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Total Ownership with Life-cycle Cost Model Under Uncertainty

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Excellence Through Knowledge

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.

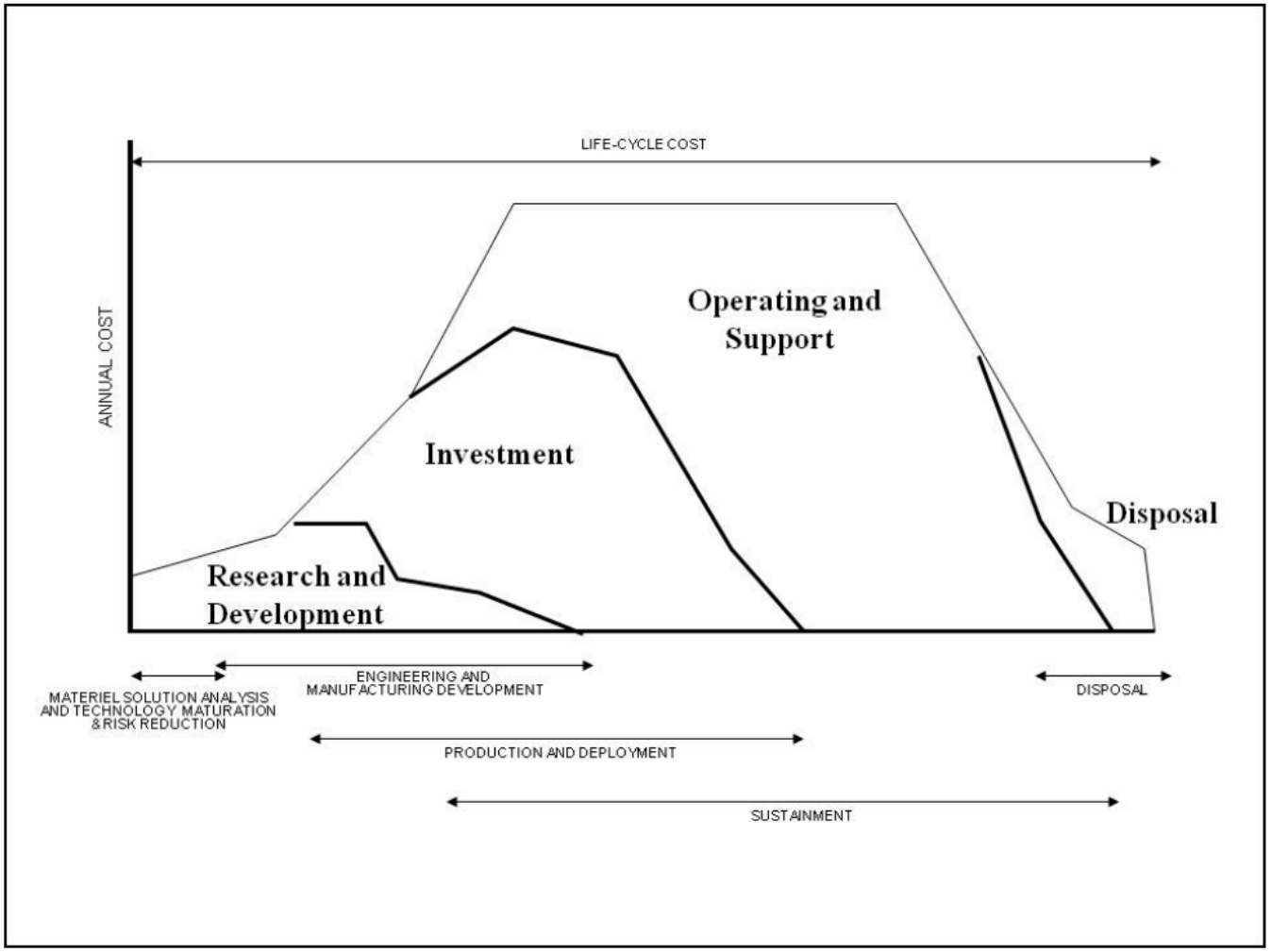
Before a program is implemented or a system purchased, decision-makers must understand the full cost that will be incurred and its effect on the DOD's budget.

