CARDEROCK DIVISION

Early-Stage Assessment of the Impacts of Next Generation Combat Power and Energy Systems on Navy Ships

NAVSEA WARFARE CENTERS

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Code: 823

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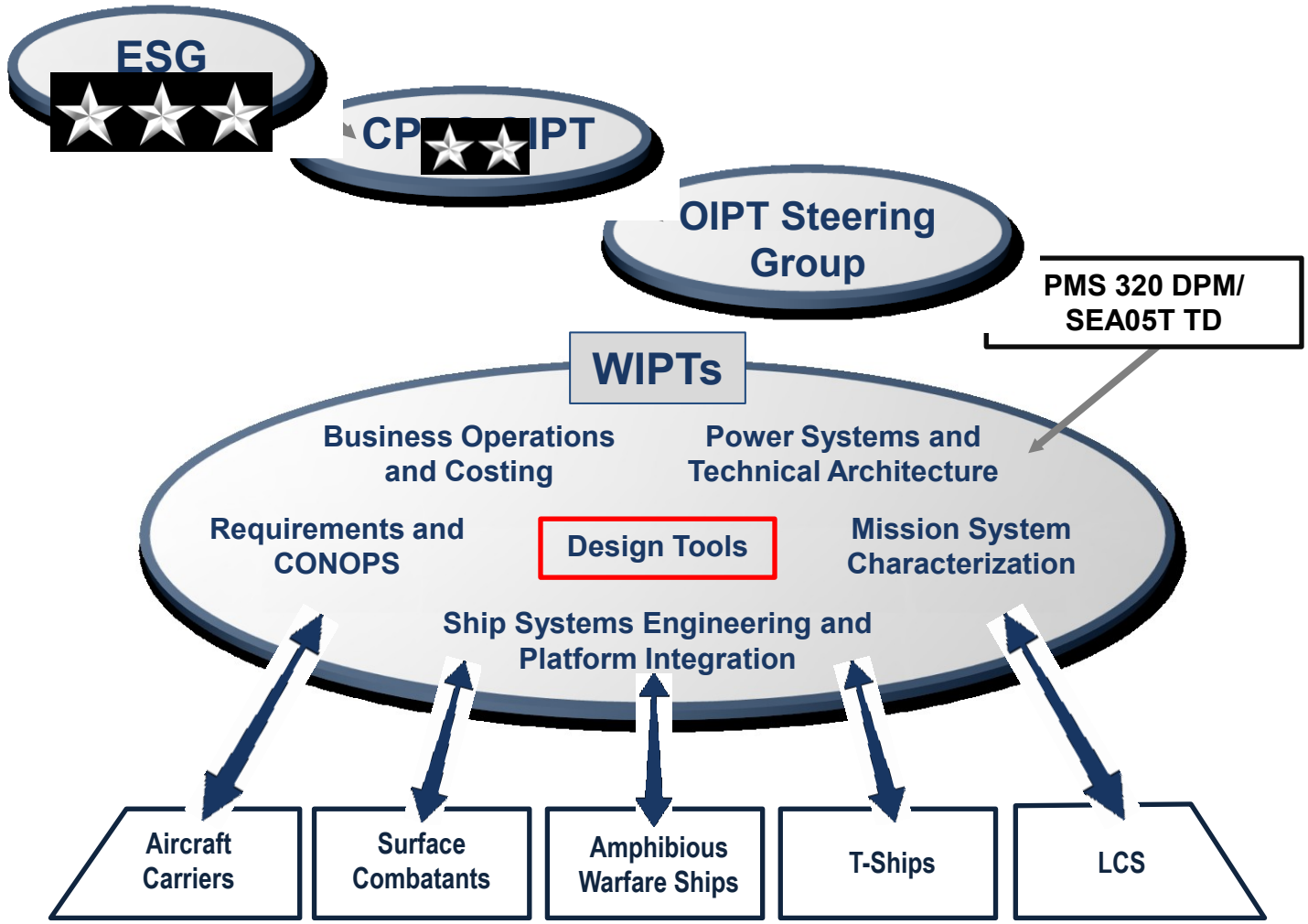
Agenda

