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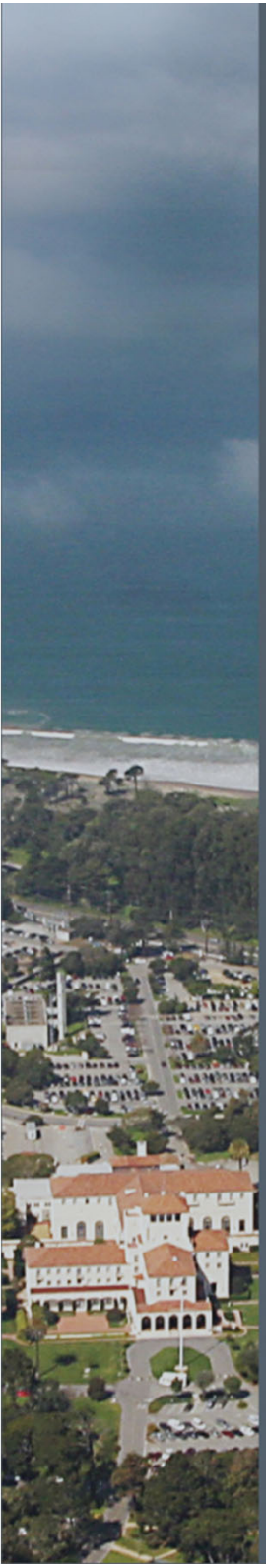
Cybersecurity, Artificial Intelligence, and Risk Management: Understanding Their Implementation in Military Systems Acquisitions

Mun, Johnathan

Monterey, California. Naval Postgraduate School



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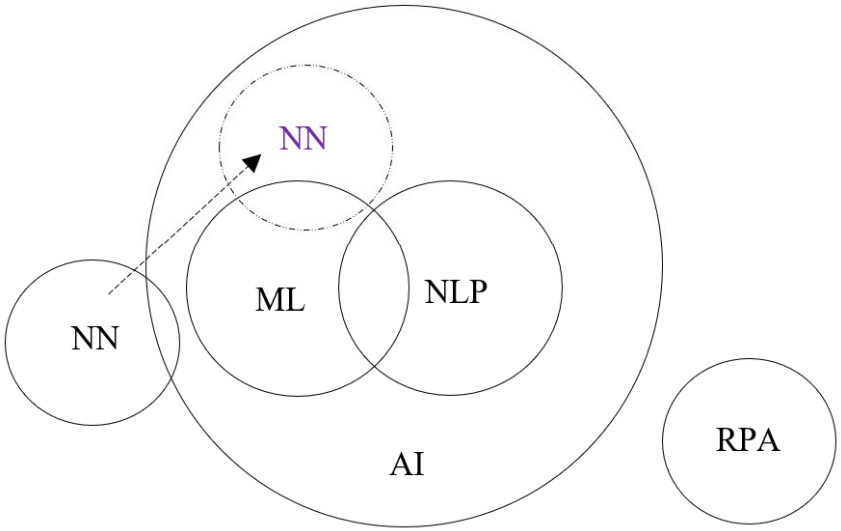
Cybersecurity, Artificial Intelligence, and Risk Management: Understanding Their Implementation in Military Systems Acquisitions

Johnathan Mun, Ph.D.
Professor of Research
Dept. Information Sciences

Quantitative Data Science Risk-Based Stochastic Decision Analytics

MAY 2022

From AI to Autonomy



Artificial Intelligence (AI):
algorithms exhibiting "smart" behavior

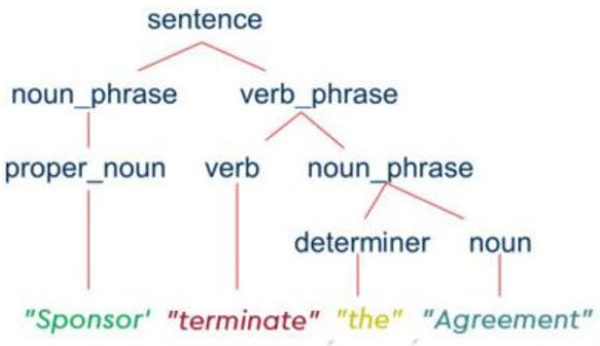
Machine Learning (ML):
algorithms that detect patterns and use them for prediction and decision making

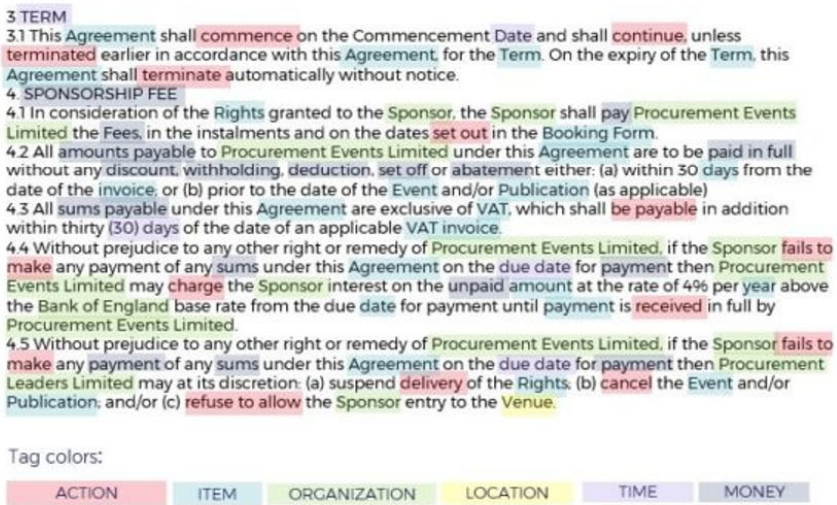
Natural Language Processing (NLP):
Algorithms that can interpret, predict, transform, and generate human language

Robotic Process Automation (RPA):
Algorithms that mimic human actions to reduce simple but repetitive tasks

NATURAL LANGUAGE PROCESSING IN PROCUREMENT

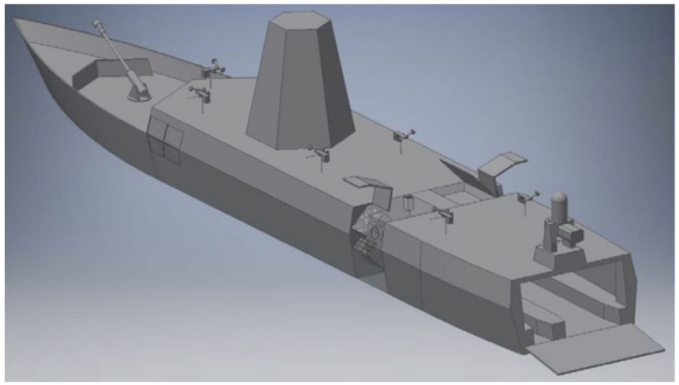
Identifying parts of a text and their grammatical roles through text parsing.



