What is Set-Based Design?

ASNE DAY
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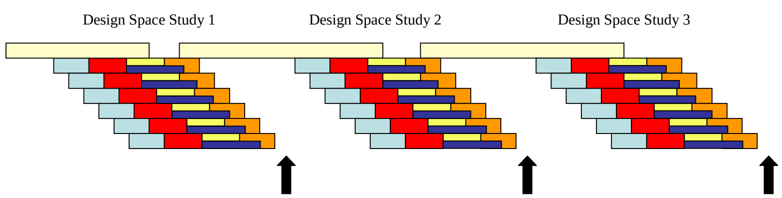
Motivation



Synthesis Model based Design Optimization

- Great for finding the right part of the design space to look for a solution
- Low level of modeling detail

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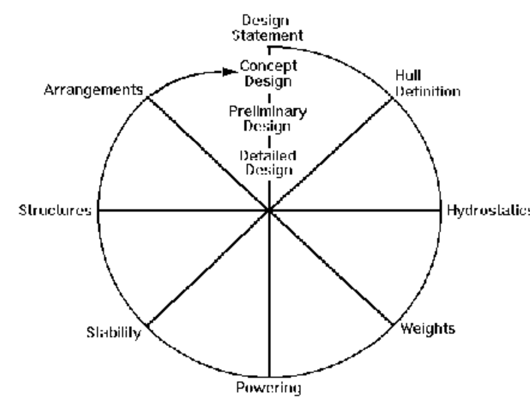
Classic Design Spiral (Point Based Design)

- Great for refining a design that nearly meets all requirements, or for optimizing a design
- Can support high level of modeling detail



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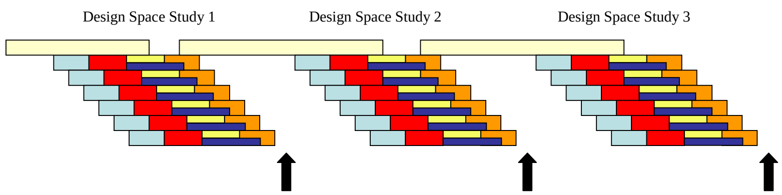

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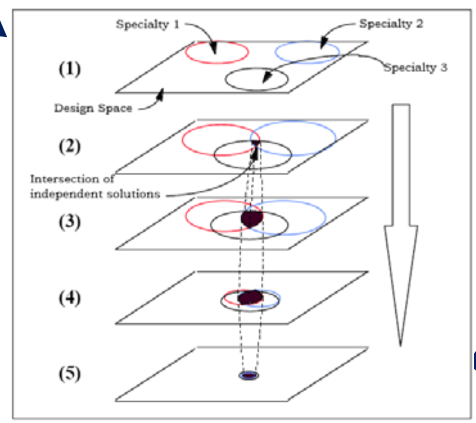
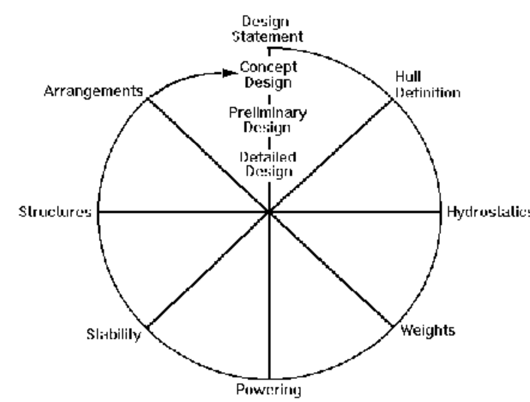


Set Based Design

- Great for finding a converged design solution within a defined Design Space
- Increasing level of modeling detail



