



An Approach to Examining Technical Alternatives

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The Bait



- Systems engineering provides a method for examining alternatives. Mr. King will discuss the application of technological forecasting, engineering, ship design, cost analysis, and operations research analysis to examine alternative approaches to solving naval problems. We will show examples of integrated analysis.

The Switch



- Systems engineering provides a method for examining alternatives. Mr. King will discuss **the fundamentals of systems engineering and the implications for technology and** application of technological forecasting, engineering, ship design, cost analysis, and operations research analysis to examine alternative approaches to solving naval problems. He will show **an** example of integrated analysis. **He will present current challenges.**

Outline



- The Principles of Systems Engineering
 - Implications for Technology
- The Dimensions of Technology Selection
 - Some Methods of Technology Selection
 - Cost-Benefit Analysis
- The Role of Probability
- Risk
- Current Challenges

PRINCIPLES OF SYSTEMS ENGINEERING



- THE FUNDAMENTAL PRINCIPLE OF SYSTEMS ENGINEERING

Maximize the Expected Value

- THE PRINCIPLE OF EVENTS OF LOW PRIORITY

The fundamental missions of the system should not be jeopardized, nor its fundamental objectives significantly compromised, in order to accommodate events of low probability.

Systems Engineering Handbook
Robert E. Machol
McGraw-Hill

Principles (Cont'd)



- THE PRINCIPLE OF CENTRALIZATION
Centralization of authority and decision-making, that is, the centralization of information as distinguished from material.
- THE PRINCIPLE OF SUBOPTIMIZATION
The optimization of each subsystem independently will not, in general, lead to a system optimum and, more strongly, improvement of a particular subsystem may actually worsen the overall system.



Some Methods of Technology Selection

Why is Technology A Concern



- Cannot afford everything
 - Not everything in basic research can be applied
 - Not everything can be implemented
- Choices
- A Systems Engineering problem
 - Cannot view each thing independently

So, how do we decide?

The Big Lie



If you say something
often enough, and with
enough enthusiasm,
it becomes fact

New York Floor



In the New York
state legislature,
who gets the floor?



