

Naval Ship Life Cycle Cost (LCC) Model



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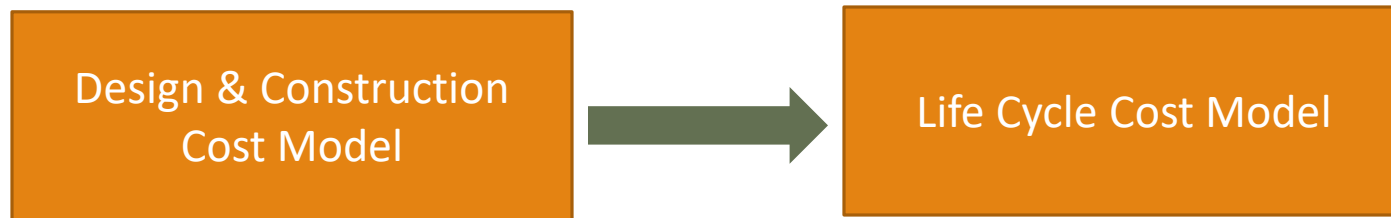
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The Life Cycle of a Ship

- **Conception Stage:** All activities necessary to develop and define a means for meeting a stated requirement. For ships and equipment, this normally includes research and development, design, contract specifications, identification of all support necessary for introduction into service, and identification of funding required and managerial structure for the acquisition.
- **Acquisition Stage:** All activities necessary to acquire the ship and provide support for the ship and equipment identified in the conception stage.
- **In-Service Stage:** All activities necessary for operation, maintenance, support and modification of the ship or equipment throughout its operational life. The in-service stage is normally the longest stage.
- **Disposal Stage:** All activities necessary to remove the ship or equipment and its supporting materials from service.

The Naval Ship Life Cycle Cost (LCC) Model is an extension to SPAR's existing cost model for estimating costs for ship design and new construction. This cost model now includes features for estimating the costs of ship operations and other life cycle activities. With the LCC estimating features linked directly to the design and construction cost model, changes in the design and production build strategy automatically flow into their impact upon LCC.

