Total Ownership with Life-Cycle Cost Model under Uncertainty for Surface Ships' Electro-Optical-Infrared-Sensors



#### NAVAL POSTGRADUATE School

### Abstract

This thesis examines the basics of total ownership cost (TOC) modeling over the life cycle of electrooptic/infrared sensors, including the inception phase of Acquisition Costs, followed by annual Operations and Maintenance (O&M) expenses, and a final set of Disposition Costs at the end of life of the sensor. This model allows cost analysts to have better decision analytics of the costs for use in cost comparisons across sensor platforms, return on investment analysis, portfolio allocation of resources, and analysis of alternatives. The findings show that the developed model is functional and could be used in the Department of Defense total ownership cost estimation process to facilitate decisions among sensor platform

International system    Jost of the system    Jost		Manag	5	tom P		Discount Poter	1.0001	1	France min Life	20 Vears				
Name of Use Small +/- Six Runder    Accusation of center order:    1.300      Answer of unks per flatform    Accusation of center order:    Six    Maintenance (Unk) her Year    Six    Dirak Acquiation of Center order:    Six (Unk) her Year    Six    Dirak Acquiation of Center order:    Six (Unk) her Year    Six	Note Bassay Libra Consult of EQU Damage	Name:	Sys	tem B		Discount Hate:	3.00%		Economic Life	120 rears				
Number of Net Orice    Operational original set of the set of	anty Range:   Use Small +/- 5% Range	Annual Gra	with or Decline (	une:	1 50%	1								
Implied of View (NFOV) Sensor    43    933    57.22.800    0.2%    51.500    0.0%    57.800.000    0.4%    55.85    5.000.000    0.3%    55.85    5.000.000    0.3%    57.85    5.000.000    0.3%    55.85    5.000.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    55.900.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00    0.3%    51.2800.00		Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M
dium field View (HKOV) Sensor:    4.3    93    57.22.90    0.2%    515.00    0.0%    557.00    0.0%				\$4,041,157.00		\$2,412,814.00		\$91,372.00		\$102,209.00		\$44,393,410.00		\$30,080,095.00
OV Director)    2    55    550.00    0.0%    57.00    0.0%    520.00    0.0%    55400.00    0.1%    5546.970.00    0.1%    5546.970.00    0.1%    5546.970.00    0.1%    5546.970.00    0.2%    577.955.00	dium Field of View (NFOV) Sensors	43	935	\$7,229.00	0.2%	\$135.00	0.0%	\$578.00	0.6%	\$5,663.00	5.5%	\$1,004,795.00	2.3%	\$925,760.00
Immal maging Sensor) - TS 81.    3    55    540.00    0.0%    523.00    0.0%    520.00    0.2%    570,880.00    0.2%    577,880.00    0.2%    577,880.00    0.2%    577,880.00    0.2%    577,880.00    0.2%    572,880.00    0.2%    557,800.00    0.2%    572,880.00    0.2%    557,800.00    0.2%    557,800.00    0.2%    557,800.00    0.2%    557,800.00    0.2%    557,870.00    0.2%    557,870.00    0.2%    557,870.00    0.2%    557,870.00    0.2%    557,870.00    0.3%    551,00    0.3%<	OV Director)	2	55	\$500.00	0.0%	\$7.00	0.0%	\$20.00	0.0%	\$400.00	0.4%	\$55,000.00	0.1%	\$46,970.00
Immal Imaging Sensor) - TS R2    4    55    532.00    0.0%    543.00    0.0%    543.00    0.2%    572.880.00    0.2%    572.580.00    0.2%    572.580.00    0.2%    572.580.00    0.2%    572.580.00    0.2%    572.570.00    0.2%    553.00    0.2	ermal Imaging Sensor) - TIS #1	3	55	\$430.00	0.0%	\$6.00	0.0%	\$23.00	0.0%	\$200.00	0.2%	\$70,950.00	0.2%	\$37,785.00