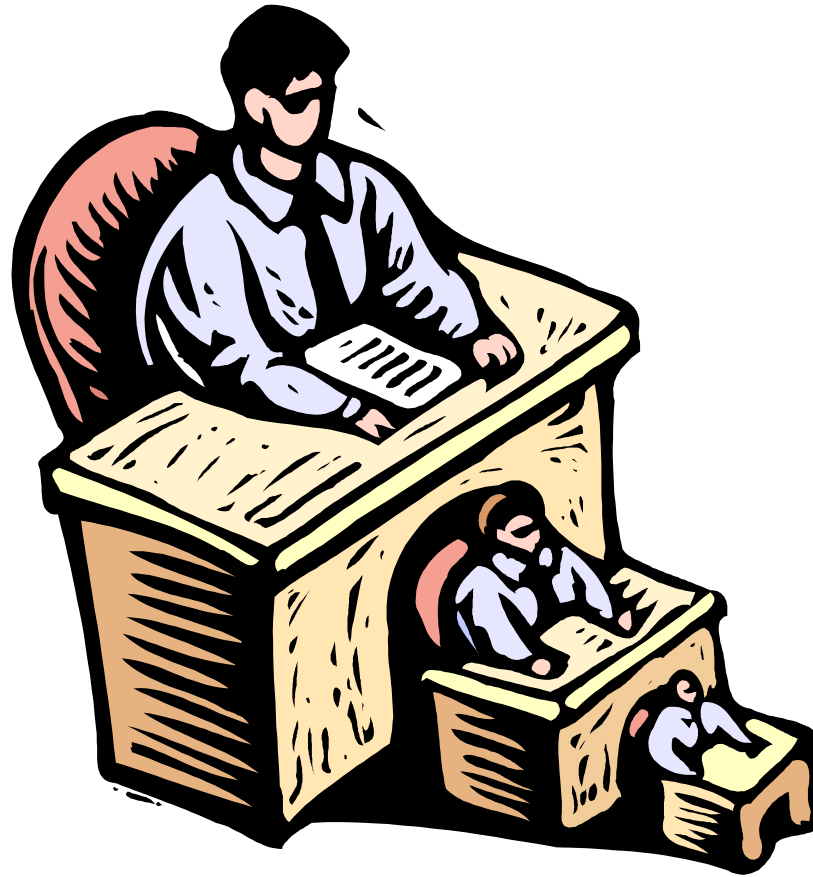
New York Floor



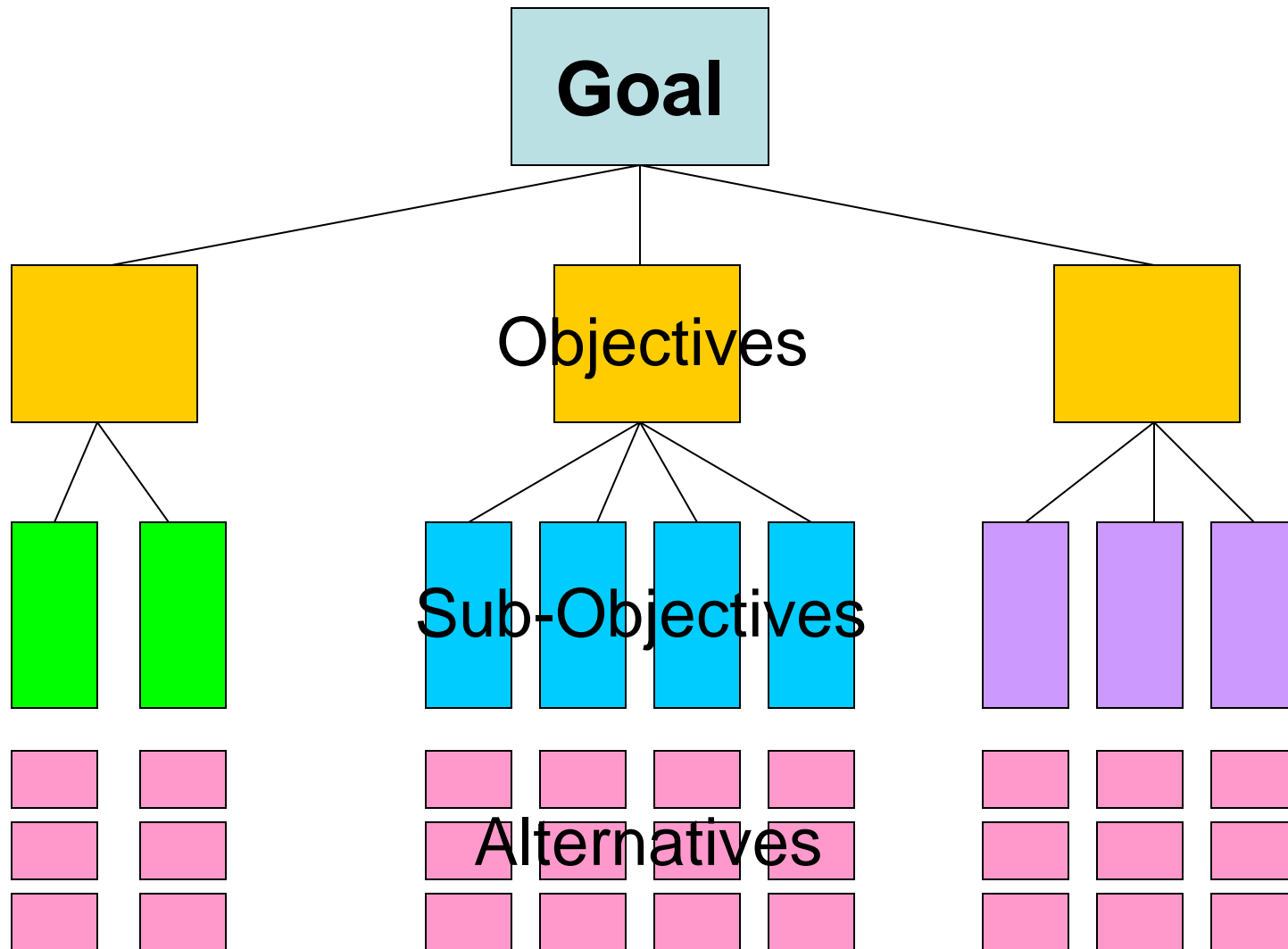
In the New York
state legislator,
who gets the floor?

The one who yells
the loudest.

Friends in High Places



Analytical Hierarchy Process



Variants



- Pareto Analysis
- Pain Analysis
- Pair wise Comparisons
- etc

Strengths



- Organized
- Transparent
- Repeatable
- Sensitivity Analysis

What Is the Key Weakness?

Opinion





Another Approach: Cost-Benefit Analysis



Design, Cost, and Effectiveness Impacts of Surface Combatant Topside Signature Reduction in Littoral Environments

