Zonal Ship Design

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NAVAL SEA SYSTEMS COMMAND
SEA 05DB

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Agenda

- ## Definitions
  - ### Survivability vs Quality of Service
  - ### Zonal vs Compartment Survivability
- ## Zonal Architectures
- ## Zonal Ship Design

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Definition: Survivability

- Design Threats
- Design Threat Outcomes
  - Performance of the ship following exposure to a Design Threat
- Elements
  - Susceptibility
  - Vulnerability
  - Recoverability
- Zonal Survivability
- Compartment Survivability
  - Provide capability to recover selected undamaged loads in a damaged zone.

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Definition: Quality of Service

- Metric for how reliable a distributed system provides its commodity to the standards required by the user
  - Measured as a MTBF
  - Not all service interruptions are QOS failures
  - Uses Reliability type analysis, but in different ways.

- QOS does not take into account Battle Damage, collisions, fire, flooding, etc.

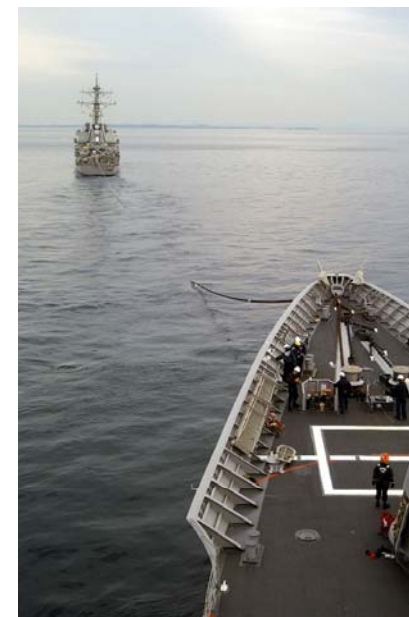- QOS ensures the ship can perform its mission under normal conditions (when it is not damaged).

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Interaction of Survivability and QOS

- Many design decisions that impact Survivability will also impact QOS
  - Redundancy
    - May be added for either Survivability (Vital Load) or for QOS
  - Rating of equipment
- Exceptions
  - QOS is not sensitive to equipment location.
  - Survivability is not very sensitive to reliability of equipment.
  - System line-ups can impact one more than the other.
    - Parallel vs. Split Plant

Survivability

Quality of Service

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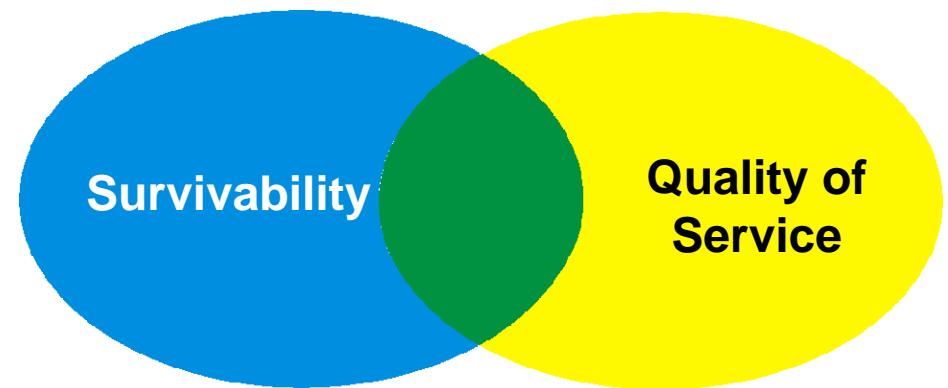
Definition: Zonal Survivability

Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6

━━━ Longitudinal Bus   ━ In-Zone Distribution Connectors

🟥 Longitudinal Bus Distribution Node   🟢 Load   🟨 In-Zone Conversion / Distribution Node