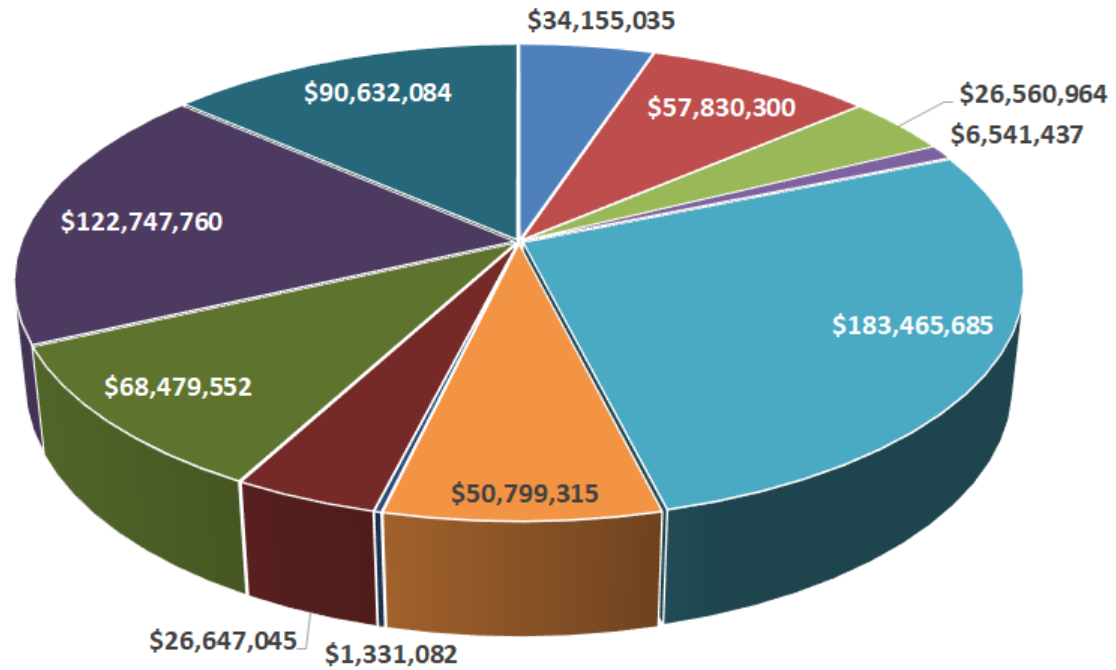


PHASE I

Initial Generation of Design &
Construction Cost – Lead Ship

Mono Hull Patrol Boat/Cutter/Frigate (Model Version May 2018)										NON-RECURRING COSTS																		
% Margin	-	%								Basic Research - Concept Design		\$	-															
% Mark-Up	-	%								Preliminary Design		\$	334,626															
% Change Orders	-	%								Contract Design		\$	4,015,514															
% Program Costs	-	%	Ship Type:			Version: A				Detail Design & Construction Engineering		\$	21,081,447															
% Contingencies	15.00	%	100 meter 30 Kt Surface Combatant			Date: 1-Apr-19				Production Planning & Scheduling		\$	4,350,140															
Pricing:																												
Shipbuilder Economic Mark-Up/Down:			0.0%		Non-Recurring Engineering & Production Planning																							
Technical Wage \$/Mhr:	\$ 90.75	\$ 92.56	w/ overhead		Standard Work Week:			40.00		hours/week		Contract Engineering Management		\$	4,350,140													
Production Wage \$/Mhr:	\$ 75.62	\$ 77.13	w/ overhead		Labor Rates:					Contingency Labor:		\$	5,019,392															
Overhead:	80.00	Cost/Labor Hour	120%		Senior Professional/Manager			\$	92.56	per hour		Data Rights Package		\$	-													
% G&A Labor:	-	%	120%		Engineer			\$	92.56	per hour		Miscellaneous Material & Support:		\$	401,215													
% G&A Material:	6.00	%	120%		Designer/Draftsperson/Planner			\$	92.56	per hour		Production Jigs, Cradles, & Templates,		\$	230,531													
Labor % Profit:	10.00	%	120%		Clerical			\$	92.56	per hour		TOTAL NON-RECURRING COSTS:		\$	44,467,772													
Material % Profit:	10.00	%	120%		Contingency (weighted average)			\$	92.56	per hour		G&A & Profit		\$	8,277,185													
													Total NRE		\$	52,744,957												
Jones Act Premium Material Factor:	No	1.00								Shipyard		Fab/Assy Mod'les																
Current Year:	2018	Shipyard Tech Support Labor Factor:			1.0000		No Ext.Modules		Estimated Schedules																			
Currency Exchange	1.0000	1.000 = none		Steel Productivity Factor:			1.3500		1.000		Est. Detail Engineering Time:		30.00		Months													
Shipyard Material Cost Factor:	1.0000	MILSPEC Prem.=1.21			Outfit Productivity Factor:			1.6580		1.000		Est. Construction Time:		30.00		Months												
Combined Material Cost Factor:	1.0000				On-Block Paint Factor:			0.9500		40 % Hours On Block		Overlap:		10.00		Months												
													RMS Men/Month:		377													
													\$		2018		\$ G&A		\$ Profit		\$		\$					
													Labor		Overhead		Labor Only		\$ Material		Material Only		Labor + Material		Total		Cum.Total	
Structures	1	927.1	198.57	-	184,092	13,921,410	14,727,361	-	2,265,340	135,920	3,105,003	34,155,035																
Propulsion	2	302.9	463.38	-	140,365	10,614,718	11,229,234	-	28,989,669	1,739,380	5,257,300	57,830,300																
Electrical	3	176.9	677.09	-	119,762	9,056,617	9,580,930	-	5,196,966	311,818	2,414,633	26,560,964																
Electronics & Navigation	4	97.7	135.72	-	13,264	1,003,058	1,061,128	-	3,662,806	219,768	594,676	6,541,437																
Auxiliary Systems	5	307.7	2,295.93	-	706,512	53,427,858	56,520,950	-	53,620,922	3,217,255	16,678,699	183,465,685																
Outfit & Furnishings	6	220.3	1,057.42	-	232,931	17,614,704	18,634,470	-	9,369,831	562,190	4,618,120	50,799,315																
Armament	7	49.7	126.64	-	6,300	476,439	504,021	-	216,618	12,997	121,007	1,331,082																
Technical Support	8	10.0%	67.37	-	140,323	12,733,777	11,225,809	-	250,000	15,000	2,422,459	26,647,045																
Shipyard Services	9	25.0%	168.44	-	350,807	26,528,701	28,064,524	-	7,227,277	433,637	6,225,414	68,479,552																
Margin, Bonds & Insurance	10	-	-	-	-	-	-	-	105,272,521	6,316,351	11,158,887	122,747,760																
Lead Ship Totals:		2,083	909.55	-	1,894,355	\$ 145,377,282	151,548,428	\$ -	\$ 216,071,950	\$ 12,964,317	\$ 52,596,198	\$ 578,558,175	\$	578,558,175														
Non-Recurring Costs:	% Total Lead Ship G1-7 Man-Hours:			25%	473,589	\$ 43,836,026	37,887,127	\$ -	\$ 631,746	\$ 37,905	8,239,280	\$ 90,632,084	\$	669,190,259														
	Technical Support:			7.39%	Production \$ Costs			See Note 1	Estimated Cost for Prime Contractor Management Team:					\$ -														
	Shipyard Services:			18.99%	Production \$ Costs				Over-All Program Management Fee:					0.0%														
	Fees & Insurance:			34.03%	Production \$ Costs				Total Price with Prime Contractor Management:					\$ 669,190,259														
	Non-Recurring Costs:			25.13%	Production \$ Costs				5.7%	Estimated CER Cost Risk		\$ 32,900,487	w/o Profit															
					Production Costs (1-7):			\$ 360,683,819	62.3%	GR 1-10		\$ 23,624,076	w/o Profit															
Production Hrs/LSW:	909.55																											
MT/MT	1																											
													57.8%	Est. Shipyard Performance Risk:		\$ 170,248,972	w/o Profit											
													57.8%	Est. Eng'r'g Performance Risk:		\$ 218,669,718	w/o Profit											
													1.5%	Est. Prod'n Schedule Cost Risk:		\$ 8,451,430	w/o Profit											
													67.8%	Lead Ship Price with 100% Risk:		\$ 1,123,084,941	w/o Profit											
													Total Price with % Risk:		20%	\$ 759,969,195												

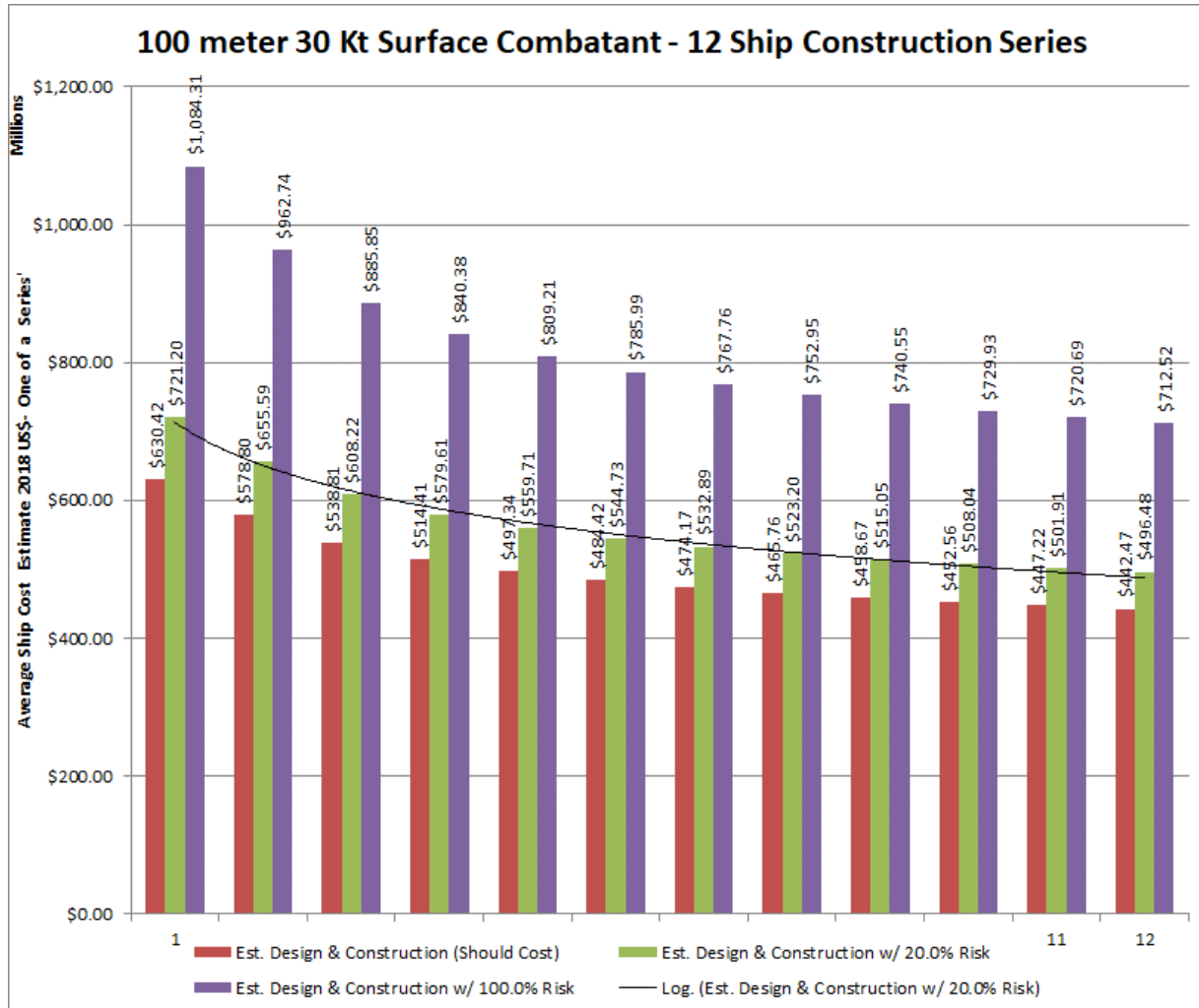
Lead Ship Design & Construction "Should" Cost Estimate



- Structures
- Propulsion
- Electrical
- Electronics & Navigation
- Auxiliary Systems
- Outfit & Furnishings
- Armament
- Technical Support
- Shipyard Services
- Margin, Bonds & Insurance
- Non-Recurring Costs

