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EASI ON THE HP-25, HP-65, AND HP-67

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ABSTRACT

EASI (Estimate of Adversary Sequence Interruption) is an effective, simple method which has been developed for use in evaluating physical security systems. The usefulness of the method is enhanced by the fact that it can be implemented on a programmable pocket calculator. A program for the Texas Instruments SR-52 programmable pocket calculator has been developed and reported upon elsewhere. The purpose of this report is to provide programs for the Hewlett-Packard programmable pocket calculators.

PREPARED FOR THE U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH
UNDER ERDA CONTRACT NO. AT(29-1)-789

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INTRODUCTION AND SUMMARY

In references [1 and 2], a method called Estimate of Adversary Sequence Interruption (EASI) has been proposed for measuring the effectiveness of physical security systems. Physical security systems may be characterized by five primary functions: detection, assessment, communications, delay, and neutralization. EASI provides a measure of the effectiveness of the first four of these functions. Neutralization (the use of force to preclude the achievement of the adversary's objective) seems to be difficult to analyze even with very complex models. The argument is made in [1] that neutralization can be separated from the other security functions and evaluated independently. Whether or not this is valid, it is probably impossible to include neutralization in a method having the simplicity of EASI. In any event, more detailed analysis of the neutralization function appears to be necessary.

In addition to its simplicity, EASI can be programmed on a programmable pocket calculator. These two facets of EASI make the method a useful tool for quick, "first cut," evaluation of physical security systems. In references [1 and 2] a program is presented for the EASI method which can be used on a Texas Instruments SR-52 programmable pocket calculator. The program is written on a magnetic card which is read into the calculator. Data on barrier delays, transit times, alarm probabilities, communication probabilities, and response force times are then entered as input to the model, and the probability of the response force interrupting the adversary along a specified path is calculated. The usefulness of this interruption probability is based on the assumption that when the response force arrives, it is sufficient either to neutralize the adversary or to delay the adversary until additional forces, which can neutralize the adversary, arrive.

The use of the EASI method on available programmable calculators is desirable. The main purpose of this report is to present programs implementing EASI on the Hewlett-Packard programmable pocket calculators HP-25, HP-25C, HP-65, and HP-67. The program for the HP-67 with a few modifications could also be used on the HP-97 which is a small desk model version of the HP-67 with printing capability.

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Any method of evaluation which could be utilized "in the field" should have at least the following two characteristics: (1) simplicity of operation, and (2) minimum potential for human error. The EASI method as used on the SR-52, HP-65, or HP-67, all with magnetic card read/write capability, appears to satisfy these two requirements. The HP-25 does not have a magnetic card read/write capability and the program must be entered each time the calculator is turned on. This is not only an inconvenience but could be a significant source of error; however, one could provide a test problem with [illegible] to check the program after it has been entered. The HP-25C does not have a magnetic card read/write capability, and once a program is entered, it remains in memory until a different program is entered.

THE EASI METHOD

The discussion in this section is distilled from references [1 and 2]. It is included in order to make this report "self contained". Although a reader of this report would not be required to refer to reference [1] , it would be advantageous for the user to have access to the EASI User's Manual [2].

The EASI method calculates the probability of interruption of an adversary action sequence aimed at theft or sabotage. This is the probability that the response force will be notified when there is sufficient time remaining in the sequence for the force to respond. The notification of the response force is called an alarm and the probability of alarm is

$$P(A) = P(D)P(C) \tag{1}$$

where P(D) = probability of detection

P(C) = probability of communication to the response force.

In the case of only one detection device, the probability of an adversary action sequence interruption is given by

$$P(I) = P(R|A)P(A) \tag{2}$$

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where P(R|A) = probability of response force arrival prior to the adversary's action sequence, given an alarm.

An adversary action sequence is defined in terms of a starting point (which can be taken as the location of the first detection device along the adversary's path since adversary activities prior to this point have no effect on the probability of interruption), a sequence of detection devices, transit delays, barrier delays, and a terminal point. The transits and barriers can be thought of as tasks the adversary must perform. It is assumed that detection devices are located only at the beginnings of tasks.

