentage. The term alarm network, as used here, includes all burglar alarm installations within the jurisdiction serviced by a police department. If it were assumed that one police department serviced the 178 central station operators mentioned above and that no other alarms were installed in the jurisdiction, then the false alarm ratio of the alarm network represented by Table I would be about 90%. In general, present-day burglar alarm networks tend to have a false alarm ratio that is greater than 90%.

The generation of false alarms in an alarm network is independent of the generation of legitimate alarms. The frequency of false alarms in the network is dependent on the number of alarm installations and the susceptibility of the installations to the causes shown in Table I.

TABLE I

DISTRIBUTION OF ALARMS BY CAUSE

	Cause	Percent
1.	Internal Any alarm initiated at the protected premises caused by other than intruders, property damage, or equipment malfunction. This category includes user error at the protected premises	41%
2.	Alarm Installation Equipment Malfunction Any alarm initiated by malfunction of the alarm equipment installed on the premises	23%
3.	Unknown	19%
4.	External Any alarm initiated in a place other than the protected premises	9%
5.	Intruder or Property Damage Alarms caused by actual or attempted entry by an intruder or by damage to property detected by the alarm installation.	8%
		100%

The frequency of legitimate alarms depends on the number of burglaries that occur and are detected within the alarm network. An alarm network installed in a low-crime area would tend to exhibit a high false alarm ratio, whereas the same alarm network installed in a high-crime area would tend to exhibit a lower false alarm ratio. A reduction in the burglary frequency in either area would tend to reduce the number of legitimate alarms and would result in higher false alarm ratios.

2.3 False Dispatch Ratio

The police response to a legitimate burglar alarm may be designated as a legitimate dispatch. The response generated by a false alarm may be designated as a false dispatch. The term false dispatch ratio--the ratio of false to legitimate dispatches--is a convenient way to describe police response to burglar alarms. Table II shows the false alarm ratios corresponding to selected false dispatch ratios when all dispatches originate from alarms generated within the alarm network. It can be seen that any alarm network with a false alarm ratio greater than 91%, will generate more than 10 false dispatches for each legitimate dispatch.

The impact of a high false alarm ratio on police response may be illustrated in the following example. Assume the following:

- All burglary targets in a city the size of Washington, D.C., have alarms installed.
- The false alarm ratio of the alarm network is about 95%.
- There are approximately 26,000 burglaries each year, or 3 legitimate alarms each hour.

An alarm network with this false alarm ratio would have a false dispatch ratio of about 20 to 1. With three legitimate dispatches every hour, there would be <u>one false dispatch every minute.</u> Fortunately, false dispatch rates this high generally do not occur today

TABLE II

FALSE ALARM RATIOS CORRESPONDING TO SELECTED FALSE DISPATCH RATIOS FOR DISPATCHES GENERATED BY THE ALARM NETWORK

False Dispatch Ratio	False Alarm Ratio (Percent)*
100/1	99
50/1	98
20/1	95
10/1	91
5/1	83
4/1	80
3/1	75
2/1	67
1/1	50

*Percentage rounded to nearest whole number.

because burglar alarms are installed in only a small fraction of the potential burglary targets.

3. THE BURGLAR ALARM RESPONSE MODEL

3.1 Parameters Included

Today, most burglar alarms are installed in business establishments. Many burglaries, however, occur in premises that are not likely to have alarms installed.[5] Burglaries in premises that do not have alarms installed are considered here to occur outside of the alarm network. These burglaries are generally reported to the police by phone; they will be referred to here as phone alarms.

The burglar alarm response (BAR) model attempts to establish the relationship among those parameters relating to police burglar alarm response requirements in a jurisdiction having a burglar alarm network. Four parameters may be considered independent variables in the BAR model. They are:

- The number of alarm network legitimate alarms received
- The number of alarm network false alarms received
- The number of phone alarms received
- The coverage ratio.

In the BAR model, all police dispatches that originate from phone alarms are considered to be legitimate dispatches. It is recognized that phone alarms reporting burglaries discovered after the fact offer no opportunity to capture the burglar on or near the premises. However, statistical information was not available to distinguish these alarms from phone alarms reporting burglaries in progress. A question also arose concerning both the definition of false phone alarms and statistical information about their prevalence. To permit development of the BAR model, a decision was made to assume that all phone alarms were legitimate alarms. The BAR model will be modified when suitable statistical information relative to phone alarms becomes available.