exten-Optic Sensor) - ICOS #1    1    55    5454.00    0.0%    554.00    0.1%    523.00    0.2%    524.750.00    0.1%    516.060.00      exto-Optic Sensor) - ICOS #1    4    55    5552.00    0.0%    554.00    0.0%    554.00    0.0%    552.00    0.0%    552.00    0.0%    552.00    0.0%    552.00    0.0%    522.0	ermal Imaging Sensor) - TIS #2	4	55	\$324.00	0.0%	\$5.00	0.0%	\$43.00	0.0%	\$300.00	0.3%	\$71,280.00	0.2%	\$76,560.00
stato-Optic Sensor) - ICOS #2    3    55    549.00    0.0%    54.00    0.1%    540.00    0.4%    \$89,995.00    0.2%    \$75,570.00      ter Dangelinder)    3    55    5200.00    0.0%    543.00    0.0%    5432.00    0.4%    5432.00    0.4%    5432.00    0.4%    5432.00    0.4%    5432.00    0.4%    5432.00    0.4%    5432.00    0.4%    5422.00    0.4%    5422.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    542.00    0.4%    552.80    0.4%    552.80    0.4%    552.80    0.4%    552.80    0.4%    552.80    0.4%    552.80    0.2%    552.84    0.0%    542.00    0.4%    552.84 <td>ectro-Optic Sensor) - EOS #1</td> <td>1</td> <td>55</td> <td>\$450.00</td> <td>0.0%</td> <td>\$6.00</td> <td>0.0%</td> <td>\$56.00</td> <td>0.1%</td> <td>\$230.00</td> <td>0.2%</td> <td>\$24,750.00</td> <td>0.1%</td> <td>\$16,060.00</td>	ectro-Optic Sensor) - EOS #1	1	55	\$450.00	0.0%	\$6.00	0.0%	\$56.00	0.1%	\$230.00	0.2%	\$24,750.00	0.1%	\$16,060.00
stro-Optic Sensor) - ICO 843    4    55    5520.00    0.0%    543.00    0.0%    5320.00    0.3%    5114.400.00    0.3%    580.520.00      ser Bangefinder)    2    55    5592.00    0.0%    552.00    0.0%    521.00    0.0%    542.00    0.4%    565.120.00    0.1%    550.380.00      ser Benginator/Rangefinder)    1    55    5502.00    0.0%    521.00    0.0%    532.00    0.3%    518.6400.00    0.1%    518.840.00    0.3%    518.840.00    0.1%    518.840.00    0.2%    522.00    0.3%    518.6400.00    0.1%    522.00    0.3%    548.840.00    0.3%    518.840.00    0.3%    518.840.00    0.3%    522.00    0.3%    548.840.00    0.3%    522.00    0.3%    548.840.00    0.3%    552.800.00    0.3%    552.800.00    0.3%    552.800.00    0.3%    552.800.00    0.3%    552.00    0.3%    552.800.00    0.3%    552.00    0.3%    552.800.00    0.3%    552.800.00    0.3%	ectro-Optic Sensor) - EOS #2	3	55	\$543.00	0.0%	\$4.00	0.0%	\$54.00	0.1%	\$400.00	0.4%	\$89,595.00	0.2%	\$75,570.00
ser Rangefinder)    3    55    520.00    0.0%    54.00    0.0%    522.00    0.0%    5420.00    0.4%    533.000.00    0.1%    533.000.00    0.1%    553.08.00      Law Designator/RangeInder/Illuminator)    1    55    5300.00    0.0%    52.00    0.0%    532.00    0.3%    515.00    0.0%    52.00    0.0%    532.00    0.3%    515.00.00    0.1%    533.00    0.0%    52.00    0.0%    532.00    0.2%    543.00.00    0.1%    533.00.00    0.1%    533.00    0.0%    543.00    0.0%    543.00    0.0%    543.00    0.0%    543.00    0.0%    543.00    0.0%    533.00    0.0%    543.00    0.0%    533.00    0.0%    533.00    0.0%    533.00    0.0%    533.00    0.0%    533.00    0.0%    543.00    0.0%    532.00    0.0%    532.00    0.0%    532.00    0.0%    532.00    0.0%    532.00    0.0%    532.00    0.0%    532.00    0.0%	ectro-Optic Sensor) - EOS #3	4	55	\$520.00	0.0%	\$3.00	0.0%	\$43.00	0.0%	\$320.00	0.3%	\$114,400.00	0.3%	\$80,520.00