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
NF-DIR (NFOV Director)
NF-TIS (Thermal Imaging Sensor) - TIS #1
NF-TIS (Thermal Imaging Sensor) - TIS #2
NF-EOS (Electro-Optic Sensor) - EOS #1
NF-EOS (Electro-Optic Sensor) - EOS #2
NF-EOS (Electro-Optic Sensor) - EOS #3
NF-LRF (Laser Rangefinder)
NF-LDR (Laser Designator/Rangefinder)
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)
NF-LP (Laser Pointer)
NF-LOI (Laser Optical/Ocular Interrupter)
NF-LI (Laser Illuminator)
NF-IRU (Inertial Reference Unit)
NF-BSM (Boresight Module)
NF-EU (Electronics Unit)
Ancillary Material (cabling, mounting hardware, etc.)
Wide Field of View (WFOV) Sensors
WF-DIR (Director)
WF-TIS (Thermal Imaging Sensor)
WF-EOS (Electro-Optic Sensor)
WF-IRU (Inertial Reference Unit)
WF-EU (Electronics Unit)
Ancillary Material (cabling, mounting hardware, etc.)
Design Interface
Technology development (TRL2 to TRL4)
Materiel development and LRIP (TRL5 to TRL7)
Operational Test (TRL8)
Combat system integration (software changes)
Reliability Growth Program
Technology Refresh (P3I, emerging threats, obsolescence…)
Technology Roadmap
Design for Maintainability
Modularity
Obsolescence Mitigation (Cost should be escalated)
Computer Resources
Manning and military occupational series training
Depot Activation
Software Sustainment
O-level publications and new equipment training
Initial Fielding Support

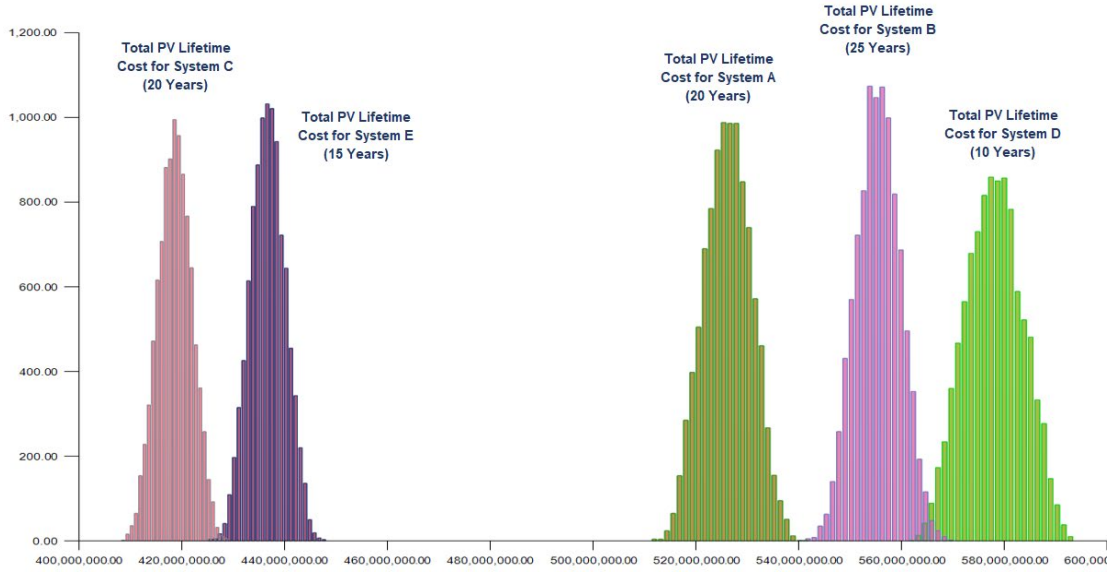
Supply Support
Wholesale and Retail Supply Chain Management
Spares Worldwide Transportation
Spares Warehousing
Consumable Spares Replenishment
Provisioning and Initial Spares Lay-in
Obsolescence Mitigation (Cost should be escalated)
Contracting Strategy
Decreasing Economies of Scale
Battle Damage
Initial Fielding Support
Prepositioned Stock
Maintenance Planning and Management
System Support Strategy
Title 10 Core 50/50
Depot Activation
Software Sustainment
Depot Repair and Overhaul
Manning and military occupational series training
O-level publications and new equipment training
Sustainment Planning and Data Procurement
Provisioning and Initial Spares Lay-in
Demilitarization and Disposal
Full Scale Production
Decreasing Economies of Scale
Initial Fielding Support
Obsolescence Mitigation (Cost should be escalated)
Training and Training Support
Depot Activation
Software Sustainment
Manning and military occupational series training
O-level publications and new equipment training
Sustainment Planning and Data Procurement
Transportability Requirements
Initial Fielding Support
Facilities and Infrastructure
Ship alteration for initial fielding
Depot Activation
Software Sustainment

