



Systems Engineering and Zonal Ship Design

May 1, 2006

***Engineering the Total Ship (ETS)
Symposium 2006
Arlington, Virginia***

CAPT Norbert Doerry

Technical Director, Future Concepts and Surface Ship Design

Naval Sea Systems Command

SEA 05DB

(202) 781-2520

norbert.doerry@navy.mil



Agenda

- Concept Design Challenges
- Good Answers Fast!
 - Study Guides
 - Naval Concept Essential Task List (NCETL)
 - System Packages
 - Systems Engineering
 - Zonal Design
 - Ship Design Environment
- Early Manpower Assessment Tool (EMAT)



Concept Design Classification

- 1 Quick ROM: 0.5 Weeks; 0.4 man-weeks
- 2 Fast ROM: 1.4 Weeks; 1.0 man-weeks
- 3 ROM: 1.5-2.5 Weeks; 6-11 man-weeks
- 4 Extended ROM: 4.5 –12 Weeks: 32+ man-weeks
- 5 Concept Studies: 3 months
- 6 Concept Studies: 4-5 months
- 7 Feasibility Studies: 6 months
- 8 Feasibility Studies: 8 months
- 9 Feasibility Studies: 1 year
- 10 Pre-Preliminary Design / Navy Indicative Design: 1+ year



Issues with Ship Concept Design

- Insight on cost vs. capability needed fast
 - Expect studies of 2 to 6 weeks duration to be the norm.
 - Longer studies will likely finish too late to impact decisions.
- Parametric Base for concept design weak
 - The “Art of the possible” extremely different from the state of practice.
 - Lack of high speed experience
 - Immature parametric methodology for IPS and other distributed systems
 - Lack of optimal manning data
 - Lack of novel hull form and materials experience
 - Lack of software design estimation methods
 - Ability to predict cost difficult
- Manual linkage of Hardware, Software, and Manpower Error Prone
- Error Estimation and Management:
 - Unable to provide level of confidence for one concept performing better than another
- Ability to rapidly design for survivability and verify survivability performance



Good Answers Fast!

- Study Guides – Study Planning
 - Document assumptions, scope, approach and products for the study
 - Clearly articulate Measures of Performance and Measures of Effectiveness and the approach to calculating each.
- Consistent approach to specifying capabilities for ship concepts
 - Naval Concept Essential Task List (NCETL)
 - Tasks, conditions, and measures
- Disciplined Systems Engineering Process
 - Linkage of Hardware, Software, and Manpower via System Packages
- Zonal Design
 - “Open Loop” vice “Closed Loop” Design
- Integration of ship design tools
 - LEAPS and ASSET
- Accuracy Control – Error Management
 - Design of Experiments / Statistical Analysis
 - Genetic Algorithms
- Data Visualization
 - Response Surface Methodology
 - Cogent
- Parallel modeling of ship concept and ship effectiveness



Study Guide

- Purpose
 - Study Planning Tool.
 - Gain concurrence on Assumptions and Scope of study with stakeholder BEFORE the study starts.
 - Answer the right question at the right time at least cost
- Contents
 - Tasking Statement
 - Establish Expectations
 - Define Products
 - General Concept of Operations
 - Assumptions and required capabilities
 - Variables to trade-off
 - Study Approach
 - Describe Resources that will be used in the study
 - Study Schedule
 - List of Tools



Naval Concept Essential Task List

- A disciplined approach to defining ship concept capabilities
- Based on the Universal Navy Task List (UNTL) defined in OPNAVINST 3500.38A
- Naval Concept Essential Task List (NCETL) Elements
 - Tasks
 - “Actions or processes performed as part of an operation”
 - Describes a discrete activity visible outside the command
 - Does not define who, or how the activity is accomplished.
 - Conditions
 - Variables of the environment that affect the performance of tasks in the context of the assigned mission.
 - Includes physical environment, military environment, and civil environment
 - Standards
 - Describe how well an organization or force must perform a task under a specific set of conditions for a specific mission.
 - Differs from a Measure of Performance (MOP) in that a Standard is an input to the design while an MOP is an output from the design (What the design is capable of doing).