arer Designator/Rangelinder/lluminator)    2    55    5592.00    0.0%    55.00    0.0%    521.00    0.0%    5432.00    0.4%    556,120.00    0.4%    558,120.00    0.4%    558,120.00    0.4%    558,120.00    0.4%    558,120.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,020.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%    558,000.00    0.4%	ser Rangefinder)	3	55	\$200.00	0.0%	\$4.00	0.0%	\$23.00	0.0%	\$420.00	0.4%	\$33,000.00	0.1%	\$73,755.00
Laser Designator/Rangefinder/Illuminator)    1    55    \$300.00    0.0%    \$2.0.0    0.0%    \$320.0.0    0.3%    \$16,500.00    0.0%    \$10,400.00      er Pointer)    2    55    \$600.00    0.0%    \$51.00    0.0%    \$53.00    0.0%    \$520.00    0.4%    \$540.00    0.4%    \$51.00    0.0%    \$520.00    0.4%    \$540.00    0.4%    \$540.00    0.4%    \$540.00    0.4%    \$540.00    0.4%    \$540.00    0.4%    \$540.00    0.4%    \$52.580.00    0.4%    \$540.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.00    0.4%    \$52.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.580.00    0.4%    \$52.00    0.2%    \$51.160.00    0.4%    \$52.280.00    0.2%    \$51.160.00    0.4%    \$52.280.00    0.4%    \$52.00    0.4%    \$52.00    0.4% </td <td>aser Designator/Rangefinder)</td> <td>2</td> <td>55</td> <td>\$592.00</td> <td>0.0%</td> <td>\$5.00</td> <td>0.0%</td> <td>\$21.00</td> <td>0.0%</td> <td>\$432.00</td> <td>0.4%</td> <td>\$65,120.00</td> <td>0.1%</td> <td>\$50,380.00</td>	aser Designator/Rangefinder)	2	55	\$592.00	0.0%	\$5.00	0.0%	\$21.00	0.0%	\$432.00	0.4%	\$65,120.00	0.1%	\$50,380.00
er Pointer)  1  55  \$600.00  0.0%  \$1.00  0.0%  \$33.00  0.2%  \$33,00.00  0.1%  \$12,870.00    er Optica/Ocular Interrupter)  2  55  \$200.00  0.0%  \$54.00  0.0%  \$54.00  0.0%  \$44.00  0.0%  \$44.000.00  0.4%  \$54.400.00  0.4%  \$54.400.00  0.4%  \$54.000  0.0%  \$52.00  0.0%  \$53.00  0.0%  \$52.00.00  0.1%  \$5	Laser Designator/Rangefinder/Illuminator)	1	55	\$300.00	0.0%	\$6.00	0.0%	\$2.00	0.0%	\$320.00	0.3%	\$16,500.00	0.0%	\$18,040.00
ere Optica/Ocular Interrupter)    2    55    \$400.00    0.0%    \$44.00    0.0%    \$44.00    0.0%    \$430.00    0.4%    \$44,000.00    0.1%    \$552,880.00      rillarinator)    1    55    \$200.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$51.00    0.0%    \$52.00	er Pointer)	1	55	\$600.00	0.0%	\$1.00	0.0%	\$33.00	0.0%	\$200.00	0.2%	\$33,000.00	0.1%	\$12,870.00
Illuminatori  1  55  \$20,00  0.0%  \$31,00  0.0%  \$321,00  0.0%  \$100,000  0.0%  \$20,845,00    rtial Reference Unit)  4  55  \$340,00  0.0%  \$21,00  0.0%  \$43,00  0.4%  \$74,850,00  0.2%  \$51,00,00  0.0%  \$51,00  0.0%  \$43,00  0.4%  \$74,250,00  0.2%  \$56,00,00    stronis Unit)  2  55  \$540,00  0.0%  \$51,00  0.0%  \$21,00  0.2%  \$55,940,00  0.1%  \$20,845,00    aterial (abling, mounting hardware, etc.)  3  55  \$51,000  0.0%  \$52,00  0.0%  \$21,00  0.2%  \$51,50,00  0.1%  \$24,240,00  0.2%  \$51,800,00  0.1%  \$24,240,00  0.2%  \$51,800,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%  \$51,280,00  0.3%	ser Optical/Ocular Interrupter)	2	55	\$400.00	0.0%	\$4.00	0.0%	\$44.00	0.0%	\$430.00	0.4%	\$44,000.00	0.1%	\$52,580.00
ettal Reference Unit)  4  55  5340.00  0.0%  52.00  0.0%  543.00  0.0%  543.00  0.4%  574.80.00  0.2%  514.50.00    orenight Module]  3  55  540.00  0.0%  53.00  0.0%  532.00  0.0%  532.00  0.3%  574.250.00  0.2%  558.200.0  0.2%  558.200.0  0.2%  558.200.0  0.2%  558.200.0  0.2%  558.200.0  0.2%  559.200.0  0.3%  527.060.00    aterial (cabing, mounting hardware, etc.)  3  55  531.00  0.0%  557.00  0.0%  523.00  0.0%  521.00  0.2%  551.150.00  0.1%  528.80.00    of term (WFOY) Sensors  20  385  528.400.00  0.1%  55.00  0.0%  534.00  0.0%  534.00  0.0%  532.00.00  0.1%  55.00  0.0%  53.00.00  0.1%  55.00  0.0%  53.00.00  0.1%  55.00  0.0%  53.00  0.0%  53.00  0.0%  53.00  0.0%  53.00  0.0%  55.00  0.0%  53.00  0.0%	r Illuminator)	1	55	\$200.00	0.0%	\$3.00	0.0%	\$55.00	0.1%	\$321.00	0.3%	\$11,000.00	0.0%	\$20,845.00
