Developing CPES Configurations (Part 1)

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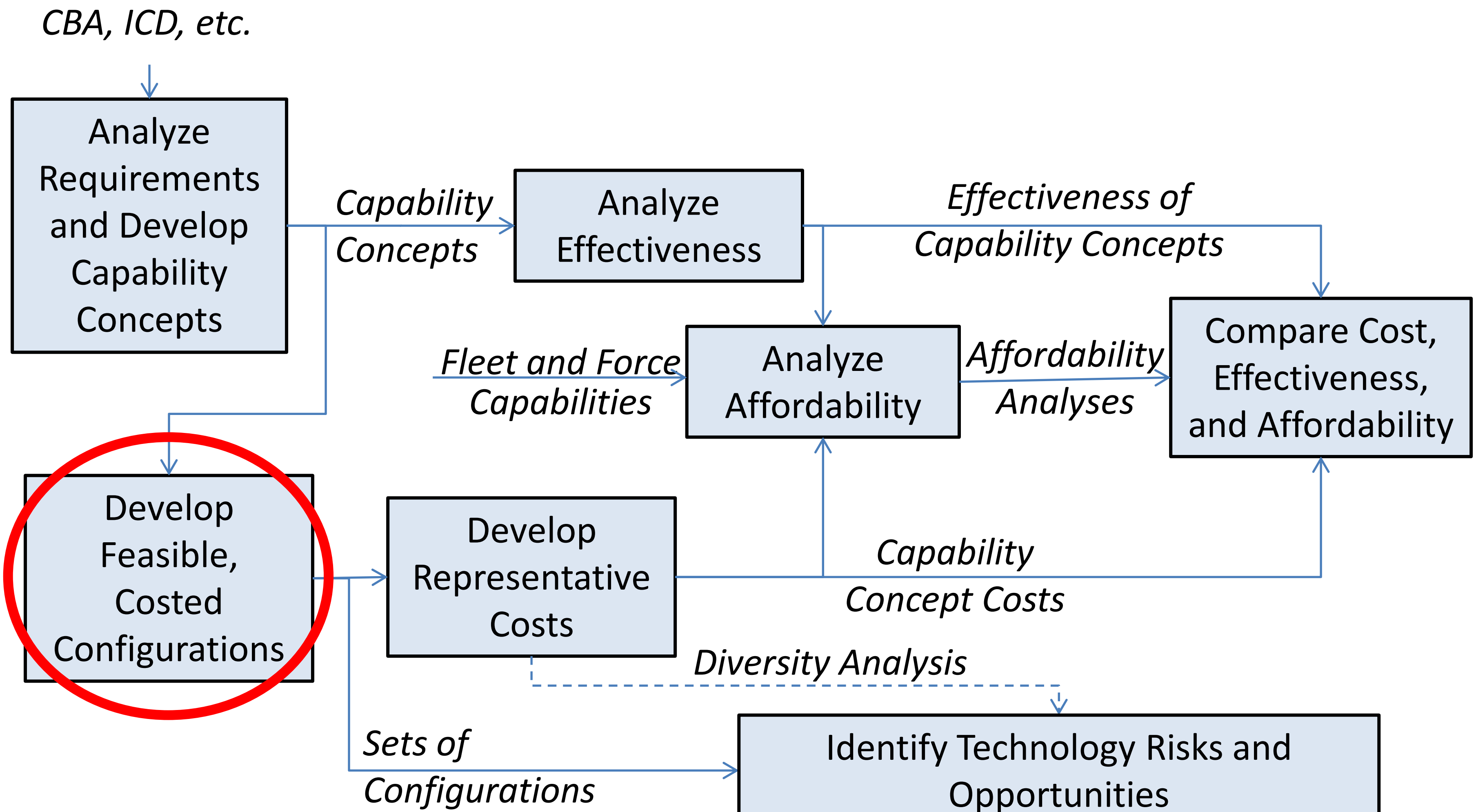
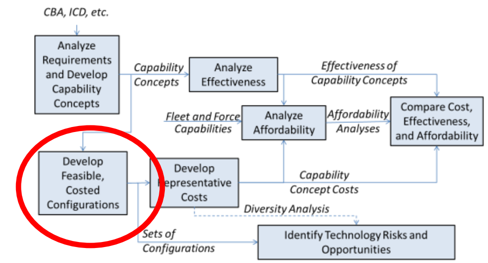
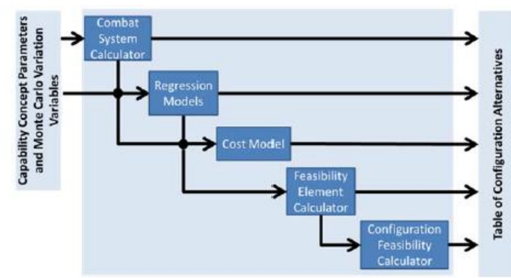
Reference Concept Exploration Process