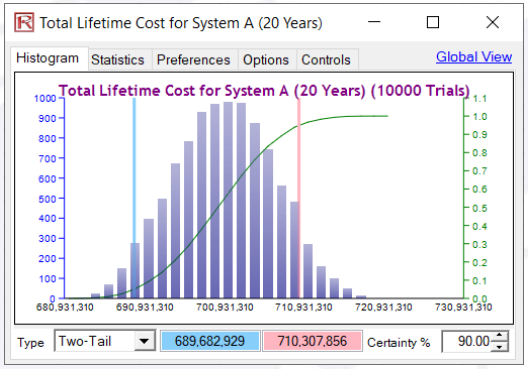
EO/IR Sensor Manager (ESM)
Processing Equipment
Processing Software
Recording Equipment
Docking Station Equipment
Ancillary Material (video converters, encoders, switches, racks, cabling)
Human Machine Interface (HMI)
HMI-B (HMI Bridge/Cockpit)
HMI-C (HMI Combat Information Center/Cabin)
HMI-I (HMI Intel)
Ancillary Material (additional displays, control panel switches, cabling, mounts)
Product Support Management
Program Management Office Team
Sustainment Planning and Data Procurement
Depot Activation
Software Sustainment
Integrated Product Support Team
Provisioning and Initial Spares Lay-in
Contracting Strategy
Full Scale Production
Support Equipment
Depot Activation
Software Sustainment
Special Tools & Equipment
Ancillary Equipment
Support Equipment Sustainment
Initial Fielding Support
Obsolescence Mitigation (Cost should be escalated)
Packaging, Handling, Storage and Transportation
Transportability Requirements
Transportation Limitations
Initial Fielding Support
Nonrecurring End of Lifecycle Costs
End of Lifecycle
Administrative Cost
Asset Management
Vendor Contract Procurement
Staging, Sanitizing, Testing
Follow-Up Support
Recycling and Disposal Fees
Value of Sold Products and Materials

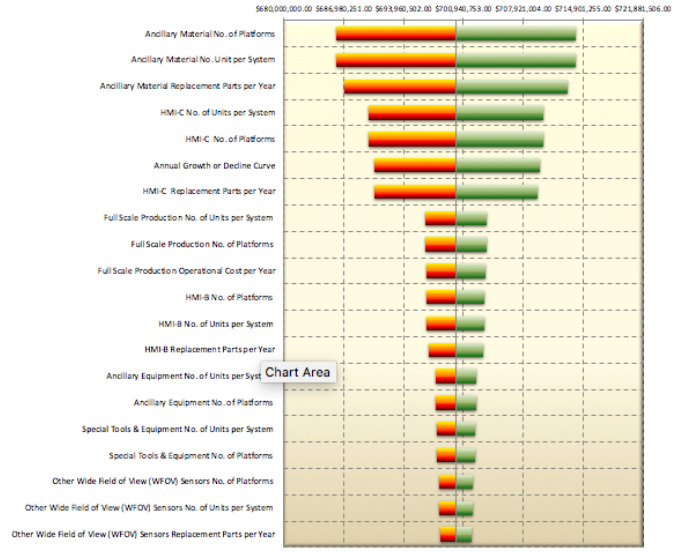
Manpower and Personnel
Program Management Office Team
Manning and military occupational series training
Depot Activation
Software Sustainment
Initial Fielding Support
Technical Data Management
Depot Activation
Software Sustainment
Manning and military occupational series training
O-level publications and new equipment training
Sustainment Planning and Data Procurement
Contracting Strategy
Other:_____
Nonrecurring Acquisition and End of Lifecycle Costs
Acquisition and Procurement
Bid Specifications Development
Proposal Evaluation
Data Collection
Data Analysis
Contracts Development
Program Planning
Hardware Purchases
Personal Computers
Peripherals
Storage
Networking
Related Equipment
Other costs
Administrative Cost
Asset Management
Overseeing Contractor Services
In-House Training for Staff
Product Maintenance
Help Desk Support
IT Support for Database Management
Network Management Support
Software Upgrades
Hardware Upgrades
Internet and Network Access Cost
Furniture and Equipment
Energy Costs
Informal Training
Downtime Support and Outsource