If t_a is the time remaining for the adversary to reach the terminal point when an alarm occurs, and t_r is the response time of the security force, then for adversary interruption it is necessary that

$$t_a - t_r \geq 0. \tag{3}$$

The random variables t_a and t_r are assumed to be independent and normally distributed and thus the random variable

$$x = t_a - t_r$$

is normally distributed with mean

$$\mu_x = E(t_a - t_r) = E(t_a) - E(t_r) ,$$

variance

$$\sigma_x^2 = \mathrm{var}(t_a - t_r) = \mathrm{var}(t_a) + \mathrm{var}(t_r)$$

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and

$$P(R|A) = P(x \geq 0) = \int_0^\infty \frac{1}{\sqrt{2\pi\sigma_x^2}} \exp\left[- \frac{(x - \mu_x)^2}{2\sigma_x^2}\right] dx. \tag{4}$$

In EASI $P(R|A)$ is approximated by

$$P(R|A) \simeq \frac{\exp(1.7\mu_x/\sigma_x)}{1 + \exp(1.7\mu_x/\sigma_x)} . \qquad (5)$$

In the case of several detection devices, the barrier delays and transit times are assumed to be mutually independent random variables. The expected time from a p int p to the terminal point n is

$$E(t_p + t_{p+1} + \ldots + t_n) = \sum_{i=p}^{n} E(t_i)$$

where $E(t_i)$ = expected time to perform task i, and the variance is

$$\mathrm{var}(t_p + \ldots + t_n) = \sum_{i=p}^{n} \mathrm{var}(t_i) .$$

The probability $P(R|A)$ is calculated at each detection device and the probability of sequence interruption is

$$P(I) = P(R|A_1)P(A_1) + \sum_{i=2}^{n} P(R|A_i)P(A_i) \prod_{j=1}^{i-1} (1 - P(A_j)) . \qquad (6)$$

$P(I)$ is the probability calculated by EASI.

TEST PROBLEM AND PROGRAMS FOR HEWLETT-PACKARD CALCULATORS

Table I contains a complete set of data for a test problem. This test problem can be used to verify that the program has been entered correctly and that the procedure for entering data has been properly interpreted. The adversary action sequence for this example is briefly described as follows. The adversary's mission is sabotage. The adversary penetrates the boundary fence, crosses the area between the fence and the facility's main building, and reaches a locked exterior door.

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TABLE I

TEST EXAMPLE

Response Time

Mean: 4.0 Min
S.D.: 0.16

Communication Probability

P(C) = 0.9

Event Time

	Mean	S.D.	Detection Device	P(D)
At Vital Component	0.1 Min	0.02 Min	3	0.97
Penetrated Locked Door	3.0	0.33		0
Crossed Second Corridor	0.07	0.01		0
Penetrated Unlocked Door	0.5	0.1		0
Along First Corridor	0.52	0.1	2	0.97
Penetrated Locked Exterior Door	3.0	0.33	1	0.3

P(I) = 0.7124797745

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While outside the building, the adversary may be detected by CCTV surveillance (Sensor 1). After penetrating the exterior door which is alarmed (Sensor 2), the adversary continues along a corridor to an unlocked door leading to another corridor. The adversary crosses this corridor, penetrates a locked door which is alarmed (Sensor 3) and enters a room containing the vital equipment.

Appendix I contains the calculation procedure and program listings for the Hewlett-Packard programmable calculators HP-65, HP-67, and HP-97.* Appendix II contains the calculation procedure and program listing for the HP-25 and HP-25C.

CONCLUSIONS

Programs for EASI have been documented for the Hewlett-Packard (HP) programmable pocket calculators in this paper. If an HP user were to apply EASI for any physical protection evaluation, then he should refer to the EASI User's Manual [2] for more illustrative examples in the application of this technique. It was not the intent of this report to provide a series of illustrative examples on how to use EASI, but solely to provide and document EASI programs for the HP series calculators.

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*The HP-67 and HP-97 are designed so that although the coding is different for the two machines, a card written on either machine can be read on the other.

REFERENCE

1. Bennett, H. A., "The EASI Approach to Physical Security Evaluation," Sandia Laboratories, Albuquerque, New Mexico, SAND76-0050, 1976.

