Design Criteria and Practices for the Electric Warship

Dr. Norbert Doerry

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Introduction

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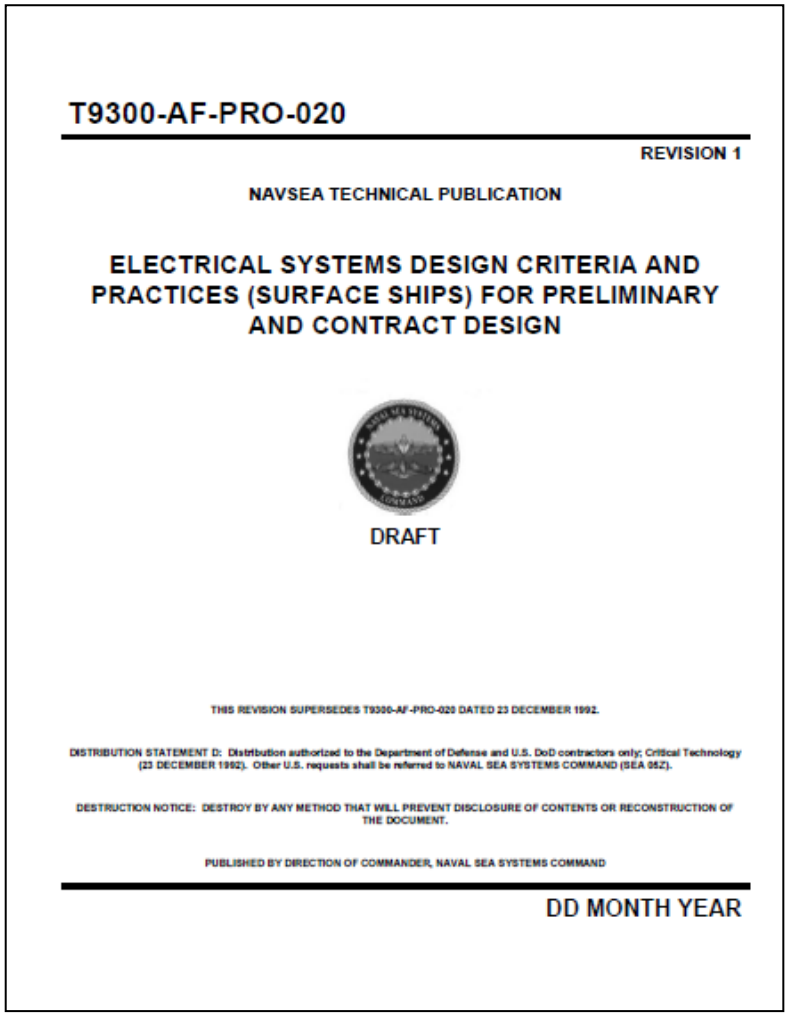

T9300-AF-PRO-020

REVISION 1

NAVSEA TECHNICAL PUBLICATION

ELECTRICAL SYSTEMS DESIGN CRITERIA AND PRACTICES (SURFACE SHIPS) FOR PRELIMINARY AND CONTRACT DESIGN

DRAFT

THIS REVISION SUPERSEDES T9300-AF-PRO-020 DATED 23 DECEMBER 1992.