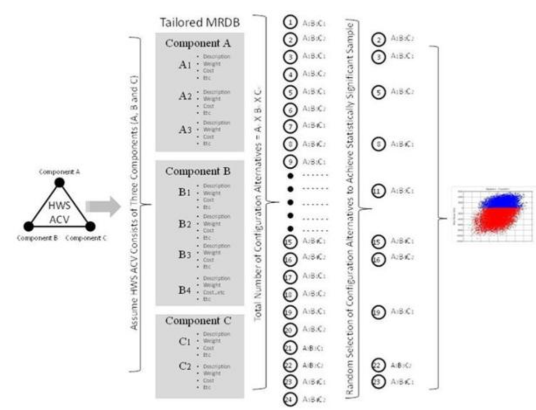
Develop Feasible Costed Configurations (review)

- Use synthesis tools to produce many diverse configurations for each capability concept.
  - SSCTF produced ~10,000 feasible configurations per capability concept
  - Use methods such as Monte Carlo to create configurations
  - Configurations should span the impact of requirements not fixed by the capability concept and not yet decided upon.
    - For example: single and twin shaft propulsion.
- Configurations represented by fixing values for a group (vector / list / array / table) of "design variables"
- Evaluate configurations for feasibility.
  - Incorporate as many feasibility "tests" as practical.
  - As the rigor of feasibility assessment increases, and as the degree that criteria are exceeded increases, the more likely feasible configurations will be viable.
  - Insight can be gained from configurations that are not feasible. (Technology Opportunities)
- Develop cost estimates for each (feasible) configuration.
  - Acquisition costs (including Combat Systems)
  - Operations and Support costs
  - Total Ownership costs
  - Include uncertainty of the cost estimate



