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February 1971

ON-LINE COMPUTER PROGRAMS FOR THE ANALYSIS OF BORDER-CONTROL PROBLEMS

G. F. Schilling and M. Turner

A Report prepared for

ADVANCED RESEARCH PROJECTS AGENCY

Rand
SANTA MONICA, CA. 90406

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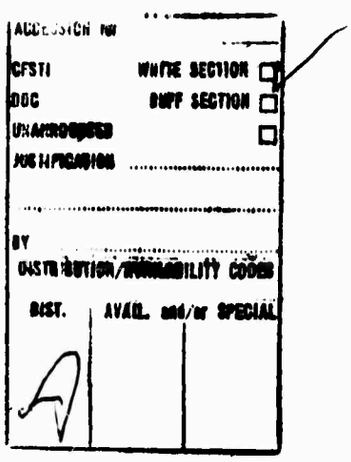

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10. ABSTRACT

Complex interactions among military, technical, geopolitical, and socioeconomic factors constitute major problems for counterinfiltration programs intended to inhibit the movement of hostile forces across defined boundaries. This report describes two versions of an on-line computer program that incorporates the methodology of a model of border control developed in RM-6250; it enables the user to analyze insurgency situations without mathematical manipulations. The computerized versions of the model permit the ready investigation of specific situations and the rapid testing of new concepts with regard to their probable utility under different contingencies. It also permits testing of quantitative sensitivity analyses of candidate border security systems and programs. Outputs include a detailed account and projected time sequence of the number of guerrillas in the area of interest as a result of infiltration, interdiction, recruitment, and attrition. For any future date, these numerical data are given in terms of actual numbers, area densities, and rates of change.

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PREFACE

An analytic model of border control has recently been developed by The Rand Corporation as part of a study of infiltration and invasion control for the Advanced Research Projects Agency. It has been published as RM-6250-ARPA, Analytic Model of Border Control.

The present Report describes computerized versions of the model for on-line use. Two of the on-line programs are available in Rand's JOSS* library file, and can be recalled from remote consoles and teletypes with access to JOSS. These programs employ everyday language rather than mathematical symbolism. They are, essentially, tools to assist in the analysis of infiltration problems and in comparative evaluations of candidate border security systems.

This Report should be of interest also to other agencies concerned with counterinsurgency research, or with the development of contingency plans for various areas of the world.

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*JOSS is the trademark and service mark of The Rand Corporation for its computer program and services using that program. For access to programs, use library 51, and recall item 1 (BRD1) or item 3 (BRD2), respectively.

SUMMARY

The complex interactions among military, technical, geopolitical, and socio-economic factors constitute major problems for counter-infiltration programs intended to inhibit the movement of hostile forces across defined boundaries. We have developed an analytic model of border control (RM-6250-ARPA) that simulates certain quantifiable aspects of these problems. It specifically treats not only guerrilla and counter-guerrilla activity in a country or a geographical area, but also infiltration or exfiltration along stretches of national border or other lines of defense.

In this Report, we describe two versions of an on-line computer program that incorporates the methodology of the model but enables the user to analyze insurgency situations without needing to follow the mathematical manipulations. In view of the complexity of insurgency problems, no simple theoretical model will illuminate them. We have therefore devised several computerized versions of the basic model to permit the ready investigation of specific situations, the rapid testing of new concepts and ideas with regard to their probable utility under different contingencies, and the conduct of quantitative sensitivity analyses of candidate border security systems and programs. Both JOSS versions of this model employ language rather than mathematical symbolism, and are therefore readily usable without instructions; both are available in Rand's JOSS library file, and can be recalled from any of the JOSS consoles within Rand or from remote consoles and teletypes.

The computer programs essentially evaluate the performance of actual or planned border security systems in the framework of a given military or geopolitical situation. The results are presented in terms of situation assessments and projected outcomes. The principal input quantities are the size of the area of interest, the length of its border, initial numbers of guerrillas and defenders, estimates or empirical values of the approximate efficiencies of internal-area security measures and local guerrilla recruitment, the design efficiency of a border security system, and characteristics of the enemy

threat in terms of either attempted or successful rates of infiltration or border penetration. Not all of these data are necessary, however, and the programs automatically select an appropriate mode of operation that depends on the amount and type of input information.

The outputs consist of three parts. The first is a brief interpretation of the implications of the input data. The second is a detailed account and projected time sequence of the variation of the number of guerrillas in the area of interest as a result of the combined effects of infiltration, interdiction, recruitment, and attrition. For any desired future calendar date, these numerical data are given in terms of actual numbers, area densities, and rates of change. The final part of the program is a brief analysis of the eventual outcome.

The presumed efficiency of border security and area security operations, and the degree of overt or covert enemy threats, can be changed at any time to compare and evaluate the probable consequences. The immediacy of the results facilitates the investigation of past as well as probable future situations, the testing of new concepts and ideas with regard to their effects in different circumstances, and the conduct of quantitative sensitivity analyses of candidate border security systems and programs.

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I. INTRODUCTION

ANALYTICAL MODEL

The analytical model of border control described in RM-6250-ARPA* is essentially a tool to assist in the analysis of actual or potential insurgent conflicts. It enables one to investigate the specific problems of counterguerrilla activities in a country, or an area, subject to infiltration along stretches of national border or other lines of demarcation. The basic analytic formulation of the model allows investigations wide latitude, ranging from critical studies and evaluations of past or current conflict situations to contingency plans for various areas of the world.

But the problems of guerrilla warfare are numerous and complex, and one cannot expect one simple model to illuminate them all. Several computerized versions of the basic model were therefore devised to permit the ready investigation of specific situations, the rapid testing of new concepts and ideas with regard to their probable utility under different contingencies, and the conduct of quantitative sensitivity analyses of candidate border security systems and programs.

The principal uses of numerical solutions of the model are as follows:

a. Through the use of historical data such as enemy orders of battle and casualty figures, the model can reproduce the actual course of events and determine the relative importance of different factors as they influenced past activities.

b. Through the use of conditional input data, one can investigate the applicability and probable usefulness of candidate border security systems and programs for different contingencies and scenarios.

c. Through the use of different model solutions that correspond to various enemy strategies, it is possible to assess the probable consequences of system implementation in terms of likely enemy response and resulting requirements for system changes.

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*G. F. Schilling, Analytic Model of Border Control, RM-6250-ARPA, The Rand Corporation, Santa Monica, 1970.

d. Through time projections, different mixes of border security systems and internal-area security programs can be tested with respect to optimal resource allocations.

JOSS PROGRAMS

In this Report, we describe and document two specific computer versions of the model that have been programmed for on-line use on JOSS.* These programs are available in the JOSS library file, and can be recalled from remote consoles. They employ everyday language rather than mathematical symbolism, and the user need neither understand computer processes nor be familiar with the mathematical formulations of the analytical model.

Both programs apply to the situation in which the user has very limited information about the strategy employed by the enemy. The two programs differ principally in their respective complexity of analysis. The more sophisticated one, called here VERSION I, incorporates internal safeguards against user errors and logical fallacies and provides a written analysis of the projected outcome. The simpler VERSION II, on the other hand, will suffice for many investigations in which only historical data are analyzed or where only limited results are needed.

A unique feature of the programs is their ability to provide instant situation assessments. They can thus be used as a means of providing quick-response analyses. They should not be regarded as more than tools, however; although they can augment analysis, they cannot replace it.

To enable this Report to serve as a programmer's manual, the programs have been described and documented in considerable detail. In conjunction with the published model (RM-6250-ARPA), the basic program can be adapted to specific geopolitical situations.

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*JOSS is an interactive, time-shared computing service developed at The Rand Corporation to provide for the solution of numerical problems.

II. PROGRAM OPERATION

EXTERNAL

The programs are stored in the JOSS library and are recalled by the following commands:

VERSION I	VERSION II
Use library 51.	Use library 51.
Recall item 1 (BRD1).	Recall item 3 (BRD2).

Program operation is initiated by the command:

Do part 1.

The subsequent operation of both programs is fully automatic. Demands for input data are made sequentially, and logic circuits select appropriate modes of operation, depending on the type and quantity of input data. After briefly recapitulating the input data and their implications, the program provides the principal output for the dates and time intervals specified by the user.

On reaching a previously specified date for re-evaluation, VERSION I provides additional output in the form of a time projection; i.e., the eventual outcome of the general situation is predicted in the absence of any changes in the original order of battle. At this date, JOSS is also ready to accept modified combat data resulting from the user's assessment of desirable system alterations, and to continue evaluations with these new data or orders of battle.

If a completely new set of basic input data is introduced, however, such as a different area of interest or length of border, the command "Delete all" should be given, and the program recalled from the library.

Both versions are programmed to be operated on JOSS consoles. They will also operate on teletype consoles, but on occasion some nonessential text near the right margin may overprint.

Examples of the operations of both programs are reproduced in Section V.

INTERNAL

The internal operation of the program is fully detailed in Sections III and IV. It should be noted that VERSION I actually occupies space for two file items; the second item is automatically recalled at the appropriate time, and excess material is deleted.