⬜ Generation Element   🟫 In-Zone Generation Node
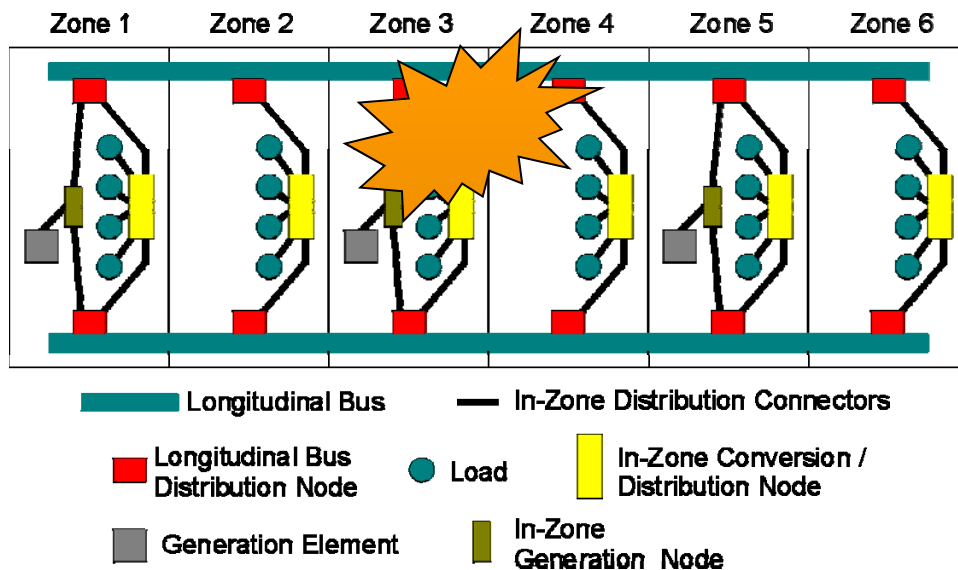
- The ability of a distributed system, when experiencing internal faults, to ensure loads in undamaged zones do not experience a service interruption.
  - Sometimes applied to only Vital Loads.
 - Usually requires one longitudinal bus to survive damage.

- Limits damage propagation to the fewest number of zones.
  - Enables concentration of Damage Control / Recoverability Efforts.

Definition: Compartment Survivability

Zone 1   Zone 2   Zone 3   Zone 4   Zone 5   Zone 6

Longitudinal Bus — **In-Zone Distribution Connectors**

Longitudinal Bus Distribution Node

Load

In-Zone Conversion / Distribution Node

Generation Element

In-Zone Generation Node
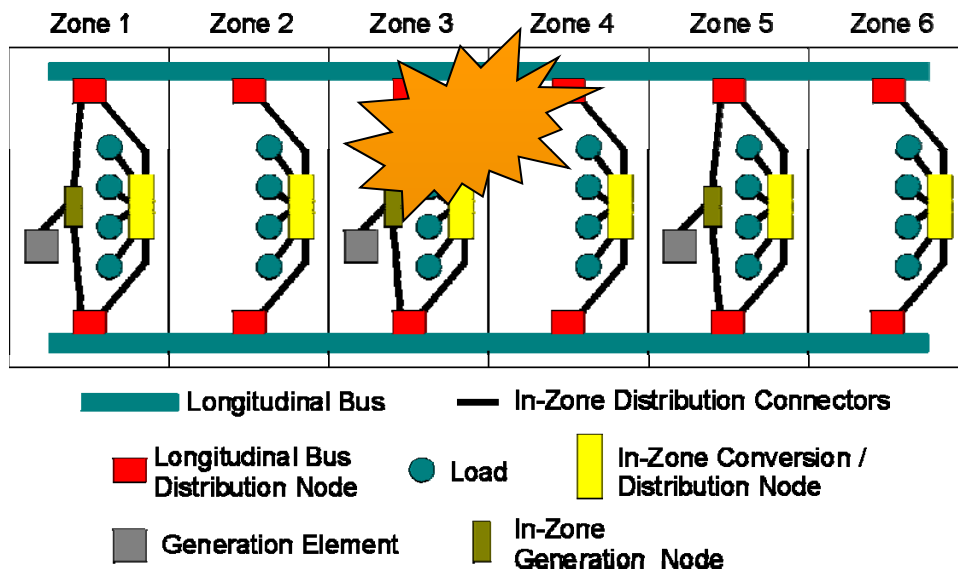
- Provide capability to recover selected undamaged loads in a damaged zone.
  - Often requires redundant feeds.