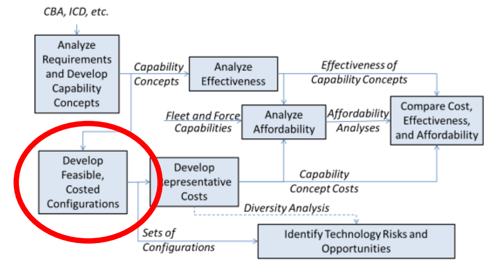


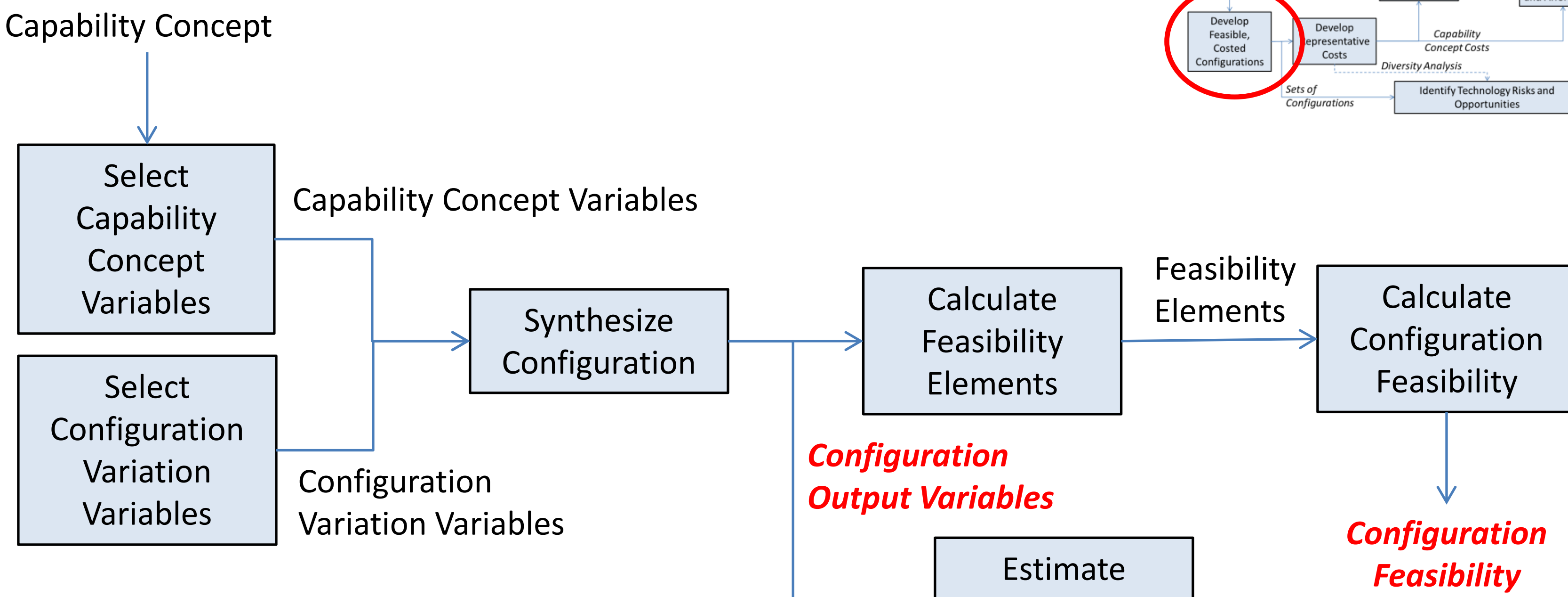
SSCTF Configuration Production



Monte Carlo Method

Develop Feasible, Costed Configurations

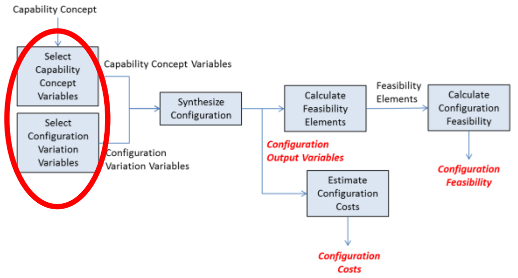




Repeat Process until have enough feasible configurations with sufficient diversity (or determine feasible configurations do not exist)

Products of Configuration Synthesis
(Collectively form the "Sets of Configurations")

Selecting Capability Concept and Configuration Variation Variables



- Translate Capability Concepts into variable values that the synthesis process uses as an input
  - Can involve picking from a list of options (i.e. combat systems)
- Determine variable values for all other inputs required by the synthesis process
  - Set to constant value or
  - Select from a range or list

Power System Architecture options will likely fall in this group

Nuances of Selecting Variable Values

- The decision process for selecting variable values can be multi-step, for example …
  - Pick architecture first
  - Then pick component values that are architecture dependent
- May limit the choice for one variable based on the selection other variable values (Enforce compatibility)
  - Improves “yield” of feasible configurations
    - If not done here, incompatible variable values must be identified as part of a feasibility element.
  - Verification of process can be challenging
    - May end up with a complex rule set
  - Must ensure variables chosen in correct order (at least track which variables have been selected and which haven’t)
  - Must consider impact on statistics on the group of feasible configurations

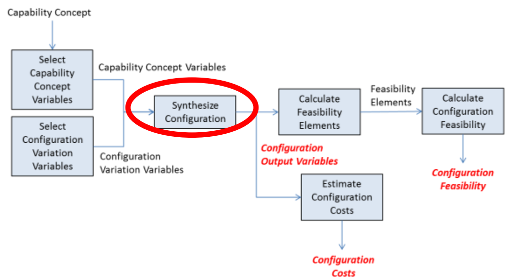
Organizing the Development of Configurations

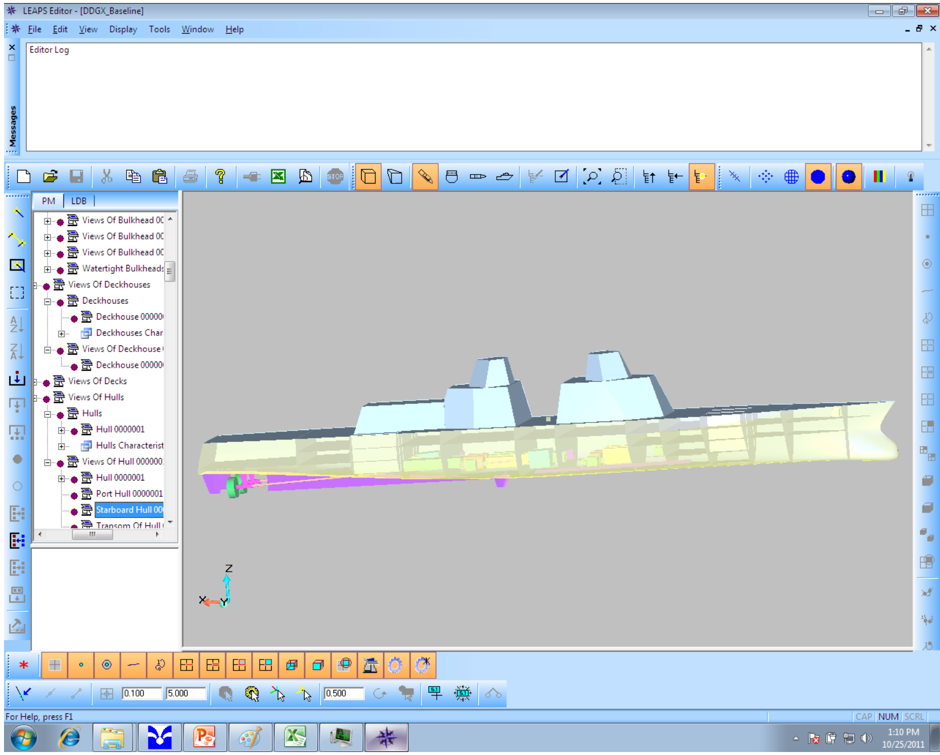
- Can implement a layered approach to developing a set of feasible configurations for a given capability concept
  - Depends on capabilities of synthesis tools

[Parent Hullforms to Explore: Steel Mono Twin Screw; Steel Mono Twin Pods. [Technical Architectures to Explore: MVDC; MVAC; etc. [Zone Cases to Explore: 4, 5, 6, etc. [Develop Feasible Costed Configurations]]]]