2. Bennett, H. A., "Preliminary User's Guide for Evaluating Physical Security Capabilities of Nuclear Facilities by the 'Estimate of Adversary Sequence Interruption' (EASI) Method", Working Paper Sandia Laboratories, Albuquerque, New Mexico, SAND77-0082, 1977.

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APPENDIX I

Calculation Procedure and Program Listings for HP-65, HP-67, HP-97

Calculation Procedure on HP-65, HP-67, HP-97

		Enter	Press	Display
1.	Read in Program			
2.	Enter Expected Response Time	$E(t_r)$	Enter	$E(t_r)$
3.	Enter S.D. of t_r	$\sigma(t_r)$	Enter	$\sigma(t_r)$
4.	Enter Probability of Communication	P(C)	A	$-E(t_r)$
5.	Enter expected time for task i (begin with task nearest terminal point)	$E(t_i)$	Enter	$E(t_i)$
6.	Enter S.D. of Task i	$\sigma(t_i)$	Enter	$\sigma(t_i)$
7.	If there is a detection device at beginning of task i, enter P(D); otherwise enter 0	P(D) or 0	B	P(I)
8.	Repeat 5, 6, 7			

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Program Listing for HP-65

Key	Display	Key	Display	Key	Display
f	31	3	03	+	61
REG	43	gR↑	35 09	RCL5	34 05
STO1	33 01	gR↑	35 09	gx↔y	35 07
gR↓	35 08	gx=y	35 23	÷	81
f^{-1}	32	RCL2	34 02	gx↔y	35 07
$\sqrt{\ }$	09	RTN	24	x	71
STO3	33 03	gR↓	35 08	gLSTx	35 00
gR↓	35 08	RCL1	34 01	1	01
CHS	42	x	71	-	51
STO4	33 04	RCL3	34 03	RCL2	34 02
RTN	24	f	31	x	71
LBL	23	$\sqrt{\ }$	09	-	51
B	12	RCL4	34 04	STO2	33 02
0	00	gx↔y	35 07	RTN	24
gR↑	35 09	÷	81		
STO	33	1	01		
+	61	.	83		
4	04	7	07		
gR↑	35 09	x	71		
f^{-1}	32	f^{-1}	32		
$\sqrt{\ }$	09	LN	07		
STO	33	STO5	33 05		
+	61	1	01		

Storage Registers

1	P(c)
2	P(I)
3	$\sum\sigma^2(t_i) + \sigma^2(t_r)$
4	$\sum E(t_i) - E(t_r)$
5	Working Storage

Labels

A	Store response force data
B	Store task data and calculate

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Program Listing for HP-67

Key	Display	Key	Display	Key	Display
fLBL A	001 31 25 11	f$\sqrt{x}$	024 31 54	STO2	047 33 02
fCLREG	002 31 43	RCL4	025 34 04	fLBLC	048 31 25 13
STO1	003 33 01	hx↔y	026 35 52	RCL2	049 34 02
hR↓	004 35 53	÷	027 81	hRTN	050 35 22
gx^2	005 32 54	1	028 01		
STO3	006 33 03	·	029 83		
hR↓	007 35 53	7	030 07		
CHS	008 42	x	031 71		
STO4	009 33 04	ge^x	032 32 52		
hRTN	010 35 22	STO5	033 33 05		
fLBLB	011 31 25 12	1	034 01		
hR↑	012 35 54	+	035 61		
hR↑	013 35 54	RCL5	036 34 05		
STO+4	014 33 61 04	hx↔y	037 35 52		
hR↑	015 35 54	÷	038 81		
gx^2	016 32 54	hx↔y	039 35 52		
STO+3	017 33 61 03	x	040 71		
hR↑	018 35 54	hLSTx	041 35 82		
f x=o	019 31 51	1	042 01		
GTO C	020 22 13	-	043 51		
RCL 1	021 34 01	RCL2	044 34 02		
x	022 71	x	045 71		
RCL3	023 34 03	-	046 51		