JAMES H. KING, Naval Architect
Head, Signature Control Technology Department
and

DANIEL J. PLATT, Naval Architect
Systems Assessment & Engineering Department

Naval Surface Warfare Center, Carderock Division



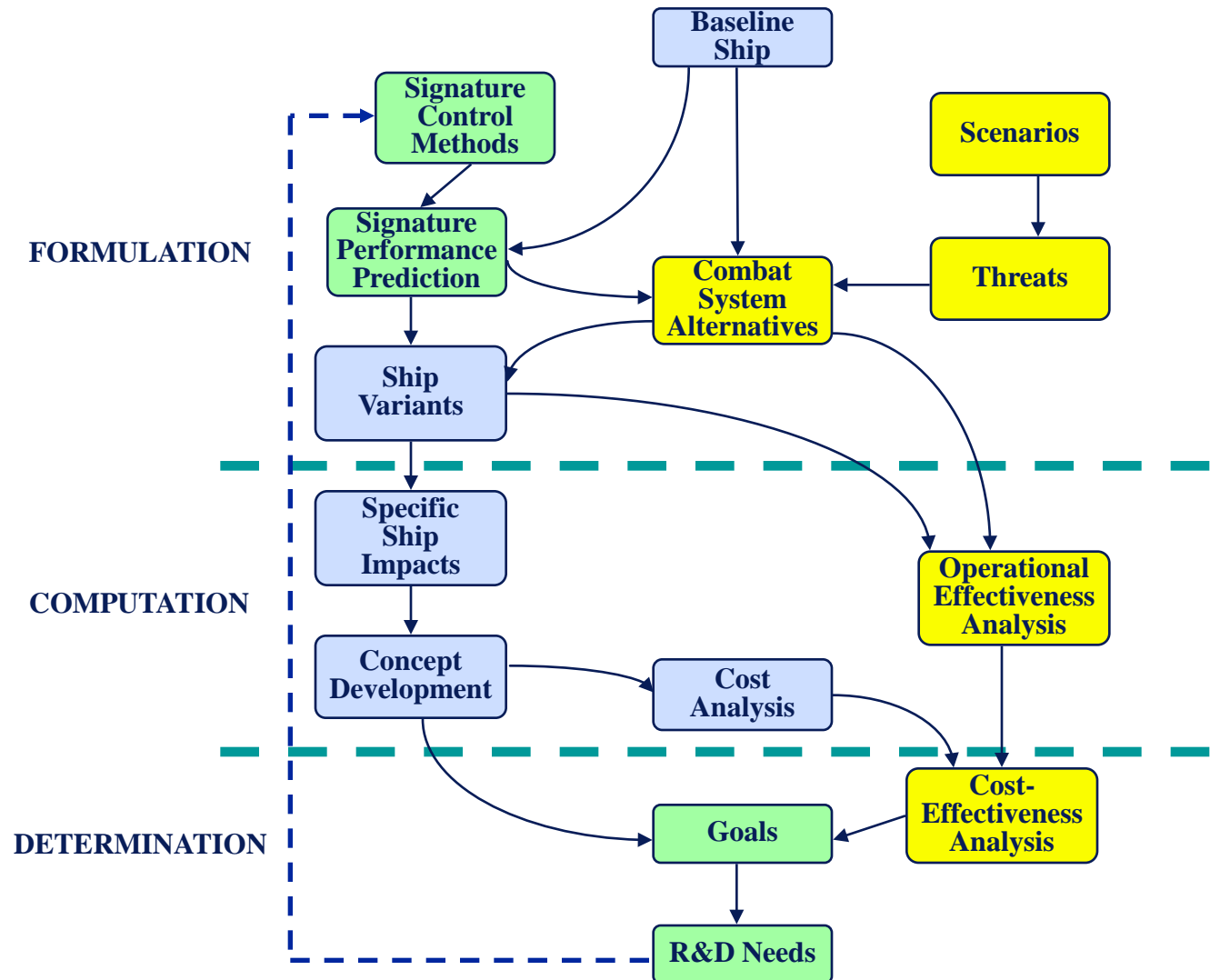
Purpose



- Traditionally, goals based on threat weapon performance
- Go beyond:
 - Impact of signature control on combat system
 - Impact of signature control measures on ship design
 - Cost drivers
- Evaluate signature control in littoral warfare



Process





Ship Variants

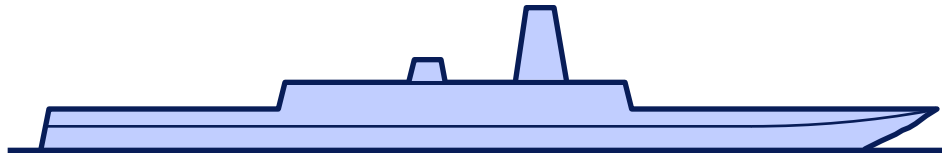


Combat System
Alternatives

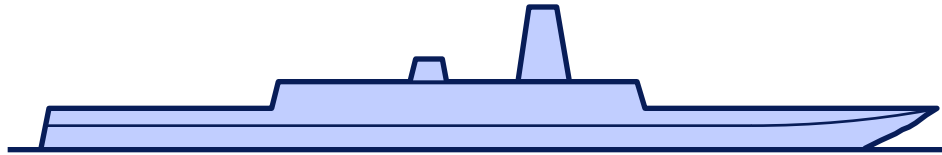
		Signature Reduction Alternatives				
		0	1	2	3	4
		(Baseline)	(separate RCS / IR)	(limited integration)	(integrated RCS / IR)	(aggressive reduction)
A	(Baseline)	✓	✓	✓		
	(passive cueing)			✓	✓	
	(no area AAW)	✓	✓	✓	✓	✓
	(autonomous ESSM)				✓	✓