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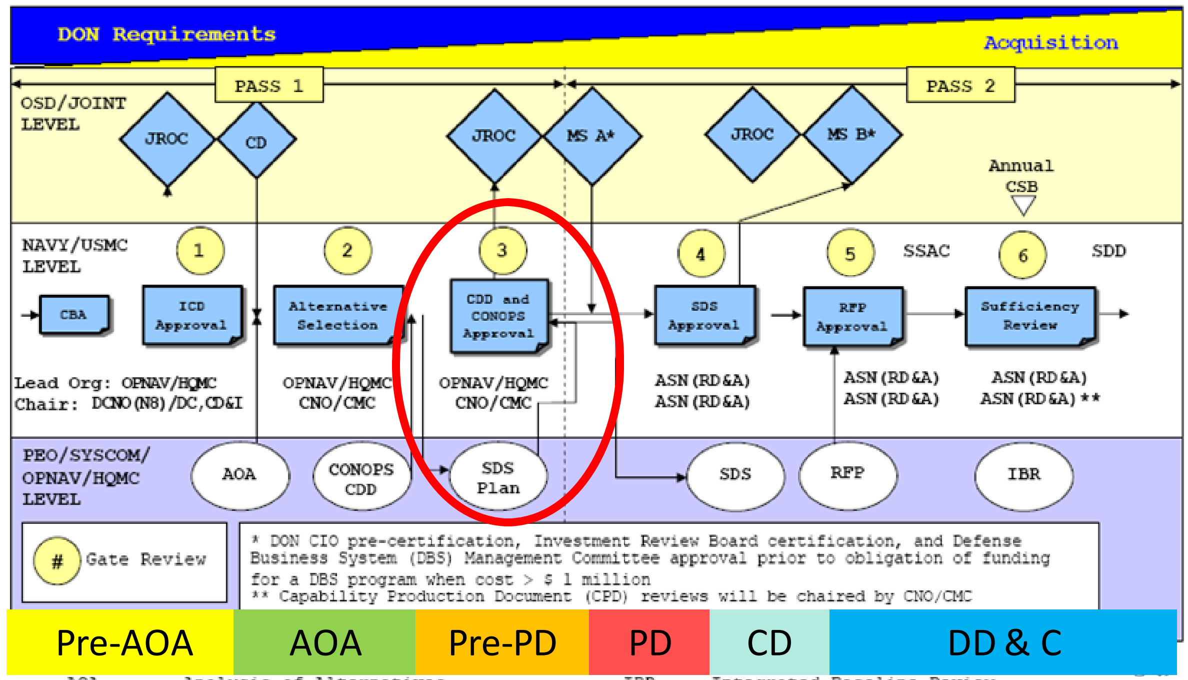
SECNAVINST 5000.2D
2 Pass 6 Gate Process



AOA	Analysis of Alternatives	IBR	Integrated Baseline Review
ASN(RD&A)	Asst Secretary of the Navy (Research, Development and Acquisition)		
CBA	Capabilities-Based Assessment	ICD	Initial Capabilities Document
CD	Concept Decision	JROC	Joint Requirements Oversight Council
CDD	Capability Development Document	PEO	Program Executive Officer
CMC	Commandant of the Marine Corps	RFP	Request for Proposal
CNO	Chief of Naval Operations	SDD	System Development & Demonstration
CONOPS	Concept of Operations	SDS	System Design Specification
CSB	Configuration Steering Board	SSAC	Source Selection Advisory Council
HQMC	Headquarters Marine Corps		

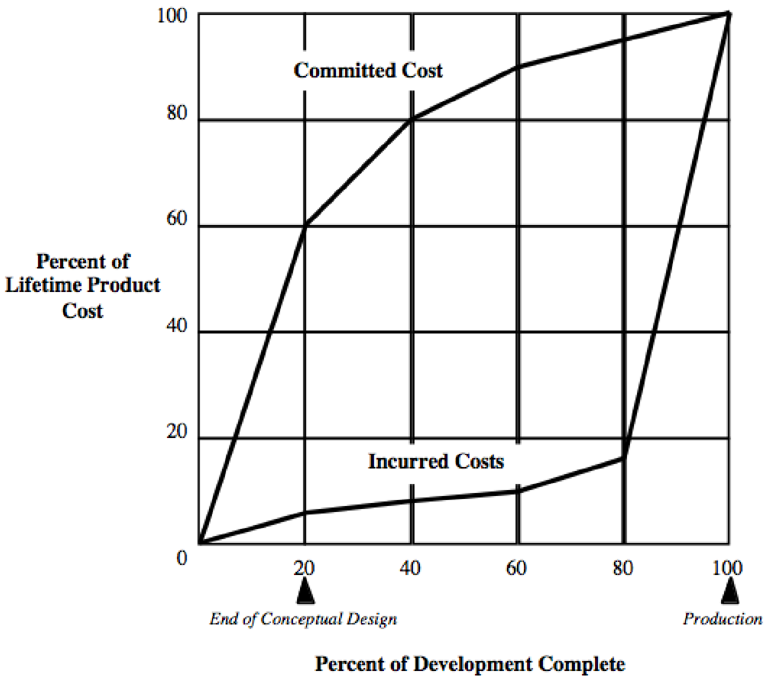
REQUIREMENTS - design　　requirements - DESIGN