The mathematical basis of the programs is described in RM-6250-ARPA, and is not repeated here. Essentially, the programs obtain a set of integral solutions to a nonlinear differential equation and solutions for several auxiliary relations. The solutions consist of numerical values of finite integrals over specified time intervals, and the instantaneous values of a series of differentials at the specified dates. In addition, VERSION I also solves for the limiting values that certain relations would reach after infinite time.

The internal logic circuits decide sequentially what input data to ask for, and then select an appropriate combination of mathematical equations that permits operation with the given input data.

III. DESCRIPTION OF JOSS PROGRAMS

This Section provides a detailed description of both program versions in the form of tables and diagrams. The programs themselves are reproduced in Section IV.

Figure 1 is a simplified schematic of the basic program flow. The part numbers listed identify the segment of the program in which the indicated activity is carried out. In addition, VERSION I contains parts 30, 31, 32, and 33, which provide error messages for incorrect input data.

Figure 2 is a detailed flow diagram of VERSION I. Note that this version has a capability for consecutive re-evaluations to facilitate sensitivity analyses whereby selected individual parameters can be varied while other parameters remain constant. The technique used involves the setting of appropriate limits of integration for each new set of integral evaluations, and the use of derived combat conditions as new starting data.

Figure 3 is a detailed flow diagram for VERSION II. This simplified program cannot perform consecutive re-evaluations. Once the end date is reached, it retains only the general input data, and demands new combat data.

Tables 1 and 2 are alphabetical listings of the program symbols used in VERSION I and II, respectively. The units given are those presently employed, namely miles and months. If necessary, they can be changed to other units without affecting the basic operation of the program. The mathematical symbols are not employed in the JOSS programs, and are listed to facilitate comparison with the analytic model.

Table 3 identifies the general input quantities that designate the geographical situation and determine the frequency of output.

Table 4 lists the input data that characterize the general combat situation in the area of interest.

Table 5 is a list of the input quantities that pertain to infiltration and border security. A comparison with Figs. 2 and 3 indicates the mechanism by which the program selects its mode of mathematical operation, depending on the available input information. A brief description of these modes is printed on demand during the operation of VERSION I, and given automatically in VERSION II. Mode A represents the condition of minimum knowledge on the user's part that still permits program operation. Under Modes B, C, or D, only two input data points are needed, and the remaining are then computed automatically.

Table 6 lists the output quantities printed before the time-sequenced computations are begun. This information represents, essentially, an analysis of the starting situation.

Table 7 is a list of the principal program output in terms of a situation assessment. The numerical values are printed at each originally specified date of evaluation, and represent a time history of the progress and development of the battle situation.

Table 8 gives the output quantities computed when the end date (or the originally specified date for re-evaluation) is reached. In VERSION I this information is printed in sentence form, and represents a projection of the eventual outcome. In practical use, it will indicate whether system data need be changed to achieve a favorable outcome.