- Which Loads to Select?
  - Non-redundant Mission Systems
  - Loads supporting damage control efforts

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# Single Bus Architectures
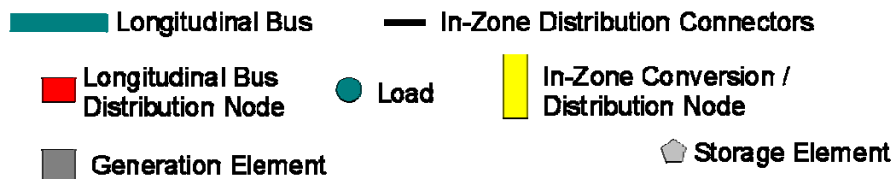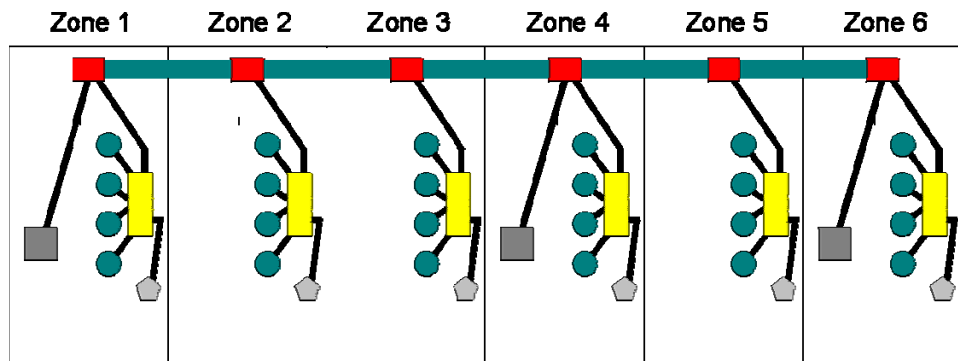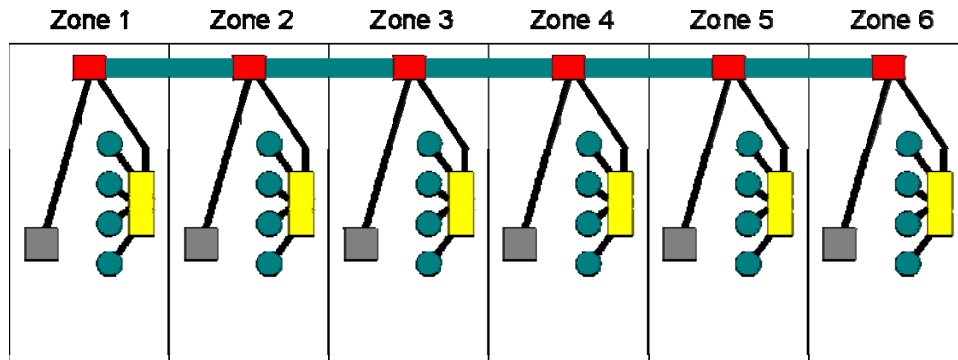
- Can achieve Zonal Survivability if Generation or Storage is in every zone.
  - Generation must be in First and Last Zones
  - In-Zone Distribution must be buffered from disturbances on longitudinal bus
- Attractive if Generation / Storage is less expensive than distribution.
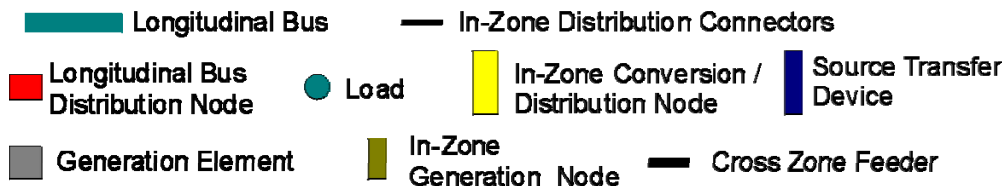
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Dual Bus Architectures