- The Future of High Energy Combat Power and Energy Systems
- The Combat Power and Energy Systems Overarching Integrated Product Team (OIPT)
- System Patterns and Templates
- Systems Patterns and Templates in Ship Design
  - The Smart Ship Systems Design (S3D) Tool
  - The LEAPS design environment
  - The ASSET Ship Synthesis Tool
  - S3D and ASSET for Point-Based Design
  - Using Patterns and Templates for Set-Based Design
- Our Next Steps

The Future of High Energy Combat Power and Energy Systems

- Within the next 4 years, a new high energy system will come online every 2 years
- Several of these systems will require similar enabling power technologies:
  - Power converters
  - Energy storage
  - Control
- Integration efforts must be streamlined & focused to save time, money, and ensure success by:
  - Sharing lessons learned and leveraging investments
  - Seeking common solutions for similar issues
  - Schedule and budget coordination
- To bring stakeholders together an OIPT co-chaired by PEO Ships and NAVSEA 05 was formed with representation from modernization, new construction, resource sponsor, and R&D communities.

CPES OIPT Organization



WIPTs work to facilitate organizational integration and collaboration

Design Tools & Methodology Working Integrated Product Team

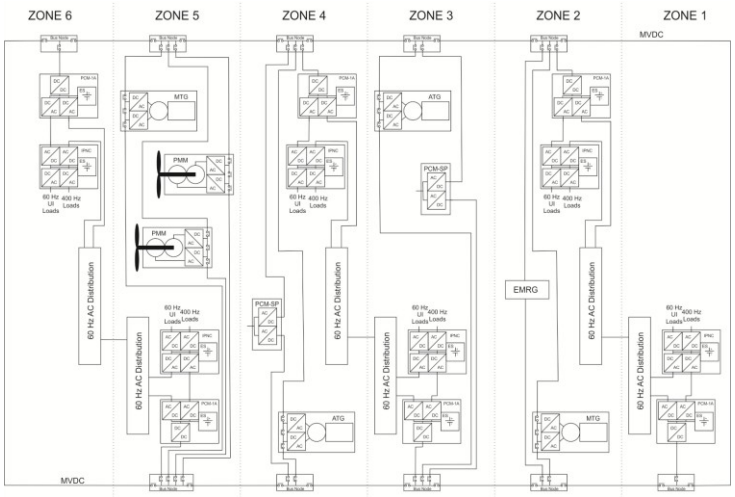
Scope: Coordinates with stakeholders (ONR, SEA 05D, 05T, PMS 320) to facilitate the development of design tools and methodology for advanced power and energy analyses. Integrates with design processes. Identifies other tools and design approaches that may be required.

Focus Areas/Boundary Conditions:

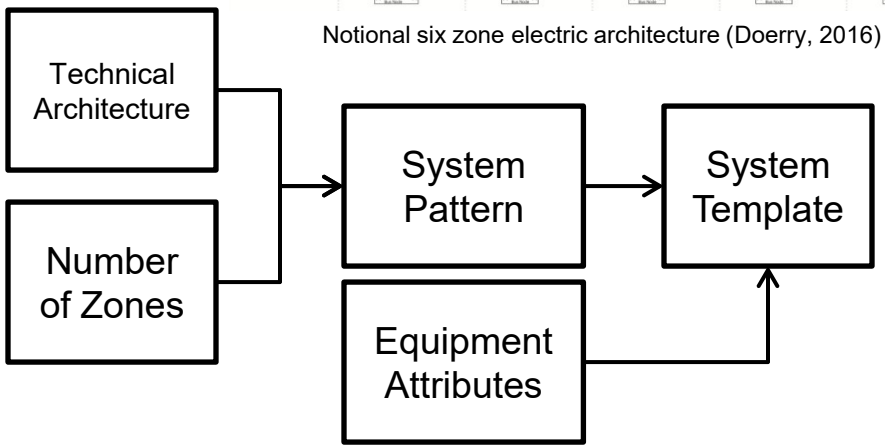
- **In** scope Focus Areas:
  - **Communicate with WIPTs for information sharing**
  - **Understanding CONOPS for design tools and design data integration**
  - **Gather data and design tools needed (requirements) especially in electrical area**
  - **Identify design tool gaps, software architecture requirements, and development strategies**
  - **Develop a prioritized list of needed tools in the best development sequence**
  - **Coordinate and facilitate ongoing tools development and common processes**
- **Out** of scope:
  - **CONOPS/CONEMPS development**
  - **Business model development**