orresight Module)  3  55  \$540.00  0.0%  \$320.00  0.0%  \$320.00  0.3%  \$74,250.00  0.2%  \$60,225.00    ttronics Unit)  2  55  \$510.00  0.0%  \$540.00  0.0%  \$521.00  0.0%  \$521.00  0.2%  \$559,400.00  0.1%  \$242,200.00    aterial (cabing, mounting hardware, etc.)  3  55  \$310.00  0.0%  \$570.00  0.0%  \$233.00  0.0%  \$510.00  0.3%  \$512,900.00  0.3%  \$512,900.00  0.3%  \$512,900.00  0.1%  \$524,200.00  0.0%  \$231.00  0.0%  \$510.00  0.3%  \$512,980.00  0.3%  \$116,600.00  0.3%  \$12,28,800.00  0.0%  \$24,240.00  0.0%  \$510.00  0.0%  \$510.00  0.0%  \$110,800.00  0.1%  \$120,800.00  0.0%  \$510.00  0.0%  \$510.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0.0%  \$120.800.00  0	ertial Reference Unit)	4	55	\$340.00	0.0%	\$2.00	0.0%	\$43.00	0.0%	\$430.00	0.4%	\$74,800.00	0.2%	\$104,500.00
tronks Unit]    2    55    5540.00    0.0%    54.00    0.0%    532.00    0.0%    5210.00    0.2%    559,400.00    0.1%    527,060.00      aterial (cabling, mounting hardware, etc.)    3    55    5310.00    0.0%    55.00    0.0%    521.00    0.0%    5230.00    0.2%    551,150.00    0.1%    542,240.00      4    55    5530.00    0.7%    541.00    0.0%    523.00    0.0%    5310.00    0.1%    542,240.00    2.%    5511,65.00    0.3%    512,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00    1.2%    53,591,890.00 <td>oresight Module)</td> <td>3</td> <td>55</td> <td>\$450.00</td> <td>0.0%</td> <td>\$3.00</td> <td>0.0%</td> <td>\$42.00</td> <td>0.0%</td> <td>\$320.00</td> <td>0.3%</td> <td>\$74,250.00</td> <td>0.2%</td> <td>\$60,225.00</td>	oresight Module)	3	55	\$450.00	0.0%	\$3.00	0.0%	\$42.00	0.0%	\$320.00	0.3%	\$74,250.00	0.2%	\$60,225.00
aterial (cabling, mounting hardware, etc.)  3  55  \$310.00  0.0%  \$520.00  0.0%  \$230.00  0.2%  \$51,150.00  0.1%  \$42,240.00    4  55  \$530.00  0.0%  \$57.00  0.0%  \$230.00  0.0%  \$500.00  0.5%  \$41,600.00  0.3%  \$129,800.00    4  55  \$530.00  0.1%  \$500.00  0.0%  \$24,000.00  0.5%  \$44,000.00  0.5%  \$44,000.00  0.5%  \$44,000.00  0.5%  \$44,000.00  0.5%  \$44,000.00  0.5%  \$44,000.00  0.2%  \$5990,000.00  2.2%  \$496,485.00    rector)  3  55  \$6,000.00  0.1%  \$50.00  0.0%  \$3,000.00  4.9%  \$23,000.00  0.6%  \$51,210.00  0.6%  \$51,210.00  0.5%  \$496,485.00    etrial Reference Unit)  2  55  \$4,500.00  0.1%  \$57.00  0.0%  \$3,200.00  3.1%  \$236,500.00  0.1%  \$57.00  0.0%  \$3,200.00  3.1%  \$236,500.00  0.1%  \$57.00  0.0%  \$116,600.00  0.0%  \$23,000.00	ctronics Unit)	2	55	\$540.00	0.0%	\$4.00	0.0%	\$32.00	0.0%	\$210.00	0.2%	\$59,400.00	0.1%	\$27,060.00
4    55    \$530.0    0.0%    \$67.00    0.0%    \$23.00    0.0%    \$500.00    0.5%    \$116,600.00    0.3%    \$129,800.00      4 New (WFOV) Sensors    20    385    \$22,400.00    0.7%    \$41.00    0.0%    \$24,000.00    2.5%    \$4,532,000.00    0.2%    \$3,591,830.00      rectori    3    55    \$6,000.00    0.1%    \$5.00    0.0%    \$54.00    0.0%    \$3,000.00    2.9%    \$393,000.00    2.9%    \$333,50.00    0.0%    \$51,00    0.0%    \$51	laterial (cabling, mounting hardware, etc.)	3	55	\$310.00	0.0%	\$5.00	0.0%	\$21.00	0.0%	\$230.00	0.2%	\$51,150.00	0.1%	\$42,240.00