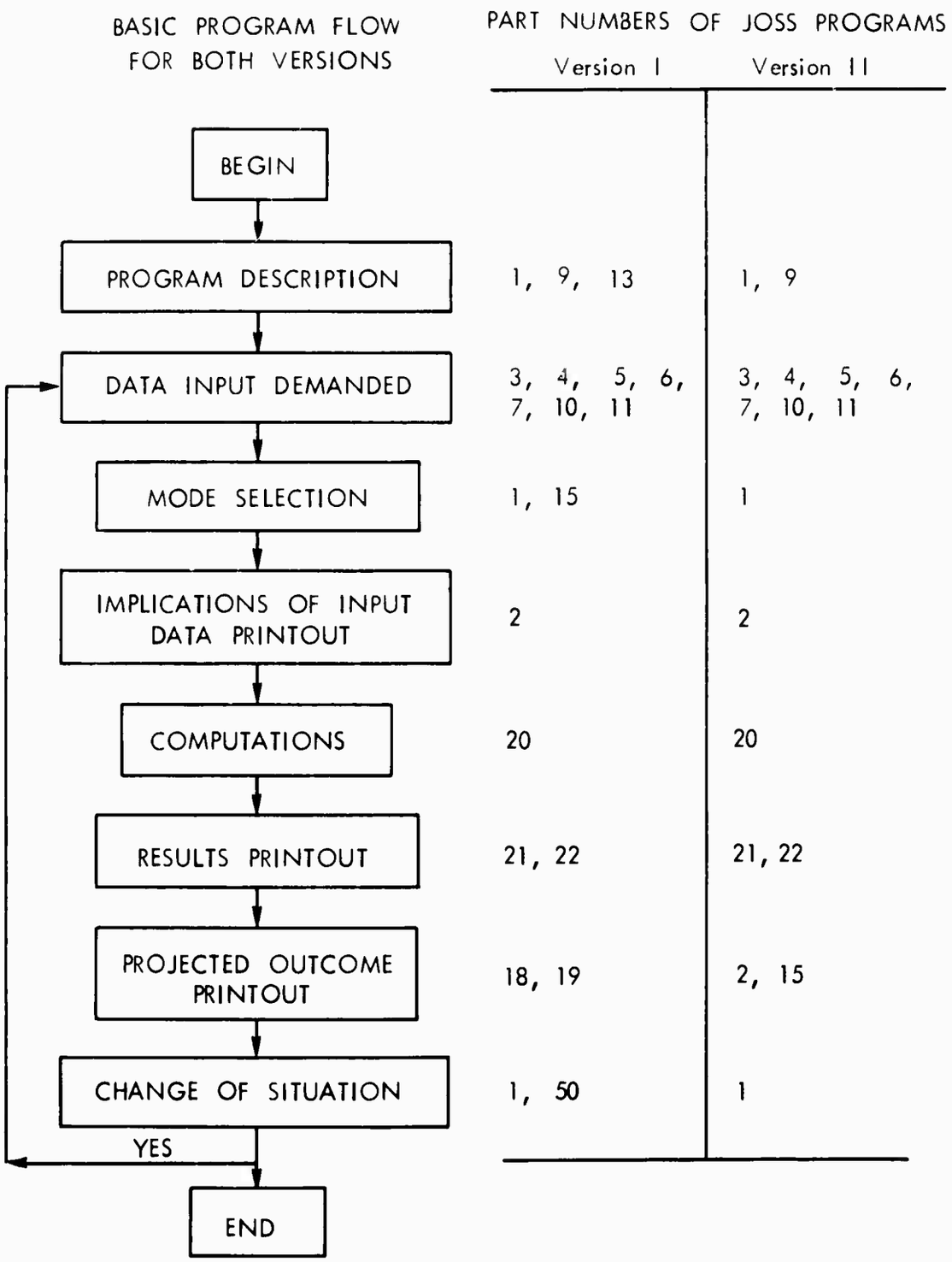

Fig. 1 -- Simplified Flow Diagram of Basic Program

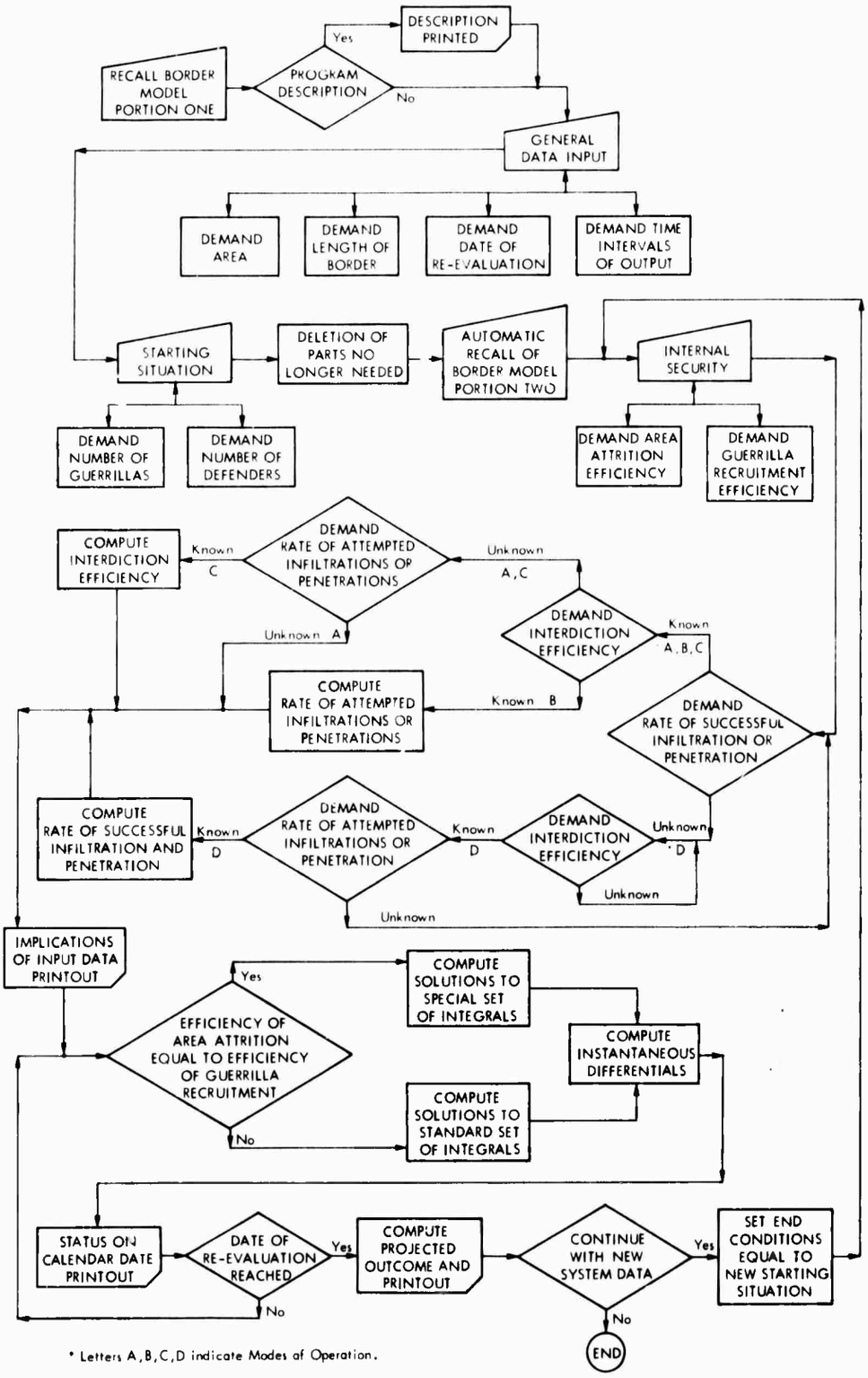

Fig. 2 -- Flow Diagram of Version I of Border-control Program

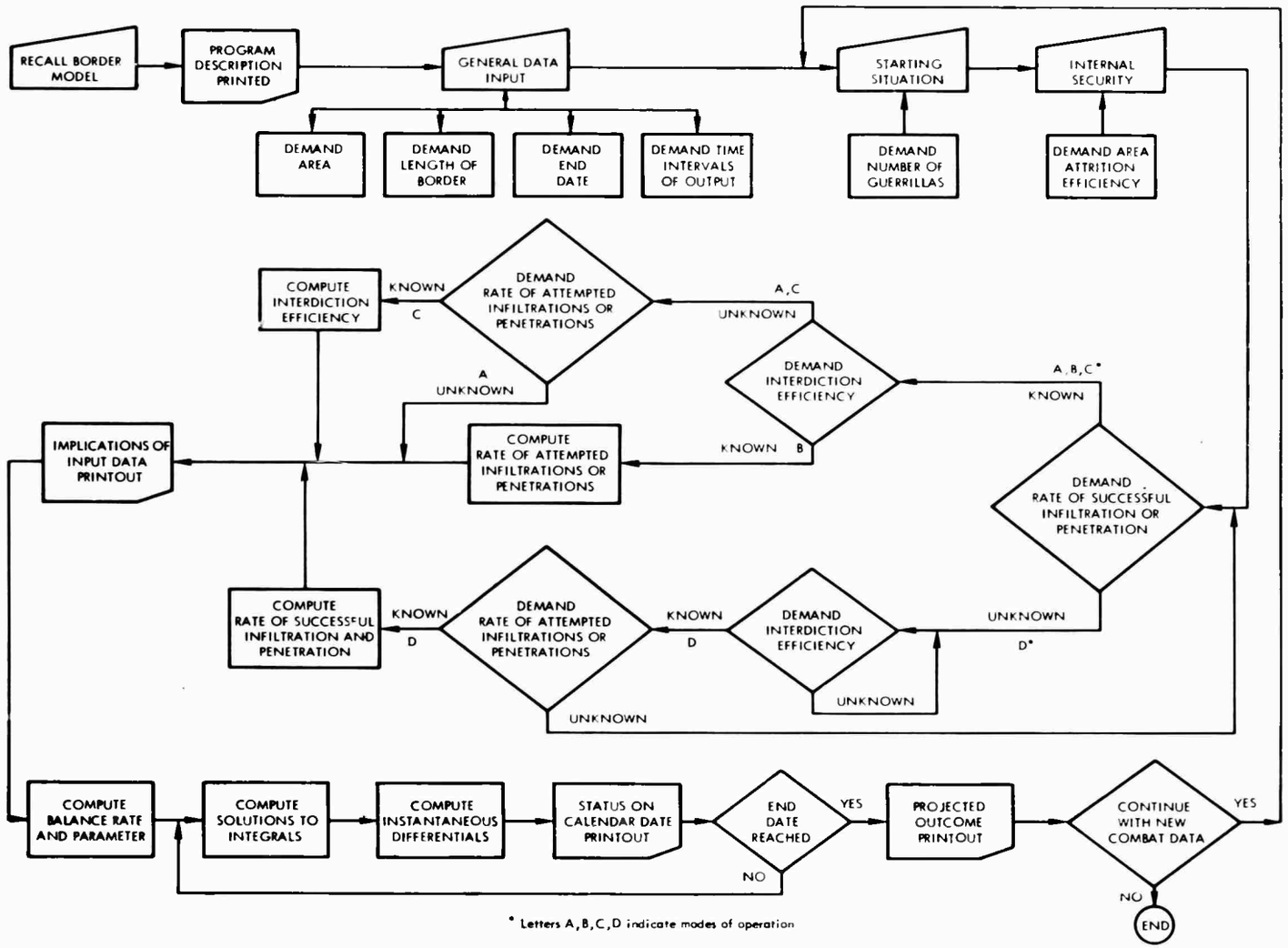

Fig. 3 -- Flow Diagram of Simplified Version II of Border-control Program

Table 1

PROGRAM SYMBOLS FOR VERSION I

Program Symbol	Mathematical Symbol	Explanation	Units
A	A	Area of interest	square miles
b		Program description control variable	
e	$\frac{1}{L}\frac{dT}{dt}$	Rate of attempted penetrations	per mile per month
E	$\frac{dT}{dt}$	Rate of attempted infiltrations	per month
g	$\frac{1}{N}\frac{dK}{dt}$	Efficiency of internal area attrition measures	percent per month
G	$\frac{1}{N}\frac{dR}{dt}$	Efficiency of guerrilla recruitment	percent per month
i	t	Calendar date of printout (upper limit of integration)	month
K(t)	K_t	Total number of guerrillas attrited in the area from time zero up to time t	
L	L	Length of border	miles
N(t)	N_t	Number of guerrillas in the area at time t	
p	$\frac{\partial S}{\partial T}$	Barrier penetration probability	percent
P	$1-\frac{\partial S}{\partial T}$	Barrier interdiction efficiency	percent
q		Mode identification control variable	
R(t)	R_t	Total number of guerrillas newly recruited in the area from time zero up to time t	
s	$\frac{1}{L}\frac{dS}{dt}$	Rate of successful penetrations	per mile per month
S(t)	S_t	Total number of successful infiltrations from time zero up to time t	

Table 1 -- continued

Program Symbol	Mathematical Symbol	Explanation	Units
t	t	Time variable	months
u, v		Mode identification control variables	
X(1)	N_o	Number of guerrillas in the area at start of each set of evaluations	
X(2)	S_o	Number of successful infiltrators prior to start of each set of evaluations	
X(3)	R_o	Number of guerrillas recruited in the area prior to start of each set of evaluations	
X(4)	K_o	Number of guerrillas attrited in the area prior to start of each set of evaluations	
X(5)	M_o	Number of defenders in the area at the start of each set of evaluations	
X(9)	$i_{t=o}$	Calendar date at start of each set of evaluations (lower limit of integration for the set)	months
X(11)	$\frac{dN}{dt}$	Guerrilla survival rate (change in the number of guerrillas per unit of time)	per month
X(12)	$\frac{dS}{dt}$	Infiltration rate (number of successful infiltrators per unit of time)	per month
X(13)	$\frac{dR}{dt}$	Guerrilla recruitment rate (number of new guerrillas recruited per unit of time)	per month
X(14)	$\frac{dK}{dt}$	Guerrilla attrition rate (number of guerrillas attrited per unit of time)	per month
X(50)	t=t	Time at end of each set of evaluations (upper limit of integration at end of set)	months
X(51)	Δt	Size of time interval for evaluations within each set	months

Table 1 -- continued

Program Symbol	Mathematical Symbol	Explanation	Units
X(90)	$\left[\frac{dN}{dt}\right]_{t=o}$	Balance Rate (indicator of the variation in the guerrilla force strength)	per month
X(92)	$[N]_{t=\infty}$	Balance parameter (number of guerrillas after infinite time)	
X(97)	$[t]_{N=1000}$	Date when number of guerrillas will reach about 1000	month
X(99)	$[t]_{N=.99N\infty}$	Date when 99% of final number of guerrillas in the area is reached	month
Z	$\frac{dS}{dt}$	Rate of successful infiltrations	per month

