2021-05-19

Total Ownership with Life-Cycle Cost Model Under Uncertainty [video]

Mun, Johnathan

Monterey, California. Naval Postgraduate School

http://hdl.handle.net/10945/68230

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Total Ownership with Life-cycle Cost Model Under Uncertainty

Johnathan Mun, Ph.D. (Research Professor, Dept. Information Sciences)

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Purpose & Approach

The **purpose** is to develop a model to estimate **Total Ownership with Life-cycle Costs** under **uncertainty and risk.**

To illustrate the approach, we used the Surface Electro-Optic Infrared (EO/IR) sensors as a case example.

The cost modeling is based on the life cycle of the EO/IR sensors, including the inception phase of Acquisition Costs, followed by annual Operations and Maintenance (O&M) expenses, along with a final set of Disposition Costs at the end of life of the sensor.

Monte Carlo risk-based stochastic simulation was also applied, as well as some parametric cost estimation models.

The TOC/LC modeling approach will allow managers to have better decision analytics of the costs of said sensors for use in subsequent cost comparisons across sensor platforms, return on investment or ROI analysis, portfolio allocation of resources, and analysis of alternatives.

Background & Motivation

DOD needs to decide how funds are optimally used to support the U.S. national defense strategy. These decisions include long-term planning, budgeting, and selecting among alternatives.

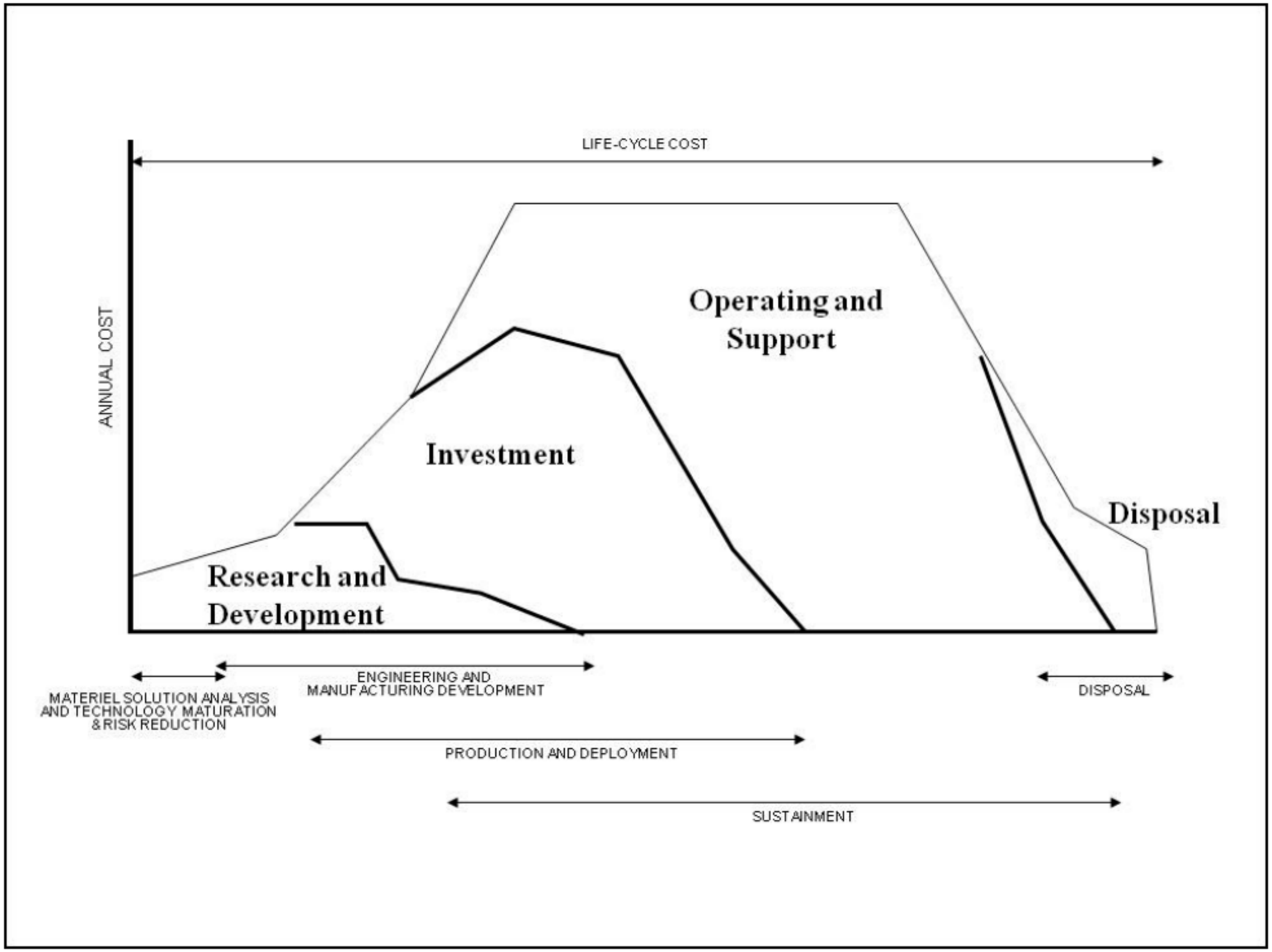
Before a program is implemented or a system purchased, decision-makers must understand the full cost that will be incurred and its effect on the DOD's budget.