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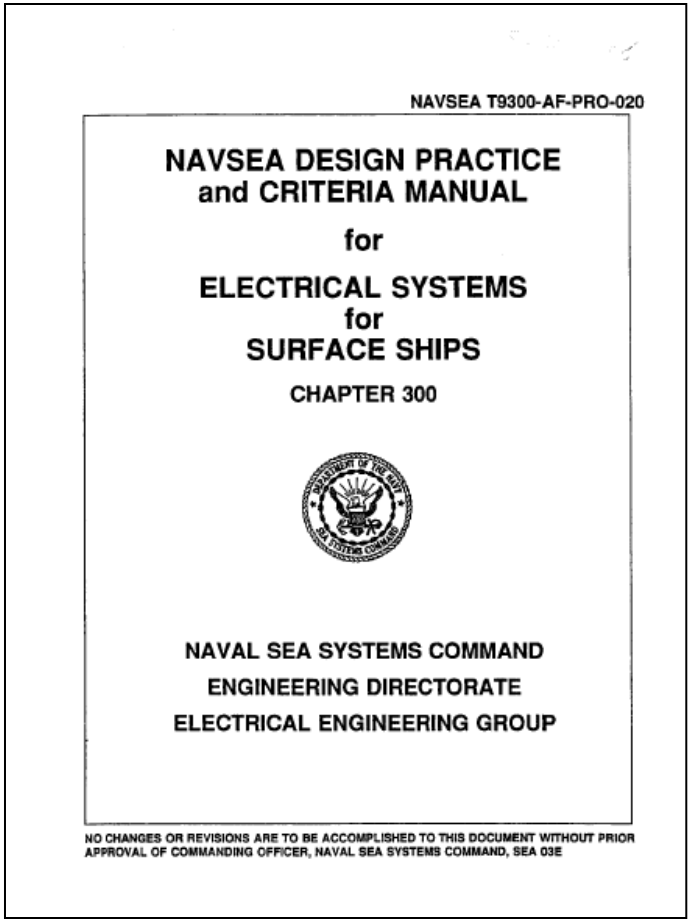
DD MONTH YEAR

Motivation

- Original Manual issued in 1992
  - Project to update circa 2002 did not result in an approved revision
- Many technological advances
  - High voltage systems
  - Energy storage
  - Integrated power systems
  - DC systems
- Document usability
  - Criteria vs practices
  - Reference vs including content from other sources