Tasks

- Navy Tactical Task List (Subset of UNTL) Structure
 - **NTA 1 DEPLOY/CONDUCT MANEUVER**
 - **NTA 2 DEVELOP INTELLIGENCE**
 - **NTA 3 EMPLOY FIREPOWER**
 - **NTA 4 PERFORM LOGISTICS AND COMBAT SERVICE SUPPORT**
 - **NTA 5 EXERCISE COMMAND AND CONTROL**
 - **NTA 6 PROTECT THE FORCE**
- Universal Joint Task List (UJTL) defines Operational and Strategic Tasks
 - Specified in CJCSM 3500.04C



Task Structure Example

- **NTA 1.1 Move Naval Tactical Forces.**
 - NTA 1.1.1 Prepare Forces For Movement
 - NTA 1.1.2 Move Forces
 - NTA 1.1.2.3 Move Units
 - NTA 1.1.2.3.3 Conduct Flight Operations.
 - » NTA 1.1.2.3.3.1 Conduct Aviation Qualification
 - » NTA 1.1.2.3.3.2 Launch Aircraft
 - » NTA 1.1.2.3.3.3 Recover Aircraft
- **NTA 1.2 Navigate and Close Forces**
- **NTA 1.4 Conduct Countermobility**
- **NTA 1.5 Dominate the Operational Area**

Reference: NTTL 3.0 draft
Of November 2004



Task Definition

NTA 1.1.2.3.3.2 Launch Aircraft.

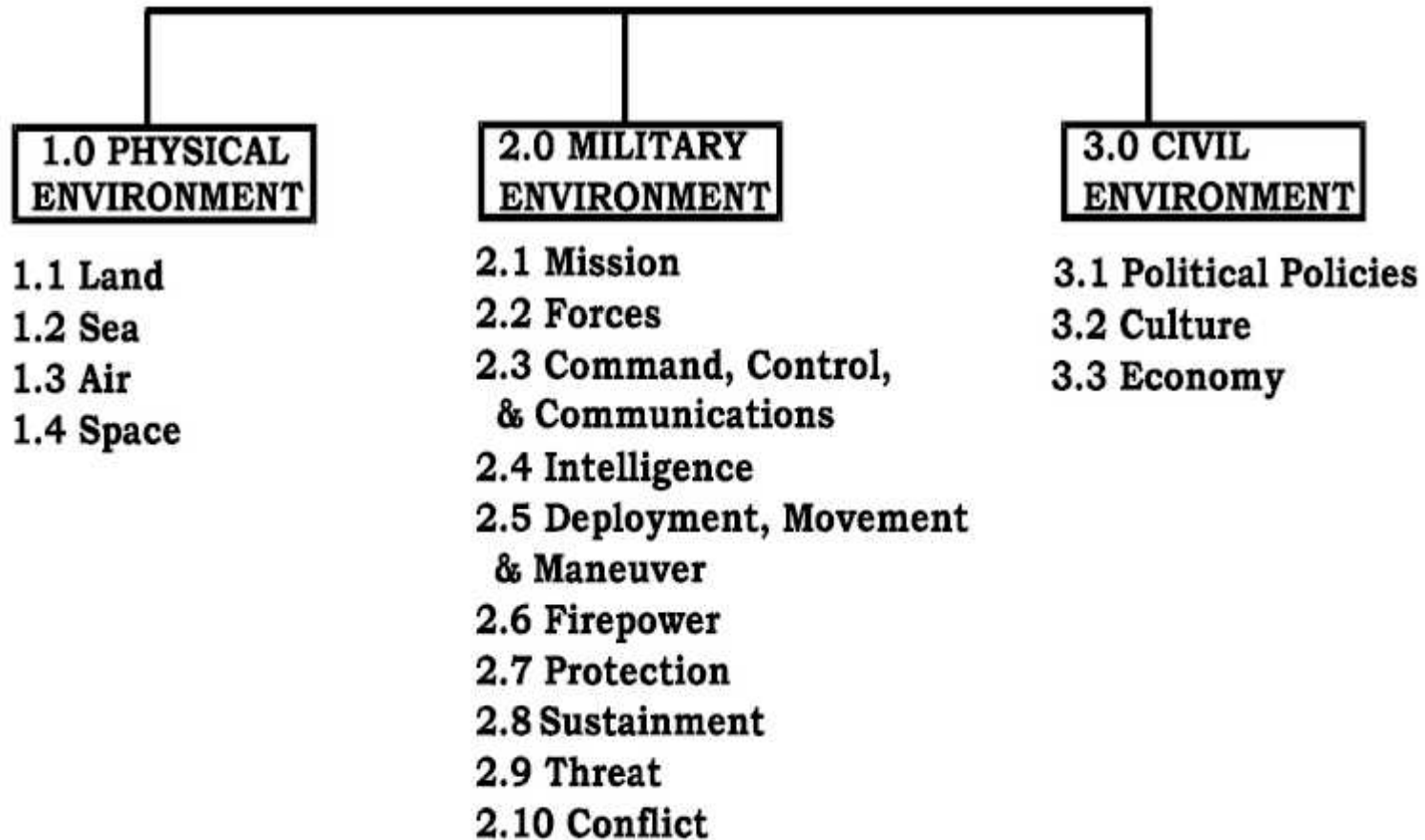
To launch aircraft from ships. This task covers all fixed-wing, tilt-rotor, and helicopter aircraft launch operations from ships, surface combatants and all other applicable sea vessels. This task requires the safe and efficient execution of all procedures applicable to launch, including: pre-launch procedures, launch procedures, instrument and visual departure procedures, departure communications procedures, departure rendezvous procedures, emergency recovery procedures, tanker procedures, and procedures for diversion of aircraft.

