Zonal Ship Design

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Agenda

• Definitions
  – Survivability vs Quality of Service
  – Zonal vs Compartment Survivability

• Zonal Architectures

• Zonal Ship Design
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.
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).
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
Definition: Zonal Survivability

• 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

• 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
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.
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.
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
Non-Zonal Loads

- 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.
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
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
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.