Ship System Patterns and Templates

- *Pattern*: non-ship specific instantiation of a ship system technical architecture
  - Technical architecture provides design criteria and specifications
  - Equipment type assigned to each zone but not model or attributes
  - Cannot be simulated
  - Useful for removing dominated system patterns from design set
- *Template*: A pattern that has had equipment attributes prescribed
  - Can be simulated
  - Can be placed in a ship design
  - Used to further eliminate dominated solutions



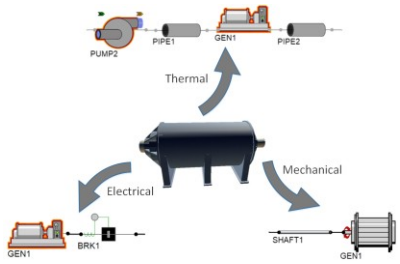
Notional six zone electric architecture (Doerry, 2016)

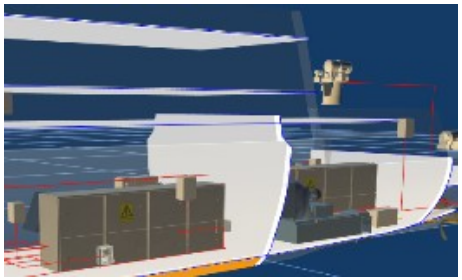


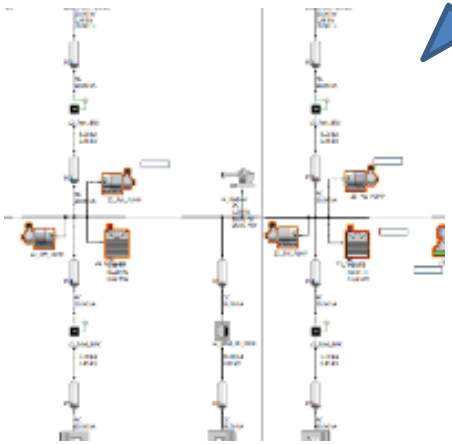
To make this approach viable there needs to be a method for quickly creating patterns, transitioning them to templates, simulating the system, and placing it within a ship design

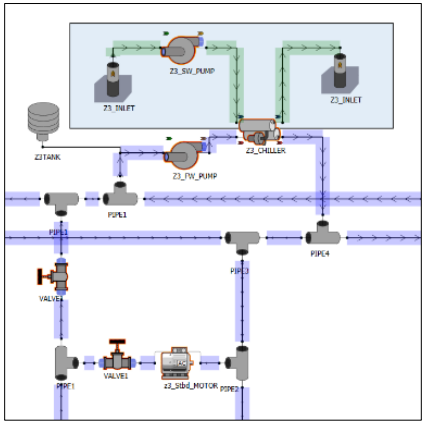
Smart Ship Systems Design (S3D) Tool

- Design
  - Layout and connectivity of electrical, mechanical, and thermal-fluid distributed systems
  - Pipe and cable routing
  - Scalable component sizing
- Analysis
  - Steady state electrical, mechanical, and thermal fluid simulation capability
  - Quasi-static mission analysis
  - Gateway to more in-depth system simulation