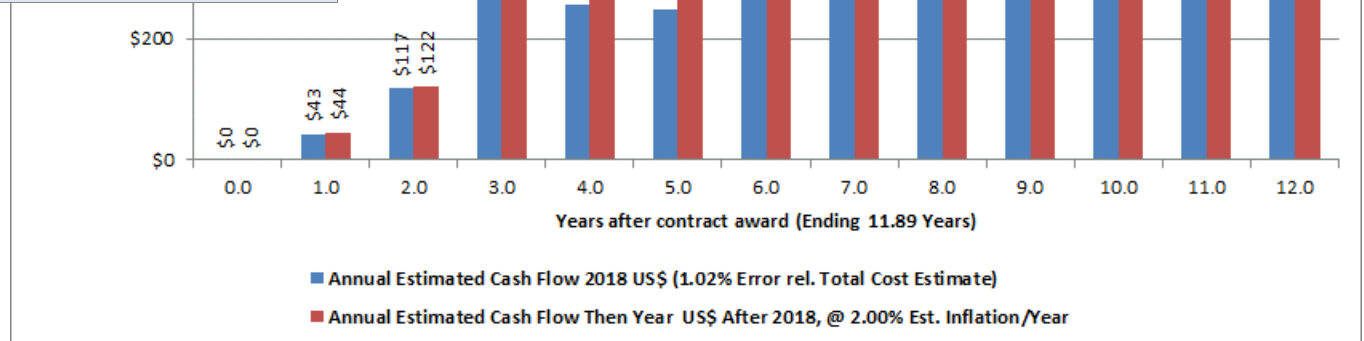
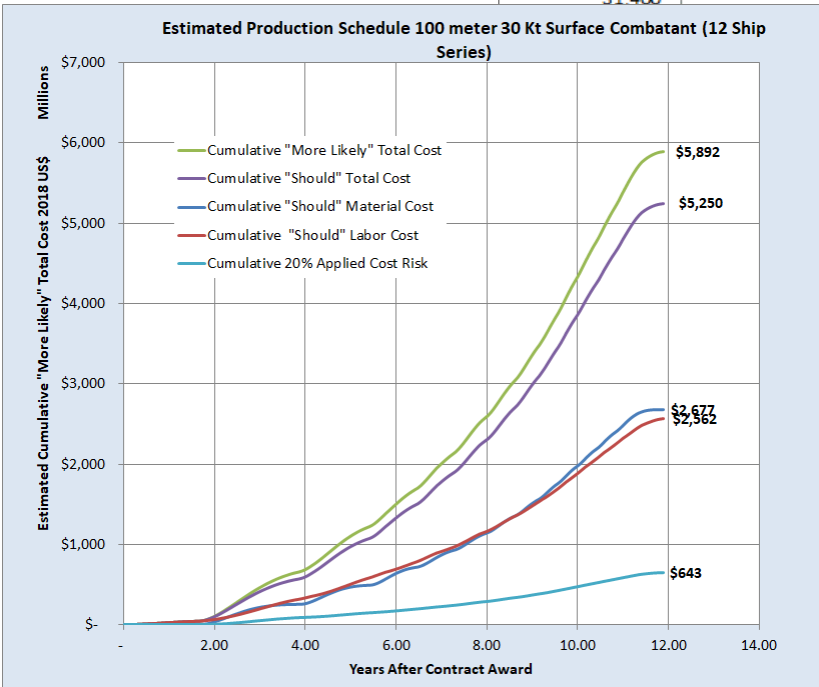
The Cost Model has features for
estimating new construction costs
for multiple vessel acquisition
programs

12 Ship New Construction Cost Estimates

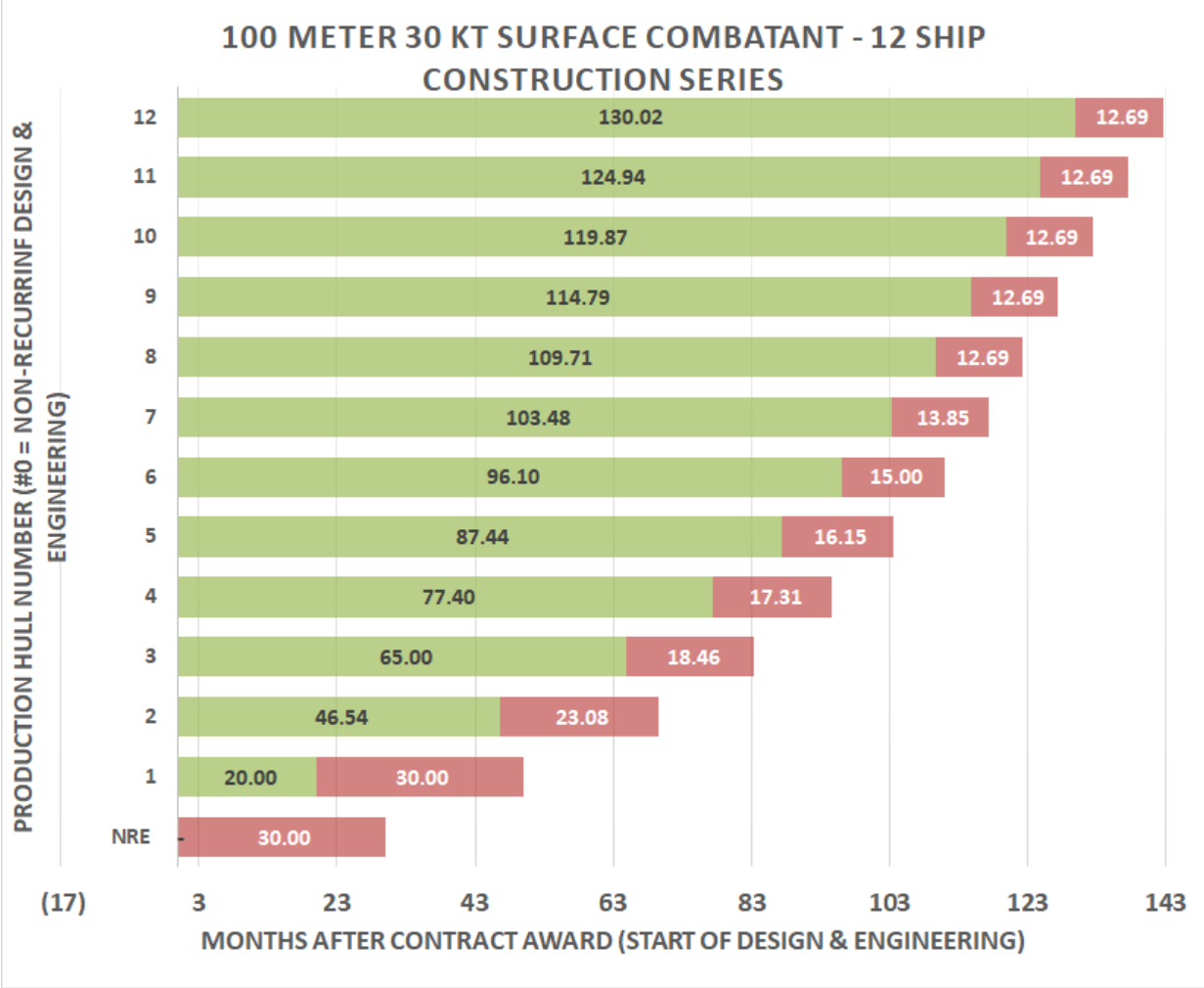


New Construction Costs & Schedules

100 meter 30 Kt Surface Combatant: 12 Ship Program



The Cost Model assumes ship operations begins when construction is completed.