Life-cycle cost is defined as the direct costs of the acquisition program, as well as the indirect costs that can be logically attributed to the program over the entire life cycle and includes the cost to the government to acquire, operate, support (manpower), and, where applicable, dispose of a system or program.

The proposed methodologies are extensible to compare any other DOD systems where the costs are uncertain and the results can be used in an analysis of alternatives.

A key point in cost estimating is that the future is uncertain. Therefore, an essential pillar in developing a defensible and credible cost estimate is ensuring that risk and uncertainty are incorporated. A cost estimate can be severely affected by factors such as technological maturity, schedule slips, software requirements, or any other unforeseen events.

Life-cycle Cost



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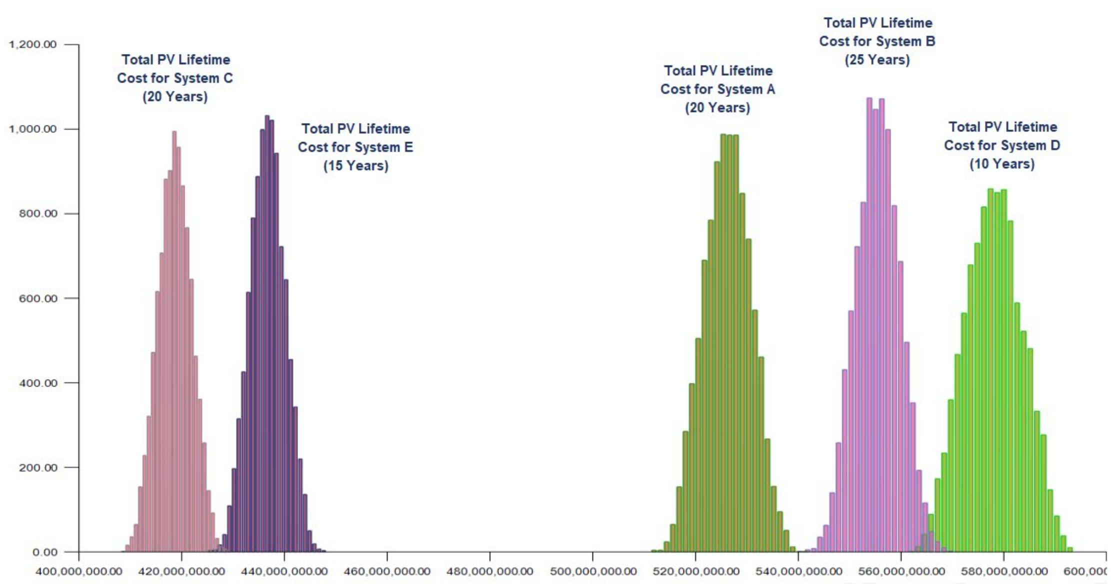
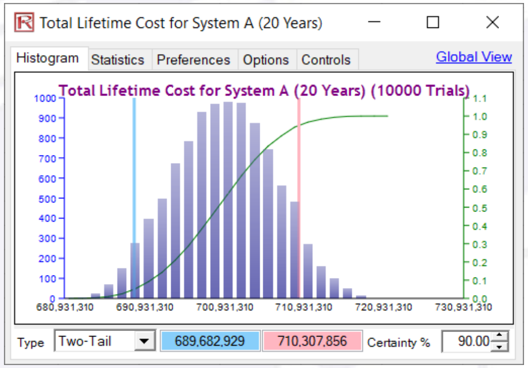
TOC Categories