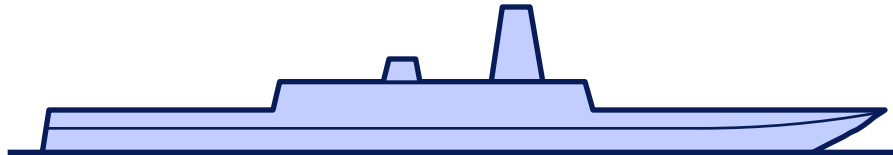
Candidate Ships



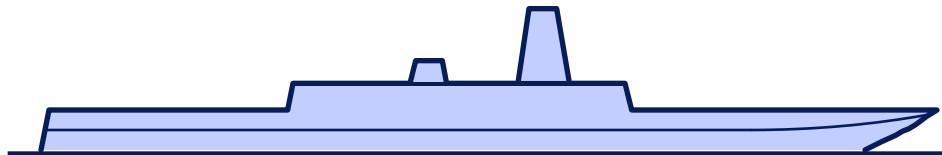
A0, A1, A2, B2



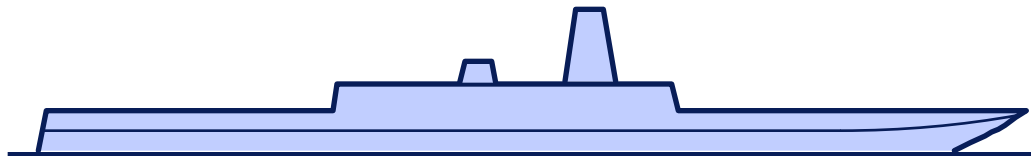
B3



C0, C1, C2

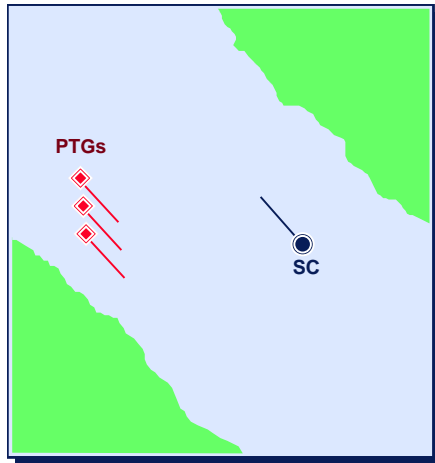


C3, D3

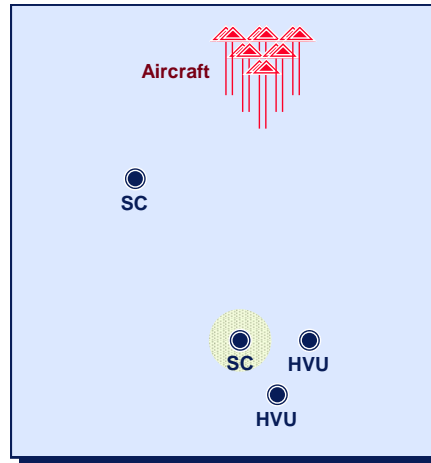


C4, D4

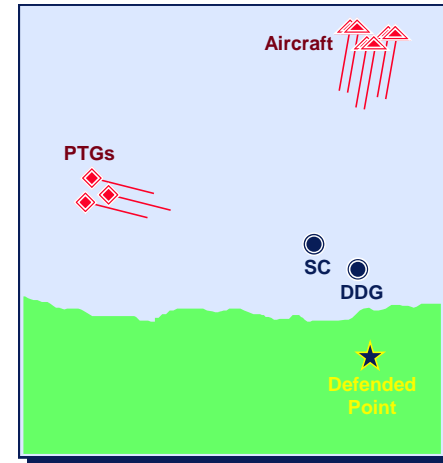
Mission Analysis



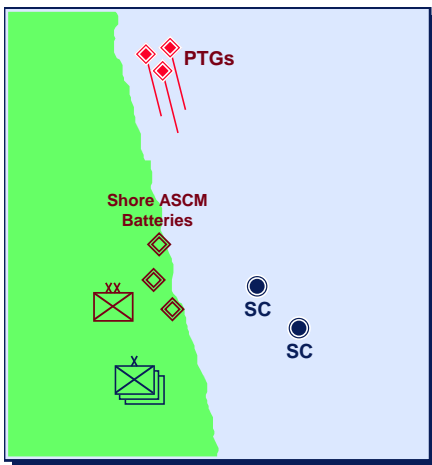
Forward Presence



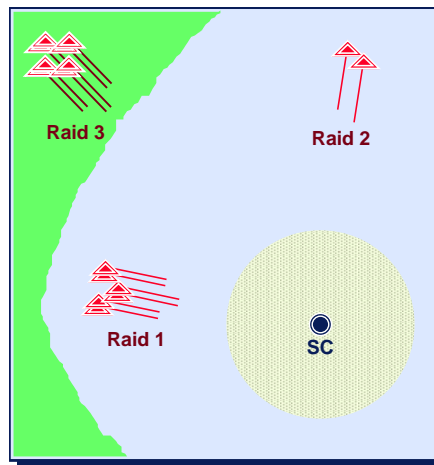
HVU Protection



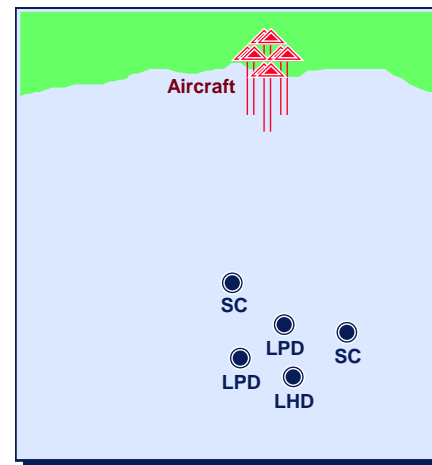
TBMD



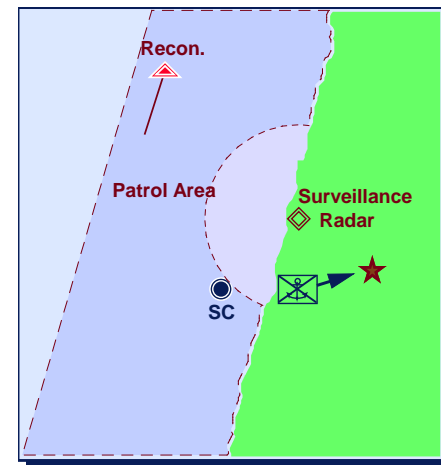
NSFS



AAW Picket



NEO



Spec Ops



Mission Effectiveness



Signature Reduction Variants

		0	1	2	3	4
Combat System Variants	A	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●		
	B			FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	
	C	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●
	D				FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●	FP ● AAW ● HVU ● NEO ● TBMD ● SPEC ● NSFS ●