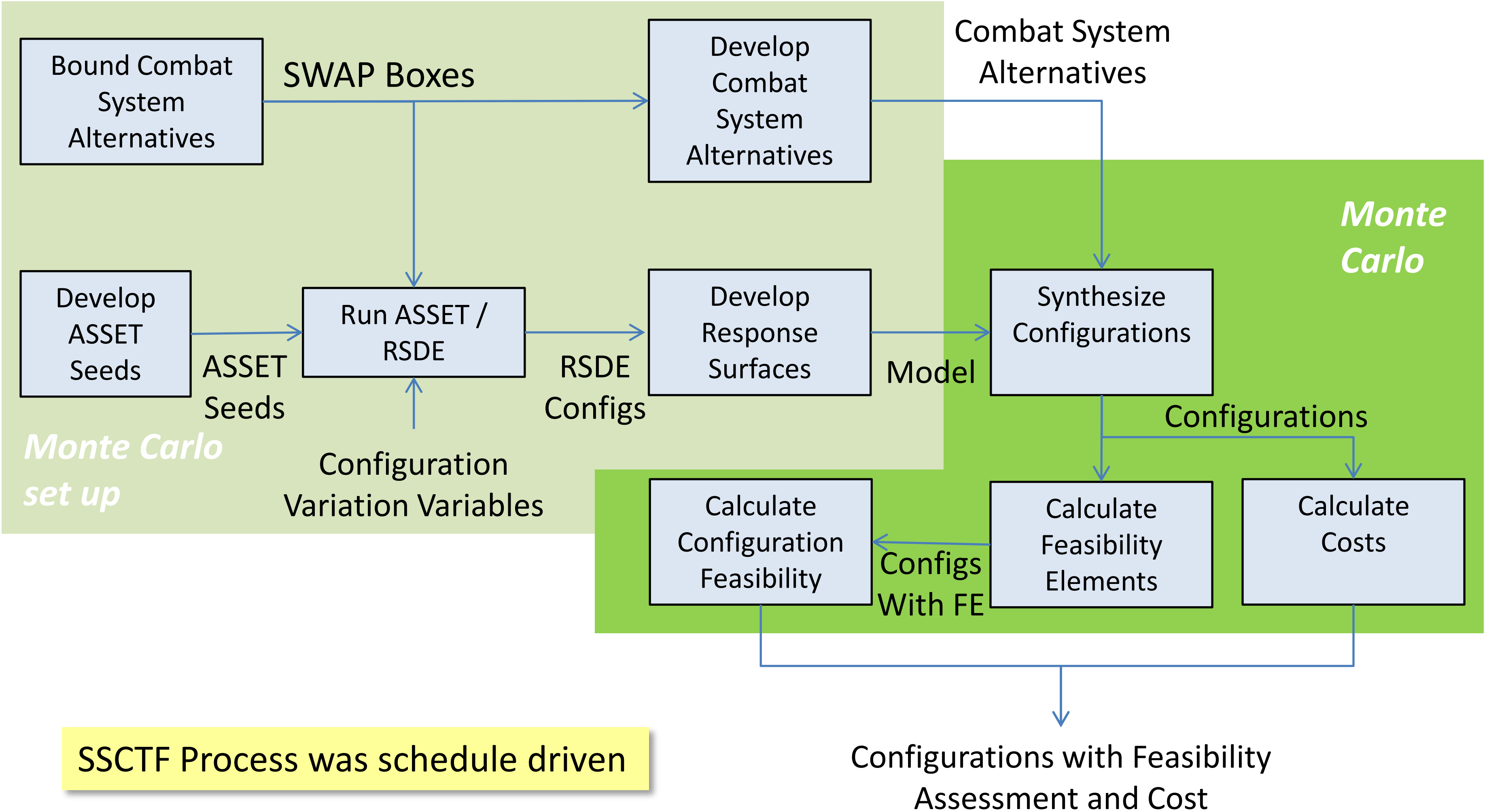
Synthesizing Configurations

- Synthesize a configuration based on the capability concept variables and the configuration variation variables
  - Output is a set of configuration output variables
  - Synthesis should be repeatable: same set of inputs should generate same outputs
  - Configurations should be consistent in terms of assumptions and externally imposed constraints
    - Process should not favor specific solutions.
- Ship Synthesis can be accomplished in many ways including ….
  - Semi-manually (SSCTF LCS mod-repeat spreadsheets)(S3D)
  - Synthesis Tool (RSDE-ASSET)
  - Behavior Objects (SSCTF new designs based on Behavior Objects derived from RSDE-ASSET configurations)