(JP 3-04.1, MCWP 3-31.5, NWP 3-04.1M, 3-22 Series)

Reference: NTTL 3.0 draft
Of November 2004



Conditions





Condition Definitions

- **C 1.2.1.1 Ocean Depth**

- The depth of ocean water at a point or for an area.
- *Descriptors*: Shallow (< 100 fathoms); Limited (100 to 500 fathoms);
- Deep (500 to 2500 fathoms); Very deep (> 2500 fathoms).

- **C 1.2.1.2 Ocean Currents**

- A steady, generally predictable flow, present either in open ocean waters or in littoral coastal ocean waters.
- *Descriptors*: Strong (> 3 knots); Moderate (1 to 3 knots); Little or no (< 1 knot).

- **C 1.2.1.3 Sea State**

- Roughness of seas caused by wind or disturbances.
- *Descriptors*: Calm to slight (Beaufort Force < 5, Sea State 3 or less, seas 4 ft or less); Moderate (Beaufort Force 5, Sea State 4, seas 4-8 ft); Rough (Beaufort Force 6-7, Sea State 5-6, seas 8-16 ft); Very Rough (Beaufort Force 8-9, Sea State 6, seas 17-20); High (Beaufort Force 10, Sea State 7, seas 20-30 ft); Extremely rough (Beaufort Force above 10, Sea State above 7, seas above 30 ft).