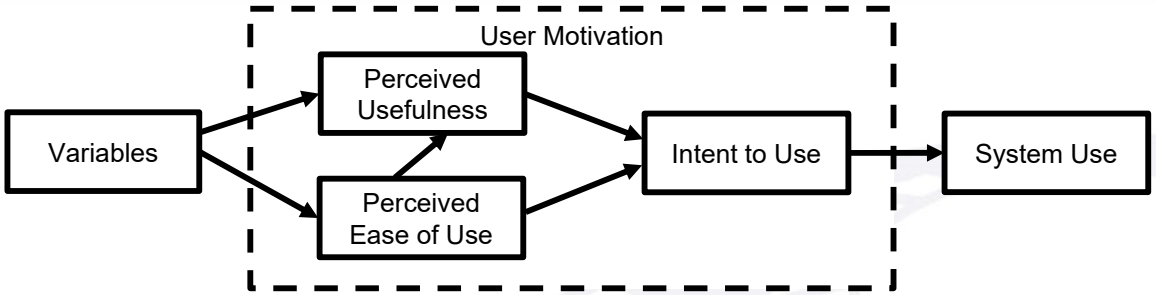


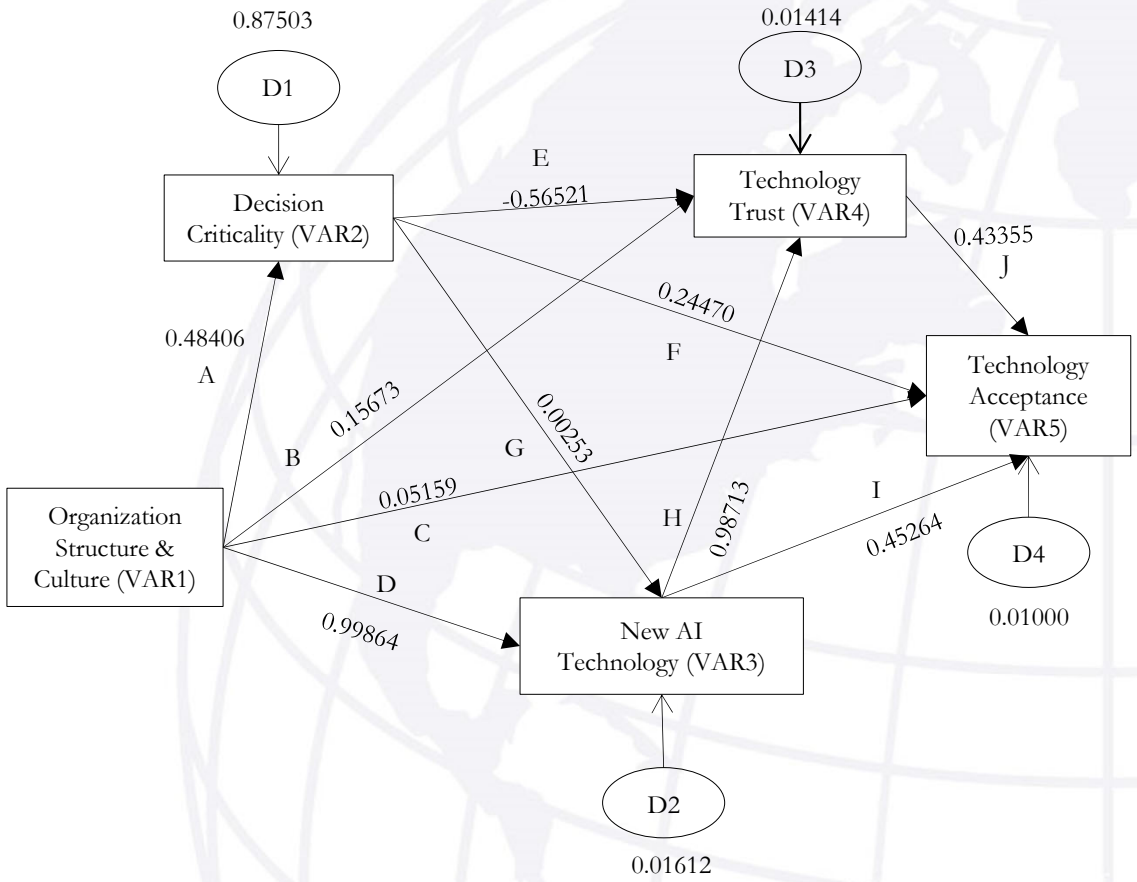
AI/Autonomy: Technology Trust & Technology Use

Sea Ox & Sea Otter (EOD)



LMACC Lightly Manned Autonomous Combat Capability (Sea Hunter/Sea Strike)