Table 2

PROGRAM SYMBOLS FOR VERSION II

Program Symbol	Mathematical Symbol	Explanation	Units
A	A	Area of interest	square miles
e	$\frac{dT}{dt}$	Rate of attempted infiltrations	per month
E	$\frac{1}{L}\frac{dT}{dt}$	Rate of attempted penetrations	per mile per month
F	$t=t$	Time at end of evaluations (upper limit of integration)	months
g	$\frac{1}{N}\frac{dK}{dt}$	Efficiency of internal area attrition measures	percent per month
K(t)	K_t	Total number of guerrillas attrited in the area from time zero up to time t	
L	L	Length of border	miles
M	N_o	Number of guerrillas in the area at time zero	
N(t)	N_t	Number of guerrillas in the area at time t	
p	$\frac{\partial S}{\partial T}$	Barrier penetration probability	percent
Q	S_o	Number of successful infiltrators prior to start of evaluations (equal to zero in this version)	
R	K_o	Number of guerrillas attrited in the area prior to start of evaluations (equal to zero in this version)	
s	$\frac{1}{L}\frac{dS}{dt}$	Rate of successful penetrations	per mile per month
S(t)	S_t	Total number of successful infiltrators from time zero up to time t	
t	t	Time variable	months

Table 2 -- continued

Program Symbol	Mathematical Symbol	Explanation	Units
u	Δt	Size of time interval for evaluations	months
U	$[N]_{t=\infty}$	Balance parameter (number of guerrillas after infinite time)	
V	$\left[\frac{dN}{dt}\right]_{t=o}$	Balance rate (indicator of the variation in the guerrilla force strength)	per month
W	$\frac{dK}{dt}$	Guerrilla attrition rate (number of guerrillas attrited per unit of time)	per month
X	$\frac{dN}{dt}$	Guerrilla survival rate (change in the number of guerrillas per unit of time)	per month
Z	$\frac{dS}{dt}$	Rate of successful infiltrations	per month

Table 3

GENERAL INPUT QUANTITIES

Term	Units	Symbol Version I	Version II
Area of interest	square miles	A	A
Length of border	miles	L	L
Size of time intervals of output	months	X(51)	u
Date of re-evaluation	month	X(50)	
End date	month		F

Table 4

COMBAT DATA INPUT QUANTITIES

Term	Units	Symbol Version I	Version II
Number of guerrillas in area at month zero		X(1)	M
Number of defenders in area at month zero		X(5)	
Efficiency of area attrition measures	percent per month	g	g
Efficiency of guerrilla recruitment	percent per month	G	

Table 5

MODE SELECTION INPUT QUANTITIES

Term	Units	Version I	Version II
MODE A			
Rate of successful infiltrations	per month	Z	Z
or	per mile	s	s
penetrations	per month		
MODE B			
Rate of successful infiltrations	per month	Z	Z
or	per mile	s	s
penetrations	per month		
AND			
Barrier interdiction efficiency	percent	P	
or			
Barrier penetration probability*	percent		p
MODE C			
Rate of successful infiltrations	per month	Z	Z
or			
penetrations	per mile	s	s
	per month		
AND			
Rate of attempted infiltrations	per month	E	e
or			
penetrations	per mile	e	E
	per month		
MODE D			
Barrier interdiction efficiency	percent	P	
or			
Barrier penetration probability*	percent		p
AND			
Rate of attempted infiltrations	per month	E	e
or			
penetrations	per mile	e	E
	per month		

* p = 1 - P

Table 6

OUTPUT QUANTITIES - RECAPITULATION OF INPUT DATA AND IMPLICATIONS

Term	Units	Symbol	
		Version I	Version II
Length of border	miles	L	L
Infiltration area	square miles	A	A
Border parameter	miles per square mile	L/A	L/A
Initial number of guerrillas in area		X(1)	M
Initial number of defenders in area		X(5)	
Rate of attempted infiltrations and penetrations	per month	E	e
	per mile per month	e	E
Barrier penetration probability	percent	p	p
Barrier interdiction efficiency	percent	P	1-p
Rate of successful infiltrations and penetrations	per month	Z	Z
	per mile per month	s	s
Internal security efficiency	percent per month	g	g
	percent per month per defender	g/X(5)	
Guerrilla recruitment efficiency	percent per month	G	
Size of guerrilla group that recruits ten new guerrillas each month		10/G	

Table 7

OUTPUT QUANTITIES - SITUATION ASSESSMENT

Term	Units	Symbol Version I	Symbol Version II
Calendar date	month	i	t
Attempted infiltrations:			
Total	number	E·i	e·t
Linear density	per mile	e·i	E·t
Rate of change	per month	E	
Attempted infiltrations interdicted at barrier:			
Total	number	E·i-S(t)	e·t-S(t)
Linear density	per mile	[E·i-S(t)]/L	[e·t-S(t)]/L
Rate of change	per month	E-X(12)	
Infiltrators across border:			
Total	number	S(t)	S(t)
Linear density	per mile	S(t)/L	S(t)/L
Rate of change	per month	X(12)	Z
Guerrillas recruited in area:			
Total	number	R(t)	
Area density	per mile^2	R(t)/A	
Rate of change	per month	X(13)	
Guerrillas attrited in area:			
Total	number	K(t)	K(t)
Area density	per mile^2	K(t)/A	K(t)/A
Rate of change	per month	X(14)	W
Guerrillas in area:			
Total	number	N(t)	N(t)
Area density	per mile^2	N(t)/A	N(t)/A
Rate of change	per month	X(11)	X

Table 8

OUTPUT QUANTITIES - PROJECTED OUTCOME*

Term	Units	Symbol Version I	Symbol Version II
Balance rate (initial rate of change in the number of guerrillas)	per month	X(90)	V
"Guerrilla force strength increasing"		X(90)>0	
or decreasing"		X(90)<0	
or constant"		X(90)=0	
Balance parameter (Number of guerrillas after infinite time)		X(92)	U
"An infinite number of guerrillas after infinite time"		g<G or g=G and s≠0	
Date when 99% of balance parameter is reached	month	X(99)	
Date when number of guerrillas will reach about 1000	month	X(97)	
Final attrition rate (after infinite time)	per month	g·X(92)	
Final recruitment rate (after infinite time)	per month	G·X(92)	

*The output of Version I is in sentence form and only the terms which apply to the specific case being evaluated will be printed.

IV. PROGRAM DOCUMENTATION

VERSION I of the JOSS border-control model is reproduced on pages 21 through 29, as filed as items 1 (BRD1) and 2 in library 51. Because of size limitations, it is split into two file items.

VERSION II is reproduced on pages 30 through 34, as filed as item 3 (BRD2) in library 51.

The general program flow will be most easily recognized by referring to the tables and diagrams of the previous section. Essentially, parts 1 and 2 in both versions control the program execution, and step 2.9 is the principal computation command.

It may appear that some of the individual program steps are not optimally expressed or are even superfluous (e.g., steps 5.3 and 5.4 in VERSION II); the reason is to be found in the versatility of the basic program. As discussed in RM-6250-ARPA, the analytical model permits the investigation of various enemy strategies that require slightly modified equations and conditions.