The term coverage ratio is used here to define the ratio of burglary targets having burglar alarms installed to the total number of burglary targets under consideration.

Two parameters may be considered as dependent variables in the BAR model. They are:

- The false alarm ratio
- The false dispatch ratio.

In the BAR model, these relationships are expressed as algebraic equations that may be combined to permit evaluation of a selected parameter in terms of two or more variables. A discussion of the BAR model and the identities and assumptions used to develop it is included in Appendix I.

3.2 <u>BAR Model False Dispatch Ratio Development</u>

The assumption is made in the BAR model that a legitimate alarm occurs each time a burglary is committed. The BAR model also assumes that a random geographical distribution exists both for burglar alarm installations and for burglaries. Therefore, the portion of the legitimate alarms originating within the alarm network is a function of the coverage ratio. The number of legitimate alarms originating within the alarm network is dependent on the number of burglaries and the coverage ratio. The number of false alarms is dependent on the equipment, installation, and operational characteristics of the alarm network, including user error. These false alarms will probably have a distribution by cause similar to the distribution shown in Table I.

The relationship between the false alarm ratio and the false dispatch ratio shown in Table II is altered when phone alarms are considered as part of the dispatch process. The development of the equation relating the false dispatch ratio to the false alarm ratio

and the coverage ratio when phone alarms are considered is shown in Appendix I. The relationship of these terms, as defined by the BAR model, is shown in Figure 1. This figure has been plotted for false dispatch ratios between 0.1 to 1 and 100 to 1. It should be noted that the curves of Figure 1 are based on a random distribution of both burglaries and burglar alarm installations.

Information obtained to date suggests that a false dispatch ratio of not more than one false dispatch to every ten legitimate dispatches probably would be acceptable in almost all police jurisdictions. The information also suggests that in all probability only those police jurisdictions that have a very low burglary frequency would find it acceptable to have a dispatch ratio in excess of 100 to 1.

The curves in Figure 1 may be placed in perspective with regard to current alarm network performance by considering the following:

- Most burglar alarm networks exhibit false alarm ratios higher than 90%
- It is estimated that few, if any, large urban areas have a burglar alarm coverage ratio larger than 10%
- It is estimated that most of the police jurisdictions have burglar alarm coverage ratios of 1% or less

The equation shown in Figure 1 indicates that the false dispatch ratio will vary directly with the coverage ratio; i.e., if the coverage doubles, the false dispatch ratio will double. The false dispatch ratio can be used by the police to estimate the resources that must be allocated to service burglar alarm dispatch requirements. However, the impact on additional police resource requirements depends on both the false alarm ratio and the present coverage, as is shown in the following example.