M View (WFOV) Sensors    20    385    528,400.00    0.7%    541.00    0.0%    524,100.00    23.6%    54,32,000.00    10.2%    53,591,80.00      rector)    3    55    56,000.00    0.1%    55.00    0.0%    54.00    0.0%    53,000.00    2.9%    599,000.00    2.2%    5495,885.00      ermal Imaging sensor)    2    55    54,300.00    0.1%    55.00    0.0%    53.00    0.0%    53,000.00    4.9%    523,000.00    0.5%    5495,820.00    0.5%    51,210.00      ectro-Optic Sensor)    1    55    54,300.00    0.1%    58.00    0.0%    53.00    0.1%    54.00.00    1.1%    535,54.00.00    0.1%    58.00    0.0%    53.00    0.0%    53.00.00    3.1%    5495,00.00    1.1%    535,54.00.00    0.1%    55.00    0.0%    55.00    0.0%    53.00    0.0%    55.00    0.0%    53.00.00    3.3%    51.188,00.00    2.0%    5075,00.00    2.0%    599,00.00.00    2.2%		4	55	\$530.00	0.0%	\$67.00	0.0%	\$23.00	0.0%	\$500.00	0.5%	\$116,600.00	0.3%	\$129,800.00
imaging Sensor)  3  55  \$6,000.00  0.1%  \$5.00  0.0%  \$4.00  0.0%  \$3,000.00  2.9%  \$990,000.00  2.2%  \$496,485.00    ermal Imaging Sensor)  2  55  \$2,300.00  0.1%  \$56.00  0.0%  \$55.00  0.0%  \$5,000.00  4.9%  \$223,000.00  0.6%  \$551,210.00    ectro-Optic Sensor)  1  55  \$4,300.00  0.1%  \$70.00  0.0%  \$3.00  0.0%  \$5,200.00  3.1%  \$223,000.00  0.5%  \$176,550.00    ectral Reference Unit)  2  55  \$4,500.00  0.1%  \$6.00  0.0%  \$3,400.00  3.1%  \$495,000.00  1.1%  \$353,340.00    etrail Reference Unit)  3  55  \$2,300.00  0.1%  \$5.00  0.0%  \$5.00  0.0%  \$4,300.00  4.2%  \$379,500.00  0.9%  \$711,645.00    aterial (cabling, mounting hardware, etc.)  4  55  \$5,600.00  0.1%  \$54.00  0.0%  \$51.00  0.0%  \$51.00  0.0%  \$51.00  0.0%  \$51.00  0.0%  \$51.00  0.0%	of View (WFOV) Sensors	20	385	\$28,400.00	0.7%	\$41.00	0.0%	\$34.00	0.0%	\$24,100.00	23.6%	\$4,532,000.00	10.2%	\$3,591,830.00
ermal Imaging Sensor)    2    55    \$2,300.00    0.1%    \$6.00    0.0%    \$5.00    0.0%    \$2,000.00    4.9%    \$253,000.00    0.6%    \$551,210.00      ectro-Optic Sensor)    1    55    \$4,300.00    0.1%    \$7.00    0.0%    \$3.00    0.0%    \$3,200.00    3.1%    \$236,500.00    0.5%    \$176,550.00      ertial Reference Unit)    2    55    \$4,500.00    0.1%    \$56.00    0.0%    \$3,200.00    3.1%    \$236,500.00    0.1%    \$350      ctronics Unit)    3    55    \$2,300.00    0.1%    \$5.00    0.0%    \$5.00    0.0%    \$3,400.00    3.3%    \$1,188,000.00    2.7%    \$750,200.00      aterial (cabling, mounting hardware, etc.)    4    55    \$5,400.00    0.1%    \$54.00    0.0%    \$5.00    0.0%    \$2,000.00    2.0%    \$990,000.00    2.7%    \$750,200.00      ctronics Unit)    50    51,000    0.1%    \$2,000    0.0%    \$51,00    0.0%    \$1,000    0.0%    <	irector)	3	55	\$6,000.00	0.1%	\$5.00	0.0%	\$4.00	0.0%	\$3,000.00	2.9%	\$990,000.00	2.2%	\$496,485.00
ectro-Optic Sensor)  1  55  \$4,300.00  0.1%  \$7.00  0.0%  \$3.00  0.0%  \$3,200.00  3.1%  \$236,500.00  0.5%  \$176,550.00    ertial Reference Unit)  2  55  \$4,500.00  0.1%  \$8.00  0.0%  \$56.00  0.0%  \$3,200.00  3.1%  \$236,500.00  1.1%  \$353,540.00    ertial Reference Unit)  3  55  \$2,300.00  0.1%  \$6.00  0.0%  \$7.00  0.0%  \$4,300.00  4.2%  \$379,500.00  0.9%  \$711,645.00  0.0%  \$5.00  0.0%  \$5,000.00  3.3%  \$1,188,000.00  2.7%  \$550,200.00  0.0%  \$5.00  0.0%  \$5,000  0.0%  \$5,000.00  2.0%  \$90,000.00  2.7%  \$550,200.00  0.0%  \$1,00  0.0%  \$1,00  0.0%  \$2,000.00  2.0%  \$90,000.00  2.0%  \$550,200.00  0.0%  \$1,00  0.0%  \$1,00  0.0%  \$2,000.00  2.0%  \$90,000.00  2.0%  \$550,200.00  0.0%  \$1,00  0.0%  \$1,00  0.0%  \$1,00  0.0%  \$1,00  0.0%	ermal Imaging Sensor)	2	55	\$2,300.00	0.1%	\$6.00	0.0%	\$5.00	0.0%	\$5,000.00	4.9%	\$253,000.00	0.6%	\$551,210.00