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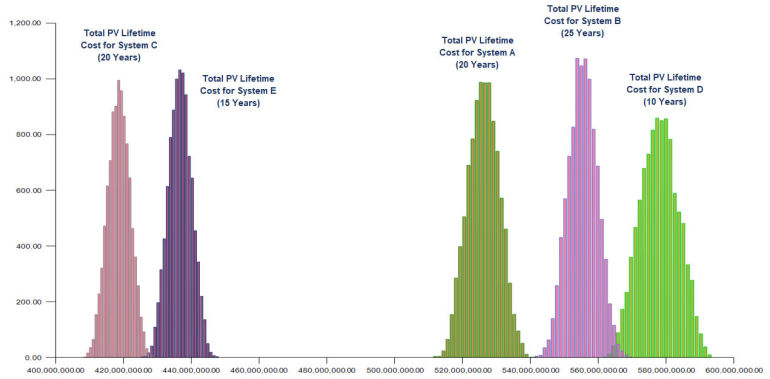
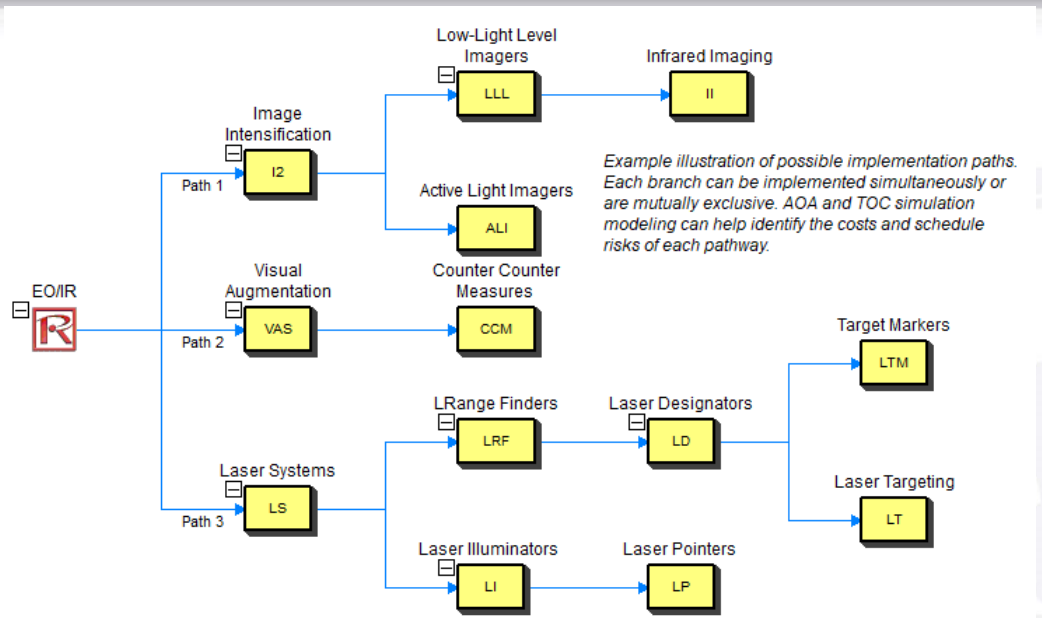
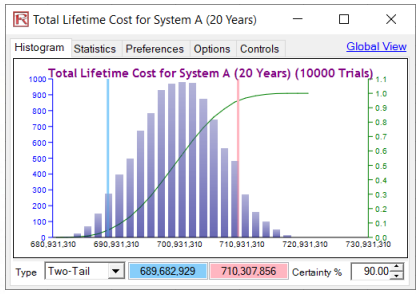
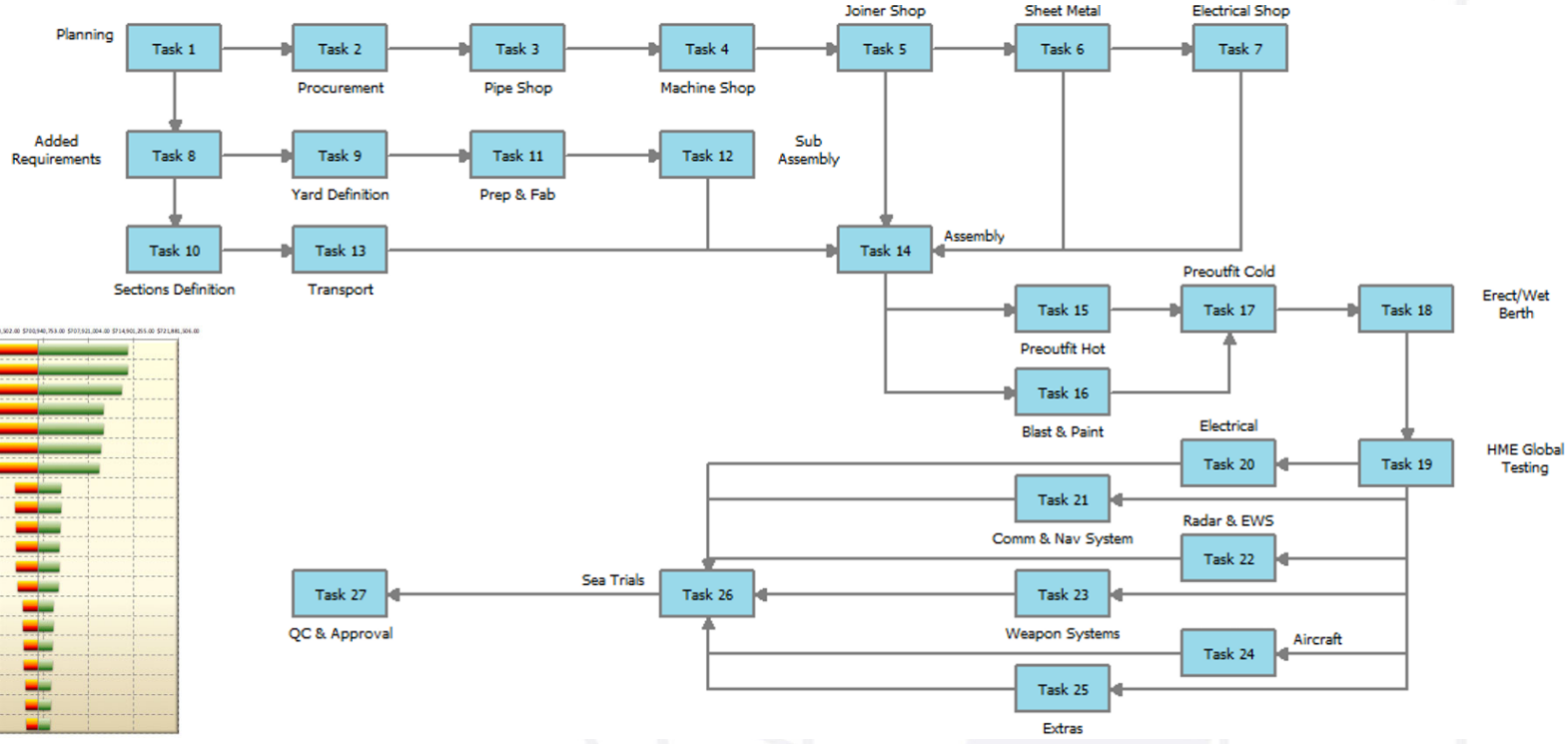
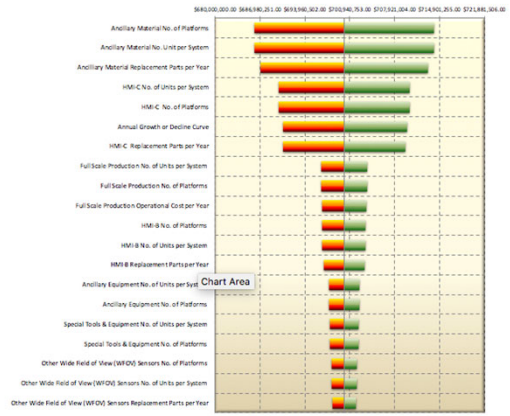
Decision Analytics (AOA & Options)











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Lifecycle and TOC: 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:

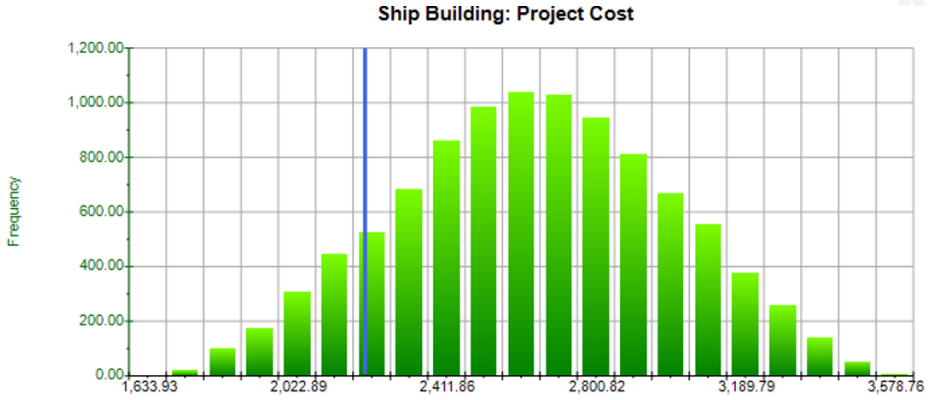
Network Diagram | Schedule & Cost

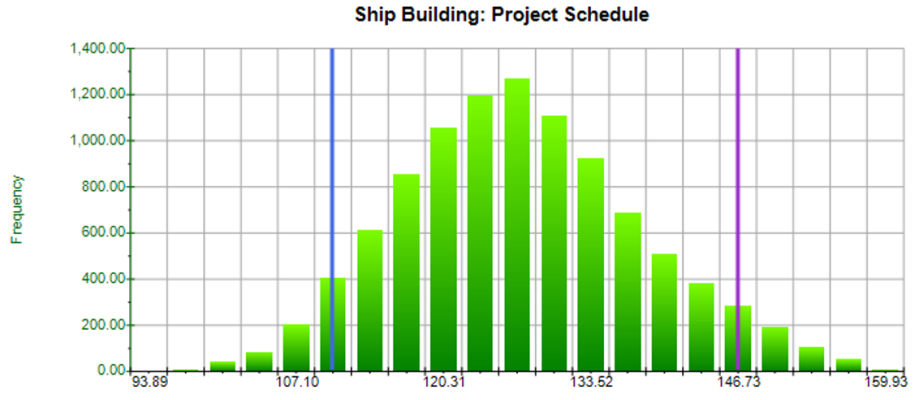
☑ Include Schedule-Based Cost Analysis ☐ Include Probabilities of Success of Each Task and Model Their Impacts

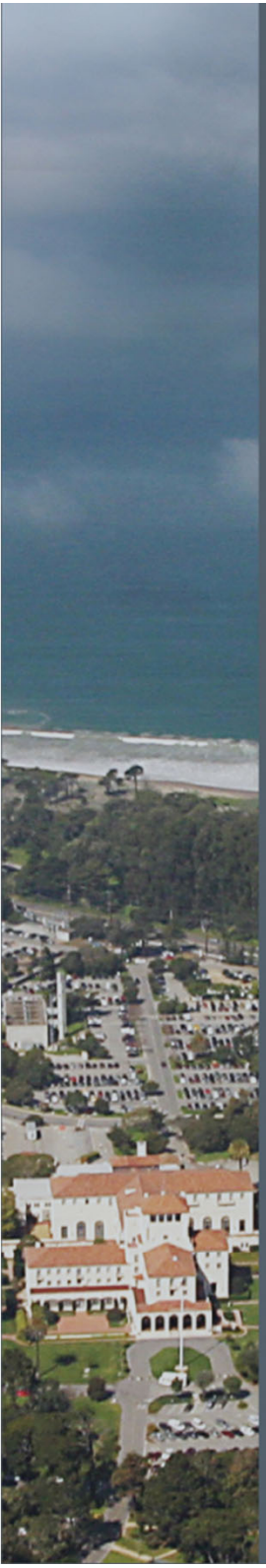
☑ Include Budget Overrun & Buffers ☑ Perform Risk Simulation Run Run All Projects

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%







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BACKUP

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

Excellence Through Knowledge

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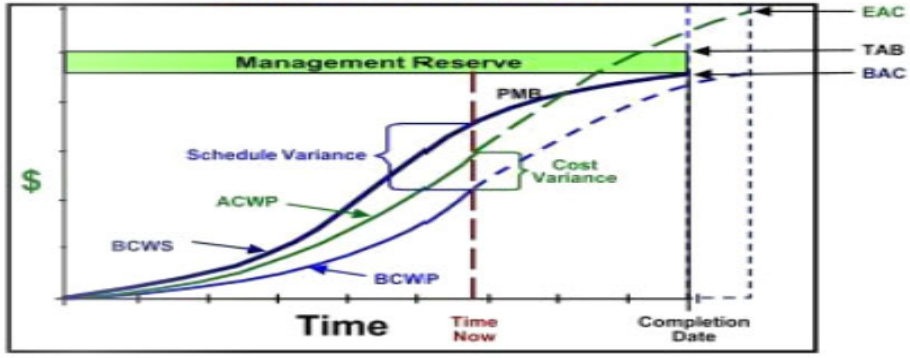
EVM to IRM

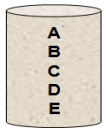
Earned Value Management 'Gold Card'



Integrated Risk Management Process

1 List of projects and strategies to evaluate

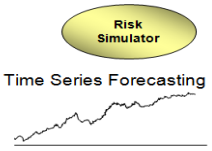
RISK IDENTIFICATION



Start with a list of projects or strategies to be evaluated… these projects have already been through qualitative screening

2 Base case projections for each project

RISK PREDICTION



…with the assistance of time-series forecasting, future outcomes can be predicted…

3 Develop static financial models

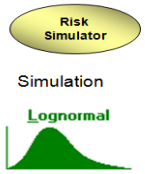
RISK MODELING

Traditional analysis stops here!

…the user generates a traditional series of static base case financial (discounted cash flow) models for each project…

4 Dynamic Monte Carlo simulation

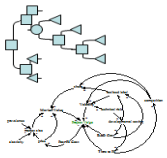
RISK ANALYSIS



…Monte Carlo simulation is added to the analysis and the financial model outputs become inputs into the real options analysis…

5 Framing Real Options

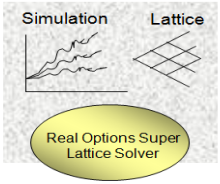
RISK MITIGATION



…the relevant projects are chosen for real options analysis and the project or portfolio real options are framed…

6 Options analytics, simulation, optimization

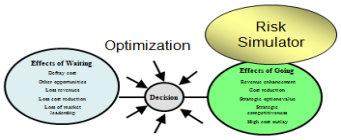
RISK HEDGING



…real options analytics are calculated through binomial lattices and closed-form partial-differential models with simulation…

7 Portfolio optimization and asset allocation

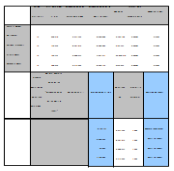
RISK DIVERSIFICATION



…stochastic optimization is the next optional step if multiple projects exist that require efficient asset allocation given some budgetary constraints… useful for strategic portfolio management…