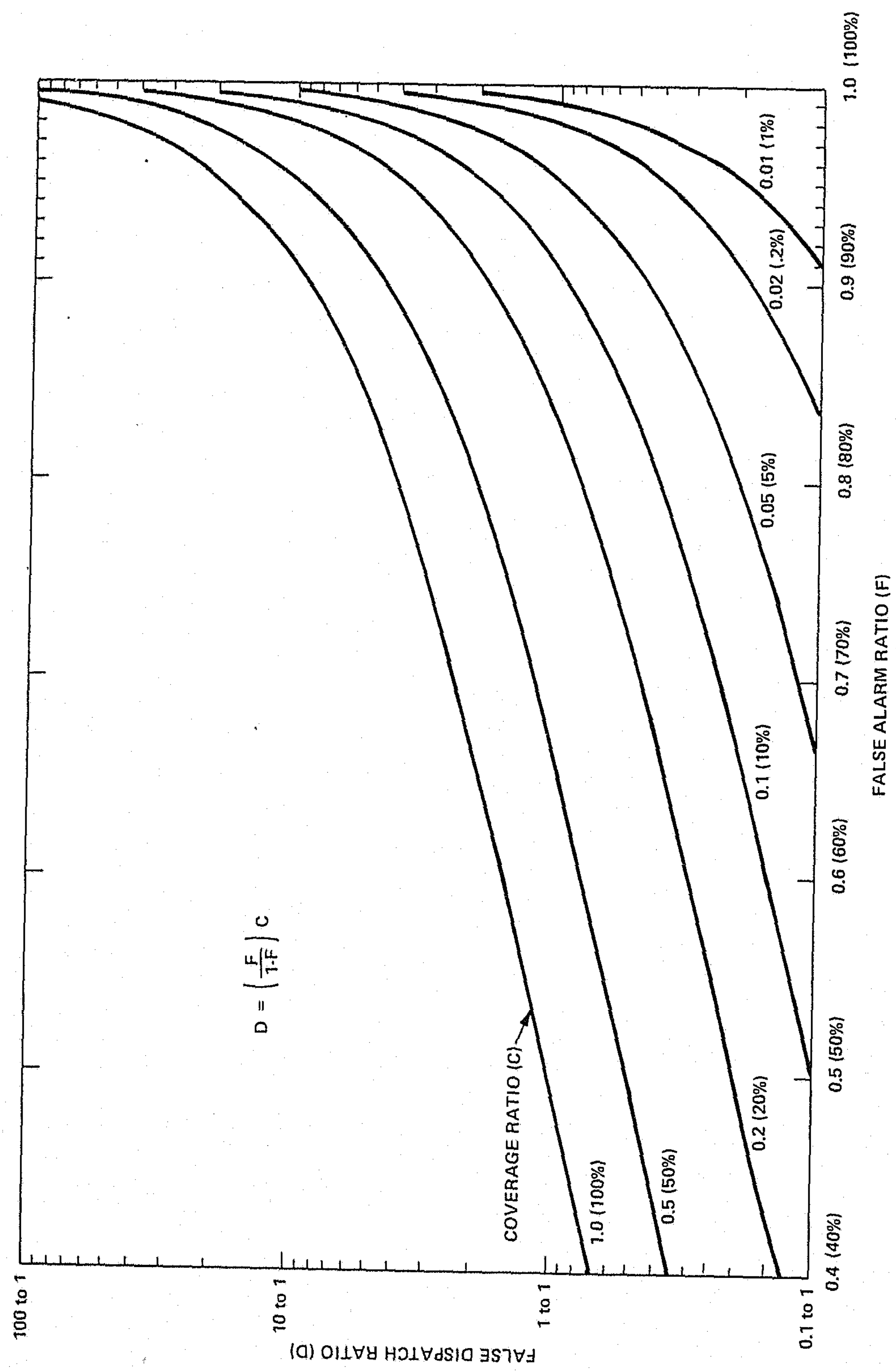


FIGURE 1
VARIATION OF FALSE DISPATCH RATIO WITH THE COVERAGE AND FALSE ALARM RATIOS

Assume the following:

- Two jurisdictions anticipate that their alarm coverages will double within a certain time interval
- The burglary frequency in each jurisdiction will remain the same
- The existing alarm network in each jurisdiction has a false alarm ratio of about 95%, and it is expected that this false alarm ratio will remain the same after the coverage is increased
- The existing coverage ratios in the two jurisdictions are 1% and 5%

The false dispatch ratio corresponding to a false alarm ratio of 95% and a coverage ratio of 1% may be found from Figure 1 to be about 0.2 to 1. If the coverage ratio is doubled, the dispatch ratio will increase to about 0.4 to 1. This represents an increase in the total number of dispatches of about 16% to accommodate double the burglar alarm coverage in the first jurisdiction.

In the second jurisdiction, the false alarm ratio is also about 95% but the present coverage ratio is 5%. The corresponding false dispatch ratio may be found from Figure 1 to be about 1 to 1. If the coverage ratio is doubled, the dispatch ratio will increase to about 2 to 1. This represents an increase in the total number of dispatches of about 50%.

It should be noted that the burglary frequency in each jurisdiction remained constant in this example. Since all the legitimate alarms receive a response regardless of the coverage, all the additional dispatches, i.e., 16% in one case and 50% in the other, will be dissipated answering false alarms.

4. ALARM NETWORK REQUIREMENTS

4.1 Acceptable False Alarm Requirements

High false dispatch ratios appear to be tolerated more readily in those areas where comparatively few burglaries occur. In these areas, the frequency of occurrence of false alarms--the false alarm rate--probably is so low that it does not interfere with normal police activity or create an excessive safety risk. While it is not now known just what constitutes an acceptable false alarm rate for various cities, towns, and villages, the downgrading of the priority of burglar alarm dispatches that is occurring in many large urban areas indicates that in these areas the tolerance limit has been reached.