ertial Reference Unit)  2  55  \$4,500.00  0.1%  \$8.00  0.0%  \$6.00  0.0%  \$3,200.00  3.1%  \$495,000.00  1.1%  \$353,540.00    ctronics Unit)  3  55  \$2,300.00  0.1%  \$6.00  0.0%  \$7.00  0.0%  \$4,300.00  4.2%  \$379,500.00  0.9%  \$711,645.00    aterial (cabling, mounting hardware, etc.)  4  55  \$5,400.00  0.1%  \$5.00  0.0%  \$4.00  0.0%  \$3,400.00  3.3%  \$1,188,000.00  2.7%  \$750,200.00    aterial (cabling, mounting hardware, etc.)  4  55  \$5,000.00  0.1%  \$2,000  0.0%  \$4.00  0.0%  \$3,400.00  3.3%  \$1,188,000.00  2.7%  \$750,200.00    r  7  330  \$2,228.00  0.1%  \$2,000  0.0%  \$135.00  0.0%  \$19,01.50  0.2%  \$552,200.00  2.7%  \$552,200.00  2.7%  \$562,000.00  2.9%  \$50,000.00  2.9%  \$570,200.00  0.0%  \$19,815.00  0.0%  \$419,815.00  0.2%  \$562,000.00  530,00  0.9%  \$5	lectro-Optic Sensor)	1	55	\$4,300.00	0.1%	\$7.00	0.0%	\$3.00	0.0%	\$3,200.00	3.1%	\$236,500.00	0.5%	\$176,550.00
ctronics Unit)  3  55  \$2,300.00  0.1%  \$6.00  0.0%  \$7.00  0.0%  \$4,300.00  4.2%  \$379,500.00  0.9%  \$711,645.00    aterial (cabling, mounting hardware, etc.)  4  55  \$5,400.00  0.1%  \$5.00  0.0%  \$5.00  0.0%  \$3,400.00  3.3%  \$1,188,000.00  2.7%  \$750,200.00	ertial Reference Unit)	2	55	\$4,500.00	0.1%	\$8.00	0.0%	\$6.00	0.0%	\$3,200.00	3.1%	\$495,000.00	1.1%	\$353,540.00
aterial (cabling, mounting hardware, etc.)  4  55  \$5,400.00  0.1%  \$5.00  0.0%  \$3,400.00  3.3%  \$1,188,000.00  2.7%  \$750,200.00	ctronics Unit)	3	55	\$2,300.00	0.1%	\$6.00	0.0%	\$7.00	0.0%	\$4,300.00	4.2%	\$379,500.00	0.9%	\$711,645.00
5    55    \$3,600.00    0.1%    \$4.00    0.0%    \$4.00    0.0%    \$2,000.00    2.0%    \$990,000.00    2.2%    \$552,200.00      r Manager (ESM)    20    330    \$2,328.00    0.1%    \$26.00    0.0%    \$135.00    0.1%    \$2,066.00    2.0%    \$419,815.00    0.9%    \$407,110.00      Equipment    3    55    \$540.00    0.0%    \$51.00    0.0%    \$12.00    0.0%    \$50.00    0.5%    \$89,100.00    0.2%    \$88,305.00      Software    4    55    \$324.00    0.0%    \$4.00    0.0%    \$21.00    0.0%    \$340.00    0.3%    \$71,280.00    0.2%    \$88,300.00      Equipment    3    55    \$563.00    0.0%    \$6.00    0.0%    \$43.00    0.0%    \$230.00    0.2%    \$92,895.00    0.2%    \$88,300.00      Equipment    3    55    \$264.00    0.0%    \$6.00    0.0%    \$12.00    0.0%    \$345.00    0.3%    \$43,560.00    0.1%	laterial (cabling, mounting hardware, etc.)	4	55	\$5,400.00	0.1%	\$5.00	0.0%	\$5.00	0.0%	\$3,400.00	3.3%	\$1,188,000.00	2.7%	\$750,200.00
r Manager (ESM)    20    330    \$2,328.00    0.1%    \$26.00    0.0%    \$135.00    0.1%    \$2,066.00    2.0%    \$419,815.00    0.9%    \$407,110.00      Equipment    3    55    \$540.00    0.0%    \$510.00    0.0%    \$512.00    0.0%    \$500.00    0.5%    \$89,100.00    0.2%    \$89,100.00    0.2%    \$85,305.00      Software    4    55    \$324.00    0.0%    \$40.00    0.0%    \$340.00    0.3%    \$71,280.00    0.2%    \$88,300.00      Equipment    3    55    \$563.00    0.0%    \$60.00    0.0%    \$43.00    0.0%    \$230.00    0.2%    \$92,895.00    0.2%    \$46,035.00      ation Equipment    3    55    \$264.00    0.0%    \$60.00    0.0%    \$12.00    0.0%    \$345.00    0.3%    \$43,560.00    0.1%    \$59,895.00    0.2%    \$59,895.00    0.3%    \$43,560.00    0.1%    \$59,895.00      atrial (video converters, encoders, ethernet switches, ng, etc.)    3    5		5	55	\$3,600.00	0.1%	\$4.00	0.0%	\$4.00	0.0%	\$2,000.00	2.0%	\$990,000.00	2.2%	\$552,200.00