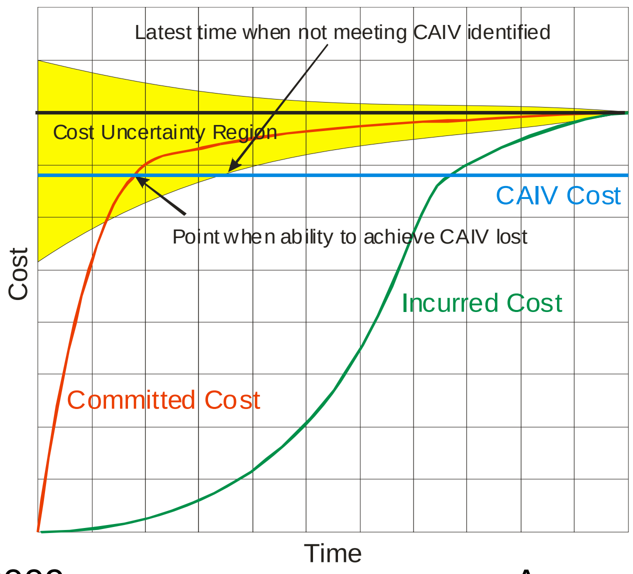
AOA = Analysis of Alternatives	PD = Preliminary Design
CD = Contract Design	DD&C = Detail Design and Construction

Why not go directly to Spiral / Point Based Design?

- Problem 1: Designing in Cost
  - Costs are committed early, when there isn't sufficient information to accurately predict cost or performance

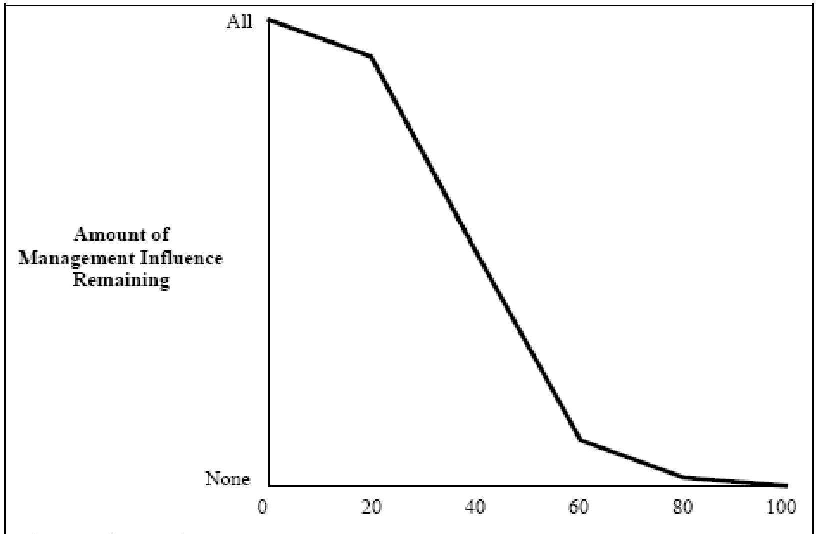
(Bernstein 1998)





Why not go directly to Spiral / Point Based Design?

- Problem 2: Requirements Understanding During Design vs. Influence / Impact on Cost
  - When knowledge is known, remaining Management influence is low