Achieving a significant reduction of false alarms in an alarm network is not an easy task. A reduction in the number of burglaries will not reduce the false alarm rate, since these two factors are independent of each other. However, the false alarm rate can be reduced by making changes in the equipment and operating procedures used in the alarm network. Much of the false alarm problem appears to be caused by user error. It should be possible to reduce false alarms caused by user error by better training or improved equipment design. User error might also be reduced by suitable incentive programs, such as the charging of a fee when user-caused false alarms occur. It should be possible to reduce false alarms due to equipment failure by improving the equipment design.

When the cause of a false alarm can be identified, changes should be made to reduce the probability of that cause generating additional false alarms. The key to effecting these changes is to establish reasonable false alarm requirement goals for alarm equipment and installations. These goals should be chosen so that they can be achieved within a justifiable expenditure of time and money. The

schedule, to implement these requirements, should be matched against the projected growth of the existing alarm networks, particularly those in the larger cities. Three factors might be considered when attempting to establish these requirements:

- The ease of making a mechanical, electrical, or operational procedure change
- The frequency of occurrence of the cause of the false alarm
- The amount of research and development needed to implement a new approach.

4.2 Mean-Time-Between-False-Alarms

The concept of defining an acceptable mean-time-between-false-alarms (MTBFA) may offer an approach to establishing reasonable false alarm requirement goals. For instance, if a tolerable false alarm rate can be established for an alarm network, the average time interval permitted between the generation of false alarms at each installation in the network--the MTBFA--can be determined. For example, assume that the alarm network contains 1000 installations and that 10 per day is the tolerable false alarm rate. Then the MTBFA can be determined as follows:

$$\text{MTBFA} \geq \frac{1000}{10/\text{day}} = 100 \text{ days}$$

If this requirement can be met by each alarm installation, the false alarm tolerance level for this network, on the average, will not be exceeded. In order to permit evaluation of the MTBFA requirements for large alarm networks, a MTBFA model has been developed that is similar in concept to the BAR model.