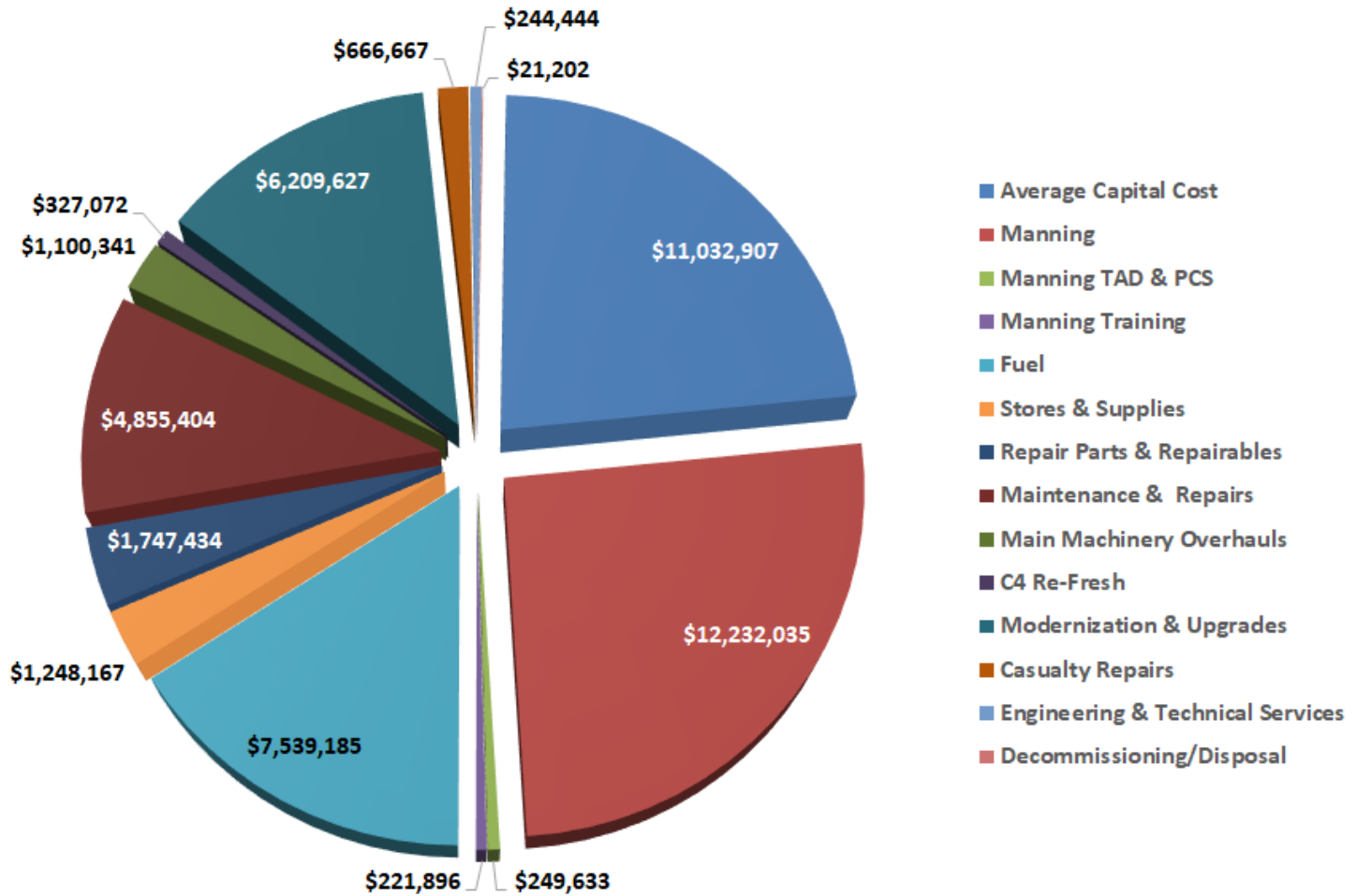
PHASE II

Generation of Operations, Repair & Maintenance Scenarios

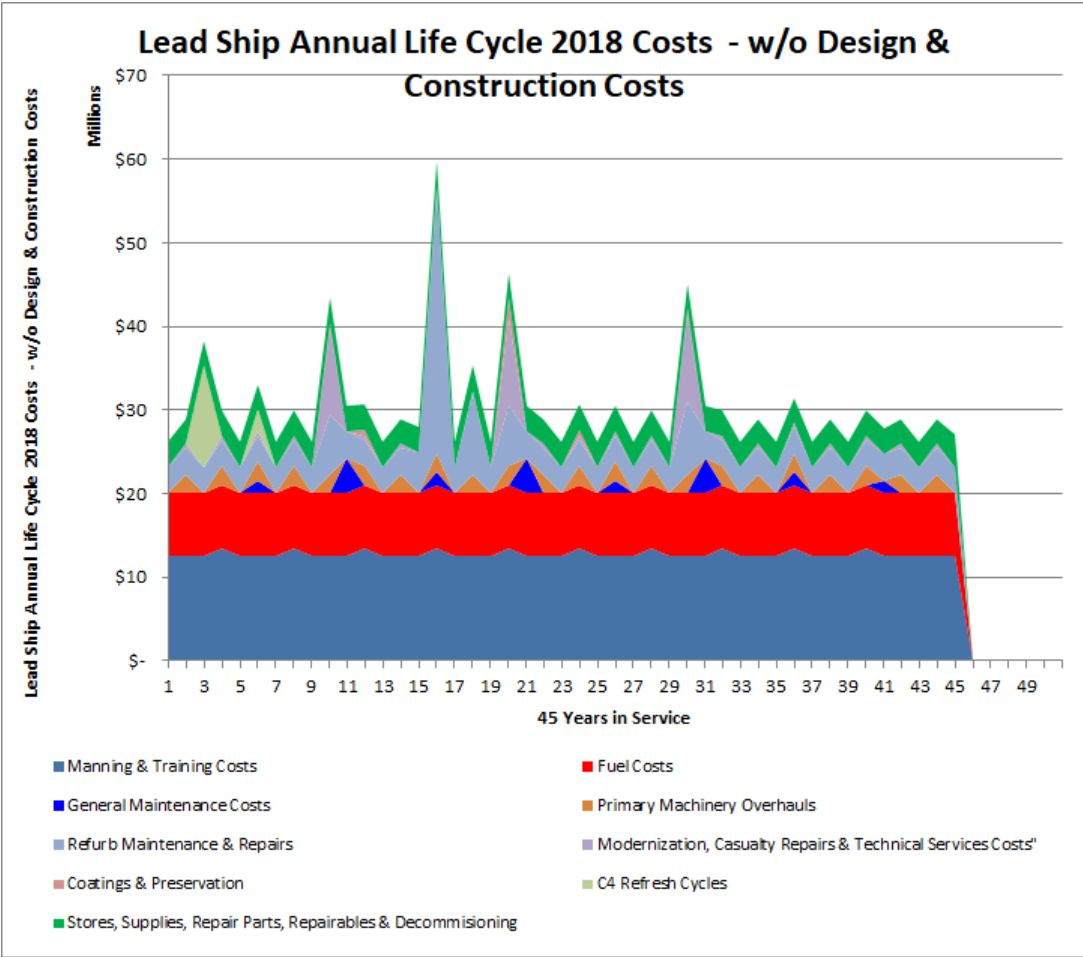
Estimated Annual Life Cycle Cost

Number of Ships Built:	12	Maximum of 8 for this analysis						
Total Price per Ship:	\$ 442,470,724		Average Life	45	Years			
Added Cost Risk	\$ 46,484,422		Average Ops Hours/Annum	2,000				
Average Acq. Cost	\$ 496,480,822		Average Ops Hours/Annual Day	5.48				
Average Acquisition \$/Annum	\$ 11,032,907	2018 US \$	Ref "Acq Summary Report" worksheet					
Av. Acquisition \$/Ops Hour	\$ 5,516							
Manning:			Designed					
			Accommodations	Av\$/Man/Annum	total Manning \$/Annum			
Commissioned Officers	12	Persons	12	\$ 165,740	\$ 1,988,875			
Non-Commissioned Officers	18	Persons	18	\$ 166,844	\$ 3,003,184			
Enlisted	76	Persons	76	\$ 95,263	\$ 7,239,977			
	106	Persons	f "Ship Characteristics"		\$ 12,232,035			
Estimated Training	\$ 998,533	8.16%	annual manning cos		percentages of manpower \$ from USN NCAD 2005 = (4/49)			
Fuel:	Ref "Propulsion" worksheet							
2018 US \$/Metric Tonne	\$ 850.00	see below for estimated fuel prices				Enter only the data cells colored gray.		
Design Total Propulsion kW	24,000							
Maximum Speed Knots	30.00							
Design Total Ship Services kW	15,534							
Estimated MT Fuel/Annum	8,870							
Estimated Fuel \$/Annum	\$ 7,539,185							
		Knots	kW	% Ops Hrs	Ops Hrs		Est. Fuel MT/Hr	MT/Annum
Estimated kW WarSide	-	15,534	30%	600	4.96		2,977	
Estimated kW at Cruise:	15.00	8,789	60%	1,200	2.81		3,368	
Full Power	30.00	39,534	10%	200	12.63		2,525	
						8,870		
				Estimated SFC: g-kw/hr	319			