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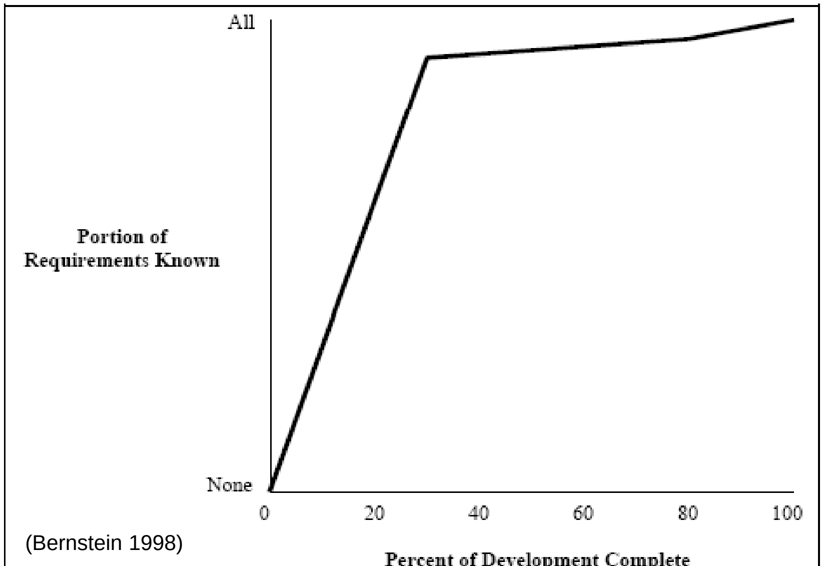

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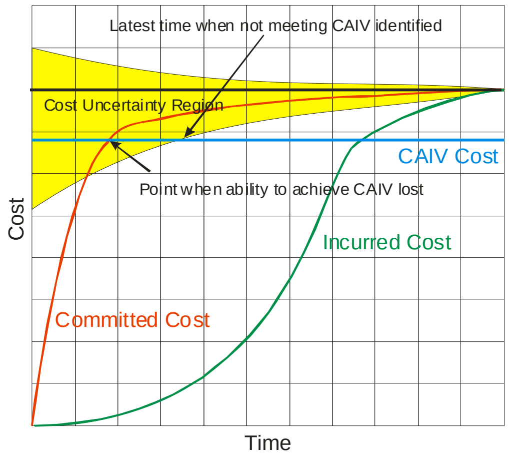
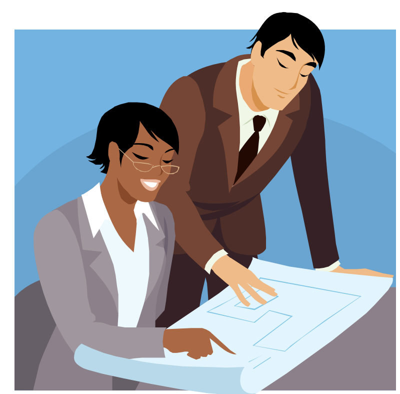


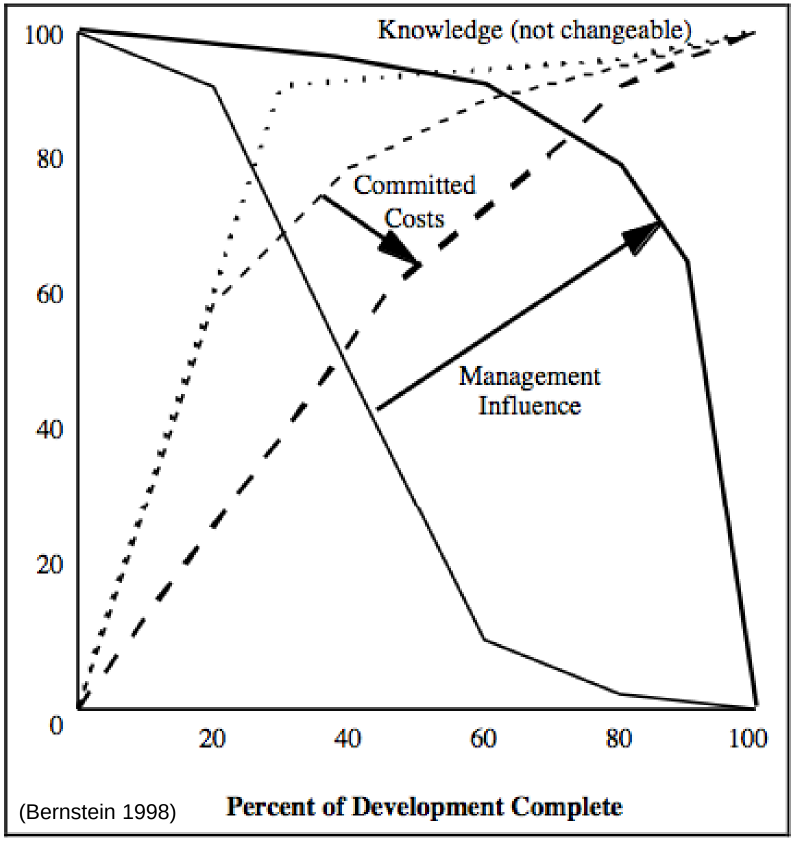
Why not go directly to Spiral / Point Based Design?

