Electrical Power System Concept of Operations

Shipboard Power System Fundamentals

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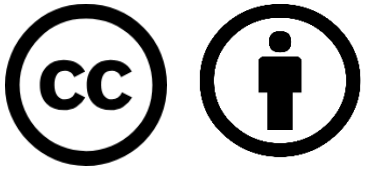

http://doerry.org/norbert/MarineElectricalPowerSystems/index.htm

Essential Questions

What is an electrical power system concept of operations?	Remember
What is an electrical power system concept of operations used for?	Understand
How is an electrical power system concept of operations developed?	Apply

Introduction

- The electrical power system concept of operations (EPS-CONOPS) documents how the designer intends for the ship's electrical power system is to be:
  - Designed
  - Operated during normal, nominal operations
  - Operated during restorative operations
  - Maintained
  - Repaired
  - Upgraded
- EPS-CONOPS is a working document
  - Content is generated during the design process as needed to support design and analysis
  - Serves as single source of truth to ensure consistency for calculations, analyses, and simulations
- IEEE Std 45.3 provides guidance for EPS-CONOPS content

EPS-CONOPS uses

- Serve as a single source of truth for design assumptions needed to support design and analysis activities (including simulations).
- Define standard electric plant line-ups.
- Reflect knowledge gained from electrical power system studies.
- Provide the basis for establishing load factors and load models in the electric power load analysis (EPLA).
- Provide operators, designers, and maintainers with insight as to how the designers intended for the electrical power system to operate under different conditions.

EPS-CONOPS as part of the design process

- Part of the digital thread within a digital design environment.
  - Evolution of the EPS-CONOPS should be traceable over time.
  - May refer to other configuration managed documents or databases that serve as a single source of truth.
    - EPS-CONPS should only link to authoritative sources of data.
- As the EPS-CONOPS evolves, changes should be examined to determine if analyses should be repeated to reflect the changes.

EPS-CONOPS content

- Overarching assumptions and requirements
- Operating conditions
- Operational scenarios
- Mission / payload system information
- Electric load Information
- Electrical power system machinery lineups
- Nominal operations
- Restorative operations
- Electrical power system / ship system trade studies
- Maintenance / repair strategy
- Modernization strategy

Overarching assumptions and requirements

- Typical overarching assumptions and requirements documented in the EPS-CONOPS:
  - Margin and service life allowance policy
  - Ship service life
  - Redundancy requirements
  - Survivability requirements
  - Minimum and maximum loading on generator sets under normal conditions
  - Functions of energy storage
  - Identification of all separately derived systems
  - QOS t1, t2 and Mean Time Between Service Interruption (MTBSI) for each separately derived system
  - Power quality interface standards for each separately derived system
  - Grounding system type for each separately derived system
  - Identification of converters as isolated or non-isolated

Operating Conditions

- Typical operating conditions include
  - Cruise
  - One or more Missions (or functional)
  - Shore
  - Anchor
  - Emergency
- Should include guidance for determining which mission system equipment and support system equipment are online
  - Particularly important to identify if large loads are online
- Used in
  - Electric Power Load Analysis (EPLA)
  - Endurance fuel calculations
  - Annual fuel calculations

Operational scenarios

- Operational scenarios consist of a timeline of
  - Operating conditions
  - Use of large loads
  - Use of significant smaller loads
  - Associated speed time profiles
- Used in
  - Annual fuel calculations
  - Energy storage system power and energy capacity sizing

Mission / payload system information

- Load models for large loads and smaller but significant loads
  - Detail power consumption under different operating modes of the equipment.
  - Identify percentage of time in each operating mode in each operational condition.
- Creation of load models
  - Initially by analogy with similar ships.
  - Refined as knowledge is gained on how the ship is intended to be operated.
- Used in
  - Creation of load factors for EPLA.

Electric load information

- Special considerations for specific loads
  - Impact on electrical power system lineups.
  - Loads that may not meet power interface requirements.
- Special considerations for the power system
  - Features in the power system, or power system operations, to mitigate loads not meeting power system interface requirements.
  - Conditions where the power system may not meet power system interface requirements.
- Used in
  - Design of the power system.

Electrical power system machinery lineups

- For each operating condition
  - Preferred electric plant line-up
    - Bus tie breaker position
  - Generator set scheduling table
  - Energy storage system mode of operation
- Used in
  - EPLA – including energy storage system sizing
  - Endurance fuel calculations
  - Annual fuel calculations

Nominal operations

- Describe how the electric plant is intended to operate:
  - For each of the operating conditions, what performance attributes should be optimized.
  - The process for transitioning between operating conditions; what is the order of changes to the electric plant lineup.
  - The method employed for power management; what is the process for bringing additional generation capacity online and dropping offline excess generation capacity?
  - The degree of autonomy expected of electrical power system controls for each operating condition.
- Used in:
  - Creating simulation models for dynamic simulations.

Restorative operations

- Describe how the electric plant is intended to be restored to nominal operation following failure or damage
  - Load shedding strategy and implementation.
  - Casualty power strategy and implementation. (if a casualty power system is installed)
  - Dark ship start procedures. (no generation online, but energy storage systems functional)
  - Dead ship start procedures. (no generation online; all energy storage systems depleted)
  - Zonal survivability assumptions and procedures.
  - Compartment survivability assumptions and procedures.
- Used in
  - Creating simulation models for dynamic simulations.
  - Survivability analyses.
  - Quality of Service and Reliability analyses.

Electrical power system / ship system trade studies

- Document insights gained from analyses and trade-studies.
- Used in
  - Ensuring all other analyses and design activities reflect the insights.

Maintenance / repair strategy

- Document maintenance and repair strategies of electrical equipment.
- Used in:
  - Determining how much redundancy to provide.
  - Determining frequency of service interruptions for QOS analysis.
  - Determining Mean-Time to Repair for reliability analysis.
    - Determining how many spare parts are required onboard.

Modernization strategy

- Describe features in the power system design that facilitate modernization:
  - How service life allowance should be allocated to the various load centers.
  - The number and rating of spare breakers in each switchboard and load center.
  - Load equipment for which space, weight, power, and cooling has been allocated, but the equipment is not intended to be installed until a time after ship delivery.
  - Power system equipment for which extra capacity is enabled but not provided at ship delivery. Examples include slots for additional power converter modules in a converter, or the ability to replace a generator set with one of higher rating without having to modify switchboards or other distribution system equipment.
  - List of power system equipment that is expected to be replaced during the ship's service life. Specify whether an equipment removal route, bolted equipment removal plate (BERP) or welded equipment removal plate (WERP) should be considered or installed onboard ship.
- Used in
  - Design of the power system.
  - General arrangements.

EPS-CONOPS development

- Should be developed incrementally in a configuration managed environment.
- Content should be developed in the order required to support ongoing analyses.
  - Information needed to support the Electric Power Load Analysis (EPLA) and endurance fuel calculations typically required first.
  - The creation of some content may be delayed to preliminary design.