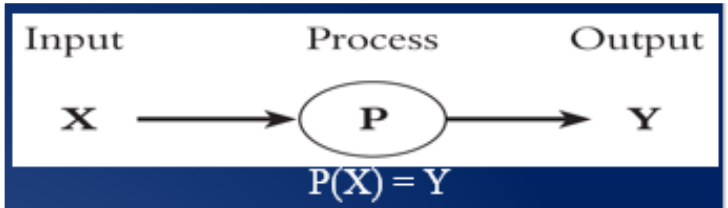
8 Reports presentation and update analysis

RISK MANAGEMENT



…create reports, make decisions, and do it all again iteratively over time…

WWW.NPS.EDU



$P(X) = Y$

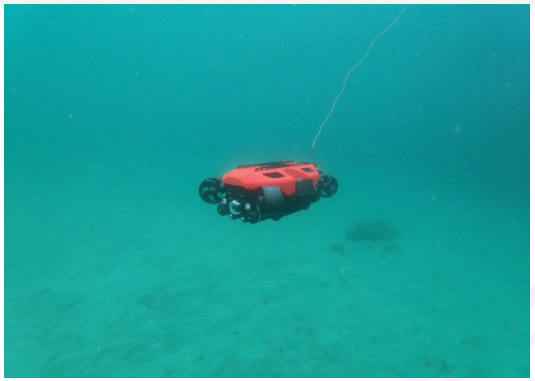
Fundamental assumptions:
1. If X = Y no value has been added.
2. "value" ∝ "change"
3. "change" can be measured by the amount of knowledge required to make the change.

So "value" ∝ "change" ∝ "amount of knowledge required to make the change"

Steps	Learning Time	Process Description	Binary Query Method
One	Identify core process and its subprocesses.		
Two	Establish common units and level of complexity to measure learning time.	Describe the products in terms of the instructions required to reproduce them and select unit of process description.	Create a set of binary yes or no questions such that all possible outputs are represented as a sequence of yes or no answers.
Three	Calculate learning time to execute each subprocess.	Calculate number of process description words, pages in manual, and lines of computer code pertaining to each subprocess.	Calculate length of sequence of yes or no answers for each subprocess.
Four	Designate sampling time period long enough to capture a representative sample of the core processes final product or service output.		
Five	Multiply the learning time for each subprocess by the number of times the subprocess executes during the sample period.	Multiply the number of process words used to describe each sub process by the number of times the subprocess executes during sample period.	Multiply the length of the yes or no string for each sub process by the number of times the subprocess executes during sample period.
Six	Calculate cost to execute knowledge (learning time and process instructions) to determine process costs.		
Seven	Calculate ROK and ROP and interpret the results.		