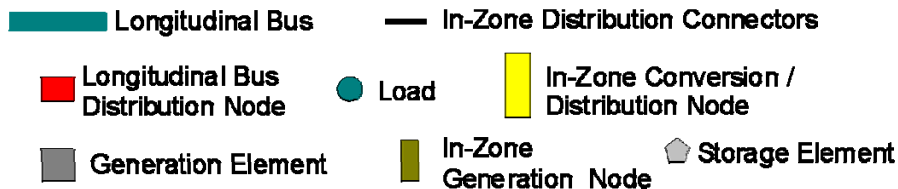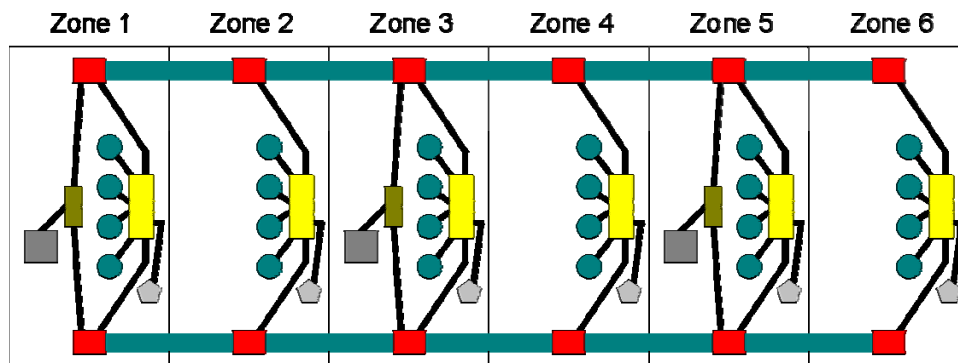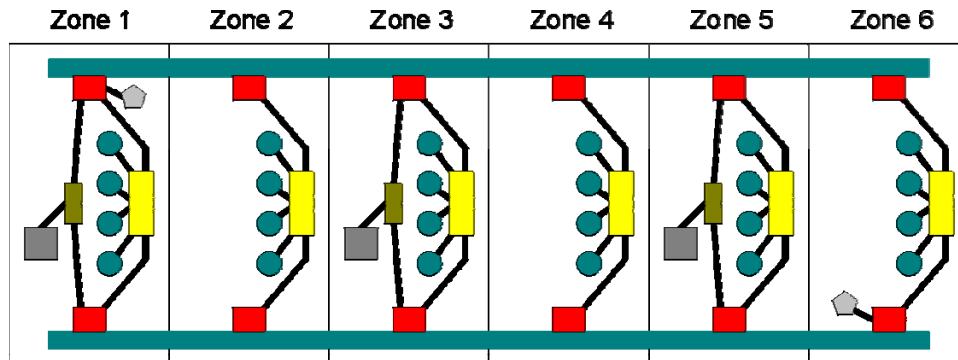
- Generation / Storage is not required in every zone.
- In-Zone Distribution must be buffered from disturbances on longitudinal bus
- Longitudinal buses must be physically protected to prevent loss of both buses from same event
- Without sufficient storage elements, generation and distribution elements must be rated to account for shifting of loads on loss of a longitudinal bus.
- Attractive if Generation / Storage is more expensive than distribution

Legend:
- Longitudinal Bus
- In-Zone Distribution Connectors
- Longitudinal Bus Distribution Node
- Load
- In-Zone Conversion / Distribution Node
- Generation Element
- In-Zone Generation Node
- Storage Element