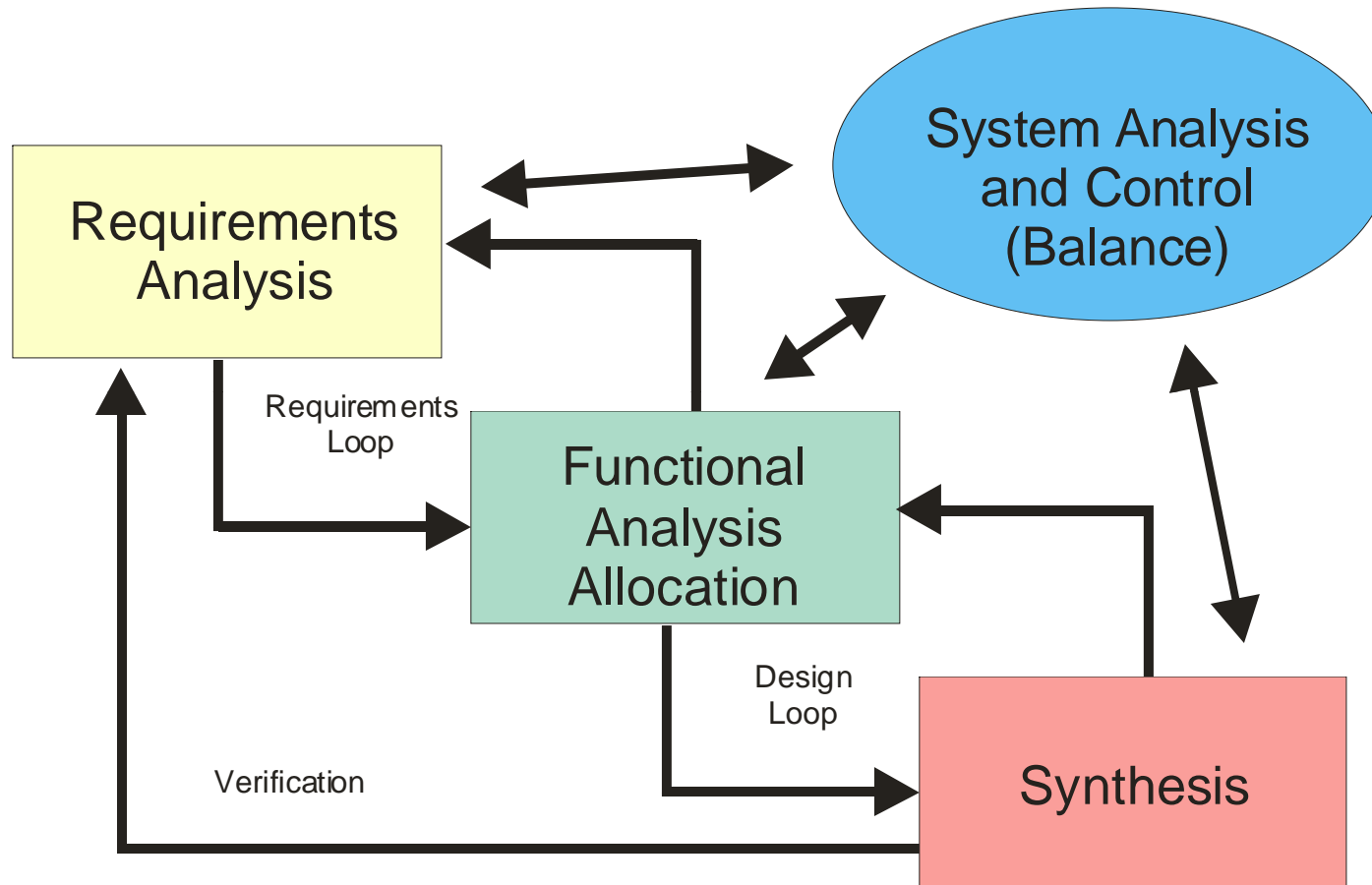


Measures, Criterion, and Standards

STANDARD - A standard provides a way to express the degree to which a ship must perform a task under the specified set of conditions. A standard consists of:

- **MEASURES** - Measures provide a dimension, capacity, or quantity description to a task. A measure provides the basis for describing varying levels of task performance and is therefore directly related to a task.
- **CRITERION** - A criterion defines acceptable levels of performance. It is often expressed as a minimum acceptable level of performance.