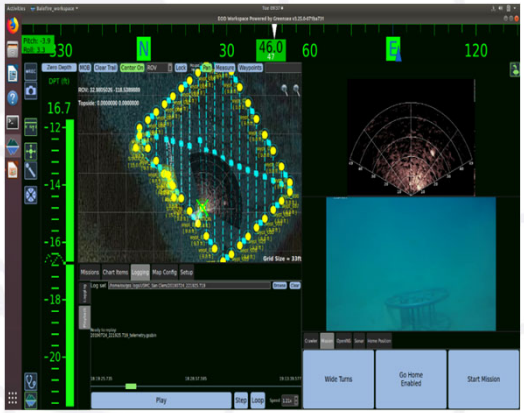
Levels of Automation

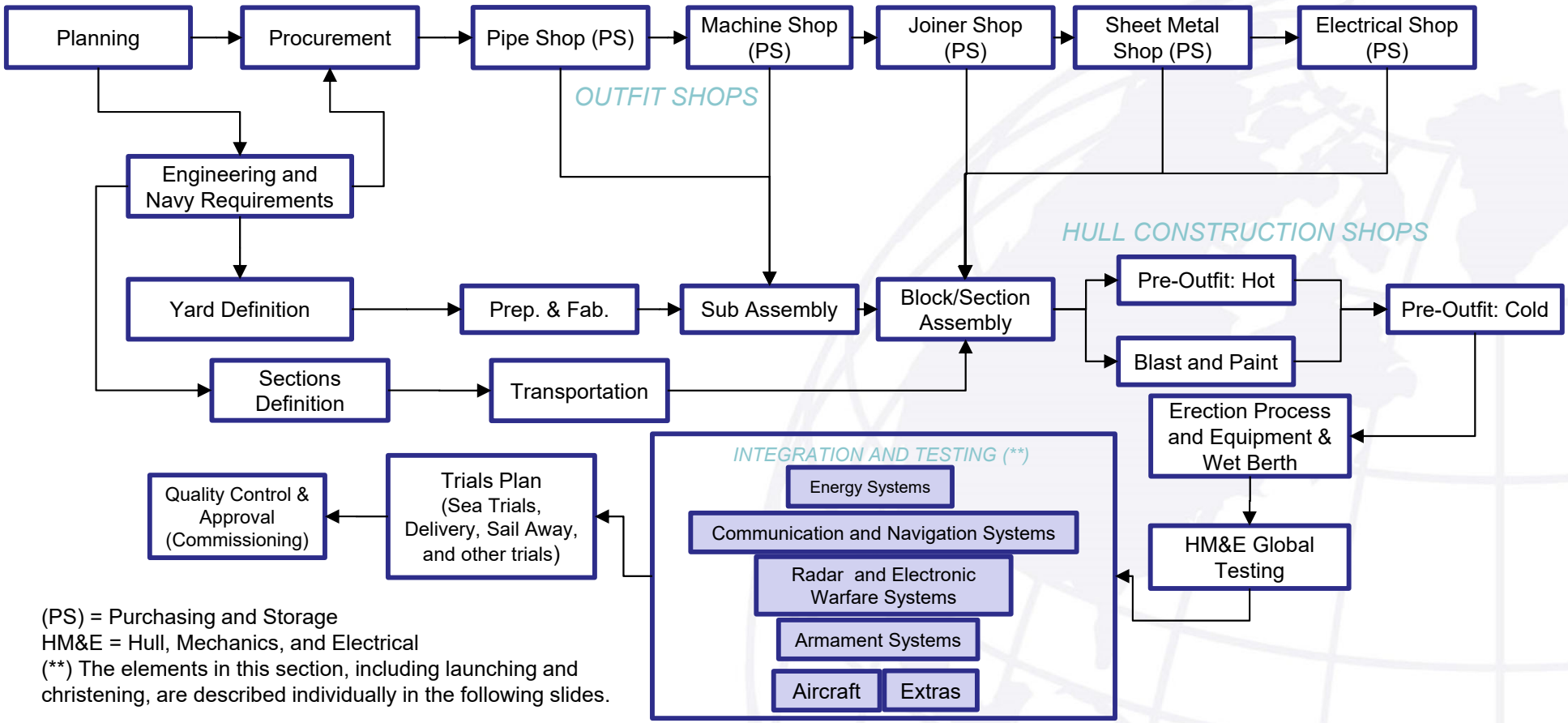
SRS Fusion ROV
Low LOA



Sonar EMILY USV
Medium LOA

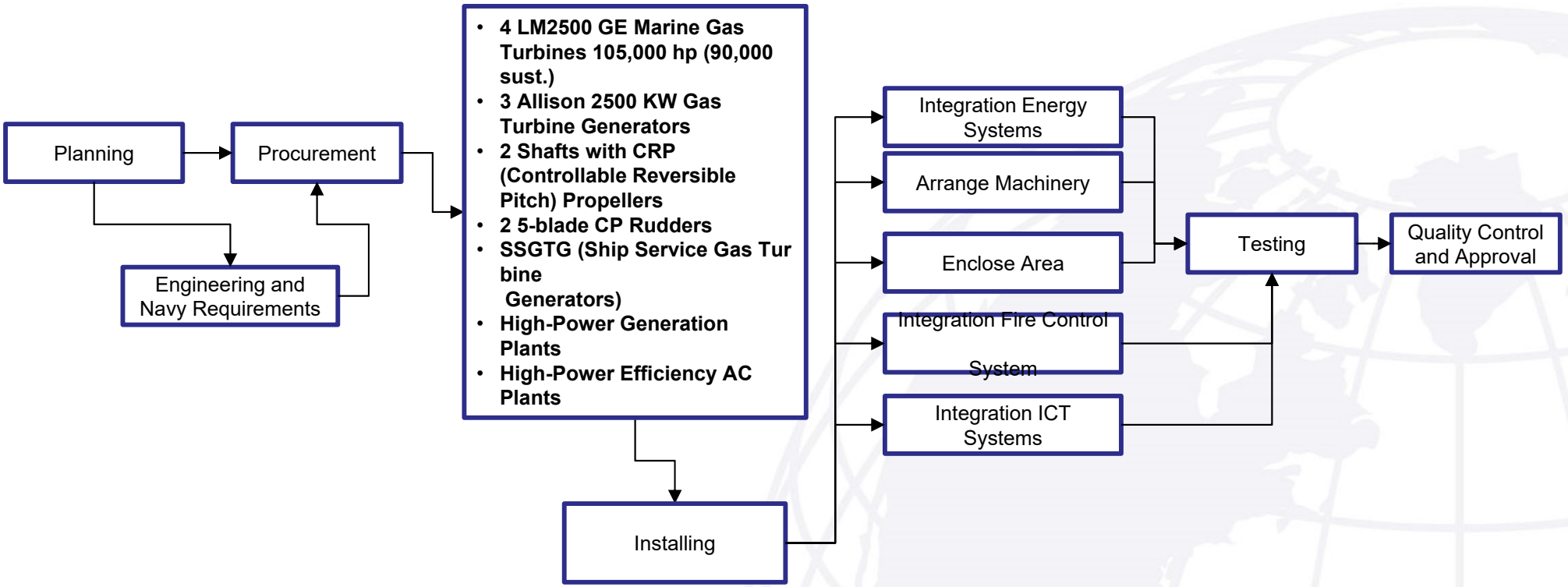
Sea OX
High LOA



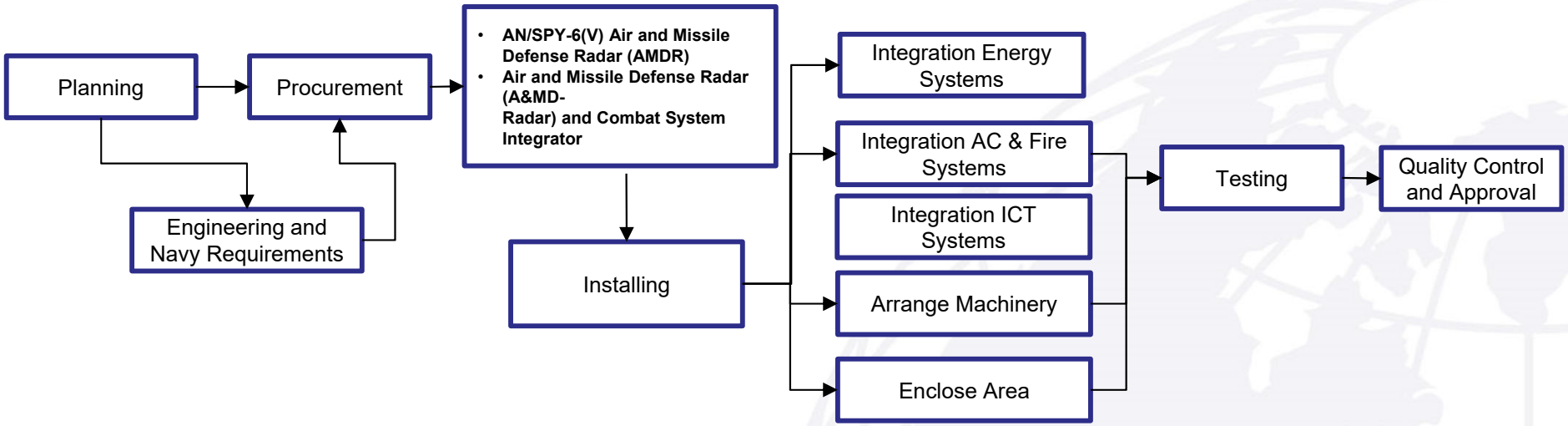


(PS) = Purchasing and Storage
HM&E = Hull, Mechanics, and Electrical
(**) The elements in this section, including launching and christening, are described individually in the following slides.