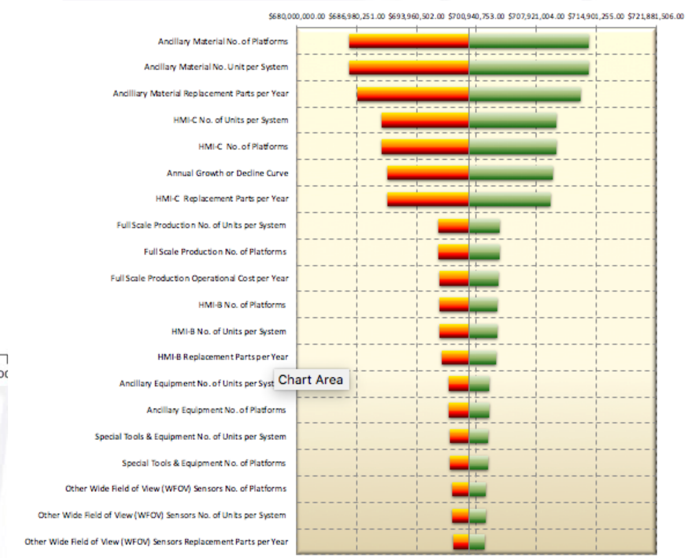
Narrow-Medium Field of View (NFOV) Sensors	**Supply Support**	**EO/IR Sensor Manager (ESM)**	**Manpower and Personnel**
NF-DIR (NFOV Director)	Wholesale and Retail Supply Chain Management	Processing Equipment	Program Management Office Team
NF-TIS (Thermal Imaging Sensor) - TIS #1	Spares Worldwide Transportation	Processing Software	Manning and military occupational series training
NF-TIS (Thermal Imaging Sensor) - TIS #2	Spares Warehousing	Recording Equipment	Depot Activation
NF-EOS (Electro-Optic Sensor) - EOS #1	Consumable Spares Replenishment	Docking Station Equipment	Software Sustainment
NF-EOS (Electro-Optic Sensor) - EOS #2	Provisioning and Initial Spares Lay-in	Ancillary Material (video converters, encoders, switches, racks, cabling)	Initial Fielding Support
NF-EOS (Electro-Optic Sensor) - EOS #3	Obsolescence Mitigation (Cost should be escalated)		
NF-LRF (Laser Rangefinder)	Contracting Strategy	**Human Machine Interface (HMI)**	**Technical Data Management**
NF-LDR (Laser Designator/Rangefinder)	Decreasing Economies of Scale	HMI-B (HMI Bridge/Cockpit)	Depot Activation
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	Battle Damage	HMI-C (HMI Combat Information Center/Cabin)	Software Sustainment
NF-LP (Laser Pointer)	Initial Fielding Support	HMI-I (HMI Intel)	Manning and military occupational series training
NF-LOI (Laser Optical/Ocular Interrupter)	Prepositioned Stock	Ancillary Material (additional displays, control panel switches, cabling, mounts)	O-level publications and new equipment training
NF-LI (Laser Illuminator)			Sustainment Planning and Data Procurement
NF-IRU (Inertial Reference Unit)	**Maintenance Planning and Management**	**Product Support Management**	Contracting Strategy
NF-BSM (Boresight Module)	System Support Strategy	Program Management Office Team	Other: __________
NF-EU (Electronics Unit)	Title 10 Core 50/50	Sustainment Planning and Data Procurement	
Ancillary Material (cabling, mounting hardware, etc.)	Depot Activation	Depot Activation	**Nonrecurring Acquisition and End of Lifecycle Costs**
	Software Sustainment	Software Sustainment	**Acquisition and Procurement**
Wide Field of View (WFOV) Sensors	Depot Repair and Overhaul	Integrated Product Support Team	Bid Specifications Development
WF-DIR (Director)	Manning and military occupational series training	Provisioning and Initial Spares Lay-in	Proposal Evaluation
WF-TIS (Thermal Imaging Sensor)	O-level publications and new equipment training	Contracting Strategy	Data Collection