- Problem 3: Ship design requires both objective knowledge (mathematical models) and subjective knowledge (expert opinion)
  - Objective and subjective knowledge require domain experts
  - In real world domain experts are not collocated
  - Design enabling communication tools are not sufficient to support tightly coupled Spiral Design methods



Why Set Based Design is Useful

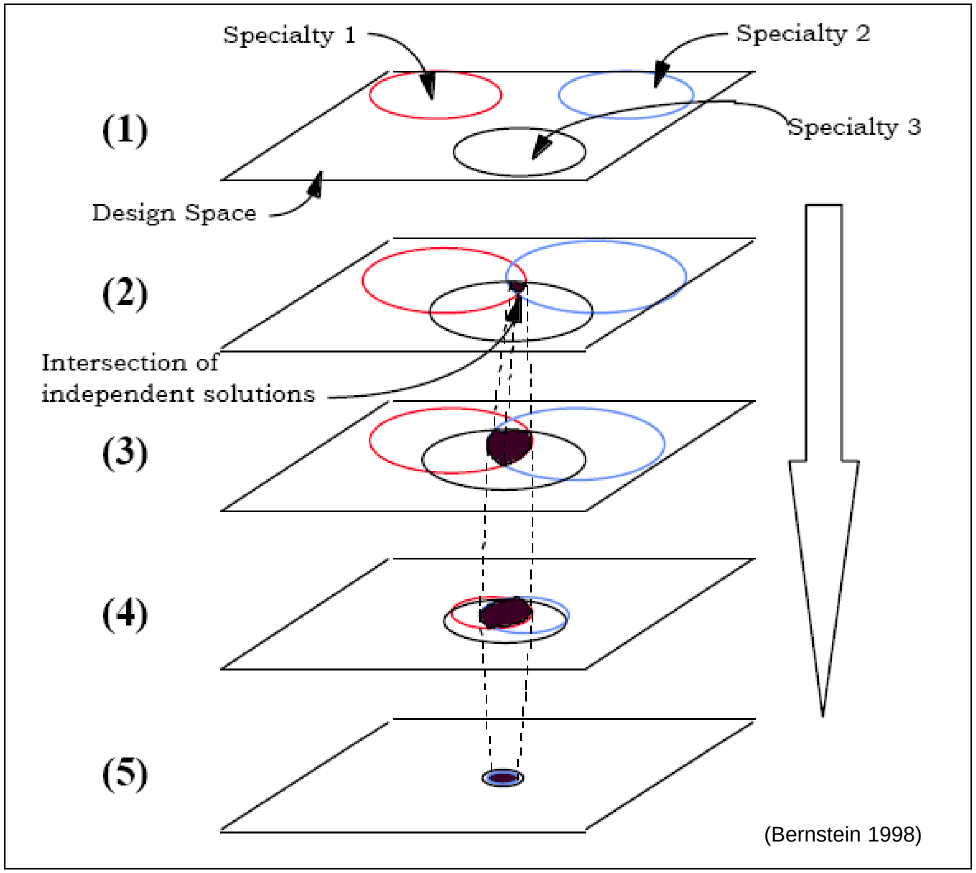
- Delay Cost Commitment until sufficient design detail enables a good choice
- Maximize Management Influence as long as possible



(Bernstein 1998)