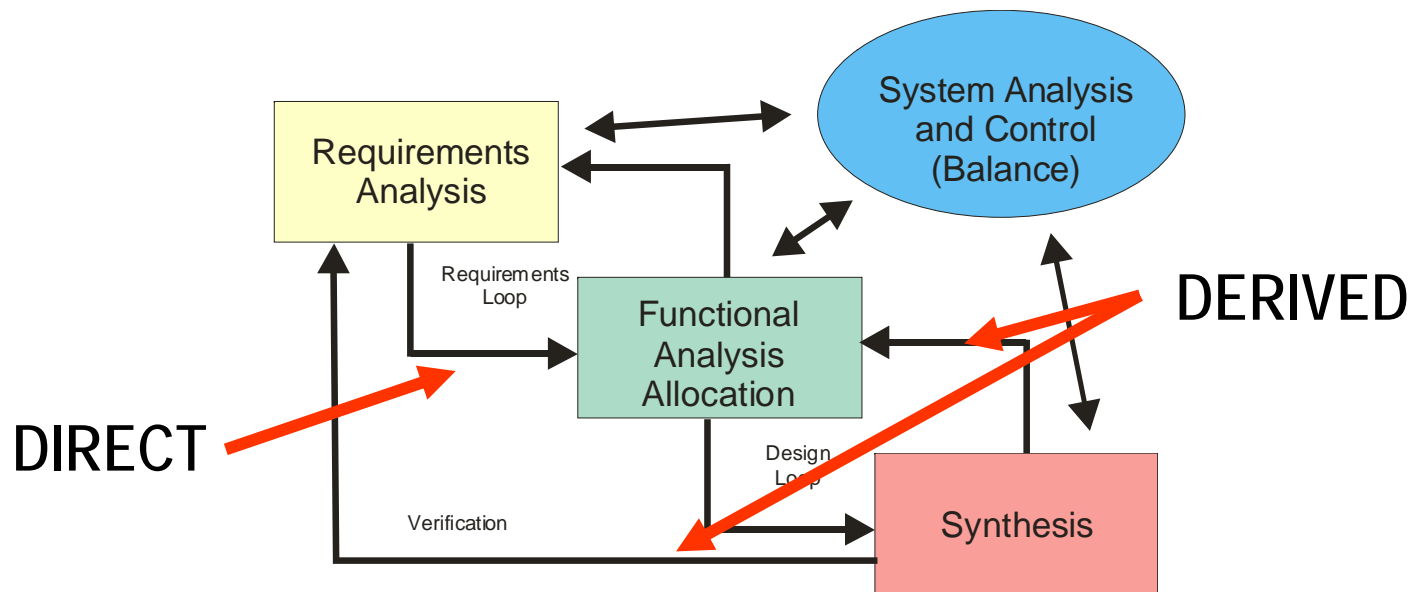
Defense Acquisition University Systems Engineering Process



**Not a serial process:
All steps occur at the same time!**

Requirement Sources

- Two Sources of Requirements
 - Direct from Customer Requirements (Operational Requirements)
 - Derived from System Implementation (Synthesis)