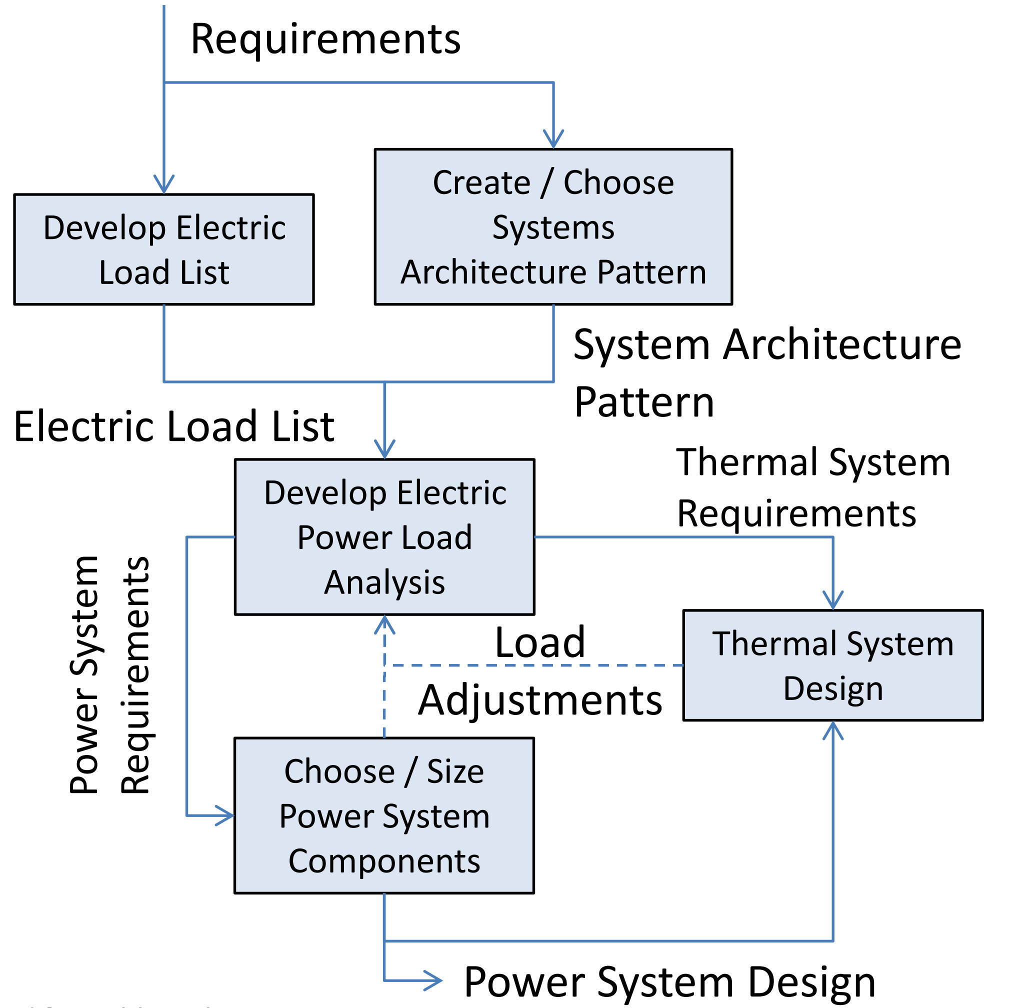
SSCTF New Design Example (simplified)



SSCTF Process was schedule driven

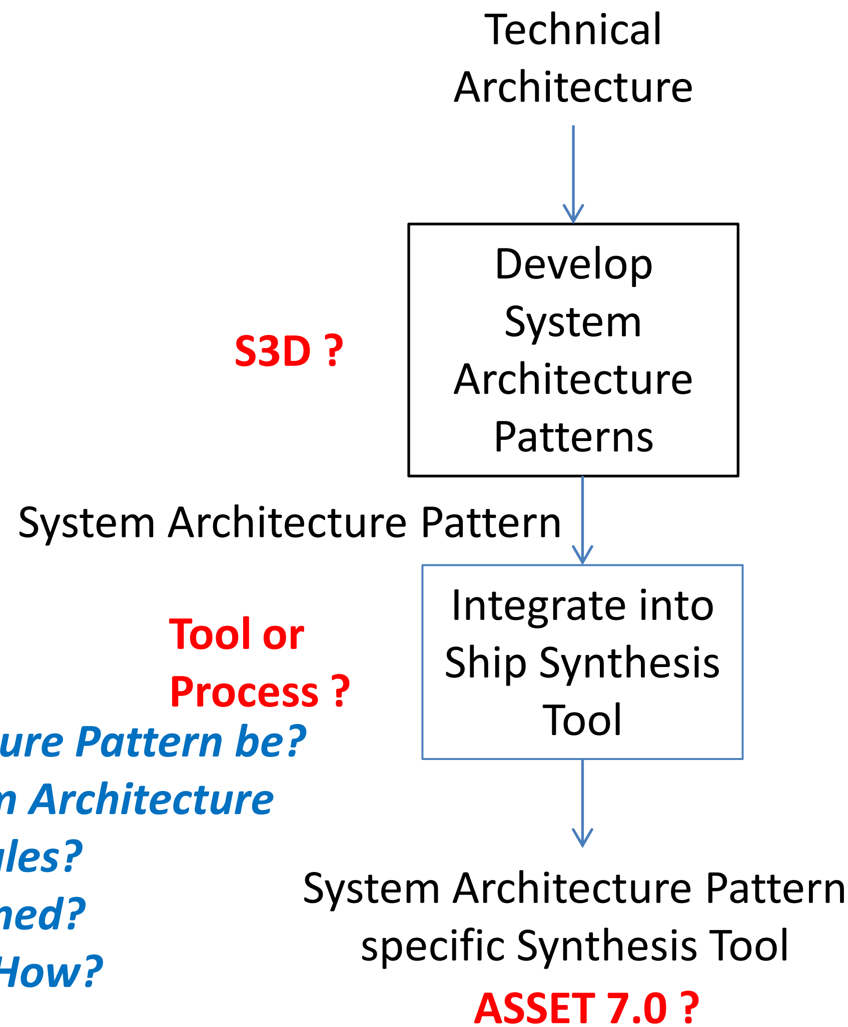
Reference Process for Synthesizing Power Systems