Storage Registers

1	P(c)
2	P(I)
3	$\sum\sigma^2(t_i) + \sigma^2(t_r)$
4	$\sum E(t_i) - E(t_r)$
5	Working Storage

Labels

A	Store response force data
B	Store task data and calculate
C	Return if $P(D_i) = 0$

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Program Listing for HP-97

Key	Display	Key	Display	Key	Display
LBLA	001 21 11	$\sqrt{x}$	024 54	STO2	047 35 02
fCLREG	002 16 -53	RCL4	025 36 04	LBLC	048 21 13
STO1	003 35 01	x↔y	026 -41	RCL1	049 36 02
R↓	004 -31	÷	027 -24	RTN	050 24
x^2	005 53	1	028 01		
STO3	006 35 03	·	029 -62		
R↓	007 -31	7	030 07		
CHS	008 -22	x	031 -35		
STO4	009 35 04	e^x	032 33		
RTN	010 24	STO5	033 35 05		
LBLB	011 21 12	1	034 01		
fR↑	012 16 -31	+	035 -55		
fR↑	013 16 -31	RCL5	036 36 05		
STO+4	014 35 -55 04	x↔y	037 -41		
fR↑	015 16 -31	÷	038 -24		
x^2	016 53	x↔y	039 -41		
STO+3	017 35 -55 03	x	040 -35		
fR↑	018 16 -31	fLASTx	041 16 -63		
f x=o	019 16 -31	1	042 01		
GTOC	020 22 13	-	043 -45		
RCL1	021 36 01	RCL2	044 36 02		
x	022 -35	x	045 -35		
RCL3	023 36 03	-	046 045		

Storage Registers

1	P(c)
2	P(I)
3	$\sum\sigma^2(t_i) + \sigma^2(t_r)$
4	$\sum E(t_i) - E(t_r)$
5	Working Storage

Labels

A	Store response force data
B	Store task data and calculate
C	Return if $P(D_i) = 0$

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APPENDIX II

Calculation Procedure and Program Listings for HP-25, HP-25C

Calculation Procedure on HP-25, HP-25C

		Enter	Press	Display
1.	Enter Program			
2.	Enter Expected Response Time	$E(t_r)$	Enter	$E(t_r)$
3.	Enter S.D. of t_r	$\sigma(t_r)$	Enter	$\sigma(t_r)$
4.	Enter Communication Probability	P(C)	GTO 00, R/S	$E(t_r)$
5.	Enter expected time for task i (begin with task nearest terminal point)	$E(t_i)$	Enter	$E(t_i)$
6.	Enter S.D. of Task i	$\sigma(t_i)$	Enter	$\sigma(t_i)$
7.	If there is a detection device at beginning of task i, enter probability P(D); otherwise enter 0	P(D) or 0	R/S	P(I) for Tasks Entered
8.	Repeat 5, 6, 7			

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Program Listing for HP-25, HP-25C

Key	Display	Key	Display
fREG	01 14 33	x↔y	24 21
STO2	02 23 02	÷	25 71
R↓	03 22	1	26 01
gx^2	04 15 02	.	27 73
STO4	05 23 04	7	28 07
R↓	06 22	x	29 61
STO-5	07 23 41 05	ge^x	30 15 07
RCL3	08 24 03	STO6	31 23 06
R/S	09 74	1	32 01
R↓	10 22	+	33 51
gx^2	11 15 02	RCL6	34 24 06
STO+4	12 23 51 04	x↔y	35 21
R↓	13 22	÷	36 71
STO÷5	14 23 51 05	x↔y	37 21
R↓	15 22	x	38 61
R↓	16 22	fLASTx	39 14 73
gx=0	17 15 71	1	40 01
GTO08	18 13 08	-	41 41
RCL2	19 24 02	RCL3	42 24 03
x	20 61	x	43 61
RCL4	21 24 04	-	44 41
f√	22 14 02	STO3	45 23 03
RCL5	23 24 05	GTO08	46 13 08

Storage Registers

2	P(c)
3	P(I)
4	$\sum\sigma^2(t_i) + \sigma^2(t_r)$
5	$\sum E(t_i) - E(t_r)$
6	Working Storage

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