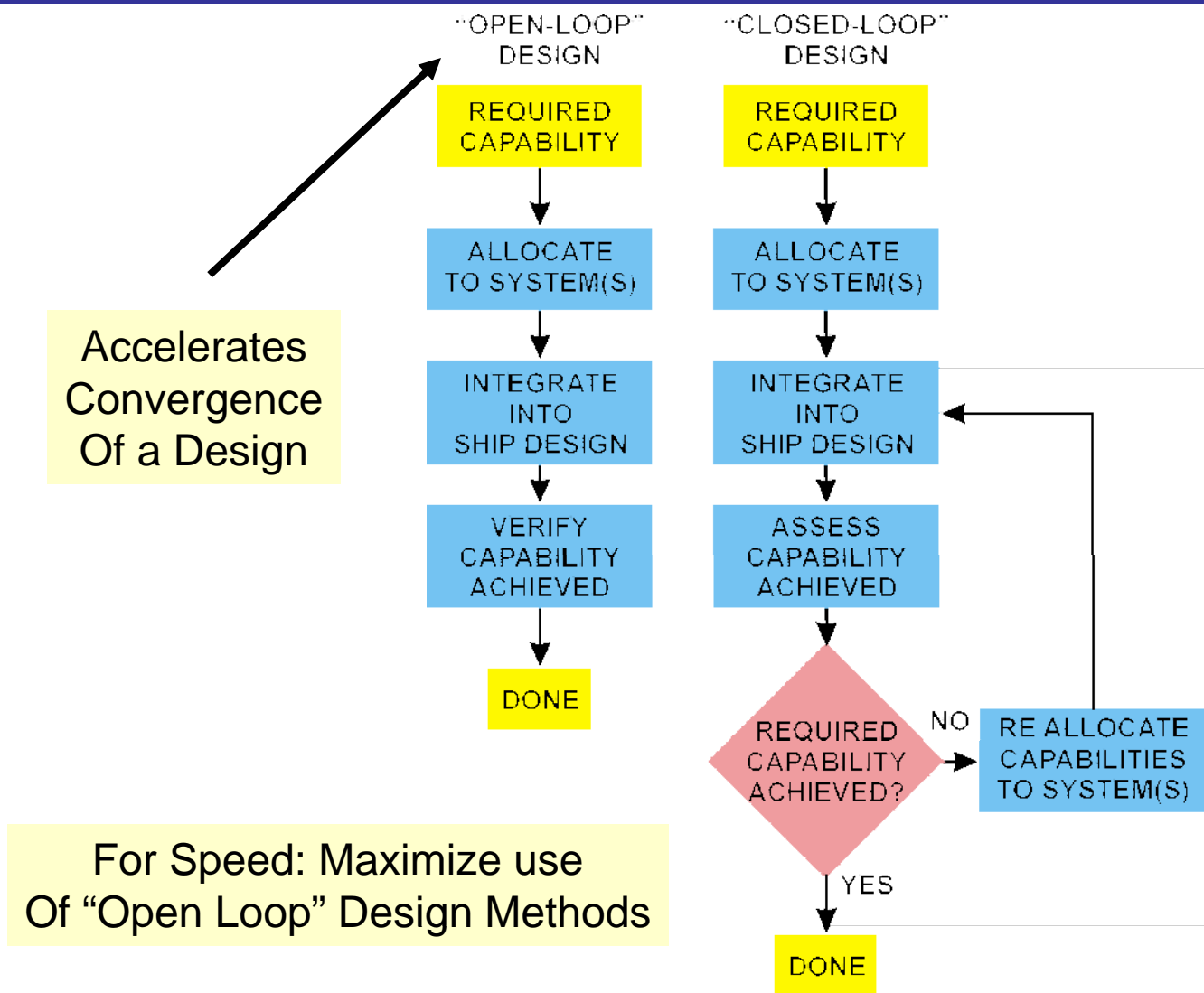


System Packages

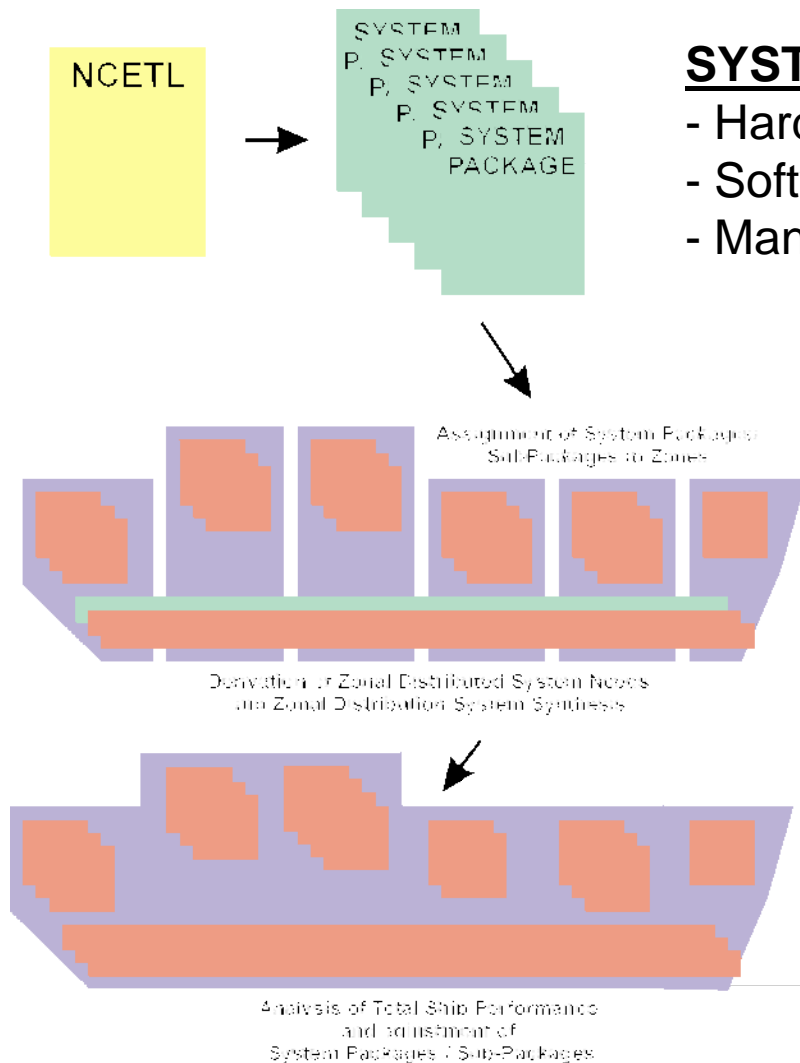
- Current Design process independently assesses Hardware, Software, and Manpower
 - Requires considerable coordination, which often results in design errors
- System Packages link Hardware, Software, and Manpower
 - Can be composed of “sub packages”
 - Allocated from NCETLs
 - Includes derived requirements
 - Ensures manpower, software and ship concept are all consistent
- Ideally, manpower requirements (and software) can be estimated solely from the collection of Systems Packages comprising a ship concept.
 - May be refined from synthesized ship concept
- Hardware elements of System Packages integrated through a ship synthesis tool (such as ASSET) into a ship concept

Packages Link Capabilities to Synthesis

Open Loop and Closed Loop Design



Zonal Design Process



SYSTEM PACKAGE:

