APPENDIX K

SELF DEFENSE DATA

Summary

Self-defense capabilities of CPCX variants were evaluated against a variety of inbound missile threats. The summary of "Self-Defense Efficiencies" of each CPCX variant against respective threats was shown in table (K-1). The self-defense efficiency was defined as the product of all the individual kill probabilities for each defensive system used in particular engagement. Individual defensive system kill probabilities were provided by the faculty and were also shown in table (K-2). Self-defense efficiencies were determined for individual as well as combined inbound threat missiles, using threat scenarios described in the Operational Requirements Document.

The model used to determine self-defense efficiencies was the "Engagement Sequence Diagram", an example of which was shown on page (K-5). The self-defense engagement model incorporated delays that occur due to human decision making such as reaction and evaluation times. Incorporation of actual operational doctrine the ship might use in detecting and engaging threats of a particular scenario was beyond the scope of this design project.

A summary of the number of self-defense weapons expended against various threats was shown in table (K-3). Characteristics of threat missiles A-1, A-2, etc. were identical to those shown in Appendix E.

Engagement Sequence Diagram Description

A description of the Engagement Sequence Diagram shown on page (K-5), used to depict a CPCX Navy 1 Variant defense against a single inbound sea skimming A-3 missile, is as follows:

1. The plot has axes of the inbound missile's time to impact vs. range from ship. The diagonal line from the upper left to lower right represents the range at any time after launch of the inbound missile, in this case the A-3, traveling at mach 0.9.

2. The inbound A-3 missile is detected at a range of 25 km, based on information found in Appendix E - Radar Calculations.

3. After a ten-second reaction time, the first self-defense anti-missile weapon in the Navy 1 Variant's arsenal, an Enhanced Sea Sparrow is fired. The slope of the solid line labeled "ESS" represents the Sea Sparrow's outbound speed. The Sea Sparrow's projected impact with the A-3 is represented by point "1".

4. After ten seconds of evaluation time, the second self-defense weapon, a Rolling Air Frame (RAM) missile, is fired. The projected impact point of this missile is represented by point "2".

5. In a similar manner, after an evaluation time, the second RAM is fired with projected impact point "3".

6. The self-defense efficiency of this engagement is therefore the product of individual kill probabilities for each defensive system used, as shown in the following equation. The CIWS point defense and Chaff decoy systems' kill probabilities were

included also.

$$P_k = 1 - (1-0.7)(1-0.7)(1-0.7)(1-0.5)(1-0.4)$$
$$= 0.992$$

This self-defense efficiency was entered in table (K-1) for variant "Navy 1" and single missile threat "A-3".

7. The numbers of self-defense weapons expended for this engagement (one ESS, two RAM, CIWS, and CHAFF) were entered in the appropriate blocks in table (K-3).