				Includes Est. Fuel Savings: Ref "Propulsion Components" Worksheet		0.00%		
LCC Cost Summary				Average Lost Ops Hours		Cost of Lost Ops Hours		
Average Cost/Annum	\$/Annum	\$/OPS Hour	\$/Annum	per Annum	per Annum			
Average Capital Cost	\$ 11,032,907	\$ 5,516	\$ 23.13%					
Manning	\$ 12,232,035	\$ 6,116	25.65%					
Manning TAD & PCS	\$ 249,633	\$ 125	2.04%	percentages of manpower \$ from USN NCAD 2005 = (1/49)				
Manning Training	\$ 221,896	\$ 111	8.16%	percentages of manpower \$ from USN NCAD 2005 = (4/49)				
Fuel	\$ 7,539,185	\$ 3,770	15.81%					
Stores & Supplies	\$ 1,248,167	\$ 624	2.62%	percentages of manpower \$ from USN NCAD 2005 = (5%/49%)				
Repair Parts & Repairables	\$ 1,747,434	\$ 874	3.66%	percentages of supplies \$ from USN NCAD 2005 (7%/5%)				
Maintenance & Repairs	\$ 4,855,404	\$ 2,428	10.18%	80	\$ 442,660			
Main Machinery Overhauls	\$ 1,100,341	\$ 550	2.31%					
C4 Re-Fresh	\$ 327,072	\$ 164	0.69%					
Modernization & Upgrades	\$ 6,209,627	\$ 3,105	13.02%	58	\$ 319,272			
Casualty Repairs	\$ 666,667	\$ 333	1.40%	-	\$ -			
Engineering & Technical Services	\$ 244,444	\$ 122	0.51%					
Decommissioning/Disposal	\$ 21,202	\$ 11	0.04%					
Total \$ per Annum	\$ 47,696,013	\$ 23,848		138	\$ 761,932			
w/o Capital Cost	\$ 36,663,106							
w/o Modernization	\$ 30,453,479							

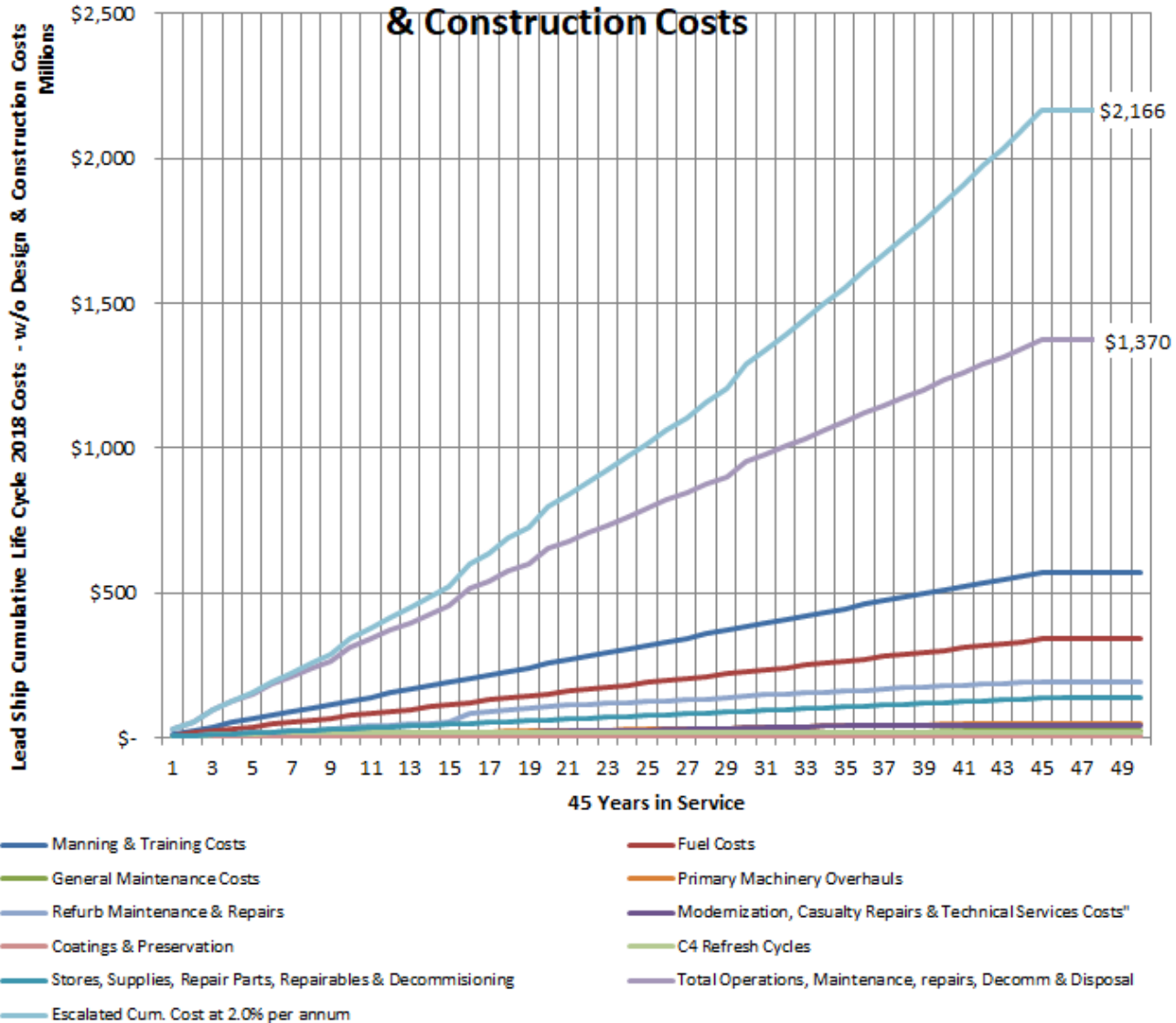
2018 Estimated Lead Ship Annual Life Cycle Cost \$47,696,013



The LCC Cost Model generates a full compliment of pertinent overview charts that easily show the effects of design/construction/operations alternatives upon LCC.
Chart does not include planned Modernization.