- Hardware
- Software
- Manpower

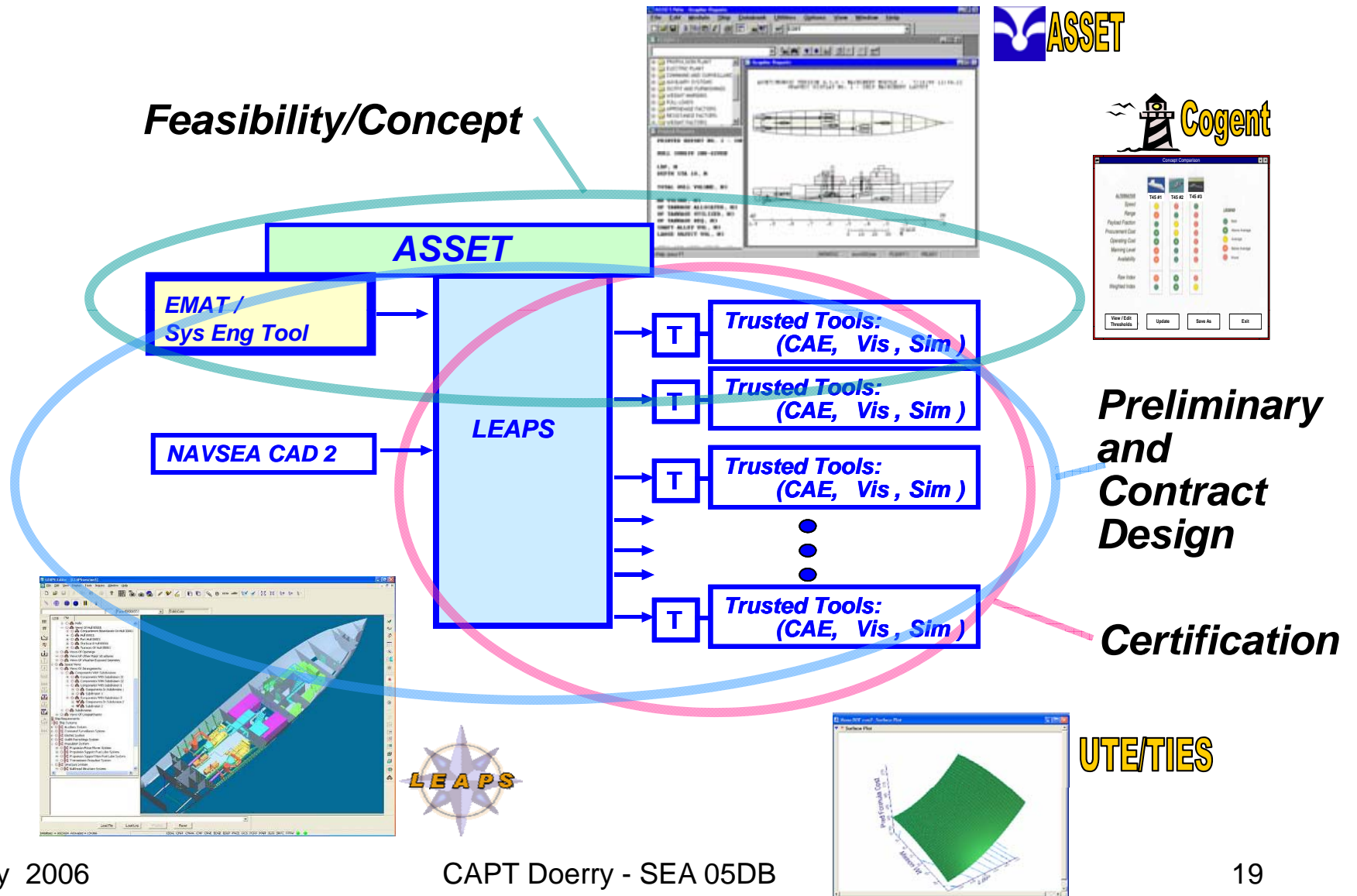
Zonal Design:

For capabilities that are required to survive, assign associated redundant Packages / Sub-packages such that loss of any 2 adjacent zones will leave sufficient functionality in undamaged zones.

Goal:

Make Survivability an "Open Loop" Design Process rather than a "Closed Loop" Process

Ship Design Tool Environment





System Engineering Tool Requirements

- Support Category 2 through 6 studies
 - 1.4 weeks to 5 month studies.
 - Should not require dedicated specialists for legacy systems.
- Link hardware, software, and manpower requirements
 - Automatically ensure consistency in design
- Capable of modeling new concepts
- Integrate with the LEAPS product model and integration tool
- Integrate with the ASSET ship synthesis tool
- Handle “Direct Requirements” and “Derived Requirements”
 - Direct Requirements expressed in terms of “NCETL”
 - Derived Requirements from “packages”
- Capable of determining impact of policy and practice.
- Capable of modeling detachments
 - Aircraft detachments
 - Embarked Staffs
- Support Zonal Design methods
- Support Genetic Algorithms
- Support Systematic automated exploration of a design space

This Tool does Not Yet Exist



EMAT – A First Step to a Systems Engineering Tool

- Early Manpower Assessment Tool “Rapid Prototype”
 - Complete by end of FY2006
- Demonstration of Methodology for a combatant
 - Definition of NCETL
 - Tasks
 - Conditions
 - Standards
 - Definition of System Packages
 - Systems
 - Manpower
 - Software
 - Method for aggregating Workload
 - Method for determining Manpower Requirements from Workload
- Development of Software Requirements for a production tool



Summary

- NCETL define capabilities that a ship concept must meet in the language of the warfighter
- System Packages link capabilities to the synthesis process.
 - Integrate Hardware, Manpower, and Software
 - Implement the DAU Systems Engineering Process
- Zonal Design enables “open loop” design for survivability
- Goal is to integrate zonal design process into ship design tool environment
- First step is the ongoing EMAT rapid prototype project