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Hybrid / Multiple Bus Architectures
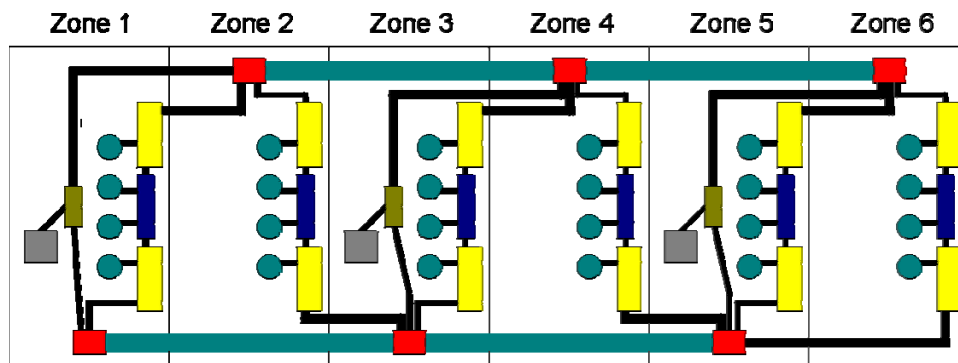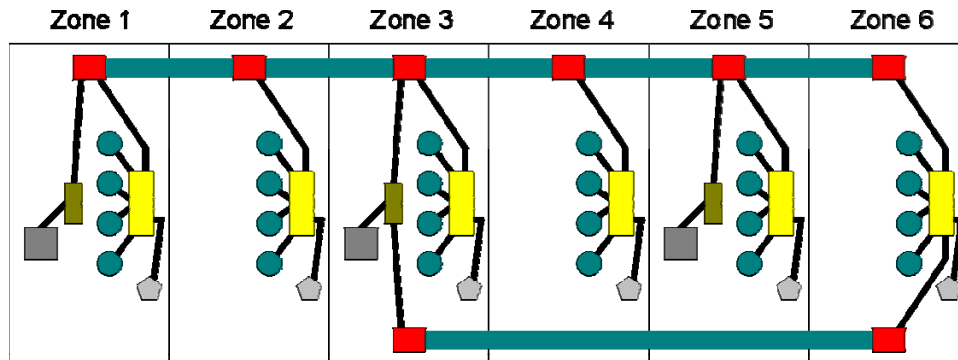
- **Variations to single and dual bus architectures can optimize cost for specific applications.**
  - Inability to locate generation in "end zones" in single bus architecture
  - Minimize cost of longitudinal bus distribution node

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Non-Zonal Loads

Zone N   Zone N+1

Zone N+1

Longitudinal Bus   —— In-Zone Distribution Connectors

Longitudinal Bus Distribution Node   Load   In-Zone Conversion / Distribution Node