- DPC 310-1 Rev 1 provides guidance on Electric Load List and Electric Power Load Analysis (EPLA)
- Algorithms are needed to develop the Electric Load List.
  - ASSET algorithms are not sufficient.
- "Choose / Size Power System Components" should be based on a design practices and criteria manual
  - Does not exist for MVDC
- The EPLA influences thermal system design
- Feedback exists
  - Eliminate with margin?



System Architecture Patterns

- No currently available ship synthesis tool can directly model CPES power and energy systems
  - Perhaps a customizable tool that could implement tailored “system architecture patterns” would work
- Modeling at a more detailed level required to develop synthesis algorithms / system architecture patterns.
  - Accomplish prior to Concept Exploration as Pre-Studies
- Base System Architecture Patterns on Technical Architectures
  - Design Practices and Criteria, specifications, and standards associated with a type of power system (i.e. MVDC, MVAC, etc.)



How Specific or General should a System Architecture Pattern be?

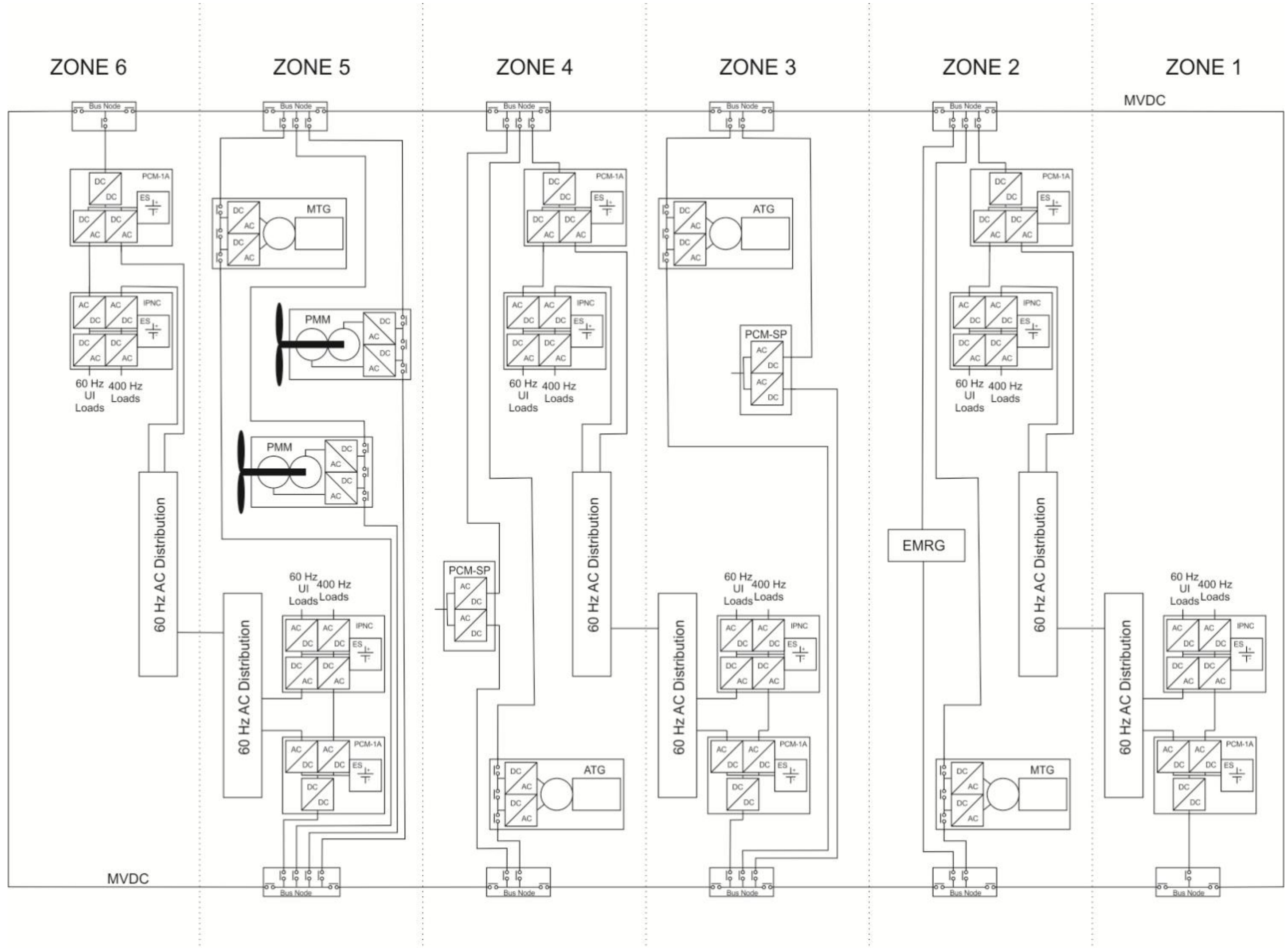
How suitable is ASSET 7.0 for implementing System Architecture Patterns as customized Machinery Modules?