Although the basic program has been constructed for convenient modification, this may require the services of an experienced programmer/analyst.

```
Use library 51.
Roger.
Recall item 1 (BRD1).
Done.
Type size.
       size =      666
Type all.

1.01 * To start type :  Do part 1.
1.1 Type "                    BORDER  CONTROL  MODEL".
1.11 Set i=0.
1.12 Line.
1.14 Type "             Version I : Analysis and Projections ".
1.16 Line.
1.2 Do part 9.
1.25 Line.
1.3 Do part 3.
1.35 Line.
1.4 Do part 4.
1.45 Line.
1.5 Do part 5.
1.51 Line.
1.52 Type "       STAND  BY".
1.53 Line.
1.54 Delete step 1.45,step 1.51,step 1.52,step 1.53.
1.55 Delete step 1.11,step 1.12,step 1.16,step 1.25,step 1.35.
1.56 Delete step 1.2,step 1.3,step 1.4,step 1.5.
1.57 Delete part 3,part 4,part 5,part 9,part 13.
1.58 Delete step 1.54,step 1.55,step 1.56,step 1.57.
1.59 Recall item 2.
1.6 Do part 6.
1.65 Line.
1.66 Set q=0.
1.67 Set v=0.
1.68 Set u=0.
1.7 Do part 7.
1.75 Line.
1.8 Do part 10.
1.85 To step 1.95 if s≥0 and p>0.
1.86 Do step 30.2 if s<0 and p<0.
1.87 To step 1.75 if s<0 and p<0.
1.9 Do part 11.
1.92 Type "Insufficient Data ....." if s<0 and e<0.
1.93 To step 1.65 if s<0 and e<0.
1.95 Do part 2.
1.952 Line.
1.96 Type "     Ready for different assumptions and/or data.".
1.962 Page.
1.965 Delete E,Z,e,p,s.
1.981 Do part 50.
1.982 To step 1.6.

3.1 Type "         GEOGRAPHICAL DATA".
3.2 Demand A as "Area of Interest [square miles]".
```

```
3.25 Do step 30.1 if A<0.
3.26 To step 3.2 if A<0.
3.3 Demand L as "Length of Border [miles]".
3.35 Do step 30.1 if L<0.
3.36 To step 3.3 if L<0.

4.1 Type "         CALENDAR".
4.2 Type "  Starting date is  Month Zero.".
4.3 Type "What date of re-evaluation is wanted?".
4.32 Demand X(50) as "   (New input data after how many months)".
4.4 Type "Size of time intervals of output:".
4.41 Demand X(51) as "         (Results every how many months?)".
4.45 Type " Please reduce size." if X(51)>X(50).
4.46 To step 4.4 if X(51)>X(50).
4.5 Type "I suggest a longer time interval." if X(50) / X(51) > 12.
4.6 To step 4.4 if X(50)/X(51)>12.

5.1 Type "         STARTING  SITUATION".
5.2 Demand X(1) as "Initial Number of Guerrillas in Area at Month Zero".
5.21 Do step 30.1 if X(1)=-1.
5.22 To step 5.2 if X(1)=-1.
5.3 Set X(2)=0.
5.4 Set X(4)=0.
5.5 Set X(3)=0.
5.6 Line.
5.61 Demand X(5) as "Initial Number of Defenders  in Area at Month Zero".
5.62 Do step 30.1 if X(5)=-1.
5.63 To step 5.61 if X(5)=-1.

9.1 Type "Would you like a brief program description?".
9.15 Demand b as "Answer yes (1) or no (0)".
9.2 To step 9.65 if b=0.
9.26 Do part 13.
9.27 Type "    There are four different modes of operation available,".
9.28 Type "depending on the type of input information given.".
9.29 Line.
9.3 Type "  Mode A:  Infiltration or Penetration Rate only.".
9.35 Line.
9.4 Type "  Mode B:  Infiltration or Penetration Rate, AND".
9.43 Type "           Barrier Efficiency.".
9.45 Line.
9.5 Type "  Mode C:  Infiltration or Penetration Rate, AND".
9.53 Type "           Threat Characteristics.".
9.55 Line.
9.6 Type "  Mode D:  Barrier Efficiency, AND".
9.63 Type "           Threat Characteristics.".
9.65 Line.
9.7 Type "     If there is no input to a question, please answer = -1 .".
9.8 Line.
9.81 Type "The program will automatically select the appropriate mode.".

13.1 Line.
13.2 Type "  This program evaluates the performance of counter-".
13.3 Type "infiltration programs in a country subjected to".
```

```
13.4 Type "guerrilla activity. It permits the investigation of a".
13.5 Type "variety of situations and presents the results in terms ".
13.6 Type "of situation projections and eventual outcome. Changes in".
13.7 Type "the efficiencies of border control and area security".
13.8 Type "systems can be made at any desired time to evaluate".
13.9 Type "the probable consequences. The program is based on the ".
13.91 Type "basic model of border control, described in RM-6250-ARPA.".
13.92 Line.

30.1 Type "This is a required input for this program version.".
```

```
Use library 51.
Roger.
Recall item 2 (BRD2).
Done.
Type size.
        size =      1485
Type all.

2.01 Page if $>20.
2.1 Type "         YOUR INPUT DATA AND IMPLICATIONS:".
2.15 Line.
2.2 Type L in form 1.
2.25 Type A in form 2.
2.28 Type L/A in form 3.
2.29 Line.
2.3 Type X(1) in form 4.
2.31 Type X(5) in form 30.
2.32 Line.
2.33 Type E in form 8 if E≥0.
2.335 Type e in form 9 if e≥0.
2.338 Line.
2.34 Type 100•p in form 7 if p≥0.
2.345 Type 100•(1-p) in form 19 if p≥0.
2.346 Type form 29 if p≥0.
2.348 Line.
2.4 Type Z in form 5.
2.45 Type s in form 6.
2.48 Line.
2.55 Type 100•g in form 18 if g≥0.
2.56 Type 100•g/X(5) in form 36 if g>0 and X(5)>0.
2.565 To step 2.58 if g≤0 or X(5)≤0.
2.57 Type "                                                    per defender".
2.58 Line.
2.6 Type 100•G in form 31 if G≥0.
2.65 Type 10/G in form 34 if G>0.
2.66 Type "    ten new guerrillas each month in the area.)" if G>0.
2.68 Line.
2.7 Do part 15.
2.8 Page.
2.82 Type "             R  E  S  U  L  T  S".
2.84 Line.
2.85 Type form 33.
2.86 Type form 10.
2.9 Do part 20 for t=0[X(51)]X(50).
2.92 Line.
2.93 Do part 18.

6.01 Type "     I N P U T  D A T A ".
6.02 Line.
6.1 Type "         INTERNAL  SECURITY".
6.2 Type "Efficiency of (Internal) Area Attrition Measures".
6.3 Demand g as "  [percent of Guerrilla Force attrited per month; e.g.: 15]".
6.4 Do part 32 if g>100.
6.5 To step 6.2 if g>100.
```

```
6.6 Set g=g/100.
6.7 Line.
6.71 Type "Efficiency of Guerrilla Recruitment".
6.72 Type "  [percent increase of Guerrilla Force per month due to ".
6.73 Demand G as "   new recruitments; e.g.: 4]".
6.75 Do part 32 if G>100.
6.76 To step 6.71 if G>100.
6.8 Set G=G/100.
6.9 Do step 30.2 if g<0 and G<0.
6.91 To step 6.1 if g<0 and G<0.
6.92 Set g=0 if g<0.
6.93 Set G=0 if G<0.

7.1 Type "     BARRIER CHARACTERISTICS".
7.15 Line.
7.2 Demand Z as "Rate of Successful Infiltration [per month]".
7.3 Set s=Z/L if Z≥0.
7.4 To step 7.7 if Z≥0.
7.5 Demand s as "Rate of Successful Penetration [per mile per month]".
7.6 Set Z=s•L if s≥0.
7.7 Line.
7.8 Set q=1 if Z≥0.

10.1 Type "Barrier Interdiction Efficiency".
10.11 Demand P as " [give as Probability of NON-Penetration in per cent]".
10.12 Do part 32 if P>100.
10.13 To step 10.1 if P>100.
10.14 Set p=100-P if P≠-1.
10.15 Set p=-1 if P=-1.
10.16 Do part 31 if s>0 and p=0.
10.17 To step 10.1 if s>0 and p=0.
10.18 Set p=p/100 if p>0.
10.2 To step 10.5 if s<0.
10.25 To step 10.5 if p≤0.
10.3 Set e=s/p.
10.4 Set E=L•e.
10.5 Line.
10.6 Set v=1 if p≥0.

11.1 Type "        THREAT  CHARACTERISTICS".
11.2 Demand E as "Rate of Attempted Infiltrations [per month]".
11.21 Do part 33 if s>0 and E=0.
11.22 To step 11.1 if s>0 and E=0.
11.3 Set e=E/L if E≥0.
11.4 To step 11.7 if E≥0.
11.5 Demand e as "Rate of Attempted Penetrations [per mile per month]".
11.51 Do part 33 if s>0 and e=0.
11.52 To step 11.5 if s>0 and e=0.
11.55 To step 11.9 if e<0.
11.6 Set E=L•e if e≥0.
11.7 Set p=s/e if s≥0 and e>0.
11.8 Set s=p•e if s<0.
11.85 Set Z=s•L.
11.86 Set u=1 if E≥0.
```

```
11.9 Line.

15.1 Type " According to the input given, the program is operating".
15.2 Type "  in MODE A." if q=1 and v=0 and u=0.
15.3 Type "  in MODE B." if q=1 and v=1.
15.4 Type "  in MODE C." if q=1 and v=0 and u=1.
15.5 Type "  in MODE D." if q=0 and v=1 and u=1.

18.10 Page.
18.11 Type "     PROJECTED OUTCOME".
18.12 Type "  (Eventual Balance Situation)".
18.21 Set X(90) = s • L - X(1) • (g - G).
18.25 Do part 19 if g≤G.
18.26 To step 18.9 if g≤G.
18.31 Set X(92) = s • L / (g - G).
18.35 Type " The Guerrilla force strength has been increasing" if X(90)>0.
18.36 Type " The Guerrilla force strength has been decreasing" if X(90)<0.
18.37 Type X(9) in form 21 if X(90) ≠ 0.
18.41 Type " The Guerrilla force strength has remained constant." if X(90)=0.
18.45 Type " There will be eventually (after infinite time)".
18.46 Type X(92) in form 11.
18.51 To step 18.59 if s=0 or X(90)=0.
18.55 Set X(99) = X(9) + (log(X(90) / (s•L•(1-1.01)))) / (g-G) if X(90)<0.
18.56 Set X(99) = X(9) + (log(X(90)/(s•L•(1-.99)))) / (g-G) if X(90)>0.
18.561 To step 18.59 if X(99)<0.
18.57 Type "If conditions remain unchanged, 99 per cent of this number".
18.58 Type X(99) in form 12.
18.59 To step 18.7 if X(1) ≤ 1000 and X(92) ≤ 1000.
18.60 To step 18.7 if X(1) ≥ 1000 and X(92) ≥ 1000.
18.61 To step 18.7 if s • L - 1000 • (g-G) = 0.
18.62 To step 18.7 if X(90) / (s•L-1000•(g-G) ) ≤ 0.
18.63 Set X(97) = X(9) + (log(X(90) / (s•L - 1000•(g-G)) )) / (g-G).
18.64 Type " The number of Guerrillas will reach about 1000".
18.65 Type X(97) in form 20.
18.7 Line.
18.81 Type g • X(92) in form 13.
18.82 Type G • X(92) in form 14.
18.9 Line.

19.1 Do step 18.41 if g=G and s=0.
19.2 To step 19.7 if g=G and s=0.
19.3 Do step 18.35.
19.4 Do step 18.37.
19.5 Do step 18.45.
19.6 Type " An infinite number of guerrillas in the area.".
19.7 Line.

20.0 Set X(9)=i if t=0.
20.01 To step 20.05 if t=0.
20.02 Set i=i+X(51).
20.05 To step 20.41 if g=G.
20.1 Set N(t)=[s•L/(g-G)]•[1-exp(-[g-G]•t)]+X(1)•exp(-[g-G]•t).
20.2 Set S(t)=X(2)+s•L•t.
20.3 Set K(t)=X(4)+[g/(g-G)]•[X(1)+S(t)-X(2)-N(t)].
```

```
20.4 Set R(t)=X(3)+[G/(g-G)]•[X(1)+S(t)-X(2)-N(t)].
20.405 To step 20.5 if g≠G.
20.41 Set N(t)=X(1)+s•L•t.
20.42 Set S(t)=X(2)+s•L•t.
20.43 Set K(t)=X(4)+g•X(1)•t+(g•s•L•t*2)/2.
20.44 Set R(t)=X(3)+G•X(1)•t+(G•s•L•t*2)/2.
20.5 Set X(11)=s•L-(g-G)•N(t).
20.6 Set X(14)=g•N(t).
20.7 Set X(13)=G•N(t).
20.8 Set X(12)=Z.
20.9 Do part 21.

21.0 Page if $≥50.
21.05 Do part 22 if e≥0.
21.1 Line.
21.3 Type i,S(t),S(t)/L,X(12) in form 15 if e<0.
21.35 Type S(t),S(t)/L,X(12) in form 25 if e≥0.
21.4 Type R(t),R(t)/A,X(13) in form 32.
21.45 Line.
21.5 Type K(t),K(t)/A,X(14) in form 16.
21.55 Line.
21.6 Type N(t),N(t)/A,X(11) in form 17.
21.9 Line.

22.1 Line.
22.2 Type i,E•i,e•i,E in form 22.
22.25 Type form 24.
22.3 Type E•i-S(t),[E•i-S(t)]/L,E-X(12) in form 23.

30.2 Type "Insufficient Data ......".
30.3 Type " Please Reconsider.".

31.1 Type " You have already given a successful Infiltration or Penetration".
31.2 Type " Rate, therefore the Penetration Probability must be >0".
31.3 Do step 30.3.

32.1 Type " You must be kidding, more than 100 o/o ?".
32.2 Do step 30.3.

33.1 Type " You have already given a successful Infiltration or Penetration".
33.2 Type " Rate, therefore the Rate of Attempted Infiltrations or".
33.3 Type " Penetrations must be >0".
33.4 Do step 30.3.

50.1 Type "  CHANGE OF SITUATION:".
50.15 Line.
50.2 Set X(1)=N(t).
50.3 Set X(2)=S(t).
50.4 Set X(4)=K(t).
50.5 Set X(3)=R(t).

Form 1:
Length of Border:  _____  miles
```