Methodology & Results

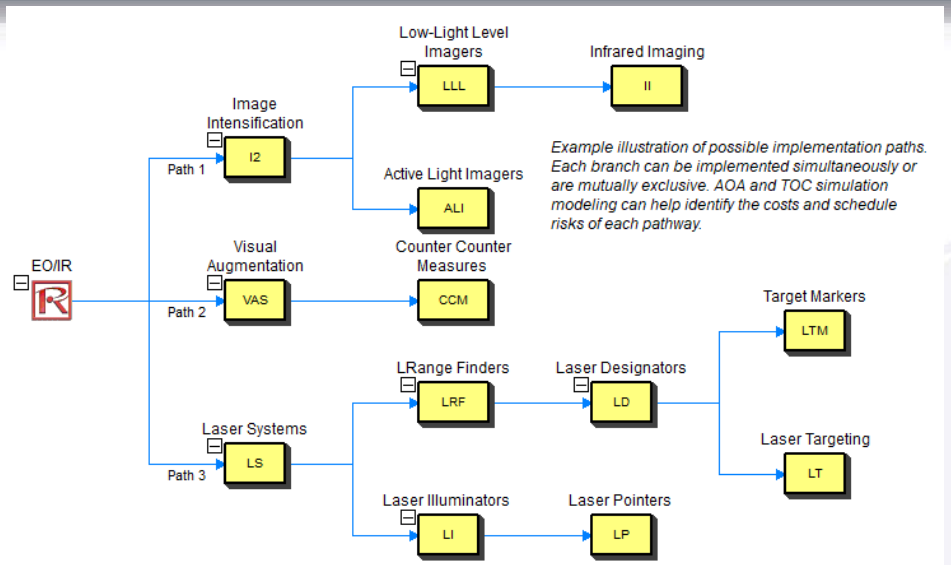
Life-cycle costs are modeled with predictive modeling and Monte Carlo risk simulation to determine the probabilistic outcomes of each cost element. Multiple EO/IR capabilities are compared side by side, with cost and risk elements directly comparable in present values. Analysis of alternatives can be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