How should a System Architecture Pattern be defined?

Could S3D create a System Architecture Pattern? How?

Can we implement this in time?

Example MVDC System Architecture Pattern



Plus algorithms for determining, size, weight, efficiency, thermal load, and cost

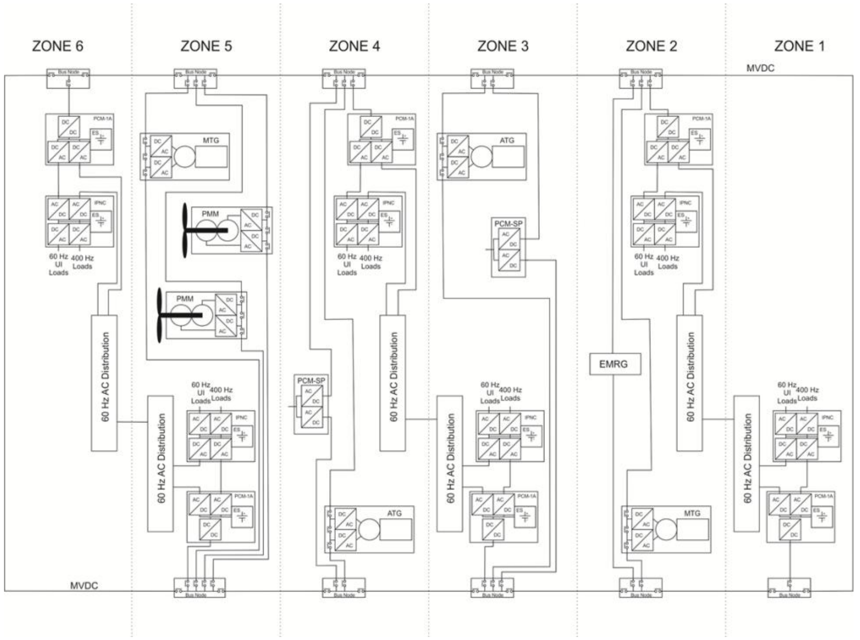
System Architecture Pattern

- Provide Topology
- Provide geography information to the zone level
- Associate with a Technical Architecture
  - Design Practices and Criteria, specifications, and standards associated with a type of power system (i.e. MVDC, MVAC, etc.)
- Include types of equipment in zone but do not select specific equipment for components
- Specific equipment power levels to be selected/varied by algorithm

Once components are selected and sized, have a System Architecture Template which can be analyzed for feasibility

System Architecture Pattern Constraints

- Number of zones
- Common to all zones
  - Bus Voltage
  - Bus type (Cable, bus duct, etc.)
- Required for all components (including distributive system components)
  - Algorithm for determining size and weight
  - Algorithm for determining cost
  - Algorithms for determining efficiency and thermal load
- Common across Zones
  - ATG (All ATGs the same)
  - MTG (All MTGs the same)
  - PCM-SP (All shore power converters the same)
  - PMM (All PMMs the same)
  - APM (possibly)
- Unique to each zone
  - Number of ATGs and MTGs
  - Number of PCMs
  - Number of PMMs
  - Number of ESMs (if applicable)
  - Number of specific types of large or pulse loads



Should the System Architecture Pattern include thermal systems?
Should the thermal systems and electrical systems be different patterns to enable some degree of mix and match?

System Architecture Pattern Nuances

- System Architecture Patterns can be fixed or flexible.
  - Fixed = number of components is not adjustable
  - Flexible = number of components is adjustable
- Ideally the System Architecture Patterns would be flexible, but may not be implementable in time ..
  - If flexible, then fewer System Architecture Patterns would be required.
  - If flexible, then the development and integration of tools will be more complex.
- The System Architecture Patterns must be aligned with appropriate Feasibility Element evaluations

CPES Issues with Synthesis

- Design Practices and Criteria not defined for MVDC systems
  - Models will have significant uncertainty until have an approved rule set for creating MVDC systems
- Existing MVAC modeling capability does not include provisions for energy storage or pulse loads
  - Doesn't implement Design Practices and Criteria Manual that is in the approval process
  - The impact of time domain dynamics not always accounted for
- Existing power system modeling not always sensitive to zonal design
  - Important for sizing zonal power conversion
  - Important for survivability assessments
- Existing power system modeling not always sensitive to control system properties
  - Cannot trade-off switchgear and energy storage for more complex control systems
- Load modeling is outdated
  - Particularly a concern for sizing zonal equipment
- Endurance fuel calculations outdated in ASSET
  - Not updated to reflect DPC 200-1 rev 1.
- Annual Fuel Use not calculated in ASSET
  - Separate tool needed to implement DPC 200-2
- Limited ability to model propulsion options

How should these issues be addressed for FSC?