Generation Element   In-Zone Generation Node   Storage Element

Source Transfer Device   Non-Zonal Load
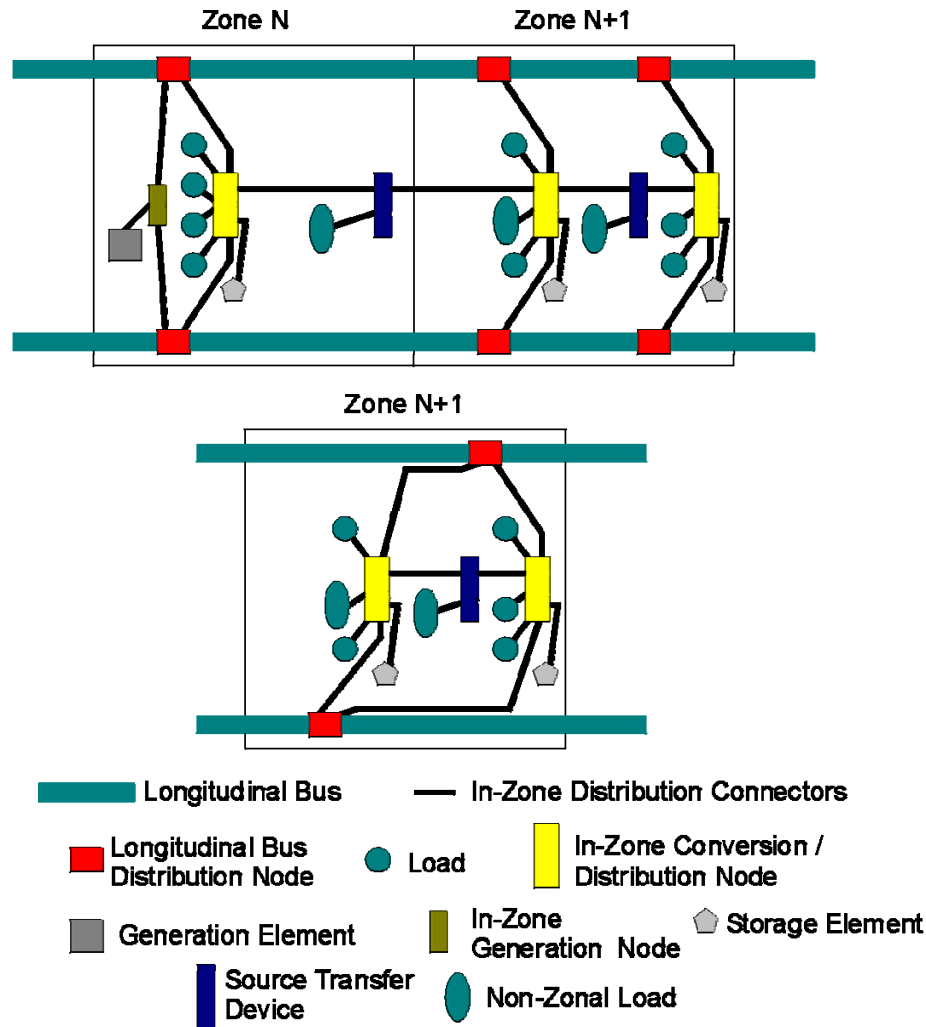
- Loads requiring "Compartment Survivability"

- Requires junction of main and alternate sources to be within damage volume of load.

- Multiple ways of providing "Compartment Survivability"

  – Most require additional equipment beyond that needed for Zonal Survivability.

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Zonal Ship Design: Concept Studies

- Identify Zone Boundaries
- Define notional architecture for each distributed system
- Identify and allocate Mission Systems elements to zones
- Create a list of equipment to implement the notional architecture and mission systems
- Incorporate the equipment and architectures into the ship synthesis model.
- Define Ship/Force CONOPS / DRM
  - Define Design Threats
  - Define Design Threat Outcomes

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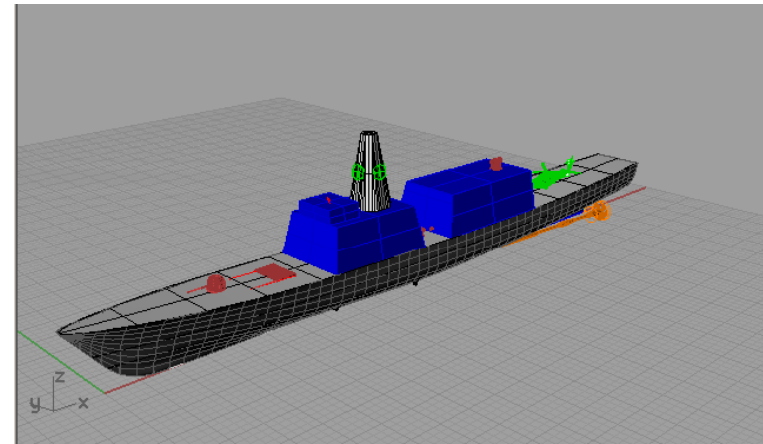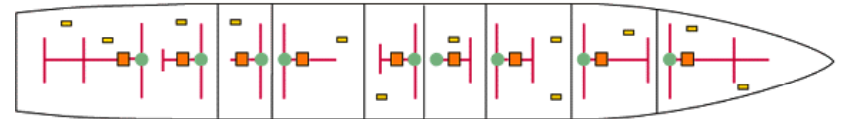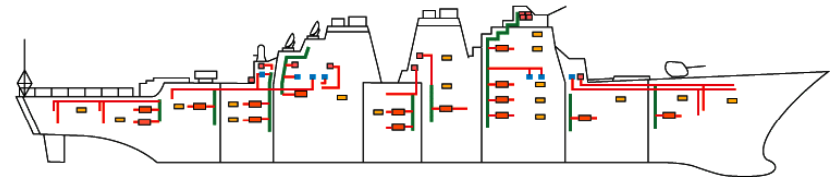
Zonal Ship Design: Preliminary & Contract Design