WF-EOS (Electro-Optic Sensor)	Sustainment Planning and Data Procurement	Full Scale Production	Data Analysis
WF-IRU (Inertial Reference Unit)	Provisioning and Initial Spares Lay-in		Contracts Development
WF-EU (Electronics Unit)	Demilitarization and Disposal	**Support Equipment**	Program Planning
Ancillary Material (cabling, mounting hardware, etc.)	Full Scale Production	Depot Activation	Hardware Purchases
	Decreasing Economies of Scale	Software Sustainment	*Personal Computers*
Design Interface	Initial Fielding Support	Special Tools & Equipment	*Peripherals*
Technology development (TRL2 to TRL4)	Obsolescence Mitigation (Cost should be escalated)	Ancillary Equipment	*Storage*
Materiel development and LRIP (TRL5 to TRL7)		Support Equipment Sustainment	*Networking*
Operational Test (TRL8)	**Training and Training Support**	Initial Fielding Support	*Related Equipment*
Combat system integration (software changes)	Depot Activation	Obsolescence Mitigation (Cost should be escalated)	Other costs
Reliability Growth Program	Software Sustainment		Administrative Cost
Technology Refresh (P3I, emerging threats, obsolescence…)	Manning and military occupational series training	**Packaging, Handling, Storage and Transportation**	Asset Management
Technology Roadmap	O-level publications and new equipment training	Transportability Requirements	Overseeing Contractor Services
Design for Maintainability	Sustainment Planning and Data Procurement	Transportation Limitations	In-House Training for Staff
Modularity	Transportability Requirements	Initial Fielding Support	Product Maintenance
Obsolescence Mitigation (Cost should be escalated)	Initial Fielding Support		Help Desk Support
		Nonrecurring End of Lifecycle Costs	IT Support for Database Management
Computer Resources	**Facilities and Infrastructure**	**End of Lifecycle**	Network Management Support
Manning and military occupational series training	Ship alteration for initial fielding	Administrative Cost	Software Upgrades
Depot Activation	Depot Activation	Asset Management	Hardware Upgrades
Software Sustainment	Software Sustainment	Vendor Contract Procurement	Internet and Network Access Cost
O-level publications and new equipment training		Staging, Sanitizing, Testing	Furniture and Equipment
Initial Fielding Support		Follow-Up Support	Energy Costs
		Recycling and Disposal Fees	Informal Training
		Value of Sold Products and Materials	Downtime Support and Outsource