Lead Ship Cumulative Life Cycle 2018 Costs - w/o Design & Construction Costs



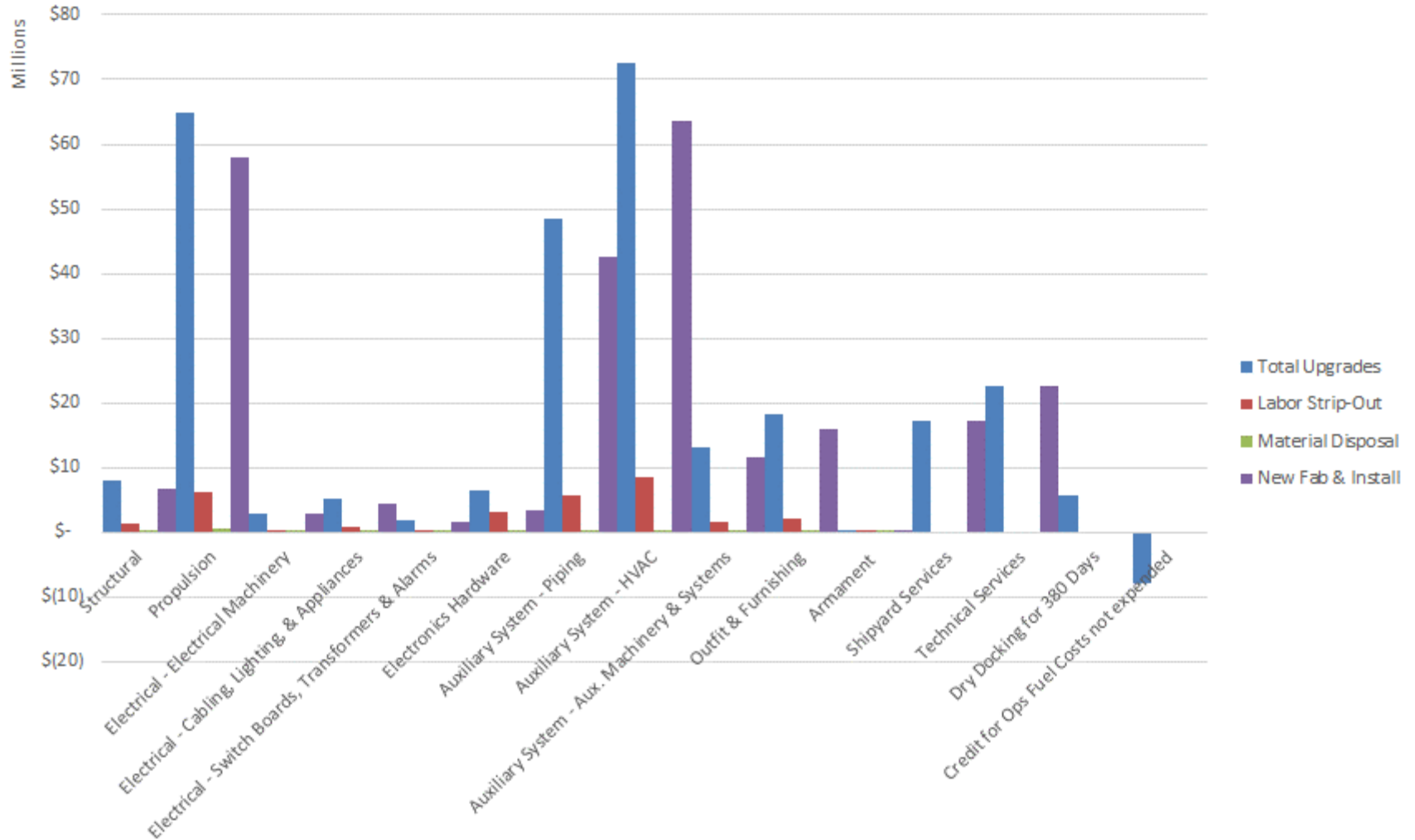
MID-LIFE MODERNIZATION

The LCC Cost Model offers features for planning large-scale re-investments for mid-life refurbishing, upgrades and modernization.

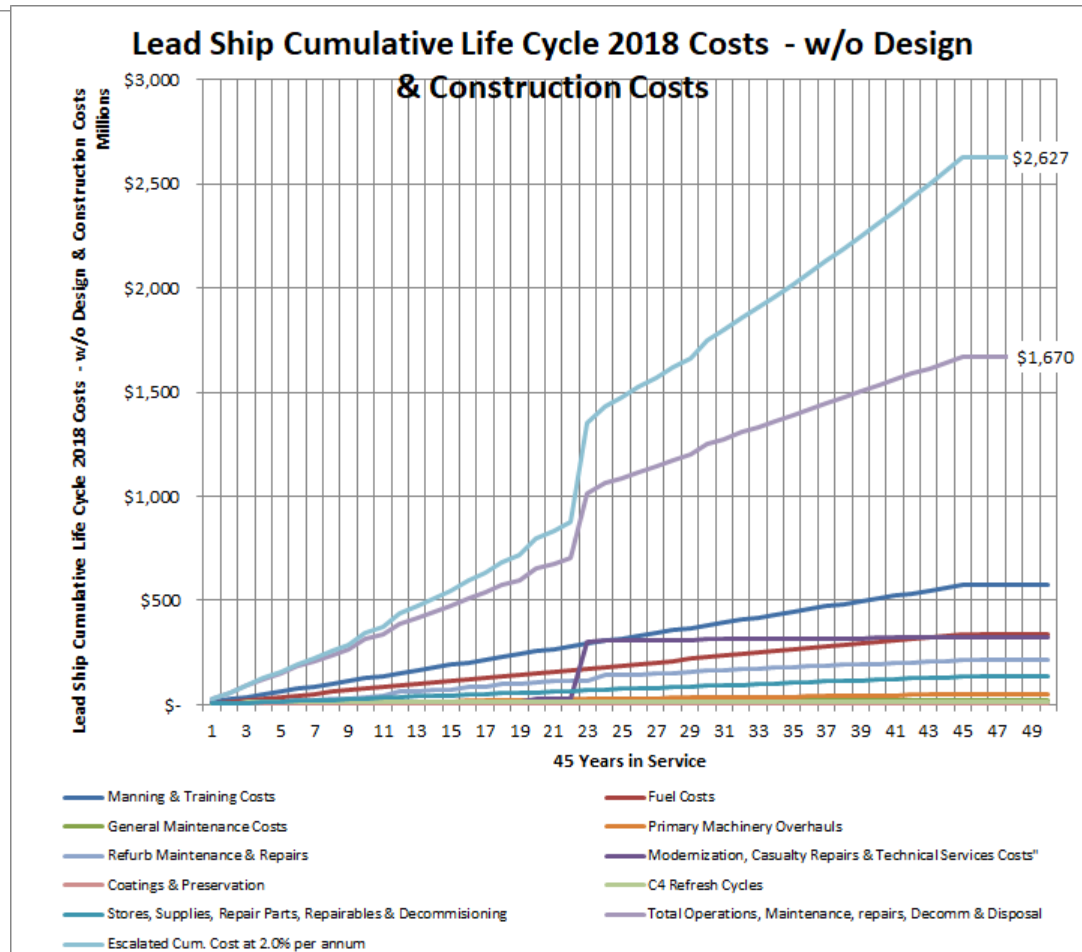
Such activities typically require costs to rip-out and dispose of existing equipment and systems prior to fabricating and installing the replacement upgrades.