Form 2:
Infiltration Area: _____ square miles

Form 3:
Border Parameter: __.____ miles per square mile

Form 4:
Initial Number of Guerrillas in Area: _____

Form 5:
Rate of Successful Infiltrations: _____ per month

Form 6:
Rate of Successful Penetrations: _____.__ per mile per month

Form 7:
Barrier Penetration Probability: _____ percent

Form 8:
Rate of Attempted Infiltrations: _____ per month

Form 9:
Rate of Attempted Penetrations: _____.__ per mile per month

Form 10:
Month NUMBERS DENSITY OF CHANGE

Form 11:
_____ Guerrillas in the area.

Form 12:
will be reached at calendar date: Month _____

Form 13:
The final attrition rate will be _____ per month;

Form 14:
The final recruitment rate will be _____ per month.

Form 15:
____ Infiltrators across Border:_____ _____ per mile _____ per month

Form 16:
Guerillas attrited in Area:_____ ____._ per mile*2 _____ per month

Form 17:
GUERRILLAS in AREA: _____ ____._ per mile*2 _____ per month

Form 18:
Internal Security Efficiency: _____.__ percent attrited per month

Form 19:
Barrier Interdiction Efficiency: _____ percent of infiltration

Form 20:
at calendar date: Month _____

Form 21:
from its initial value at calendar date: Month ____.

Form 22:
____ Attempted Infiltrations: _____ _____ per mile _____ per month

Form 23:
interdicted at Barrier: _____ _____ per mile _____ per month

Form 24:
Attempted infiltrations

Form 25:
Infiltrators across Border:_____ _____ per mile _____ per month

Form 29:
attempts stopped.

Form 30:
Initial Number of Defenders in Area: _____

Form 31:
Guerrilla Recruitment Efficiency: ___._ percent increase per month

Form 32:
Guerillas recruited in Area:_____ ____._ per mile*2 _____ per month

Form 33:
DATE CUMULATIVE AREA TIME RATE

Form 34:
(This means that each group of about _____ guerrillas recruits

Form 36:
..... percent attrited per month

```
Use library 51.
Roger.
Recall item 3 (BRD2).
Done.
Type size.
       size =     1042
Type all.

1.01 * To start type : Do part 1.
1.1 Type "                    BORDER  CONTROL  MODEL".
1.12 Line.
1.14 Type "          Version II : Continuous Evaluations ".
1.16 Line.
1.2 Do part 9.
1.25 Line.
1.3 Do part 3.
1.35 Line.
1.4 Do part 4.
1.45 Line.
1.5 Do part 5.
1.55 Line.
1.6 Do part 6.
1.65 Line.
1.7 Do part 7.
1.75 Line.
1.8 Do part 10.
1.85 To step 1.95 if s>0 and p>0.
1.86 Type " Insufficient Data ..." if s<0 and p<0.
1.87 To step 1.75 if s<0 and p<0.
1.9 Do part 11.
1.92 Type "Insufficient Data ......" if s<0 and E<0.
1.93 To step 1.65 if s<0 and E<0.
1.95 Do part 2.
1.952 Line.
1.96 Type "     Ready for different assumptions and/or data.".
1.962 Page.
1.965 Delete E,Z,e,p,s.
1.98 To step 1.5.

2.01 Page if $>20.
2.1 Type "         YOUR INPUT DATA AND IMPLICATIONS:".
2.15 Line.
2.2 Type L in form 1.
2.25 Type A in form 2.
2.28 Type L/A in form 3.
2.29 Line.
2.3 Type M in form 4.
2.38 Line.
2.4 Type Z in form 5.
2.45 Type s in form 6.
2.48 Line.
2.5 Type 100*p in form 7 if p>0.
2.51 Type 100*(1-p) in form 19 if p>0.
2.515 Type form 29 if p>0.
```

```
2.52 Line.
2.55 Type 100•g in form 18.
2.58 Line.
2.6 Type e in form 8 if e>0.
2.65 Type E in form 9 if E>0.
2.68 Line.
2.7 Do part 15.
2.8 Page.
2.82 Type "            R  E  S  U  L  T  S".
2.84 Line.
2.86 Type form 10.
2.9 Do part 20 for t=0(u)F.
2.92 Line.
2.94 Type U in form 11.
2.96 Type V in form 12.

3.1 Type "         GEOGRAPHICAL DATA".
3.2 Demand A as "Area of Interest [square miles]".
3.25 Type step 30.1 if A<0.
3.26 To step 3.2 if A<0.
3.3 Demand L as "Length of Border [miles]".
3.35 Type step 30.1 if L<0.
3.36 To step 3.3 if L<0.

4.1 Type "         CALENDAR".
4.2 Type "  Starting date is  Month Zero.".
4.3 Demand F as "End date (terminate after how many months?):".
4.4 Demand u as "Size of time intervals (results every how many months?):".
4.45 Type " Please reduce size." if u>F.
4.46 To step 4.4 if u>F.

5.1 Type "         STARTING  SITUATION".
5.2 Demand M as "Initial Number of Guerrillas in Area at Month Zero".
5.3 Set Q=0.
5.4 Set R=0.

6.01 Type "    I N P U T  D A T A ".
6.02 Line.
6.1 Type "         INTERNAL  SECURITY".
6.2 Type "Efficiency of (Internal) Area Attrition Measures".
6.3 Demand g as "  [give as percent attrited per mo h; e.g.: 50]:".
6.4 Type step 30.1 if g<0.
6.5 To step 6.2 if g<0.
6.6 Set g=g/100.

7.1 Type "     BARRIER CHARACTERISTICS".
7.15 Line.
7.2 Demand Z as "Rate of Successful Infiltration [per month]".
7.3 Set s=Z/L if Z>0.
7.4 To step 7.7 if Z>0.
7.5 Demand s as "Rate of Successful Penetration [per mile per month]".
7.6 Set Z=s•L if s>0.
7.7 Line.
```

```
9.1 Type "     There are four different modes of operation available,".
9.2 Type "depending on the type of input information given.".
9.25 Line.
9.3 Type "  Mode A:  Infiltration or Penetration Rate only.".
9.35 Line.
9.4 Type "  Mode B:  Infiltration or Penetration Rate, AND".
9.43 Type "           Barrier Efficiency.".
9.45 Line.
9.5 Type "  Mode C:  Infiltration or Penetration Rate, AND".
9.53 Type "           Threat Characteristics.".
9.55 Line.
9.6 Type "  Mode D:  Barrier Efficiency, AND".
9.63 Type "           Threat Characteristics.".
9.65 Line.
9.7 Type "     If there is no input to a question, please answer = -1 .".

10.1 Type "Barrier In-Efficiency".
10.11 Demand p as " [Probability of Penetration in percent]".
10.15 Set p=p/100 if p>0.
10.2 To step 10.5 if s<0.
10.25 To step 10.5 if p<0.
10.3 Set E=s/p.
10.4 Set e=L•E.
10.5 Line.

11.1 Type "        THREAT  CHARACTERISTICS".
11.2 Demand e as "Rate of Attempted Infiltrations [per month]".
11.3 Set E=e/L if e>0.
11.4 To step 11.7 if e>0.
11.5 Demand E as "Rate of Attempted Penetrations [per mile per month]".
11.55 To step 11.9 if E<0.
11.6 Set e=L•E if E>0.
11.7 Set p=s/E if s>0 and E>0.
11.8 Set s=p•E if s<0.
11.85 Set Z=s•L.
11.9 Line.

15.1 Set V=Z-g•M.
15.2 Set U=s•L/g.

20.1 Set N(t)=(s•L/g)•[1-exp(-g•t)]+M•exp(-g•t).
20.2 Set S(t)=Q+s•L•t.
20.3 Set K(t)=R+S(t)-Q-[N(t)-M].
20.5 Set W=Z-V•exp(-g•t).
20.6 Set X=V•exp(-g•t).
20.9 Do part 21.

21.05 Do part 22 if E>0.
21.1 Line.
21.3 Type t,S(t),S(t)/L,Z in form 15 if E<0.
21.35 Type S(t),S(t)/L,Z in form 25 if E>0.
21.4 Type K(t),K(t)/A,W in form 16.
21.45 Line.
21.5 Type N(t),N(t)/A,X in form 17.
```