Methodology & Results

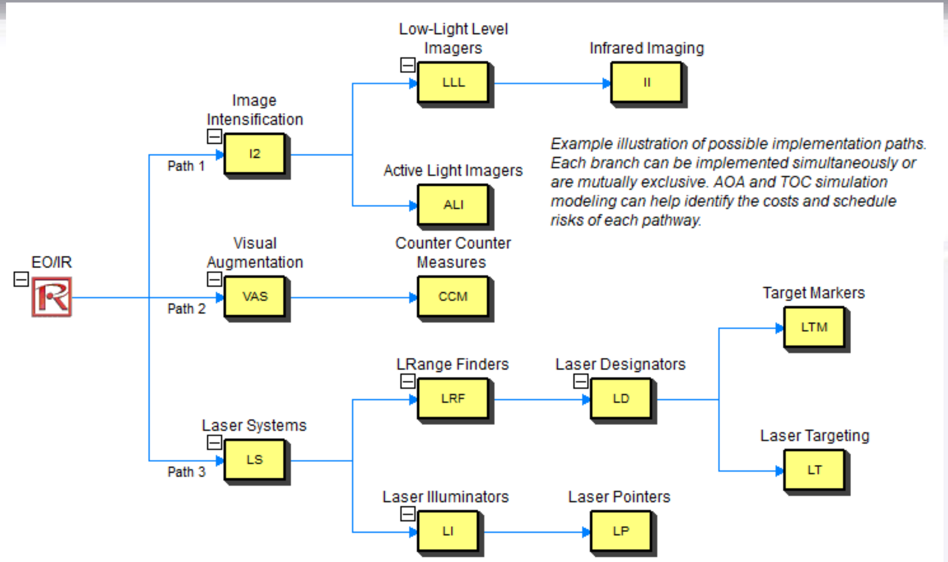
Life-cycle costs are modeled with predictive modeling and Monte Carlo risk simulation to determine the probabilistic outcomes of each cost element. Multiple EO/IR capabilities are compared side by side, with cost and risk elements directly comparable in present values. Analysis of alternatives can be easily implemented using the same cost modeling techniques for cross-comparisons of multiple programs simultaneously.