- Establish Zone Boundaries and Zonal Architectures
- Develop System CONOPS
- Develop Equipment Lists
- Based on CONOPS / DRM develop ship QOS requirements and allocate QOS requirements to Distributed Systems.
  – Verify QOS by analysis
- Arrangement of major equipment and longitudinal buses
  – Meet Design Threat Outcome requirements
- Total Ship Survivability Analysis
  – Verify Design Threat Outcomes
- Incorporation of Zonal Design requirements into Ship Specification

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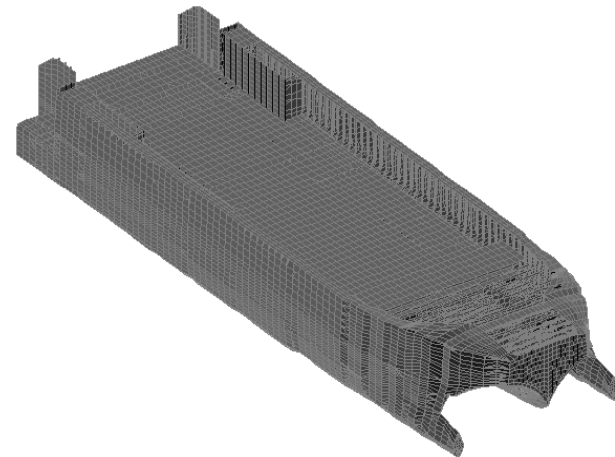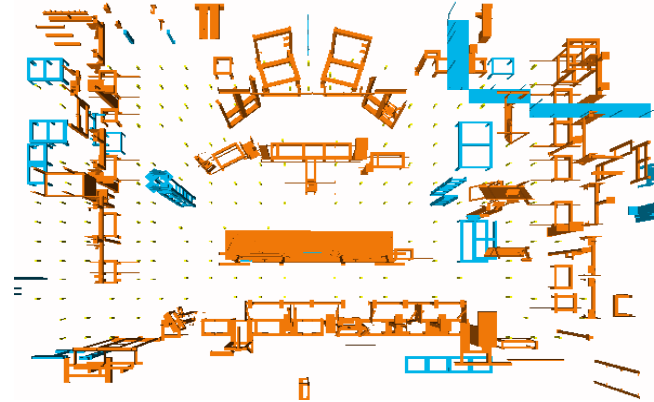
Zonal Ship Design: Detail Design and Construction

- Finalize location of equipment and distributed system routing

- Evaluate survivability of longitudinal buses and apply selective protection where needed

- Ensure selected equipment are provided compartment level survivability

- Verify QOS and Survivability requirements are met

- Ensure Procurement Requests for equipment contain the necessary allocated requirements to meet QOS and survivability requirements

Summary

- Zonal Ship Design must be done from a Total Ship perspective.
  - Mission Systems and Distributed Systems must be designed synergistically
- Distributed System Design must account for both Survivability and Quality of Service.
- The choice of Distributed System Architecture depends on survivability and QOS requirements and the relative cost of different elements of the distributed system.

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