Project Tasks (Energy Systems)



Propulsion is supported by 4 General Electric LM2500 gas turbines each generating 26,500 hp (19,800 kW);[4] coupled to two shafts, each driving a five-bladed reversible controllable-pitch propeller



The program completed Technology Development (TD) contracts in September 2012 and released a Request for Proposals for the E&MD Phase in June 2012. The AMDR program achieved Milestone B in September 2013 and received a signed Acquisition Decision Memorandum on October 4, 2013. After a full and open competition, an Engineering and Manufacturing Development (E&MD) phase contract was awarded to Raytheon on October 10, 2013. Raytheon was awarded a $385,742,176 cost-plus-incentive-fee contract for the engineering and modeling development phase design, development, integration, test, and delivery of Air and Missile Defense S-Band Radar (AMDR-S) and Radar Suite Controller (RSC).

http://www.globalsecurity.org/military/systems/ship/systems/amdr.htm

Cost information on Navigation, Weapons, and Aircraft was similarly obtained and is illustrated below:

Category	*Items*	*Quantity*	*Min Unit Cost*	*Aveg Unit Cost*	*Max Unit Cost*	*Total Cost ($M)*
Navigational Equipment	AN/WSN-5 Inertial Navigation System; AN/WRN-6 ; ANISRN-25 (V); MK 4	1	8	14	20	14.00
	MK 6 MOD 4D Digital Dead Reckoning Tracer					
	AN/URN-25 TACAN; AN/SPS-64 (V) 9 I Band Radar					
	Navy Standard No. 3 Magnetic Compass;					
	Total Navigation system	1	15.84	19.8	23.76	19.80
	Chronometer Size 85; Flux Compass					
Total		***2***	***23.84***	***33.80***	***43.76***	***33.80***
Weapons						
	RIM-66 Standard Missile SM-2MR; RIM-67/RIM-156 Standard Missile SM-2ER					
	RIM-161 Standard Missile SM-3	74	3	3.24	10.07	239.76
	Vertical Launch ASROC (VLA) missiles;					
	MK 41 Vertical Missile Launch Systems (VLS)	2	38.2	110.1	182	220.20
	BGM-109 Tomahawk	1	0.4552	0.569	0.6828	0.57
	MK-46 torpedoes (from two triple tube mounts);	6				
	Close In Weapon System (CIWS),	1	3.04	3.8	4.56	3.80
	Mk-45 (Mod.1/2) 5"/54					
	RIM Evolved Sea Sparrow Missile (ESSM)	1	0.84	0.905	0.97	0.91
	MK 38 self--defense guns					
	Land-Attack Guns					
	Other type of Guided Missiles (Guided shell)	10	0.025	0.0375	0.05	0.38
	Other type of defined Guns and Torpedoes, missiles, being part of the ship's	1	641.40344	796.77	1296.242	796.77
Total		***96***	***686.96***	***915.42***	***1494.57***	***1262.38***
Aircraft	MH-60 B/R Seahawk LAMPS III helicopters with Penguin/ Hellfire missiles	2	27.693	30.77	60	61.54
	MK 46/MK 50 torpedoes					

WBS and Global Network Diagram of Warship Building

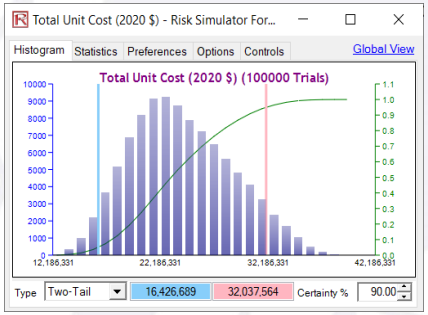
The figures illustrates the analysis of alternatives or strategic options. Based on the pricing policy on PC 14 at the Bollinger Machine Shop and Yard, we were able to extrapolate the data for 1990 to current dollar values (2020) for patrol coastal (PC) boats. The Monte Carlo simulated cost shows a range of $16.4 million to $32 million, with a 90% confidence interval. The range depends on the number of ships, where there is a learning curve (i.e., cost reduces over the course of multiple ships). The figures also show the simulated expected value of PC boats at $23.6 million.

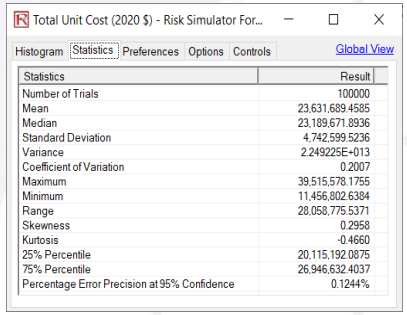
170 foot Patrol Coastal (PC) by Bollinger Shipyards

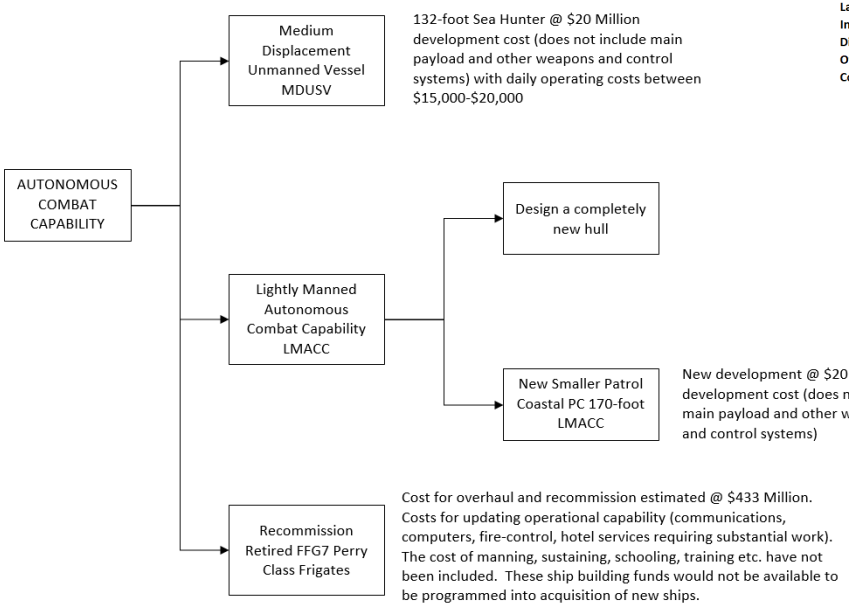
	1990	$11.42				2020	$23.06	Inflation	2.37%	
	Direct Labor		Direct Materials & Overhead		Total	Direct Labor		Direct Materials & Overhead		Total
ITEMIZATION	Hours	Dollar	Materials	Overhead		Hours	Dollar	Materials	Overhead	
Hull Structure	41,734	$476,602	$122,800	$738,733	$1,338,135	41,734	$962,359	$247,959	$1,491,656	$2,701,974
Propulsion Plant	1,897	$21,664	$3,254,200	$33,578	$3,309,442	1,897	$43,744	$6,570,907	$67,801	$6,682,452
Electric Plant	6,640	$75,829	$307,000	$117,534	$500,363	6,640	$153,114	$619,897	$237,326	$1,010,337
Command and Surveillance	1,897	$21,664	$798,200	$33,578	$853,442	1,897	$43,744	$1,611,732	$67,801	$1,723,277
Auxiliary Systems	11,382	$129,982	$798,200	$201,472	$1,129,654	11,382	$262,462	$1,611,732	$406,814	$2,281,007
Outfit and Furnishings	15,176	$173,310	$614,000	$268,630	$1,055,940	15,176	$349,949	$1,239,794	$542,420	$2,132,163
Armament	949	$10,838	$122,800	$16,798	$150,436	949	$21,883	$247,959	$33,919	$303,761
Integration and Engineering	949	$10,838	$61,400	$16,798	$89,036	949	$21,883	$123,979	$33,919	$179,781
Ship Assembly and Support Services	14,227	$162,472	$61,400	$251,832	$475,704	14,227	$328,065	$123,979	$508,501	$960,546
SUBTOTAL	94,851	$1,083,198	$6,140,000	$1,678,953	$8,902,151	94,851	$2,187,203	$12,397,938	$3,390,156	$17,975,297
CONTRACTOR PROFIT @ 10%					$890,215					$1,797,530
GRAND TOTAL UNIT PRICE					**$9,792,367**					**$19,772,827**