21.9 Line.

22.1 Line.
22.2 Type t,e•t,E•t in form 22.
22.25 Type form 24.
22.3 Type e•t-S(t),[e•t-S(t)]/L in form 23.

30.1 Type "This is a required input for this program version.".

Form 1:
Length of Border: _____ miles

Form 2:
Infiltration Area: _____ square miles

Form 3:
Border Parameter: __.____ miles per square mile

Form 4:
Initial Number of Guerrillas in Area: _____

Form 5:
Rate of Successful Infiltrations: _____ per month

Form 6:
Rate of Successful Penetrations: _____ per mile per month

Form 7:
Barrier Penetration Probability: ___._ percent

Form 8:
Rate of Attempted Infiltrations: _____ per month

Form 9:
Rate of Attempted Penetrations: _____ per mile per month

Form 10:
MONTH NUMBER DENSITY RATE OF CHANGE

Form 11:
Balance Parameter: ..... Final Guerrillas after infinite time.

Form 12:
Balance Rate: ..... per month initially.

Form 15:
____ Infiltrators across Border:_____ _____ per mile _____ per month

Form 16:
Guerillas attrited in Area:_____ _____ per mile*2 _____ per month

Form 17:
GUERRILLAS in AREA: _____ _____ per mile*2 _____ per month

Form 18:
Internal Security Efficiency: ___._ percent attrited per month

Form 19:
Barrier Interdiction Efficiency: ___._ percent of infiltration

Form 22:
____ Attempted Infiltrations: _____ _____ per mile

Form 23:
interdicted at Barrier: _____ _____ per mile.

Form 24:
Attempted infiltrations

Form 25:
Infiltrators across Border: _____ _____ per mile _____. per month

Form 29:

attempts stopped.

V. SAMPLE PROGRAM RUNS

An example of a computer run of VERSION I is reproduced on pages 36 through 41. A sample of a computer run of VERSION II is reproduced on pages 42 through 44.

In addition, pages 45 through 49 are examples of the type of projected outcome that is computed in VERSION I (see also Table 8). The concept of "Eventual Number of Guerrillas in the Area" is used as an indicator of the effectiveness of operations. As derived with the analytical model, this number, as well as the "final" attrition and recruitment rates, are projections of the eventual outcome if all operations were continued without change for a mathematically infinite time. For practical purposes, it reflects whether, and to what degree, the trend of battle operations is favorable or unfavorable for the defenders. When mathematical conditions are appropriate (asymptotic solutions), the time when 99 percent of the "final" values are reached is also given.

```
Do part 1.
                    BORDER  CONTROL  MODEL

                Version I : Analysis and Projections

Would you like a brief program description?
Answer yes (1) or no (0) = 1

  This program evaluates the performance of counter-
infiltration programs in a country subjected to
guerrilla activity. It permits the investigation of a
variety of situations and presents the results in terms
of situation projections and eventual outcome. Changes in
the efficiencies of border control and area security
systems can be made at any desired time to evaluate
the probable consequences. The program is based on the
basic model of border control, described in RM-6250-ARPA.

    There are four different modes of operation available,
depending on the type of input information given.

  Mode A:  Infiltration or Penetration Rate only.

  Mode B:  Infiltration or Penetration Rate, AND
           Barrier Efficiency.

  Mode C:  Infiltration or Penetration Rate, AND
           Threat Characteristics.

  Mode D:  Barrier Efficiency, AND
           Threat Characteristics.

     If there is no input to a question, please answer = -1 .

The program will automatically select the appropriate mode.

          GEOGRAPHICAL DATA
Area of Interest [square miles] = 66000
Length of Border [miles] = 1000

          CALENDAR
  Starting date is  Month Zero.
What date of re-evaluation is wanted?
   (New input data after how many months) = 8
Size of time intervals of output:
          (Results every how many months?) = 4

          STARTING  SITUATION
Initial Number of Guerrillas in Area at Month Zero = 100000

Initial Number of Defenders  in Area at Month Zero = 500000

        STAND  BY
```

```
     I N P U T   D A T A

         INTERNAL  SECURITY
Efficiency of (Internal) Area Attrition Measures
  [percent of Guerrilla Force attrited per month; e.g.: 15] = 4

Efficiency of Guerrilla Recruitment
  [percent increase of Guerrilla Force per month due to
   new recruitments; e.g.: 4] = 1

     BARRIER CHARACTERISTICS

Rate of Successful Infiltration [per month] = -1
Rate of Successful Penetration [per mile per month] = -1


Barrier Interdiction Efficiency
 [give as Probability of NON-Penetration in per cent] = 0

        THREAT  CHARACTERISTICS
Rate of Attempted Infiltrations [per month] = 10000

         YOUR INPUT DATA AND IMPLICATIONS:

Length of Border:          1000  miles
Infiltration Area:        66000  square miles
Border Parameter:         .0152  miles per square mile

Initial Number of Guerrillas in Area:   100000
Initial Number of Defenders in Area:    500000

Rate of Attempted Infiltrations:         10000  per month
Rate of Attempted Penetrations:          10.00  per mile per month

Barrier Penetration Probability:           100  percent
Barrier Interdiction Efficiency:             0  percent of infiltration
                                                   attempts stopped.

Rate of Successful Infiltrations:        10000  per month
Rate of Successful Penetrations:         10.00  per mile per month

Internal Security Efficiency:             4.00  percent attrited per month
                                       8.0-06  percent attrited per month
                                               per defender

Guerrilla Recruitment Efficiency:           1.0  percent increase per month
   (This means that each group of about    1000 guerrillas recruits
    ten new guerrillas each month in the area.)

 According to the input given, the program is operating
  in MODE D.
```

R E S U L T S

DATE Month		CUMULATIVE NUMBERS	AREA DENSITY	TIME RATE OF CHANGE
0	Attempted Infiltrations:	0	0 per mile	10000 per month
	Attempted infiltrations interdicted at Barrier:	0	0 per mile	0 per month
	Infiltrators across Border:	0	0 per mile	10000 per month
	Guerillas recruited in Area:	0	.0 per mile*2	1000 per month
	Guerillas attrited in Area:	0	.0 per mile*2	4000 per month
	GUERRILLAS in AREA:	100000	1.5 per mile*2	7000 per month
4	Attempted Infiltrations:	40000	40 per mile	10000 per month
	Attempted infiltrations interdicted at Barrier:	0	0 per mile	0 per month
	Infiltrators across Border:	40000	40 per mile	10000 per month
	Guerillas recruited in Area:	4538	.1 per mile*2	1264 per month
	Guerillas attrited in Area:	18153	.3 per mile*2	5055 per month
	GUERRILLAS in AREA:	126385	1.9 per mile*2	6208 per month
8	Attempted Infiltrations:	80000	80 per mile	10000 per month
	Attempted infiltrations interdicted at Barrier:	0	0 per mile	0 per month
	Infiltrators across Border:	80000	80 per mile	10000 per month
	Guerillas recruited in Area:	10071	.2 per mile*2	1498 per month
	Guerillas attrited in Area:	40284	.6 per mile*2	5991 per month
	GUERRILLAS in AREA:	149787	2.3 per mile*2	5506 per month

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has been increasing
from its initial value at calendar date: Month 0.
There will be eventually (after infinite time)
333333 Guerrillas in the area.
If conditions remain unchanged, 99 per cent of this number
will be reached at calendar date: Month 142