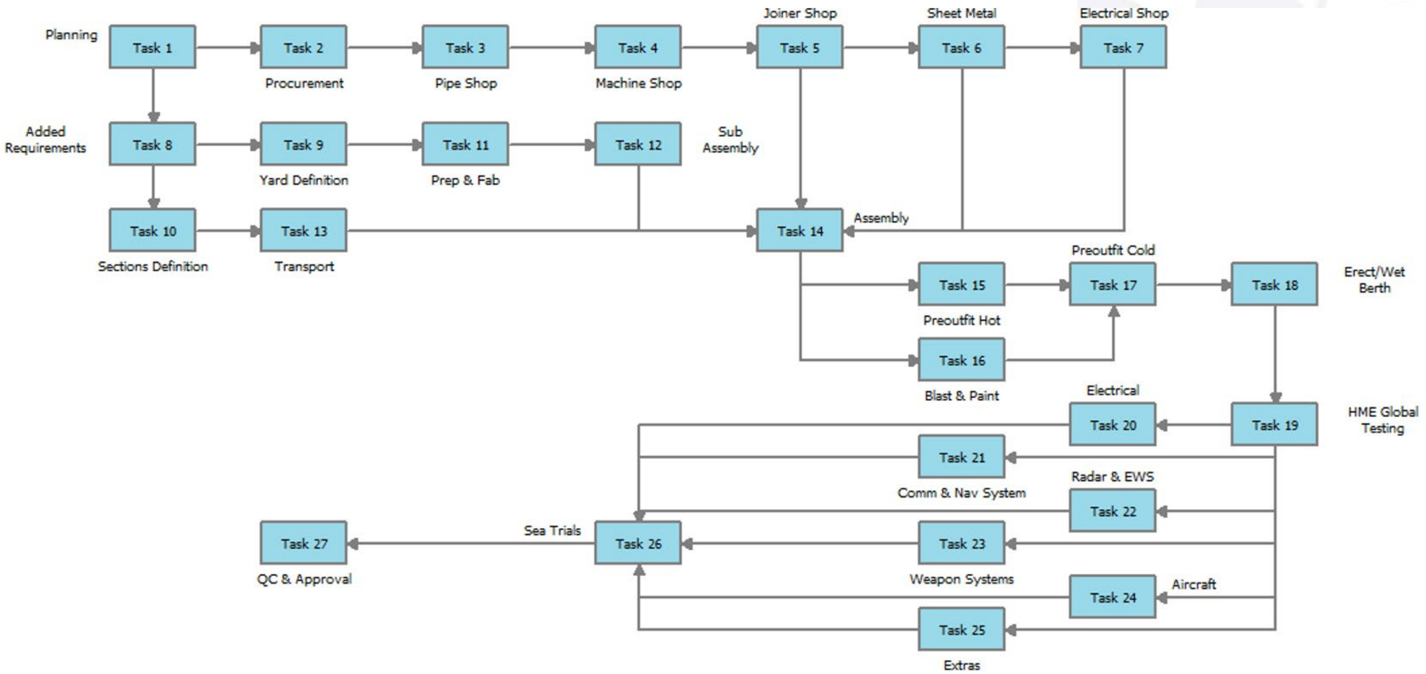






Results & Extensions





Related Research: Cost & Schedule Risk

Project Management | Applied Analytics | Risk Simulation | Options Strategies | Options Valuation | Forecast Prediction | Dashboard | Knowledge Center

Ship Building | ICT Navigation | Weapon Systems | Aircraft | Electrical Systems | Radar Systems | Extra Systems | Support Processes | Portfolio Analysis

Select the Project Schedule & Cost Risk Model to use: ○ Sequential Path ◉ Complex Network Path Project Name/Notes:

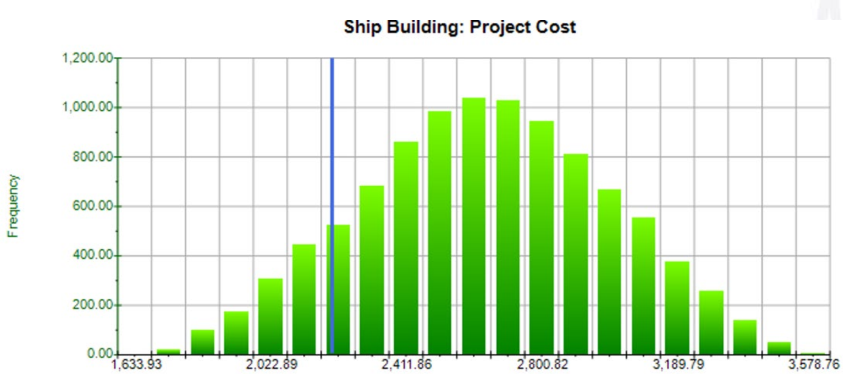
Network Diagram | Schedule & Cost

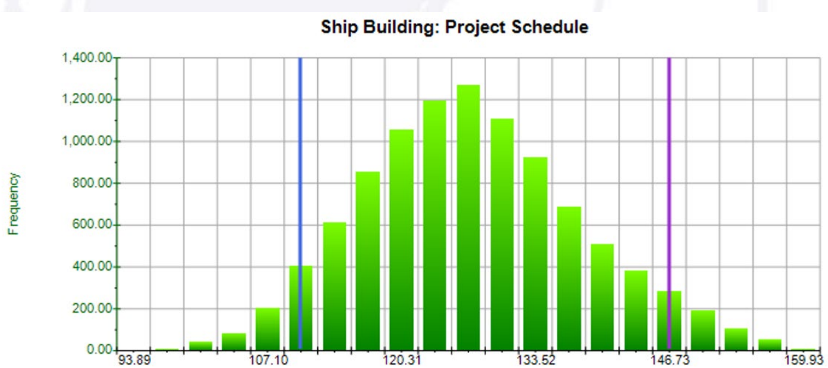
☑ Include Schedule-Based Cost Analysis ☐ Include Probabilities of Success of Each Task and Model Their Impacts

☑ Include Budget Overrun & Buffers ☑ Perform Risk Simulation Run | Run All Projects