ENGAGEMENT SEQUENCE DIAGRAM

NAVY VARIANT 1 - MISSILE A-3

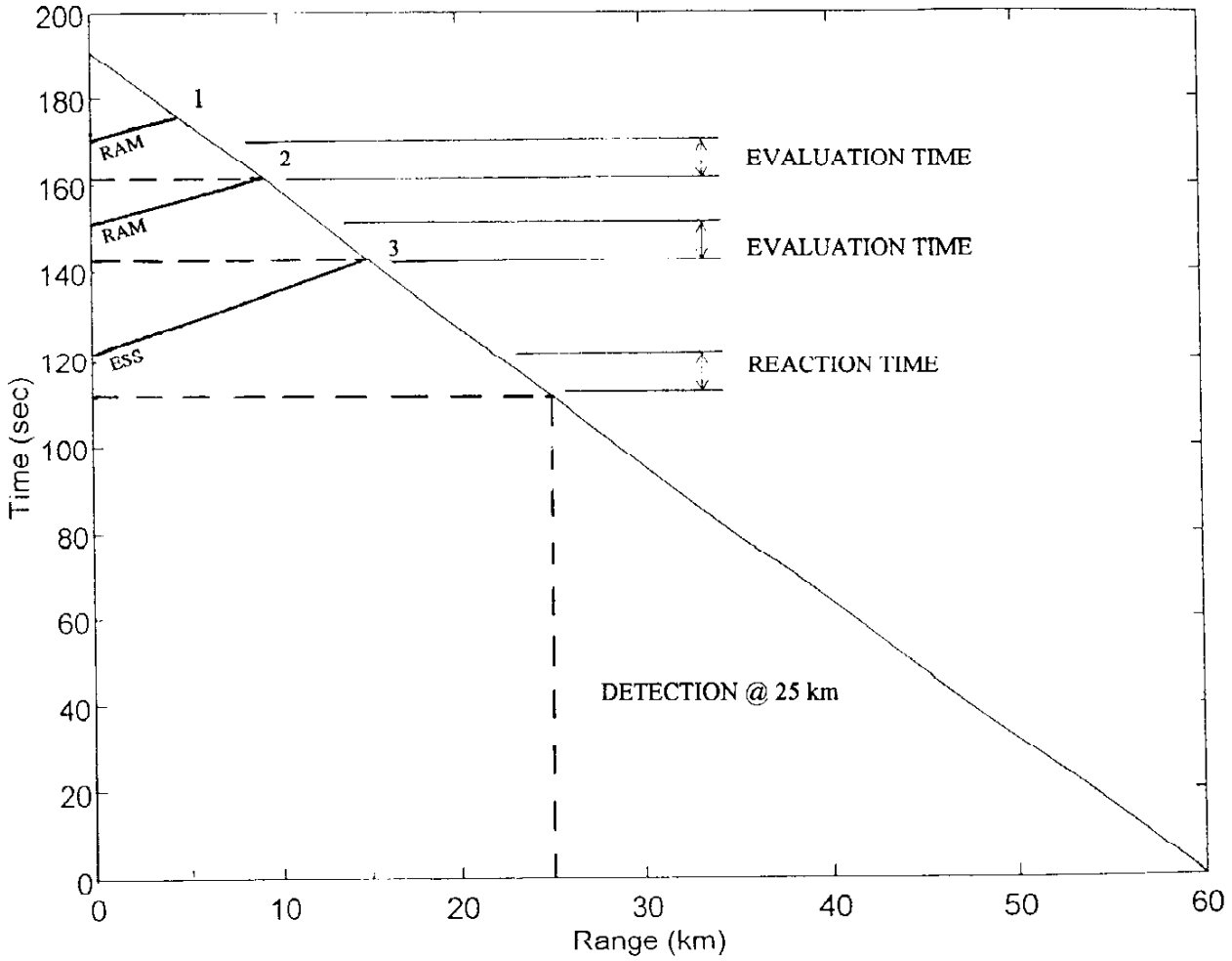

Table K-1: Self-Defense Efficiencies

		VARIANT				
	NAVY	NAVY	NAVY	CG	CG	CG
SINGLE MISSILE THREAT	1	2	3	1	2	3
A-1	0.996	0.997	0.989	0.989	0.989	0.874
A-2	0.986	0.952	0.700	0.973	0.973	0.910
A-3	0.992	0.992	0.992	0.992	0.992	0.910
A-4	0.998	0.998	0.998	0.995	0.998	0.998
M-2	0.995	0.995	0.943	0.943	0.943	0.881
COMBINED MISSILE THREAT						
THREE A-3'S						
(similar bearings)	0.993	0.993	0.987			
TWO A-3'S and ONE A-1						
(different bearings)	0.991	0.992	0.936			

Table K-2: Individual Defensive System Kill Probabilities (provided by faculty)

Defensive Missile System	A-1	A-2	A-3	A-4	M-1	M-2
SM2-MR	0.6	0.8	0.7	0.7		0.7
ESS	0.6	0.8	0.7	0.7		0.7
RAM	0.7	0.7	0.7	0.7	0.7	0.7
STINGER	0.7	0.7	0.7	0.7	0.7	0.7
CIWS/40 MM GUN	0.3	0.5	0.5	0.5	0.2	0.3
SLQ-32/CHAFF/DECOYS	0.4	0.4	0.4	0.4	0.3	0.1

Table K-3: Self-Defense Weapons Expended Against Various Threats

			SINGLE A-1 MISSILE				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	2	2	0	0	X		X
NAVY 2	2	1	1	0		X	X
NAVY 3	0	0	3	0		X	X
CG 1	0	0	3	0	X		X
CG 2	0	0	3	0		X	X
CG 3	0	0	0	1		X	X

			SINGLE A-2 MISSILE				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	0	2	0	0	X		X
NAVY 2	0	2	1	0		X	X
NAVY 3	0	0	0	0		X	X
CG 1	0	0	2	0	X		X
CG 2	0	0	2	0		X	X
CG 3	0	0	0	2		X	X

			SINGLE A-3 MISSILE				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	0	1	2	0	X		X
NAVY 2	0	0	0	0		X	X
NAVY 3	0	0	3	0		X	X
CG 1	0	0	3	0	X		X
CG 2	0	0	3	0		X	X
CG 3	0	0	0	2		X	X

			SINGLE A-4 MISSILE				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	1	3	0	0	X		X
NAVY 2	1	3	0	0		X	X
NAVY 3	0	0	4	0		X	X
CG 1	0	0	4	0	X		X
CG 2	0	0	4	0		X	X
CG 3	0	0	0	2		X	X

			SINGLE M-2 MISSILE				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	2	2	0	0	X		X
NAVY 2	2	2	0	0		X	X
NAVY 3	0	0	2	0		X	X
CG 1	0	0	2	0	X		X
CG 2	0	0	2	0		X	X
CG 3	0	0	0	2		X	X

			THREE A-3 MISSILES ON SIMILIAR BEARINGS				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	2	2	2	0	X		X
NAVY 2	2	2	2	0		X	X
NAVY 3	0	0	3	0		X	X
CG 1							
CG 2							
CG 3							

			TWO A-3'S, ONE A-1 MISSILE ON DIFFERENT BEARINGS				
SHIP OPTION	**SM2**	**ESS**	**RAM**	**STINGER**	**CIWS**	**40MM**	**CHAFF**
NAVY 1	2	5	5	0	X		X
NAVY 2	2	10	0	0		X	X
NAVY 3	0	0	9	0		X	X
CG 1							
CG 2							
CG 3							