What is the best long term solution?

Alternate Synthesis Approach

- Fix the ship full load displacement and volume in ASSET
- Let the endurance fuel load vary
- Synthesize Power and Thermal systems outside of ASSET (spreadsheets)
- Calculate changes in lightship weight and volume required
- Calculate endurance fuel load to keep the full load displacement fixed
- Calculate the updated endurance and compare to the requirement as a feasibility element
- Calculate the required volume to the fixed volume as a feasibility element.

Will This Work?

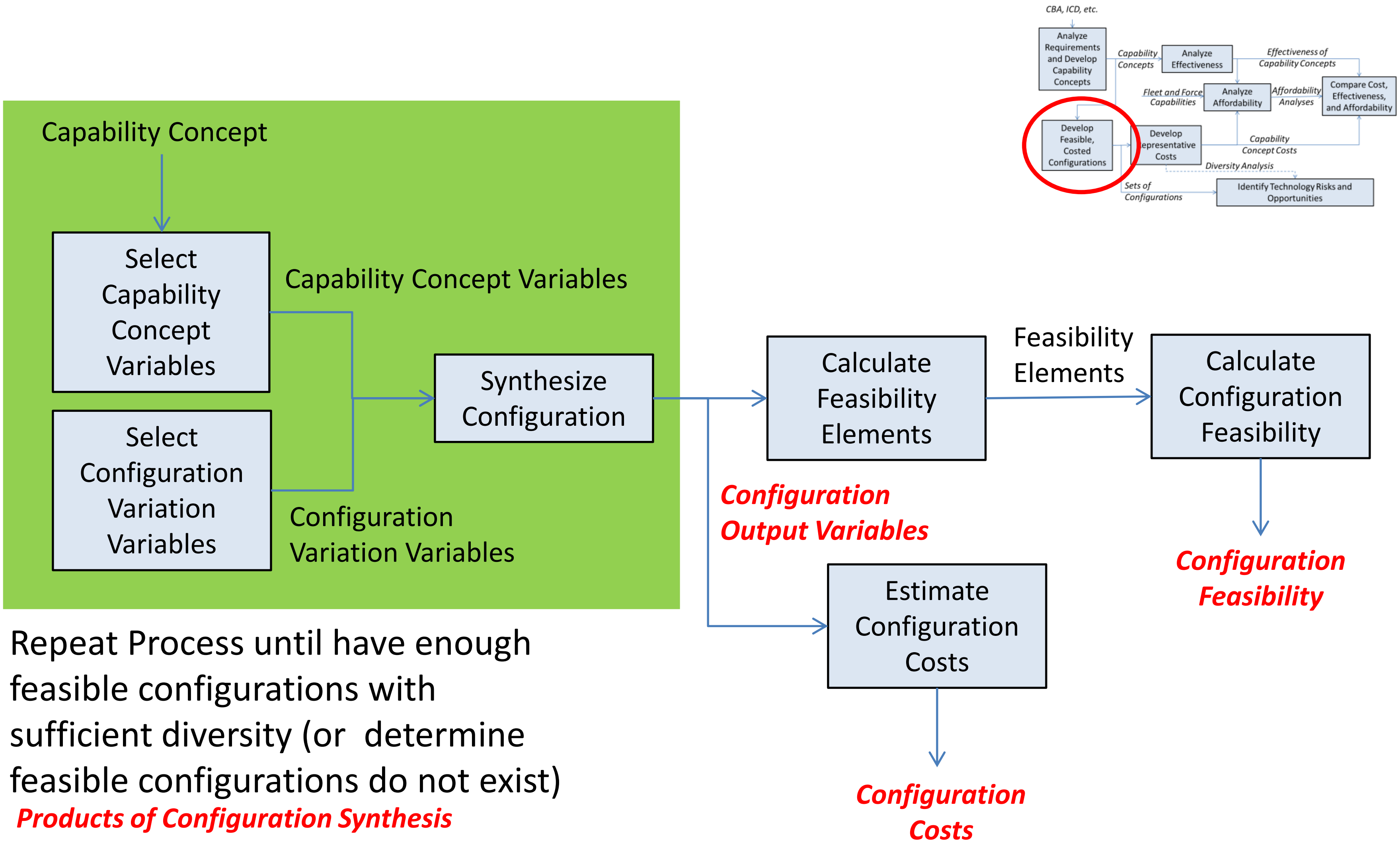
Are the other ASSET module dependencies on the Machinery Module adequately addressed?

What are the challenges in using this method?

How would the spreadsheet synthesis models be created?

Are there other alternate Synthesis approaches?

Develop Feasible, Costed Configurations



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