4.3 MTBFA Model

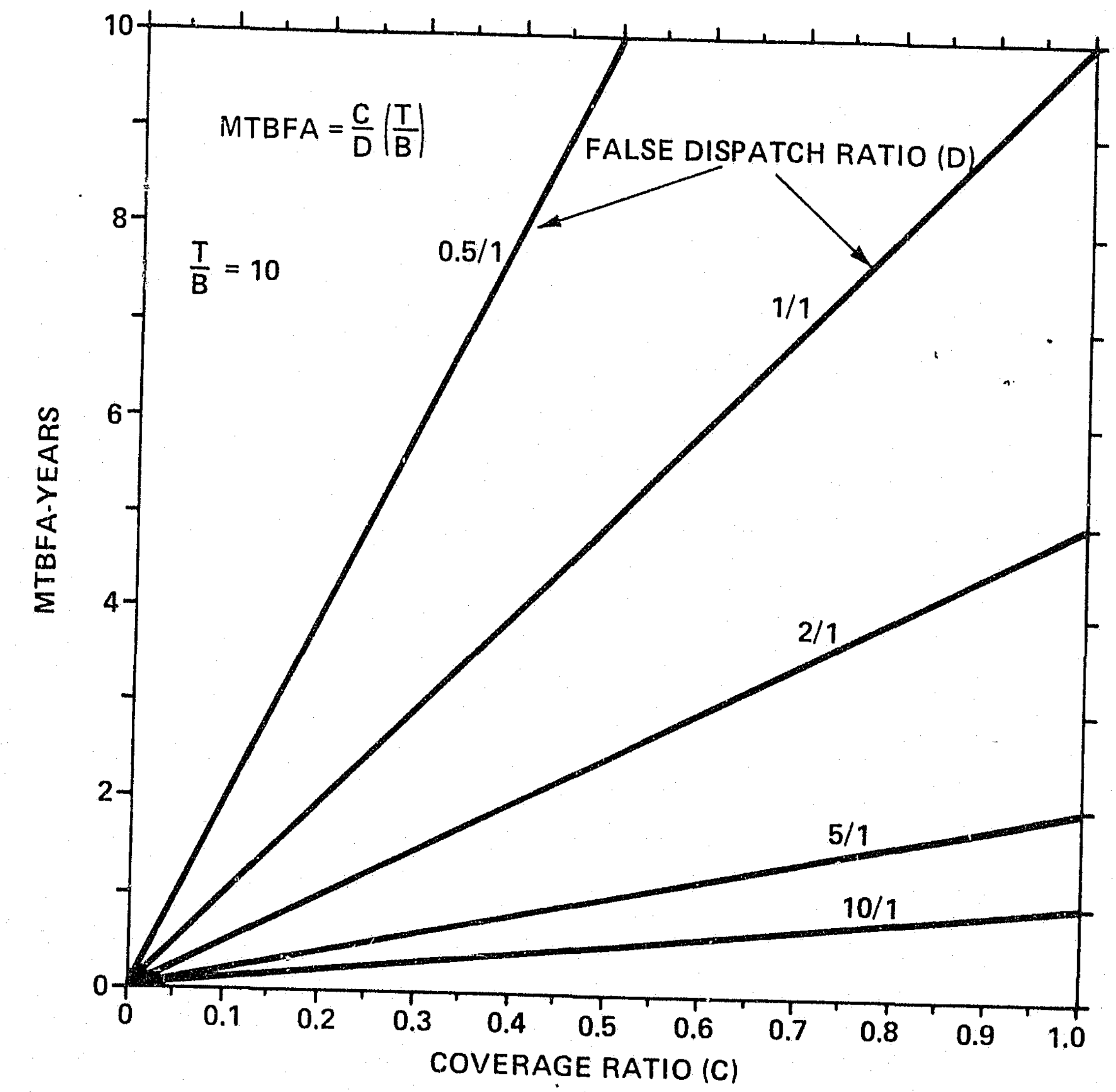
The MTBFA model attempts to establish the relationship among those parameters that determine the minimum MTBFA required for each alarm installation in an alarm network. Five parameters may be considered variables and are included in the MTBFA model:

- Burglary frequency
- Number of burglar alarms installed
- Number of burglary targets
- Alarm network false alarm rate
- Coverage ratio.

In the MTBFA model, the relationship among these parameters is expressed as a set of algebraic equations. As in the BAR model, these equations may be combined to permit evaluation of a selected parameter in terms of two or more other variables. A discussion of the MTBFA model and the identities and assumptions used to develop it is included in Appendix II.

4.4 MTBFA Model Development

An equation that relates the MTBFA required for individual alarm installations to the coverage ratio and the false dispatch ratio, and combines the identities of the BAR model and the MTBFA model is plotted graphically in Figure 2. The ratio of the number of potential burglary targets (T) to the yearly burglary frequency (B) is included in this equation as a constant. The value of T/B must be determined separately for each jurisdiction. This value was set at 10 in Figure 2 since this appears to be a good approximation for large urban areas. As indicated before, few if any alarm networks installed in large urban areas provide a coverage ratio larger than 10%. It can be seen from Figure 2 that where the target coverage is low (less than 10%), and the false dispatch ratio high (greater than 2 to 1), a significant reduction in the false dispatch ratio may be achieved with improvements on the order of a month or two in the MTBFA of each alarm installation.



T = TOTAL NUMBER OF BURGLARY TARGETS
B = YEARLY BURGLARY FREQUENCY

FIGURE 2
VARIATION OF MEAN-TIME-BETWEEN-FALSE-ALARMS (MTBFA) WITH THE COVERAGE AND FALSE DISPATCH RATIOS

5. ALARM SYSTEM MTBFA DETERMINATION

The BAR model may be utilized to estimate the police work load that will be experienced as more burglar alarms are added to an existing alarm network. In conjunction with the MTBFA model, it may also be used to identify the individual burglar alarm installation MTBFA required to maintain a chosen false dispatch ratio as the size of the alarm network increases. The following example illustrates a methodology that might be used to establish such a MTBFA requirement. Assume the following:

- The burglar alarm coverage increases from the present 10% to 30%
- The number of burglary targets (250,000) remains constant.
- The yearly burglary frequency (25,000) remains constant
- The tolerance level of burglary dispatches has been reached. It is desired to keep the total number of daily burglary dispatches no higher than at present
- The present alarm network has a false alarm ratio of 95%.