Set Based Design Process

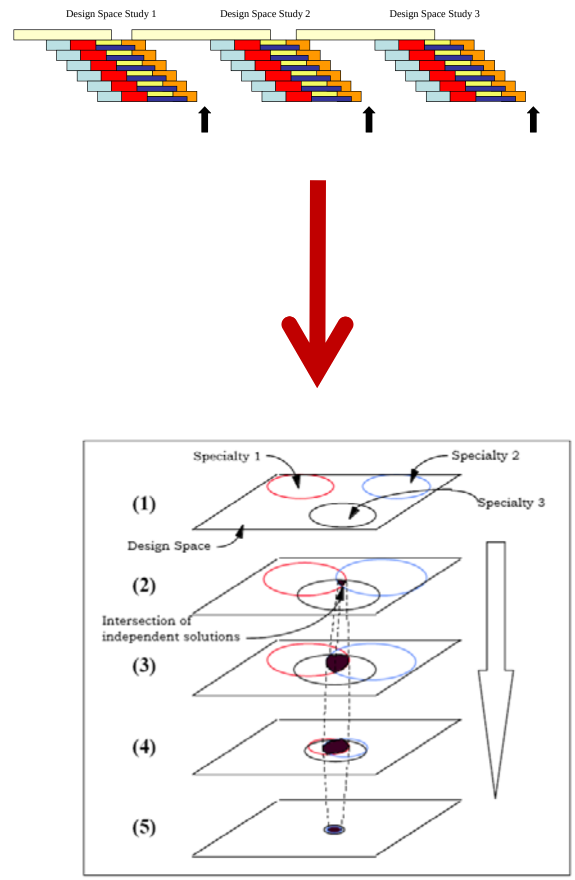
- Understand the design space
  - Define feasible regions
  - Explore tradeoffs by designing multiple alternatives
  - Communicate sets of possibilities
- Integrate by intersection
  - Look for intersections of feasible sets
  - Impose minimum (maximum) constraint
  - Seek conceptual robustness
- Establish feasibility before commitment
  - Narrow sets gradually while ***increasing detail***
  - Stay within set once committed
  - Control by managing uncertainty at process gates



Decide at the last responsible moment

How to start Set Based Design

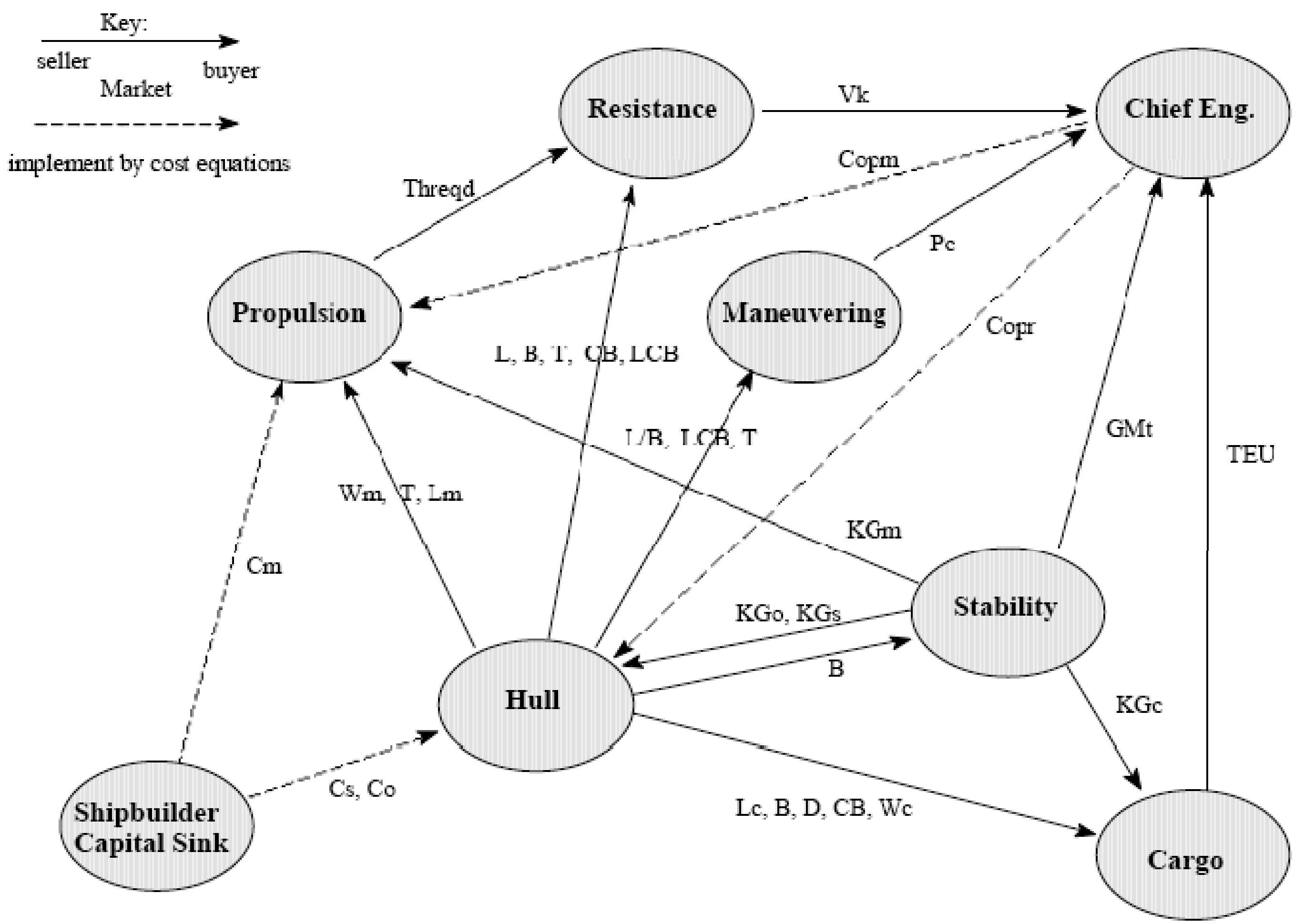
- Identify the different “Specialties”
- Identify key attributes that define the “set” for each “Specialty”
- Define the initial boundaries for each “set”
- Look for an intersection of the “sets”
- If none exist, or the area of intersection is small, expand the “sets” until the intersection is robust