FP=Forward Presence

HVU=High-Value Unit Protection

TBMD=Theater Ballistic Missile Defense

NSFS=Naval Surface Fire Support

AAW=Anti-Air Picket

NEO=Noncombatant Evacuation Operations

SPEC=Special Operations

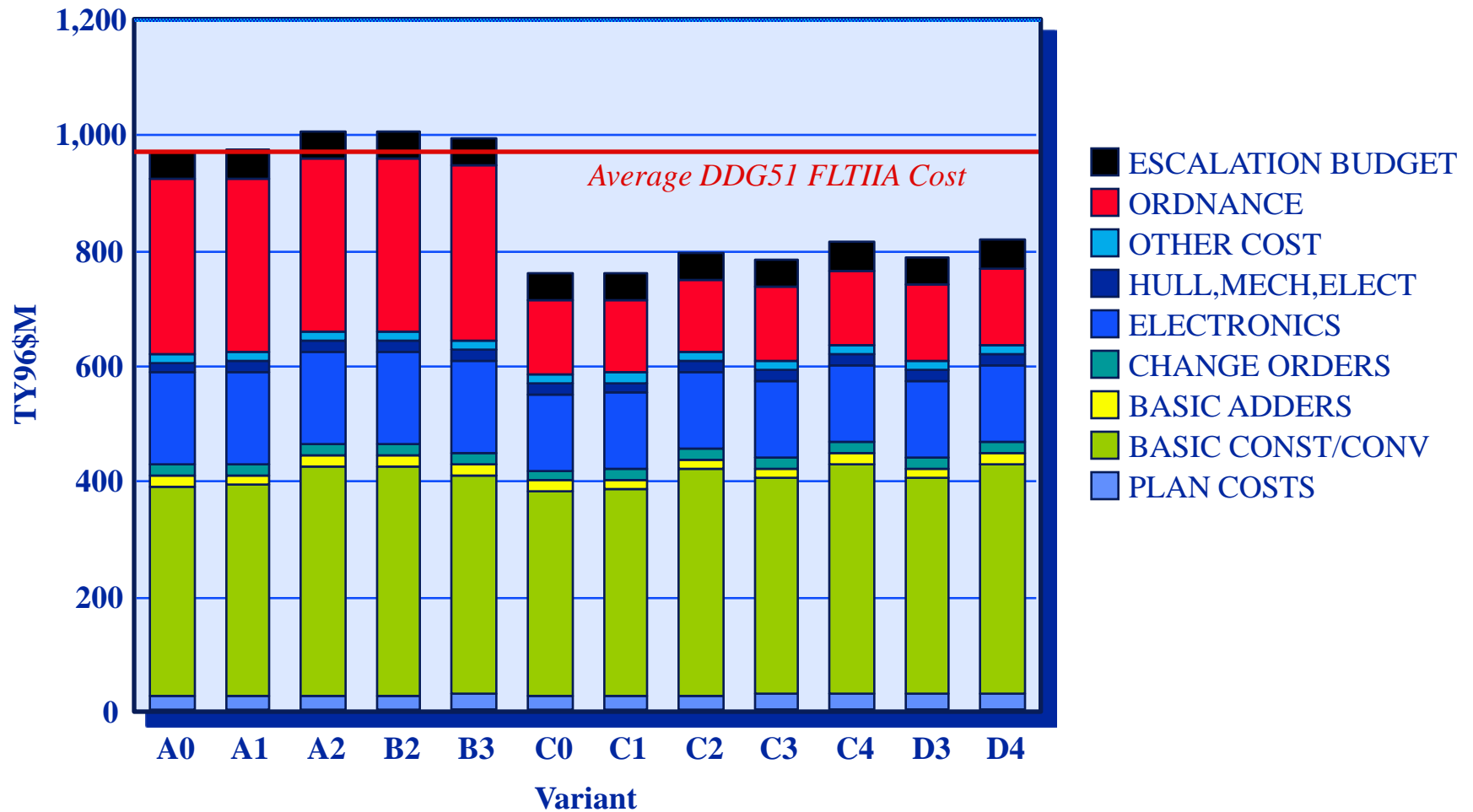