The present false dispatch ratio for a false alarm ratio of 95% and a coverage of 10% is approximately 2 to 1 (Fig. 1). If the coverage increases to 30% and the false alarm ratio remains at 95%, the new false dispatch ratio becomes approximately 6 to 1. Since the yearly burglary frequency remains fixed, the average daily number of legitimate dispatches remains fixed. To keep the total number of daily dispatches no higher than at present, the false dispatch ratio must be held to 2 to 1 or less. A false dispatch ratio of 2 to 1 with 30% coverage can be achieved by reducing the number of false alarms generated in the alarm network to give a false alarm ratio of 86%.

Since the number of burglary targets (T) remains at ten times the yearly burglary frequency (B), Fig. 2 may be used to estimate the new MTBFA requirement. The present MTBFA achieved by this network

which has a false alarm ratio of 95%, a coverage ratio of 10%, and a 2 to 1 false dispatch ratio is 0.5 year or better per installation. The MTBFA required for the new network with a false alarm ratio of 86%, a coverage ratio of 30%, and a 2 to 1 false dispatch ratio is 1.5 years or better per installation. In this case, the increase in the coverage from 10% to 30% is assumed to be obtained by adding to the existing network. The 1.5 year MTBFA requirement is for the composite network at 30% coverage. Since the original installations comprising one-third of the new network have a MTBFA of 0.5 year, the alarm installations in the added two-thirds must have an MTBFA of at least 2 years to achieve a 1.5 year average for the composite network.

6. CONCLUSIONS

It is anticipated that the BAR model discussed here will be modified as more statistical information becomes available. As a result of the effort to date, the following conclusions can be drawn:

- A need exists to quantify the false alarm tolerance level in different police jurisdictions in order that alarm network performance requirements can be established
- Alarm installation MTBFA requirement goals can be generated using alarm network performance as a criterion
- In some existing alarm networks, significant reduction in the false dispatch ratio may be achieved by a comparatively small improvement in the MTBFA of the alarm installation.

W. F. de Dufour

WFdeD:bm

APPENDIX I

BURGLAR ALARM RESPONSE (BAR) MODEL

INTRODUCTION

The BAR model is being developed to gain a better understanding of the interaction of the parameters that affect police dispatches related to the crime of burglary. The assumptions constraining the model were chosen both to simplify the model and to make it compatible with those burglar alarm and police response statistics which might be expected to be available.

DEFINITION OF TERMS

The following definitions apply to this model:

Alarm Network

The assemblage of all burglar alarms within the jurisdiction serviced by a police force

Burglar Alarm

Any installed device or equipment whose purpose is to signal the presence of an intruder

Coverage Ratio

The ratio of the number of burglary targets having burglar alarms installed to the total number of burglary targets under consideration

False Dispatch Ratio

The ratio of the number of false dispatches to the number of legitimate dispatches

False Alarm

An alarm initiated by any cause other than an actual or attempted burglary

False Alarm Ratio

The ratio of the number of false alarms originating within the alarm network to the total number of alarms originating within the alarm network (commonly expressed as a percentage)

False Dispatch

A police response to a false alarm

Legitimate Alarm

An alarm initiated by an actual or attempted burglary

Legitimate Dispatch

A police response to a legitimate alarm

Phone Alarm

Any notification to the police of a burglary or attempted burglary that does not involve the alarm network.

MODEL ASSUMPTIONS

The model assumes that a random geographical distribution applies both to burglar alarm installations and to burglaries. Therefore, the number of burglaries that occur within the alarm network is proportional to the coverage ratio. It is assumed that all burglaries that occur outside the alarm network are reported by phone alarms and that no false alarms occur outside the alarm network. It is

assumed that each burglar alarm has a probability of detection of 1.0 and that each burglary results in one legitimate alarm. Police response is considered to be the same for each alarm, i.e., there is one police dispatch for each alarm, whether it is false or legitimate. These assumptions are summarized in Table III.

TABLE III

SUMMARY OF ASSUMPTIONS

1. There is a random distribution of burglaries over all target premises.
2. There is a random distribution of burglar alarms.
3. The probability of detection of each burglar alarm is 1.0.
4. Each burglary results in one legitimate alarm.
5. All phone alarms are legitimate.
6. Each alarm generates one dispatch.