Labor Strip-Out	Material Disposal	New Fab & Install	Total Mod	
\$ 1,260,546	\$ 10,566	\$ 6,831,007	\$ 8,102,118	Structural
\$ 6,302,730	\$ 676,039	\$ 57,830,300	\$ 64,809,069	Propulsion
\$ 146,482	\$ 40,398	\$ 2,752,329	\$ 2,939,209	Electrical - Electrical Machinery
\$ 790,756	\$ 8,371	\$ 4,372,334	\$ 5,171,460	Electrical - Cabling, Lighting, & Appliances
\$ 197,689	\$ 11,828	\$ 1,579,825	\$ 1,789,342	Electrical - Switch Boards, Transformers & Alarms
\$ 3,151,365	\$ 42,708	\$ 3,270,718	\$ 6,464,792	Electronics Hardware
\$ 5,610,449	\$ 288,290	\$ 42,466,752	\$ 48,365,490	Auxiliary System - Piping
\$ 8,415,673	\$ 432,435	\$ 63,700,127	\$ 72,548,236	Auxiliary System - HVAC
\$ 1,647,479	\$ 64,948	\$ 11,484,795	\$ 13,197,223	Auxiliary System - Aux. Machinery & Systems
\$ 2,167,658	\$ 104,229	\$ 16,049,748	\$ 18,321,635	Outfit & Furnishing
\$ 32,355	\$ 758	\$ 199,662	\$ 232,775	Armament
\$ -	\$ -	\$ 17,119,888	\$ 17,119,888	Shipyards Services
\$ -	\$ -	\$ 22,658,021	\$ 22,658,021	Technical Services
			\$ 5,671,975	Dry Docking for 380 Days
			\$ (7,958,029)	Credit for Ops Fuel Costs not expended

Ship Upgrade & Modernization



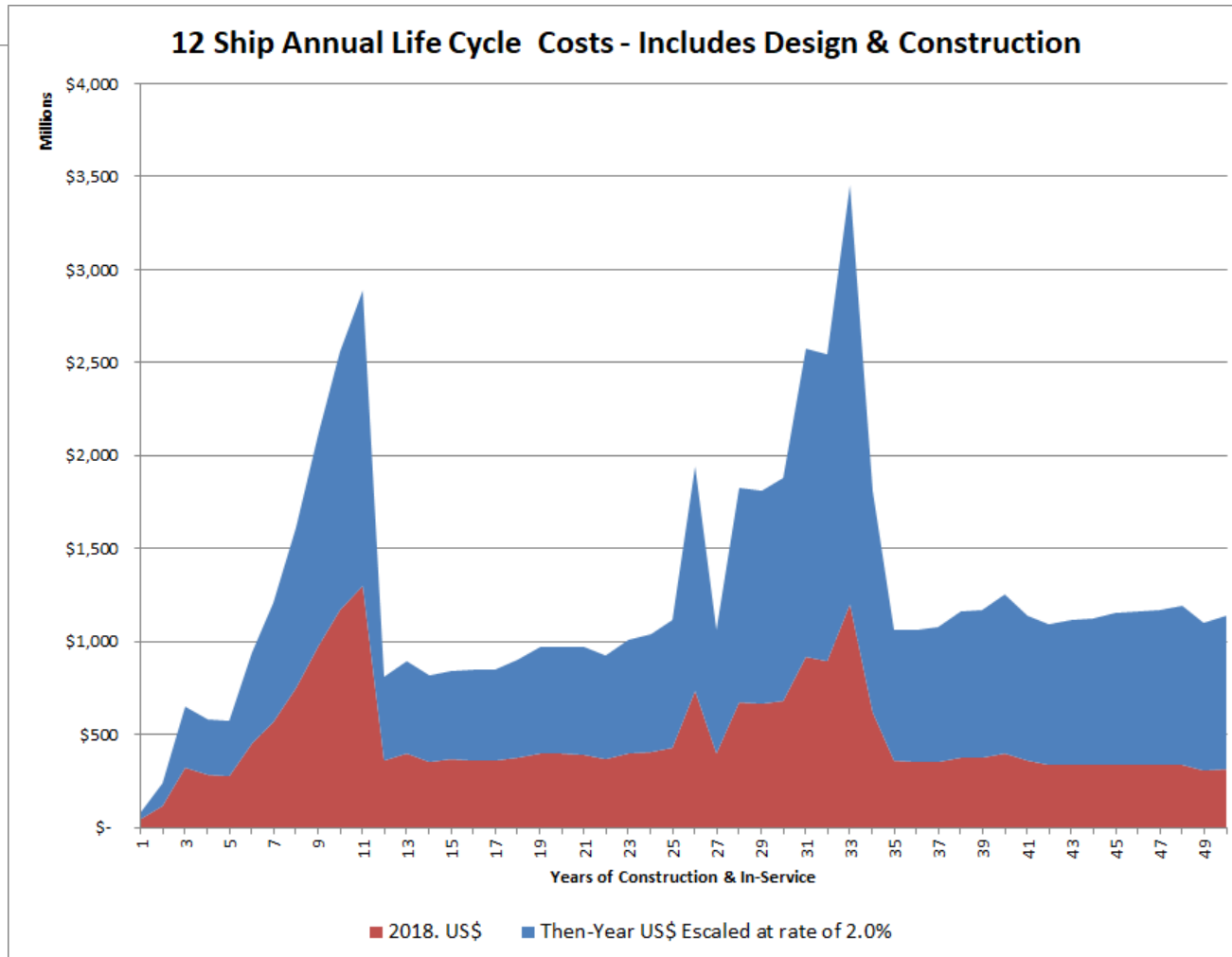
Cumulative Costs that Include Mid-Life Modernization