● =Good

● =Fair

● =Poor

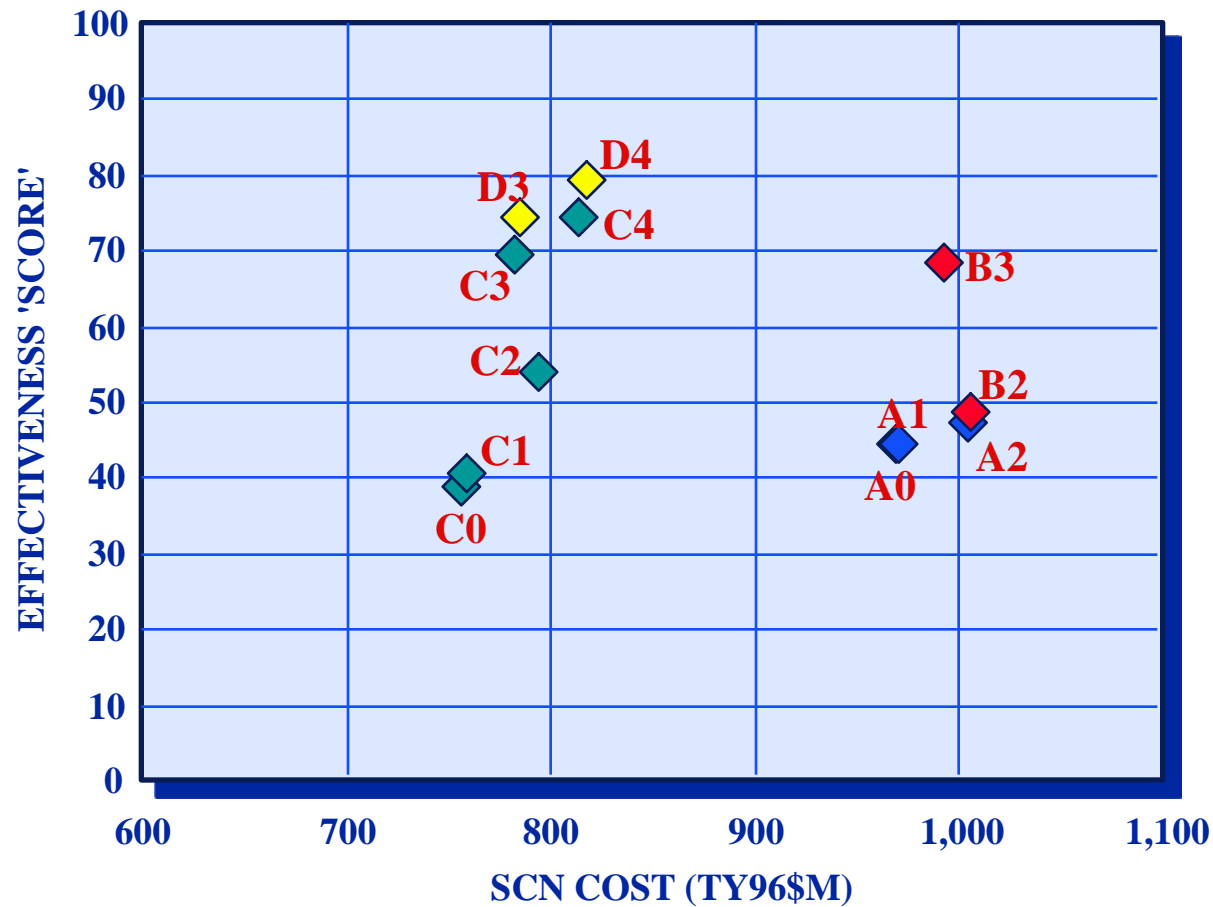


Cost





Cost-Effectiveness





Conclusions

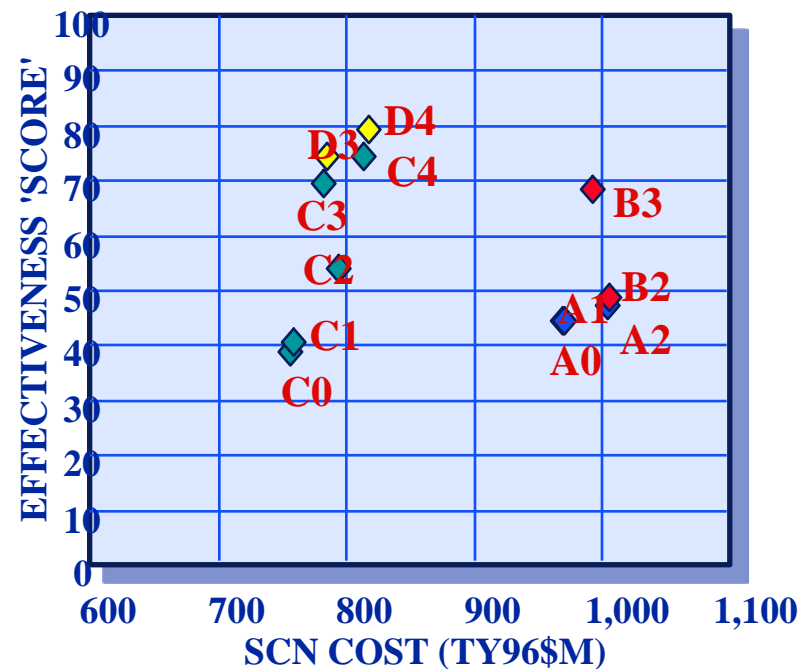
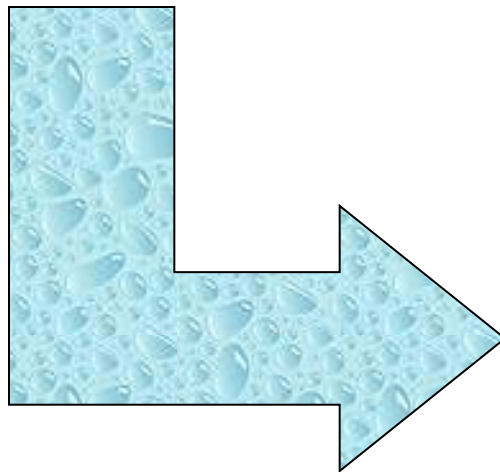
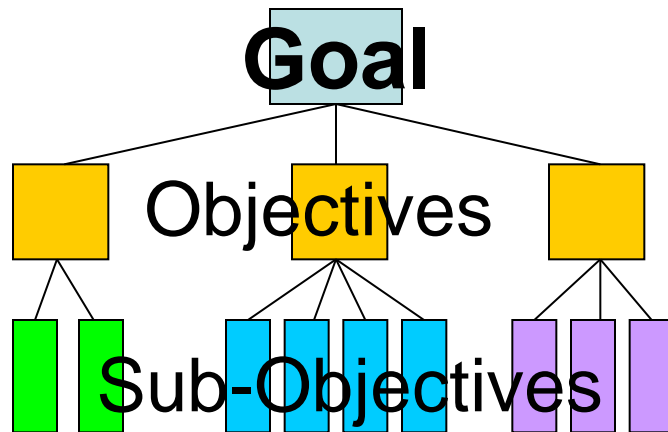