Terms Used in the Model

The following terms are used in the identities that comprise the structure of the BAR model:

A	=	Total number of all alarms received
A_f	=	Total number of false alarms received
A_l	=	Total number of legitimate alarms received
C	=	Coverage ratio
D	=	False dispatch ratio
F	=	False alarm ratio
P	=	Number of phone alarms
S	=	Number of burglar alarm network alarms
S_f	=	Number of burglar alarm network false alarms
S_l	=	Number of burglar alarm network legitimate alarms.

Identities

The following identities comprise the structure of the BAR model. These identities may be manipulated algebraically to develop an equation that describes how one parameter changes as the others are varied.

The false dispatch ratio is equal to the total number of false alarms received divided by the total number of legitimate alarms received,

$$D = \frac{A_f}{A_l} \quad (1)$$

All false alarms are generated within the alarm network,

$$A_f = S_f \quad (2)$$

The total number of all alarms received is the sum of the false and legitimate network alarms plus the phone alarms,

$$A = S_f + S_l + P \quad (3)$$

The alarm network legitimate alarms and the phone alarms are the only source of legitimate alarms,

$$A_l = S_l + P \quad (4)$$

The false and legitimate alarms generated in the alarm network constitute the total number of alarms generated within the network,

$$S = S_f + S_l \quad (5)$$

The false alarm ratio is equal to the alarm network false alarms divided by the total number of alarm network alarms,

$$F = \frac{S_f}{S} \quad (6)$$

The number of legitimate alarms occurring within the alarm network is equal to the total number of legitimate alarms times the coverage ratio,

$$S_l = CA_l. \quad (7)$$

Model Development

In this application of the BAR model, it is desired to obtain an expression for the false dispatch ratio in terms of the coverage ratio and the false alarm ratio. The following development may be made using the BAR model identities:

From (1), (2), (7)

$$D = \frac{A_f}{A_l}$$

$$D = \frac{S_f C}{S_l} \quad (8)$$

From (5)

$$S_l = S - S_f$$

From (6)

$$S_f = FS$$

Substituting in (8)

$$D = \frac{FS}{S-FS} C$$

$$D = \frac{F}{1-F} C \quad (9)$$

This function, which has been plotted for several values of C and F, is shown in Figure 1. The reader is cautioned not to interpret equation (9) as being independent of the remainder of the terms used in the model. All the identities must be satisfied simultaneously.

APPENDIX II

MEAN-TIME-BETWEEN-FALSE-ALARMS (MTBFA) MODEL

INTRODUCTION

The MTBFA model is being developed in an attempt to provide a means to quantify the false alarm requirements for individual burglar alarms within an alarm network. It can be used to identify the maximum false alarm rate that would be allowed for each burglar alarm installation within an alarm network in order for the network false alarm rate to stay at or below a selected value.

DEFINITION OF TERMS

The following definitions apply to the MTBFA model. Refer to Appendix I for the definition of terms not listed below.

Mean-Time-Between-False-Alarms

The average time interval between false alarms from any cause which are introduced into the alarm network by an individual burglar alarm

Number of Burglar Alarms Installed

The total number of burglar alarm installations in the alarm network

Total Number of Burglary Targets

All premises that are considered potential burglary targets within a defined area

Burglary Frequency

The number of burglaries committed in the defined area during a specified interval.

Network False Alarm Rate

The number of false alarms occurring within the alarm network in a specified interval.

Network Legitimate Alarm Rate

The number of legitimate alarms occurring within the alarm network in a specified interval.

Total Network Alarm Rate

Total number of both false and legitimate alarms occurring within the alarm network in a specified interval.

MODEL ASSUMPTIONS

The assumptions stated for the BAR model in Appendix I apply to the MTBFA model.

TERMS USED IN THE MODEL

B	=	Yearly Burglary Frequency
C	=	Coverage Ratio
F	=	False Alarm Ratio
MTBFA	=	Mean-Time-Between-False-Alarms
N	=	Number of Burglar Alarms Installed
T	=	Total Number of Burglary Targets
Y	=	Yearly Network Total Alarm Rate
Y_f	=	Yearly Network False Alarm Rate
Y_l	=	Yearly Network Legitimate Alarm Rate

IDENTITIES

The following identities comprise the structure of the MTBFA model. These identities may be manipulated algebraically to develop an equation that describes how one parameter changes as others are varied. Yearly rates have been selected for the model.