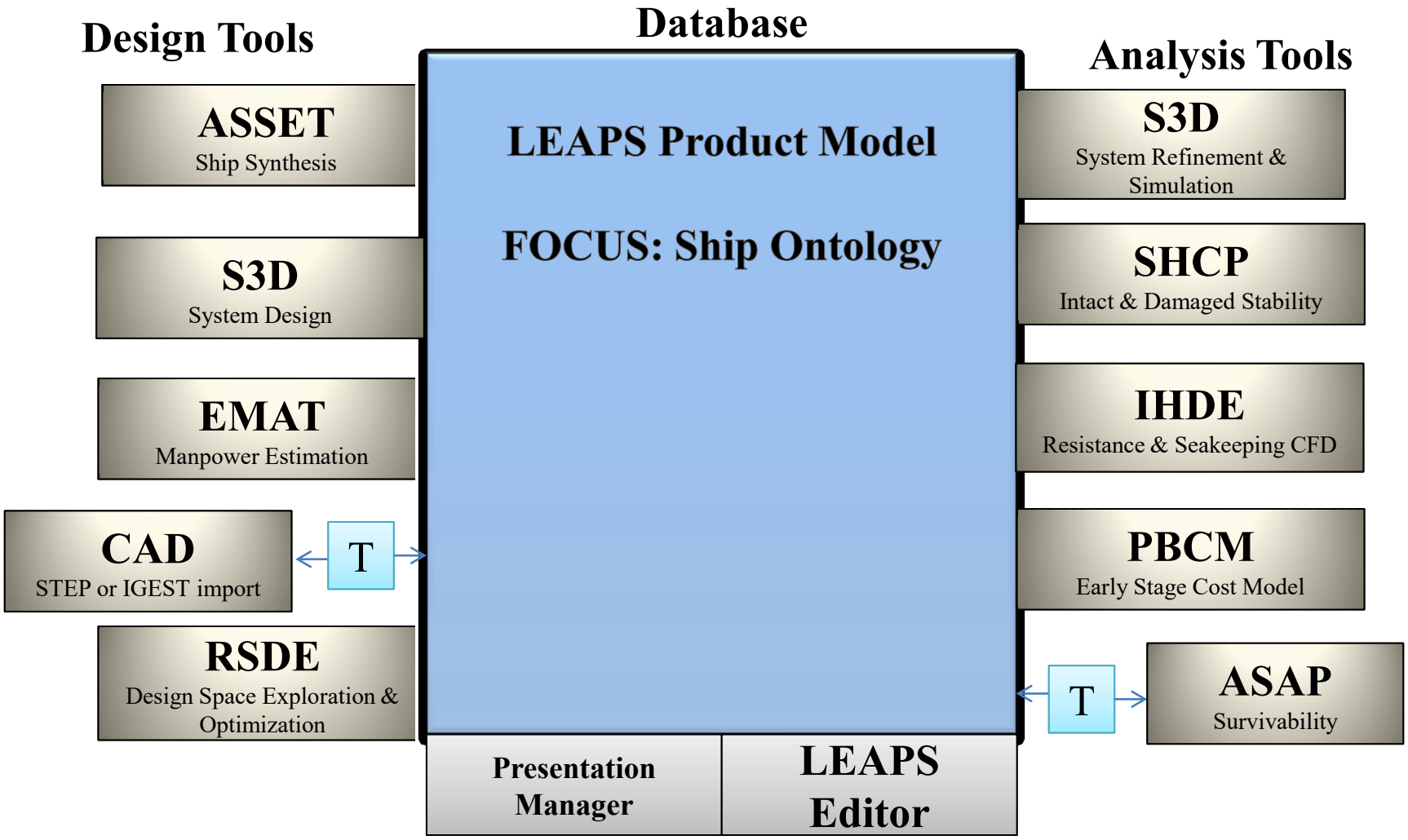




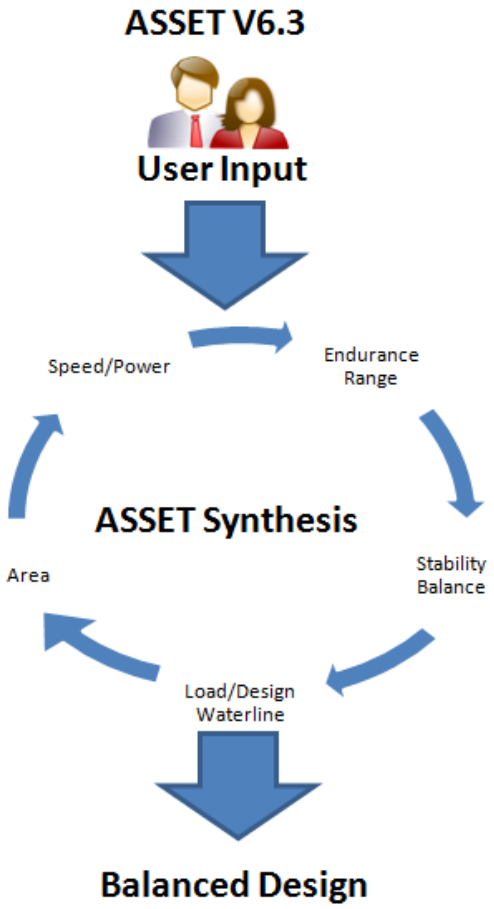
Notional S3D Models provided by ESRDC

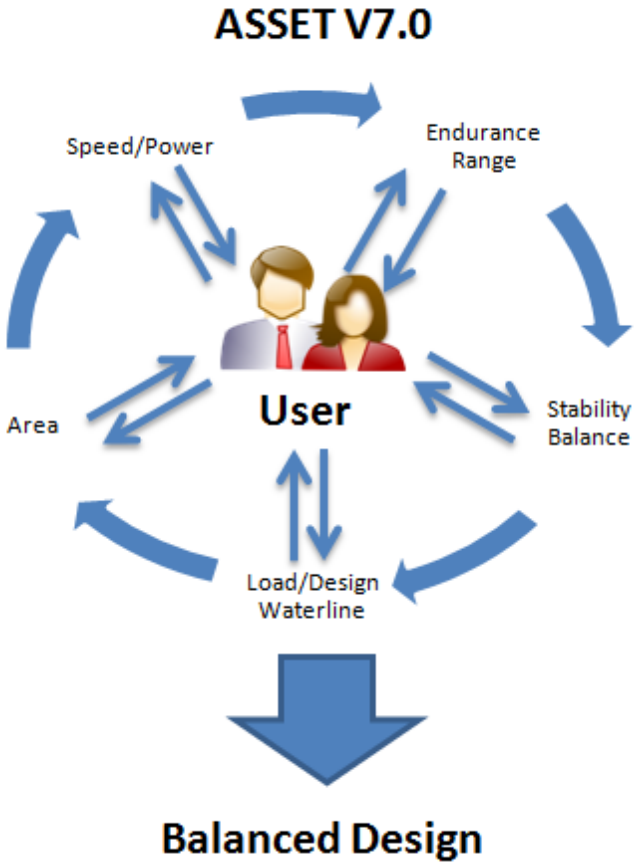
S3D goes one step beyond template creation by allowing the user to place and simulate a system within a ship design. Once in the design the whole ship impacts can be investigated.

Investigating Whole Ship Impacts Via LEAPS



ASSET: Ship Synthesis Tool





ASSET 7.0 will give the user added design control and flexibility at the expense of automation

ASSET – S3D Use Cases

Near Term

http://www.navy.mil/navydata/our_ships.asp

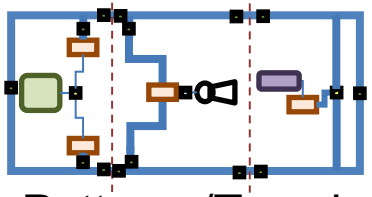
Generate Ship Concept in ASSET

Store in LEAPS DB

S3D:

- Read Concept from LEAPS
- Add detail/refine systems
- Analyze systems
- Persist simulation results to LEAPS

Long Term



Create System Patterns/Templates in S3D

Trade-off different Ship-system combos Using whole suite of LEAPS tools

http://www.navy.mil/navydata/our_ships.asp

Generate Ship Concept in ASSET

Near term use case is focused on point-based design while long term the goal is to focus on set-based design

RSDE Supported Set-Based Design

Design Space Exploration (DSE)

Designers provide **ASSET Baseline +** **Ranges** of inputs. Requirements, etc. {min,max}