Equipment  3  55  \$540.00  0.0%  \$5.00  0.0%  \$12.00  0.0%  \$500.00  0.5%  \$89,100.00  0.2%  \$85,305.00    Software  4  55  \$324.00  0.0%  \$4.00  0.0%  \$21.00  0.0%  \$340.00  0.3%  \$71,280.00  0.2%  \$88,305.00    Equipment  3  55  \$563.00  0.0%  \$6.00  0.0%  \$43.00  0.0%  \$230.00  0.2%  \$92,895.00  0.2%  \$46,035.00    ation Equipment  3  55  \$264.00  0.0%  \$6.00  0.0%  \$12.00  0.0%  \$345.00  0.3%  \$43,560.00  0.1%  \$59,895.00    aterial (video converters, encoders, ethernet switches, ng, etc.)  4  55  \$325.00  0.0%  \$4.00  0.0%  \$22.00  0.0%  \$330.00  0.3%  \$71,500.00  0.2%  \$78,320.00	r Manager (ESM)	20	330	\$2,328.00	0.1%	\$26.00	0.0%	\$135.00	0.1%	\$2,066.00	2.0%	\$419,815.00	0.9%	\$407,110.00
Software  4  55  \$324.00  0.0%  \$4.00  0.0%  \$21.00  0.0%  \$340.00  0.3%  \$71,280.00  0.2%  \$80,300.00    Equipment  3  55  \$563.00  0.0%  \$6.00  0.0%  \$43.00  0.0%  \$230.00  0.2%  \$92,895.00  0.2%  \$46,035.00    ation Equipment  3  55  \$264.00  0.0%  \$6.00  0.0%  \$12.00  0.0%  \$345.00  0.3%  \$43,560.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$59,895.00  0.1%  \$51,800.00  0.1%  \$59,895.00  0.1%  \$51,800.00  0.1%  \$57,8320.00  0.1%  \$57,8320.00  0.2%  \$78,320.00  0.1%  \$57,255.00  0.0%  \$321.00  0.3%  \$51,480.00  0.1%	Equipment	3	55	\$540.00	0.0%	\$5.00	0.0%	\$12.00	0.0%	\$500.00	0.5%	\$89,100.00	0.2%	\$85,305.00
Equipment    3    55    \$563.00    0.0%    \$6.00    0.0%    \$43.00    0.0%    \$230.00    0.2%    \$92,895.00    0.2%    \$46,035.00      ation Equipment    3    55    \$264.00    0.0%    \$6.00    0.0%    \$12.00    0.0%    \$345.00    0.3%    \$43,560.00    0.1%    \$59,895.00      aterial (video converters, encoders, ethernet switches, ng, etc.)    4    55    \$325.00    0.0%    \$40.00    0.0%    \$22.00    0.0%    \$330.00    0.3%    \$71,500.00    0.2%    \$78,320.00	Software	4	55	\$324.00	0.0%	\$4.00	0.0%	\$21.00	0.0%	\$340.00	0.3%	\$71,280.00	0.2%	\$80,300.00
ation Equipment  3  55  \$264.00  0.0%  \$6.00  0.0%  \$12.00  0.0%  \$345.00  0.3%  \$43,560.00  0.1%  \$59,895.00    aterial (video converters, encoders, ethernet switches, ng, etc.)  4  55  \$325.00  0.0%  \$4.00  0.0%  \$22.00  0.0%  \$330.00  0.3%  \$71,500.00  0.2%  \$78,320.00	Equipment	3	55	\$563.00	0.0%	\$6.00	0.0%	\$43.00	0.0%	\$230.00	0.2%	\$92,895.00	0.2%	\$46,035.00
aterial (video converters, encoders, ethernet switches, ng, etc.)  4  55  \$325.00  0.0%  \$4.00  0.0%  \$22.00  0.0%  \$330.00  0.3%  \$71,500.00  0.2%  \$78,320.00    ng, etc.)  3  55  \$312.00  0.0%  \$1.00  0.0%  \$25.00  0.0%  \$321.00  0.3%  \$51,480.00  0.1%  \$57,255.00	ation Equipment	3	55	\$264.00	0.0%	\$6.00	0.0%	\$12.00	0.0%	\$345.00	0.3%	\$43,560.00	0.1%	\$59,895.00
3 55 \$312.00 0.0% \$1.00 0.0% \$25.00 0.0% \$321.00 0.3% \$51,480.00 0.1% \$57,255.00	laterial (video converters, encoders, ethernet switches, ing, etc.)	4	55	\$325.00	0.0%	\$4.00	0.0%	\$22.00	0.0%	\$330.00	0.3%	\$71,500.00	0.2%	\$78,320.00
		3	55	\$312.00	0.0%	\$1.00	0.0%	\$25.00	0.0%	\$321.00	0.3%	\$51,480.00	0.1%	\$57,255.00