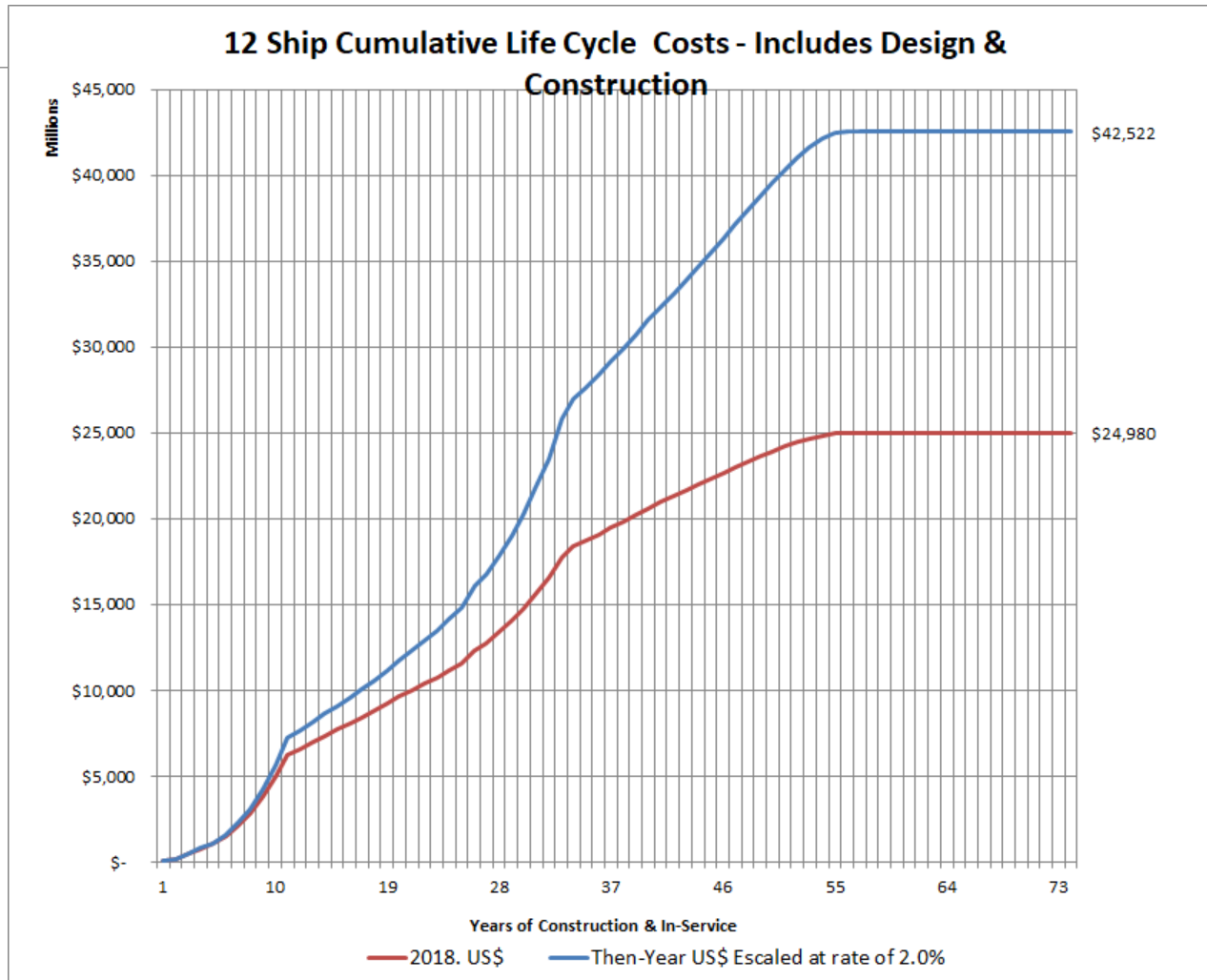
LCC for Multi-Vessel Class Programs

Since the Design & Construction Cost Model has features for estimating costs for multiple ship acquisition programs, additional features estimate LCC across the multiple ship class.

Estimated Annual LCC Costs Across Class



Cumulative LCC Costs Across Class

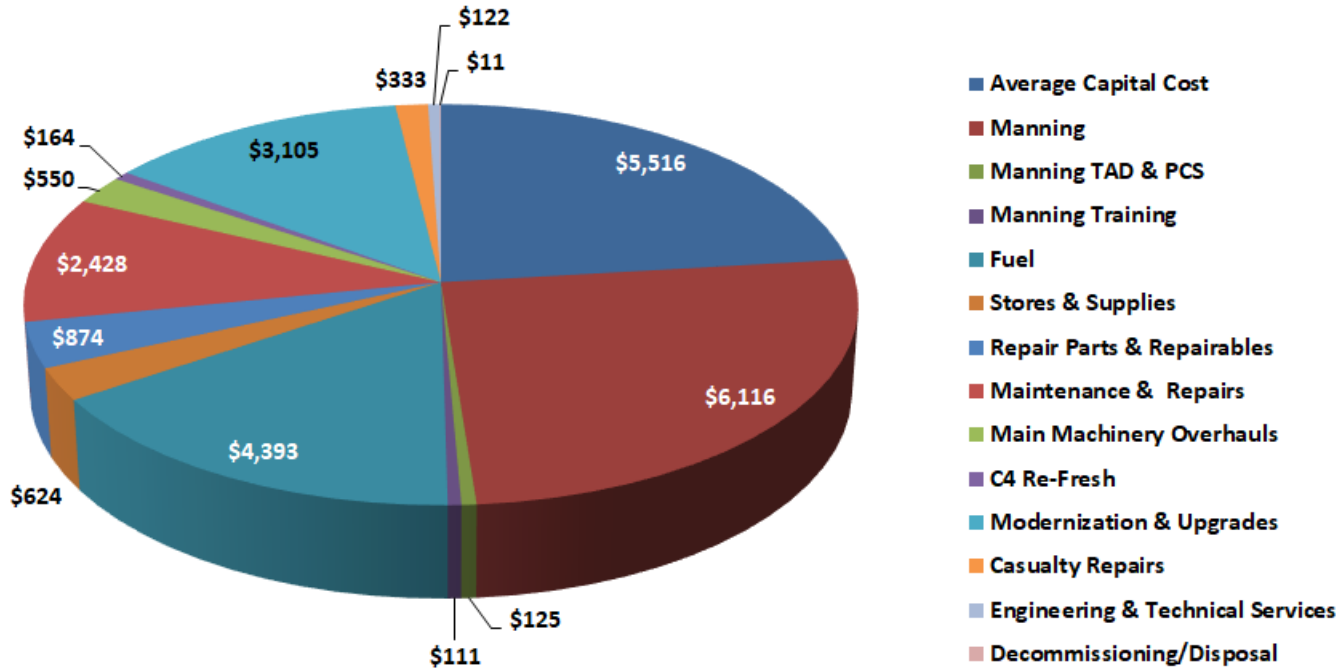


The LCC Cost Model can be used to identify differences in LCC with alternative ship systems, materials, construction build strategies as well as operations and maintenance scenarios.

Selecting better design choices can produce ships that are less expensive to operate and maintain and can increase the in-service time, and even lengthen its useful life expectancy in meeting the ship's mission requirements.

Summarizing LLC per Ship Operating Hours

2018 Estimated Lead Ship Life Cycle Cost per OPS Hour \$23,848



PHASE III

Evaluate impact on LCC for changes in design/construction scenarios, operations requirements, repair & maintenance plans

Life cycle costing can be applied to establish improvements at different levels of technology evolution:

- 1. Ship Design Decisions**
- 2. Ship Alterations/Modifications/Conversions**
- 3. Equipment Selections**
- 4. Plant Configurations**
- 5. Commonality Evaluations**
- 6. Replacement Upgrades versus Maintaining Older Obsolete Equipment/Systems**
- 7. Substituting Different Materials & Methods in Design, Engineering, & Manufacture**
- 8. Alternate Maintenance and Upgrade Plans & Schedules**

The life cycle modeling provides many ways to vary not only the impact of changes in elements of design and construction, but also the many variations of operation requirements, maintenance and upgrade plans.

While the cost model offers cost data extracted from SPAR's wide ranging libraries, other sources of cost data can be added.

For additional details of the LCC cost model, its [user manual](#) can be downloaded from SPAR's web site.

Over 45 Years Serving the Shipbuilding & Repair Industry