- Study conclusions
 - The combination of signature control and appropriate combat systems yields cost-effective ship options
 - Increased cost of signature control is easily outweighed by decreased combat system cost
 - For some missions, signature control is vital to success
 - Future focus will be on the technologies appropriate to signature level 3
- Process conclusions
 - Small team, focused on limited missions and scenarios
 - Effective model for future studies



What are the Weaknesses of
This Approach?

An Idea: A Hybrid Approach



Hybrid Approach



- Use AHP, or a similar approach, to identify and weigh objectives
- Use rigorous cost-benefit analysis to evaluate alternative technology systems for achieving the objectives.
- Evaluate the alternative systems using AHP
- Guide investment decisions.



What is the Fundamental Principle of Systems Engineering?



What is the Fundamental Principle of Systems Engineering?

Maximize the Expected Value

What is Implied?

The Role of Probability



- Remember, Maximize the Expected Value
 - Performance
 - Cost
 - Weight
 - Risk
 - Etc
- Expected value implies probabilistic assessment.
- Results are rarely expressed this way



The Two Sides to Risk

Risk



Risk Management Assessment		Event Probability		
		Low	Medium	High
Event Consequence	Low			
	Medium			
	High			

The Risk of Action

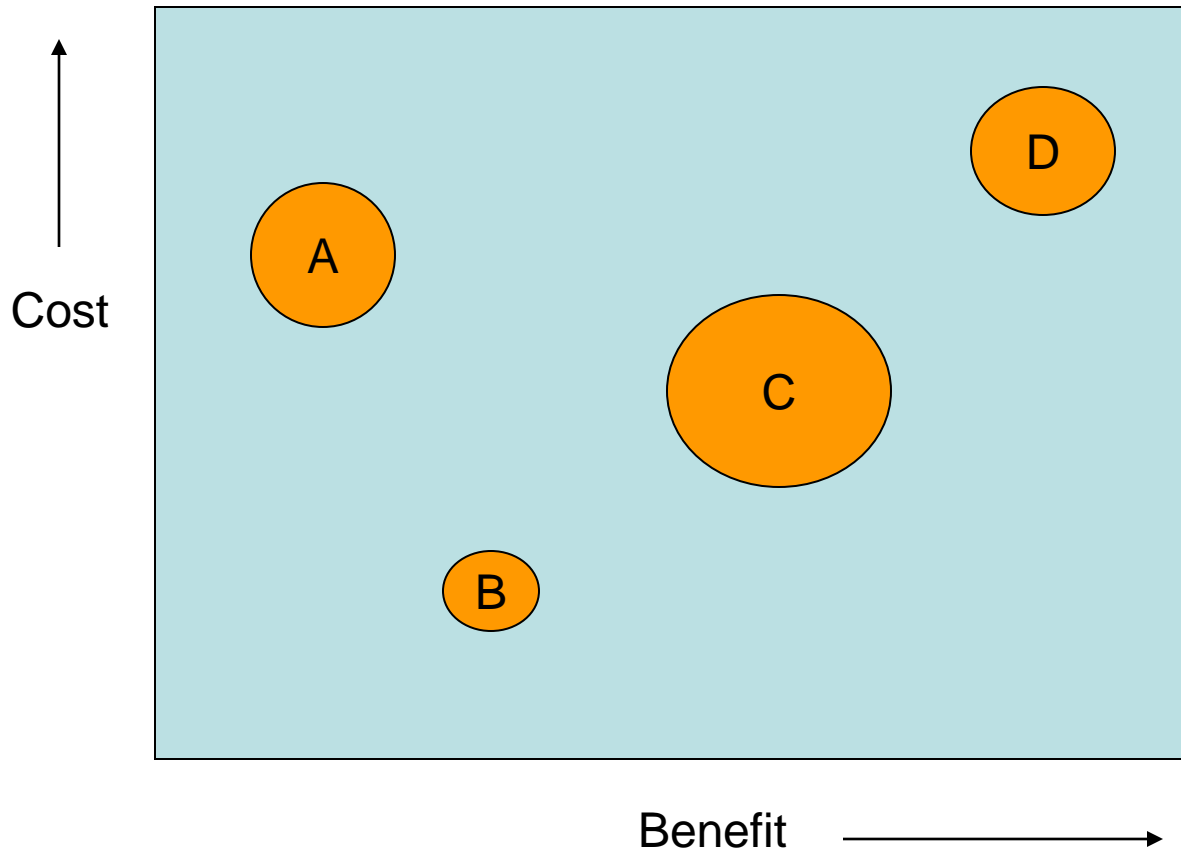
Risk



- But what about The Risk of Inaction?
 - Adversary development
 - Program delay
 - Increased cost
 - Technology abandonment
 - Etc.