Run **RSDE**

Sample Point

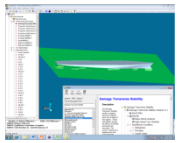
ASSET

***Included* Analyses:**

IHDE

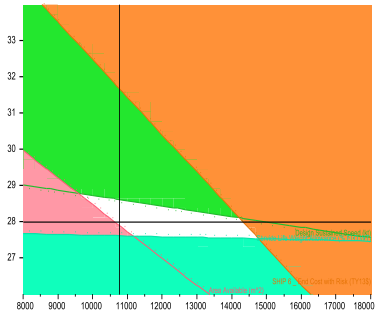
SHCP-L

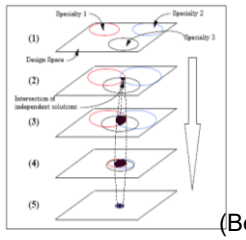
Etc…



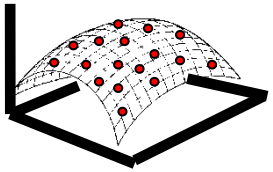
Automatically Re-samples for additional design points

Visualizations & Behavior Models

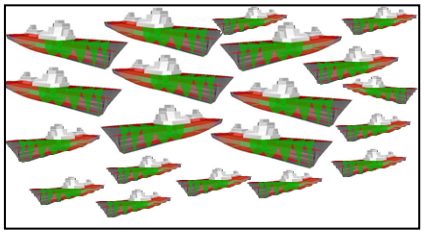


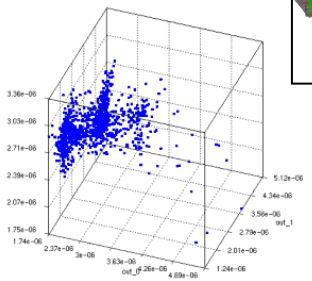


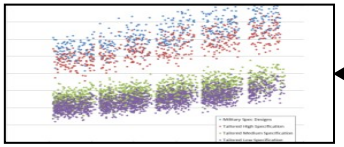
(Bernstein, 1998)



Set of Points







Output

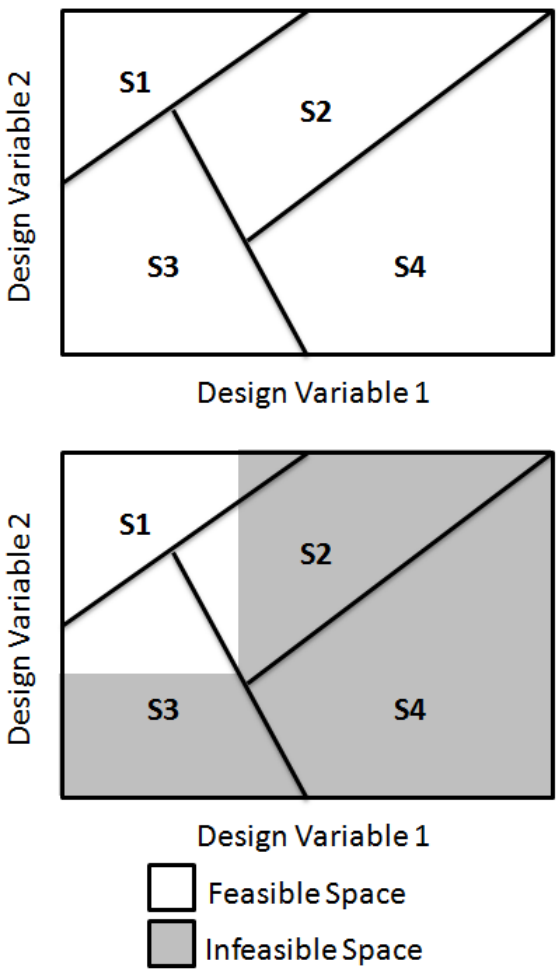
Designs & Analyses

In LEAPS

Set-Based Design Using S3D and RSDE

1. Create an initial ship design in ASSET and an initial system pattern and template in S3D
2. Populate system template into ASSET and create a balanced baseline ship design
3. Use RSDE to populate the ship design space with 1,000s of ship design concepts that have varying SWAP-C allocations for systems
4. Manually create ~10 new system templates
5. Overlay the ship and system design spaces to see which systems can fit within which ranges of SWAP-C locations
6. Apply additional design constraints (speed/range/etc.) to narrow design space

- Intention is to implement with a team of interns this summer



Questions?

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