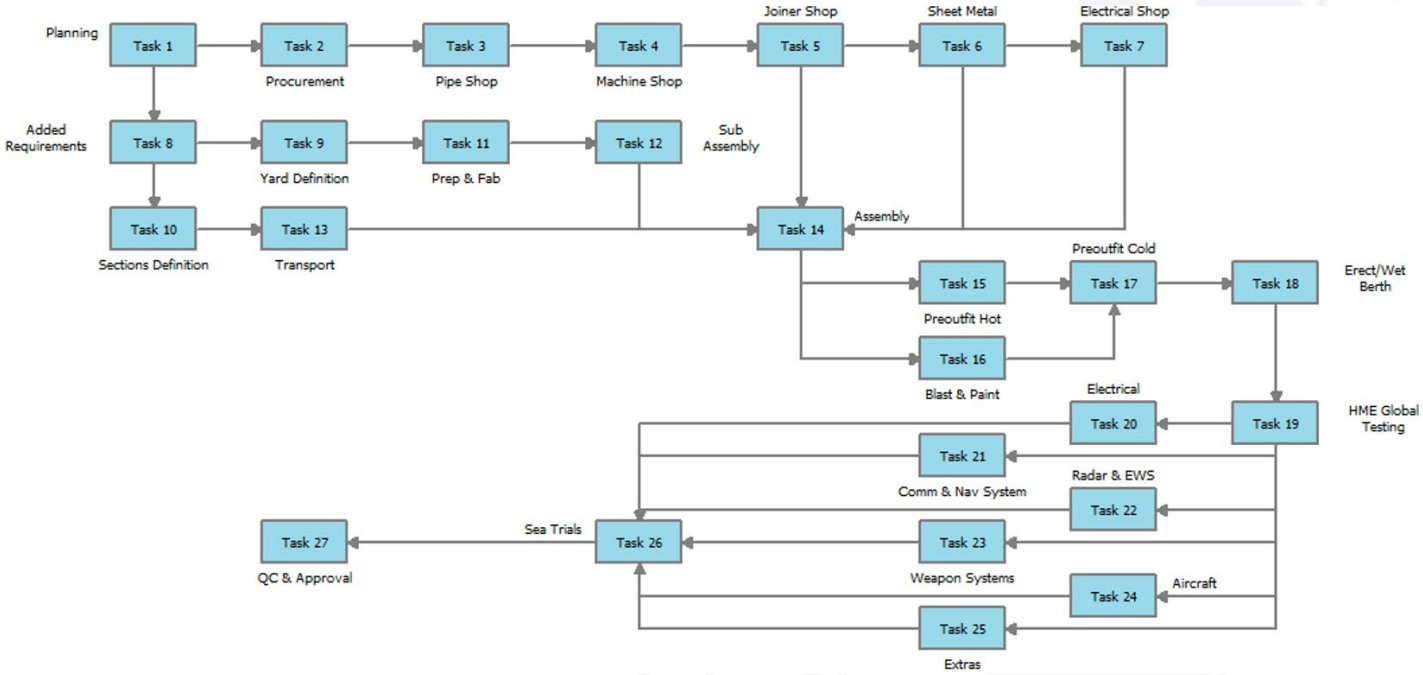






Results & Extensions





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

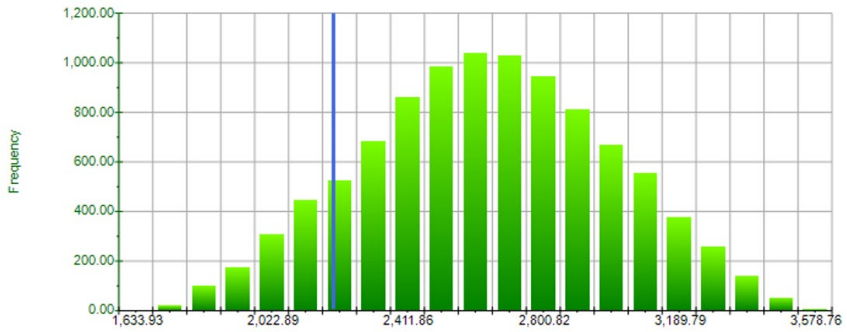
☑ Include Schedule-Based Cost Analysis ☐ Include Probabilities of Success of Each Task and Model Their Impacts

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

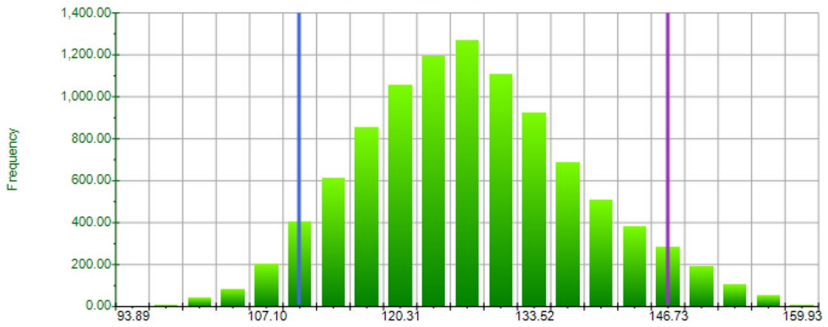
Show 27 Tasks with Weekly Simulation Trials: 1,000,000 ☑ Apply Seed Value: 123 Triangular

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%

Ship Building: Project Cost



Ship Building: Project Schedule



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 α = 0.10
** Significant at Alpha Level α = 0.05