The final attrition rate will be 13333 per month;
The final recruitment rate will be 3333 per month.

```
   Ready for different assumptions and/or data.
 CHANGE OF SITUATION:

   I N P U T  D A T A

       INTERNAL  SECURITY
Efficiency of (Internal) Area Attrition Measures
  [percent of Guerrilla Force attrited per month; e.g.: 15] = 8

Efficiency of Guerrilla Recruitment
  [percent increase of Guerrilla Force per month due to
   new recruitments; e.g.: 4] = 1

   BARRIER CHARACTERISTICS

Rate of Successful Infiltration [per month] = -1
Rate of Successful Penetration [per mile per month] = -1


Barrier Interdiction Efficiency
 [give as Probability of NON-Penetration in per cent] = 75

       THREAT  CHARACTERISTICS
Rate of Attempted Infiltrations [per month] = 10000

        YOUR INPUT DATA AND IMPLICATIONS:

Length of Border:          1000  miles
Infiltration Area:        66000  square miles
Border Parameter:         .0152  miles per square mile

Initial Number of Guerrillas in Area:   149787
Initial Number of Defenders in Area:    500000

Rate of Attempted Infiltrations:          10000  per month
Rate of Attempted Penetrations:           10.00  per mile per month

Barrier Penetration Probability:             25  percent
Barrier Interdiction Efficiency:             75  percent of infiltration
                                                    attempts stopped.

Rate of Successful Infiltrations:          2500  per month
Rate of Successful Penetrations:           2.50  per mile per month

Internal Security Efficiency:              8.00  percent attrited per month
                                          1.6-05  percent attrited per month
                                                  per defender

Guerrilla Recruitment Efficiency:           1.0  percent increase per month
   (This means that each group of about     1000 guerrillas recruits
    ten new guerrillas each month in the area.)

 According to the input given, the program is operating
  in MODE D.
```

R E S U L T S

DATE Month		CUMULATIVE NUMBERS	AREA DENSITY	TIME RATE OF CHANGE
8	Attempted Infiltrations:	80000	80 per mile	10000 per month
	Attempted infiltrations interdicted at Barrier:	0	0 per mile	7500 per month
	Infiltrators across Border:	80000	80 per mile	2500 per month
	Guerillas recruited in Area:	10071	.2 per mile*2	1498 per month
	Guerillas attrited in Area:	40284	.6 per mile*2	11983 per month
	GUERRILLAS in AREA:	149787	2.3 per mile*2	-7985 per month
12	Attempted Infiltrations:	120000	120 per mile	10000 per month
	Attempted infiltrations interdicted at Barrier:	30000	30 per mile	7500 per month
	Infiltrators across Border:	90000	90 per mile	2500 per month
	Guerillas recruited in Area:	15479	.2 per mile*2	1219 per month
	Guerillas attrited in Area:	83551	1.3 per mile*2	9754 per month
	GUERRILLAS in AREA:	121928	1.8 per mile*2	-6035 per month
16	Attempted Infiltrations:	160000	160 per mile	10000 per month
	Attempted infiltrations interdicted at Barrier:	60000	60 per mile	7500 per month
	Infiltrators across Border:	100000	100 per mile	2500 per month
	Guerillas recruited in Area:	19916	.3 per mile*2	1009 per month
	Guerillas attrited in Area:	119042	1.8 per mile*2	8070 per month
	GUERRILLAS in AREA:	100874	1.5 per mile*2	-4561 per month

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has been decreasing
from its initial value at calendar date: Month 8.
There will be eventually (after infinite time)
35714 Guerrillas in the area.
If conditions remain unchanged, 99 per cent of this number
will be reached at calendar date: Month 90

The final attrition rate will be 2857 per month;
The final recruitment rate will be 357 per month.

Ready for different assumptions and/or data.
CHANGE OF SITUATION:

I N P U T D A T A

INTERNAL SECURITY
Efficiency of (Internal) Area Attrition Measures
[percent of Guerrilla Force attrited per month; e.g.: 15] =
I'm at step 6.3.
Delete all.

```
Do part 1.
                    BORDER  CONTROL  MODEL

            Version II : Continuous Evaluations

     There are four different modes of operation available,
depending on the type of input information given.

  Mode A:  Infiltration or Penetration Rate only.

  Mode B:  Infiltration or Penetration Rate, AND
           Barrier Efficiency.

  Mode C:  Infiltration or Penetration Rate, AND
           Threat Characteristics.

  Mode D:  Barrier Efficiency, AND
           Threat Characteristics.

     If there is no input to a question, please answer = -1 .

          GEOGRAPHICAL DATA
Area of Interest [square miles] = 66000
Length of Border [miles] = 1000

          CALENDAR
  Starting date is  Month Zero.
End date (terminate after how many months?): = 8
Size of time intervals (results every how many months?): = 4

          STARTING  SITUATION
Initial Number of Guerrillas in Area at Month Zero = 100000

    I N P U T  D A T A

          INTERNAL  SECURITY
Efficiency of (Internal) Area Attrition Measures
  [give as percent attrited per month; e.g.: 50]: = 4

     BARRIER CHARACTERISTICS

Rate of Successful Infiltration [per month] = -1
Rate of Successful Penetration [per mile per month] = -1


Barrier In-Efficiency
 [Probability of Penetration in percent] = 100

        THREAT  CHARACTERISTICS
Rate of Attempted Infiltrations [per month] = 10000
```

YOUR INPUT DATA AND IMPLICATIONS:

Length of Border:	1000	miles
Infiltration Area:	66000	square miles
Border Parameter:	.0152	miles per square mile

Initial Number of Guerrillas in Area: 100000

Rate of Successful Infiltrations:	10000	per month
Rate of Successful Penetrations:	10	per mile per month
Barrier Penetration Probability:	100.0	percent
Barrier Interdiction Efficiency:	.0	percent of infiltration attempts stopped.
Internal Security Efficiency:	4.0	percent attrited per month
Rate of Attempted Infiltrations:	10000	per month
Rate of Attempted Penetrations:	10	per mile per month

R E S U L T S

MONTH		NUMBER	DENSITY	RATE OF CHANGE
0	Attempted Infiltrations:	0	0 per mile	
	Attempted infiltrations interdicted at Barrier:	0	0 per mile.	
	Infiltrators across Border:	0	0 per mile	10000 per month
	Guerillas attrited in Area:	0	0 per mile*2	4000 per month
	GUERRILLAS in AREA:	100000	2 per mile*2	6000 per month
4	Attempted Infiltrations:	40000	40 per mile	
	Attempted infiltrations interdicted at Barrier:	0	0 per mile.	
	Infiltrators across Border:	40000	40 per mile	10000 per month
	Guerillas attrited in Area:	17822	0 per mile*2	4887 per month
	GUERRILLAS in AREA:	122178	2 per mile*2	5113 per month
8	Attempted Infiltrations:	80000	80 per mile	
	Attempted infiltrations interdicted at Barrier:	0	0 per mile.	
	Infiltrators across Border:	80000	80 per mile	10000 per month
	Guerillas attrited in Area:	38922	1 per mile*2	5643 per month
	GUERRILLAS in AREA:	141078	2 per mile*2	4357 per month

Balance Parameter: 2.5000 05 Final Guerrillas after infinite time.
Balance Rate: 6.0000 03 per month initially.

Ready for different assumptions and/or data.

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has been decreasing
from its initial value at calendar date: Month 12.
There will be eventually (after infinite time)
0 Guerrillas in the area.
The number of Guerrillas will reach about 1000
at calendar date: Month 64

The final attrition rate will be 0 per month;
The final recruitment rate will be 0 per month.

Ready for different assumptions and/or data.

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has been decreasing
from its initial value at calendar date: Month 84.
There will be eventually (after infinite time)
2222 Guerrillas in the area.
If conditions remain unchanged, 99 per cent of this number
will be reached at calendar date: Month 94

The final attrition rate will be 2000 per month;
The final recruitment rate will be 0 per month.

Ready for different assumptions and/or data.

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has remained constant.

Ready for different assumptions and/or data.

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has been increasing
from its initial value at calendar date: Month 48.
There will be eventually (after infinite time)
125000 Guerrillas in the area.
If conditions remain unchanged, 99 per cent of this number
will be reached at calendar date: Month 83

The final attrition rate will be 12500 per month;
The final recruitment rate will be 2500 per month.

Ready for different assumptions and/or data.

PROJECTED OUTCOME
(Eventual Balance Situation)
The Guerrilla force strength has been increasing
from its initial value at calendar date: Month 72.
There will be eventually (after infinite time)
An infinite number of guerrillas in the area.

Ready for different assumptions and/or data.

VI. CONCLUDING REMARKS

The programs described here are only two of several versions that have been developed as part of the study of infiltration and invasion control. There are other versions that omit many of the descriptive sections and several of the internal program error controls. These have been used to evaluate several candidate border-control systems, since they save computer print-out time and space. With the help of this manual, such modifications can be effected easily.

In addition, other programs provide supplemental quantities that measure the effectiveness of operations, and sub-routines have been devised to permit trade-off analyses.

These programs are not available in the JOSS program library, and the authors may be contacted for further information.