	Min	Likely	Max	Simulation
Manhours	65,000	94,851	125,000	94,851
Labor Rate	$13.11	$23.06	$47.97	$23.06
Inflation Rate	0.46%	2.37%	4.90%	2.37%
Direct Materials	$6,140,000	$12,397,938	$25,788,912	$12,397,938
Overhead	$1,678,953	$3,390,156	$7,051,852	$3,390,156
Contractor Profit	9.00%	10.00%	11.00%	10.00%
	Total Unit Cost for Ship Only (2020 Dollars)			**$19,772,827**

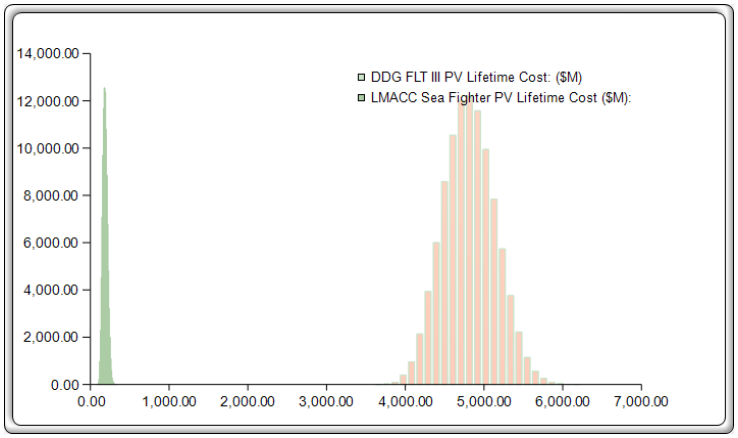
As a basis of comparison, we use the 32 foot Sea Hunter Cost of Sea Hunter in 2020 is approximately $20 Million







Using the same approach, we can estimate using notional values to determine the costs of the three alternatives as proposed using a life cycle of 30 years, with a single replacement in Year 15. The figures show the confidence intervals of the costs and simulated values. Sea Fighter has a life-cycle cost of $181.9 million versus $4.76 billion for the DDG 51 FLT III.



Acquisition Cost ($ Billion) [with LCS Mission Packages]

	Option 1			Option 2			Option 3		
	Ships	Costs $B	Cost/Unit	Ships	Costs $B	Cost/Unit	Ships	Costs $B	Cost/Unit
Littoral Combat Ship	53	33.20	0.626	28	17.10	0.611	53	33.100	0.625
Littoral Combat Ship (CG Variant)	25	12.10	0.484	0			0		
National Security Cutter	5	2.90	0.580	5	2.60	0.520	25	12.500	0.500
National Security Cutter (CG Variant)	0			20	10.70	0.535	0		
Offshore Patrol Cutter	0			25	11.10	0.444	0		

Acquisition Cost ($ Billion) [without LCS Mission Packages]

	Option 1			Option 2			Option 3		
	Ships	Costs $B	Cost/Unit	Ships	Costs $B	Cost/Unit	Ships	Costs $B	Cost/Unit
Littoral Combat Ship	53	29.80	0.562	28	15.30	0.546	53	29.70	0.560
Littoral Combat Ship (CG Variant)	25	12.10	0.484	0			0		
National Security Cutter	5	2.90	0.580	5	2.60	0.520	25	12.500	0.500
National Security Cutter (CG Variant)	0			20	10.70	0.535	0		
Offshore Patrol Cutter	0			25	11.10	0.444	0		

Total Lifecycle Cost ($ Billion) [Discounted to NPV from 2009-2055]

	Option 1			Option 2			Option 3		
	Ships	Costs $B	Cost/Unit	Ships	Costs $B	Cost/Unit	Ships	Costs $B	Cost/Unit
Littoral Combat Ship	108	65.10	0.603	58	35.30	0.609	108	65.900	0.610
Littoral Combat Ship (CG Variant)	50	23.30	0.466	0			0		
National Security Cutter	13	10.40	0.800	13	9.90	0.762	53	31.200	0.589
National Security Cutter (CG Variant)	0			40	25.00	0.625	0		
Offshore Patrol Cutter	0			50	21.60	0.432	0		

Total Lifecycle Costs include acquisition costs, cost of replacing the ship one time, cost of operating the ships (fuel, maintenance of structures and systems, and personnel costs)

Option 1 explores the feasibility of having the Coast Guard buy a variant of the Navy's LCS—specifically, the semiplaning monohull—to use as its offshore patrol cutter. (The rationale for this option is that, according to some analysts, the NSC's longer mission range and higher endurance might make it better suited than the LCS to act as a "patrol frigate," which would allow the Navy to carry out certain activities—maritime security, engagement, and humanitarian operations—outlined in the sea services' new maritime strategy.)

Alternative 3 ($ Millions)	1	2	3	4	5	6	7	8	9	10	...	28	29	30
Ship Cost (Platform Only, including Contract, Design, and Acquisition):	$20.00													
Additional Cost (Weapons, Systems, Electrical, Sensors):	$7.00													
Ship Operations and Maintenance Cost Annually (O&M):	$3.00	$3.12	$3.24	$3.37	$3.51	$3.65	$3.80	$3.95	$4.11	$4.27		$8.65	$9.00	$9.36
Any Typical Ship Alterations and Modifications Cost:														
Personnel Cost Pear Year:	$1.00	$1.04	$1.08	$1.12	$1.17	$1.22	$1.27	$1.32	$1.37	$1.42		$2.88	$3.00	$3.12
Any Nonrecurring Costs:	$3.00													
Decommissioning Costs at End of Life:														$0.00
Net Costs Per Year:	$34.00	$4.16	$4.33	$4.50	$4.68	$4.87	$5.06	$5.26	$5.47	$5.69		$11.53	$11.99	$12.47
Total Lifetime Cost:	$308.37													
PC Sea Hunter Total Present Value of Lifetime Cost ($M):	$162.10													