Show 27 Tasks with Weekly Simulation Trials: 1,000,000 ☑ Apply Seed Value: 123 Triangular

Task 6	Sheet Metal	19.70	24.62	29.55	27	1.27	2.00	2.73	0.04	10.00%
Task 7	Electrical Shop	19.70	24.62	29.55	29	3.17	5.00	6.84	0.40	10.00%
Task 8	Added Requirements	2.36	3.07	4.76	4	2.53	4.00	5.47	0.16	10.00%
Task 9	Yard Definition	2.63	3.41	5.29	4	2.53	4.00	5.47	0.16	10.00%
Task 10	Sections Definition	2.89	3.75	5.82	4	1.27	2.00	2.73	0.16	10.00%
Task 11	Prep & Fab	1.84	2.38	3.70	4	3.80	6.00	8.20	0.16	10.00%
Task 12	Sub Assembly	21.01	27.25	42.33	31	2.53	4.00	5.47	0.24	10.00%
Task 13	Transport	13.13	17.03	26.45	20	1.90	3.00	4.10	0.24	10.00%
Task 14	Assembly	31.51	40.88	63.49	47	3.17	5.00	6.84	0.40	10.00%
Task 15	Preoutfit Hot	13.13	17.03	26.45	20	1.90	3.00	4.10	0.24	10.00%
Task 16	Blast & Paint	3.15	4.09	6.35	5	1.90	3.00	4.10	0.24	10.00%
Task 17	Preoutfit Cold	2.63	3.41	5.29	4	1.27	2.00	2.73	0.16	10.00%
Task 18	Erect/Wet Berth	39.39	51.10	79.36	57	1.90	3.00	4.10	0.24	10.00%
Task 19	HME Global Testing	55.14	71.54	111.10	87	6.33	10.00	13.67	0.79	10.00%
Task 20	Electrical	4.40	11.05	17.70	20	17.07	44.00	70.93	0.16	10.00%
Task 21	Comm & Nav System	19.64	47.07	74.50	61	19.40	50.00	80.60	0.16	10.00%
Task 22	Radar & EWS	158.16	385.70	613.24	435	23.28	60.00	96.72	0.16	10.00%
Task 23	Weapon Systems	514.54	1,262.38	2,010.21	1,397	18.62	48.00	77.38	0.16	10.00%
Task 24	Aircraft	24.56	61.54	98.52	71	13.97	36.00	58.03	0.08	10.00%
Task 25	Extras	18.03	45.24	72.44	52	9.31	24.00	38.69	0.08	10.00%
Task 26	Sea Trials	42.01	54.50	84.65	74	5.06	8.00	10.94	1.59	10.00%
Task 27	QC & Approval	26.26	34.07	52.91	38	1.90	3.00	4.10	0.24	10.00%





DOD Applications

The current research can act as a proof of concept for life-cycle cost and TOC simulation and modeling for other DOD programs.

Results from said models will assist in making strategic investment and acquisition decisions and provide an objective set of comparisons across multiple programs within an analysis of alternatives paradigm.

Various implementation paths can be modeled for each program, or multiple dependent programs can be nested and linked to each other, and the optimal implementation paths based on cost and schedule risks can be determined.

Conclusions

Obtaining the correct cost projections over the life cycle of an EO/IR program is critical to making the correct strategic decisions in terms of portfolio program selection subject to a set allocation of cost.

The recommended next step is to collect additional data for other technologies to implement the proposed methodology, and to create a modeling standard for analysis of alternatives of multiple EO/IR sensors and beyond.

Cost estimation is not an exact science; however, this model provides a coherent method of estimating the total ownership with life-cycle costs under uncertainty for EO/IR sensors on surface ships. It gives a decision-maker another tool when evaluating alternative programs and courses of action. The ultimate goal of this model is to provide a more effective tool in determining how the DOD spends its limited resources on competing priorities.

* Significant at Alpha Level $\alpha = 0.10$
** Significant at Alpha Level $\alpha = 0.05$