This should be considered!

Technology Risk vs Potential



Size of Circle
Indicates
Technology
Readiness
Level

Which would you
choose?



The Challenge

Current Challenges

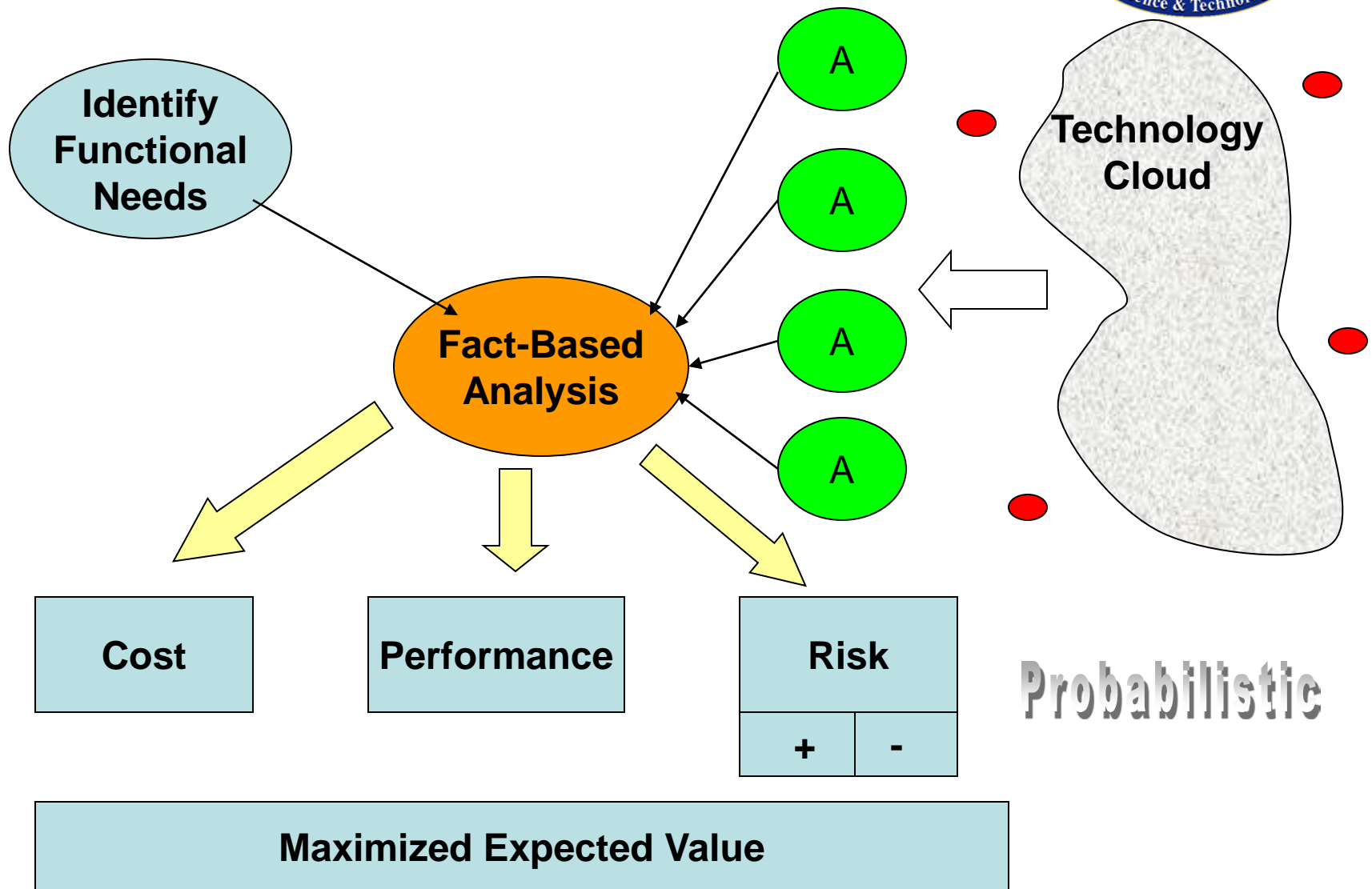


- What is desired?
 - A fact-based technology evaluation system
 - Recognize uncertainty
 - Identify uncertainty
 - Balance risk of action and risk of inaction
 - Effective and efficient cost analysis
 - Suited to the immaturity and uncertainty of technology

Current Challenges



- Technology Solutions
 - Systems-based
 - Alternate technical system approaches
 - Use mixes of technologies that makes sense
 - Maximize expected value
 - Catch the revolutionary technology
- Institutionalize systems engineering approach to technology selection





Discussion

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