# Methods

• TOC's are modeled with predictive

The Model input interface

# Results

- TOC modeling over the life cycle of EO/IR sensors develop a useful model for TOC estimations. Monte Carlo risk simulation allows this model to account for risk and uncertainty when producing cost estimates.
- This model provides analysts with a realistic estimate by factoring in economic theory, such as economic growth, annual discount rate, and inflation allowing better decision analytics of the costs of EO/IR surface sensors. These analytics can be used in subsequent cost comparisons

modeling and Monte Carlo risk simulation to determine the probabilistic of each cost element

• Multiple EO/IR capabilities are compared side by side with costs and risk element directly comparable in present values



between different sensor platforms, Analysis of Alternatives, and portfolio allocation of resources.

Probability Distribution Cost Overlay of the Five Systems

# Recommendations

- Use empirical cost data from a current EO/IR program to compare the results produced by the model.
- Executing this study would determine whether the TOC model developed in this thesis is a superior method of cost estimation for the DoD.
- PEO IWS and NAVSEA can utilize this model in future program cost estimation development. Since the model is tailorable to different sensor configurations, it can provide clarity in analyzing different and complex alternative sensor systems to develop and outfit the fleet.

Acquisition Research Program Graduate School of Defense Management

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George, Katelyn, LT, USN Ledbetter, Eliah, LT, USN

Advisors: Dr. Johnathan Mun Dr. Robert Mortlock