The MTBFA is equal to the total number of burglar alarms installed, divided by the Network false alarm rate.

$$MTBFA = \frac{N}{Y_f} \qquad (1)$$

The alarm network total alarm rate is equal to its false alarm rate plus its legitimate alarm rate,

$$Y = Y_f + Y_l \qquad (2)$$

The alarm network false alarm rate is equal to the total network alarm rate times the false alarm ratio,

$$Y_f = FY \qquad (3)$$

The coverage ratio is equal to the number of burglar alarms installed divided by the total number of burglary targets,

$$C = \frac{N}{T} \qquad (4)$$

The alarm network legitimate alarm rate is equal to the burglary rate times the coverage ratio,

$$Y_l = BC. \qquad (5)$$

MODEL DEVELOPMENT

In this application of the MTBFA model, it is desired to obtain an expression for the MTBFA in terms of the dispatch ratio and the coverage ratio. The following development may be made using the MTBFA model identities.

From (1) and (3)

$$MTBFA = \frac{N}{Y_f}.$$

$$MTBFA = \frac{N}{FY} \qquad (6)$$

From (2) and (3)

$$Y - Y_f = Y_l$$

$$Y - FY = Y_l$$

$$Y = \frac{Y_l}{1-F}. \qquad (7)$$

From (4) and (5)

$$Y_l = \frac{NB}{T}. \qquad (8)$$

Substituting (8) in (7)

$$Y = \frac{NB}{T(1-F)}. \qquad (9)$$

Substituting (9) in (6)

$$MTBFA = \frac{T}{B} \cdot \frac{(1-F)}{F}. \qquad (10)$$

From Appendix I (9)

$$\frac{F}{1-F} = \frac{D}{C} \cdot \qquad (11)$$

Substituting (11) in (10)

$$MTBFA = \frac{T}{B}\left(\frac{C}{D}\right). \qquad (12)$$

It can be seen from this equation that the MTBFA requirement can be reduced to a function of the coverage ratio and the dispatch ratio if the burglary rate and the total number of potential burglary targets are specified. The reader is cautioned not to interpret equation (12) as being independent of the remainder of the terms used in the model. All the identities must be satisfied simultaneously. Equation (12) is plotted in Figure 2 for the case in which the total number of burglary targets is ten times the number of burglaries per year.

REFERENCES

1. Uniform Crime Reports for the United States - 1970. Issued by the FBI. USGPO 2701-0008, p. 18.

2. Crime Against Small Business. A Report of the Small Business Administration. April 3, 1969. 91st Congress; 1st Session; Doc. No. 91-14, USGPO 26-389 0. p. 37.

3. Private Police in the United States. Vol. 1-R-869/DOJ, PR72-4. February 1972. J. S. Kakalik and S. Wildhorn, the Rand Corporation. Published by the U.S. Department of Justice, National Institute of Law Enforcement and Criminal Justice, pp. 23, 29, 60, 103.

4. "AICCC Releases False Alarm Report." National Burglar and Fire Alarm Association (NBFAA) Signal, First Quarter 1972, p. 40.

5. Patterns of Burglary. PR 72-10/February 1972. Harry A. Scarr et al., Human Sciences Research. Published by the U.S. Department of Justice, National Institute of Law Enforcement and Criminal Justice. USGPO 2700-0148, p. 44.

DISTRIBUTION LIST

MITRE

D-12 C. C. Grandy
C. A. Zraket

D-20 W. F. Mason

D-30 J. Dominitz
A. Mahoney
J. Selinka
W. Woodward
W. F. Yondorf

D-34 L. L. Holmes

D-38 W. F. de Dufour
W. A. Eliot
M. J. Gordon (3)
W. E. Holden (5)
S. H. Roth
S. I. Solomon

C-92 MITRE Washington Library

EXTERNAL

LEAA/NILECJ

J. Kochanski
M. Nerenstone (5)
N. Solomon/Contracts Office

APPROVED FOR PROJECT DISTRIBUTION: William E. Holden
W. E. Holden

END

7 [illegible]