Example of a "Set"

- For an Electrical Plant
  - Scalable from 40 MW to 80 MW
  - Common 4160 VAC architecture
  - Combination of 4 and 8 MW Diesel GENSETS and 22 MW Gas Turbine Generator Sets
  - Scalable transformers for zonal distribution
- For a hull
  - Scalable hull / family of hulls from 20,000 to 40,000 LT
  - May also have a variable length to beam ratio and a variable beam to draft ratio.
  - May also have a variable length parallel midbody.

Containership SBD Example



Comparing Point and Set Based Design

Task	Point Based Design	Set Based Design
Search: How should solutions be found?	Iterate an existing idea by modifying it to achieve objectives and improve performance. Brainstorm new ideas	Define a feasible design space, then constrict it by removing regions where solutions are proven to be inferior
Communication: Which ideas are communicated to others?	Communicate the best idea.	Communicate sets of possibilities that are not Pareto dominated.
Integration: How should the system be integrated?	Provide teams design budgets and constraints. If a team can't meet budget or constraints, reallocate to other teams	Look for intersections that meet total system requirements.

Comparing Point and Set Based Design (continued)

Task	Point Based Design	Set Based Design
Selection: How is the best idea identified?	Formal schemes for selecting the best alternative. Simulate or make prototypes to confirm that the solution works	Design alternatives in parallel. Eliminate alternatives proven inferior to others. Use low cost tests to prove infeasibility or identify Pareto dominance
Optimization: How should the design be optimized?	Analyze and test the design. Modify the design to achieve objectives and improve performance.	Design alternatives in parallel. Eliminate alternatives when proven inferior to others.
Specification: How should you constrain others with respect to your own subsystem design?	Maximize constraints in specifications to assure functionality and interface fit.	Use minimum control specifications to allow optimization and mutual adjustment.

Comparing Point and Set Based Design (continued)

Task	Point Based Design	Set Based Design
Decision Risk Control: How should one minimize the risk of "going down the wrong path?"	Establish feedback channels. Communicate often. Respond quickly to changes.	Establish feasibility before commitment. Pursue options in parallel. Seek solutions robust to physical, market, and design variation.
Rework risk control: How should one minimize damage from unreliable communications? How should the communication process be controlled?	Establish feedback channels. Communicate often. Respond quickly to changes. Review designs and manage information at transition points.	Stay within sets once committed. Manage uncertainty at process gates.

Summary

- Consider a large number of design alternative by understanding the design space,
- Allow specialists to consider a design from their own perspective and use the intersection between individual sets to optimize a design and
- Establish feasibility before commitment
  - Narrowing sets gradually while increasing detail,
  - Staying within a set once committed and
  - Maintaining control by managing uncertainty at process gates.

QUESTIONS?