NAVSEA T9300-AF-PRO-020

NAVSEA DESIGN PRACTICE
and CRITERIA MANUAL

for

ELECTRICAL SYSTEMS
for
SURFACE SHIPS

CHAPTER 300

NAVAL SEA SYSTEMS COMMAND
ENGINEERING DIRECTORATE
ELECTRICAL ENGINEERING GROUP

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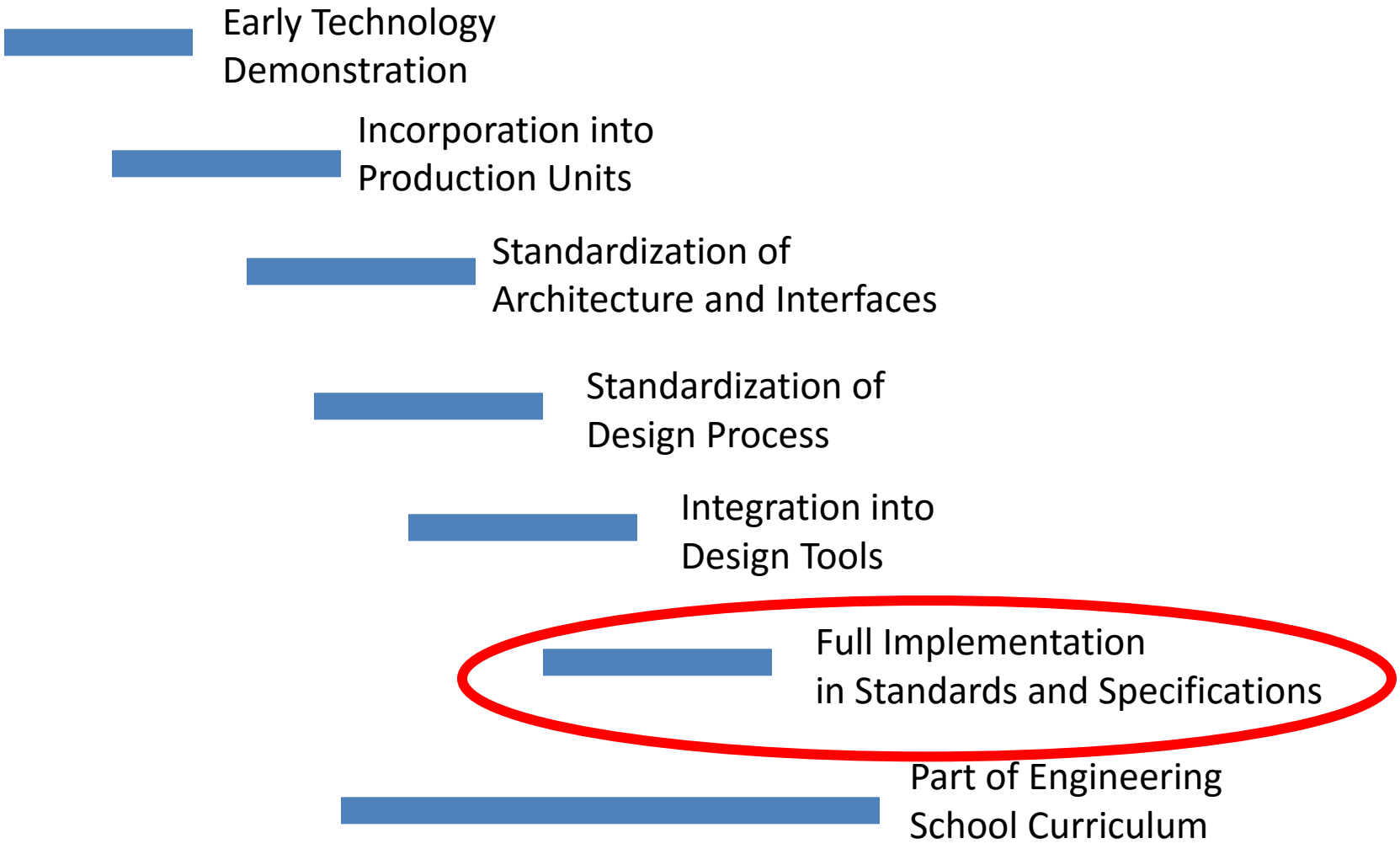
Institutionalizing Technology



Document Structure

- How to ensure that criteria (required) and practices (recommended) were clearly identified as such?
- Solved via the Document Structure:
  - Chapter 1: Introduction
  - Chapter 2: Design Criteria
  - Chapter 3: Design Practices
- Sections of Chapter 2 and 3 complement each other
  - Section 2.4 and 3.4 are both “Generating Plant and Energy Storage”
- Simplifies incorporating criteria into Statements of Work and Specifications.

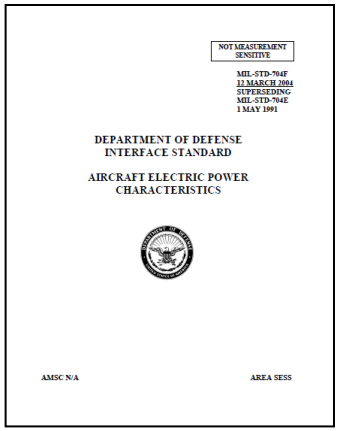
High Voltage and Electric Propulsion

- Ship Service loads have grown significantly since 1992
- Integrated power systems enable more efficient utilization of power systems
- High voltage (> 1000 V) power systems adopted
  - LHD 8 / LHA 6
  - DDG 1000
  - T-AKE 1
  - DDG 51 Flight III
- Criteria and practices provided for high voltage systems including integrated power systems

Dec 7, 2015: DDG 1000 on Builder's Trials

DC Systems

- DDG 1000 re-introduces DC power to Naval Combatants
- Standard DC Voltage Levels are defined
- Power Quality Standards for voltages above 270 V are currently under development and not included in this revision


NOT MEASUREMENT SENSITIVE

MIL-STD-704F
12 MARCH 2004
SUPERSEDING
MIL-STD-704E
1 MAY 1991

DEPARTMENT OF DEFENSE
INTERFACE STANDARD

AIRCRAFT ELECTRIC POWER
CHARACTERISTICS

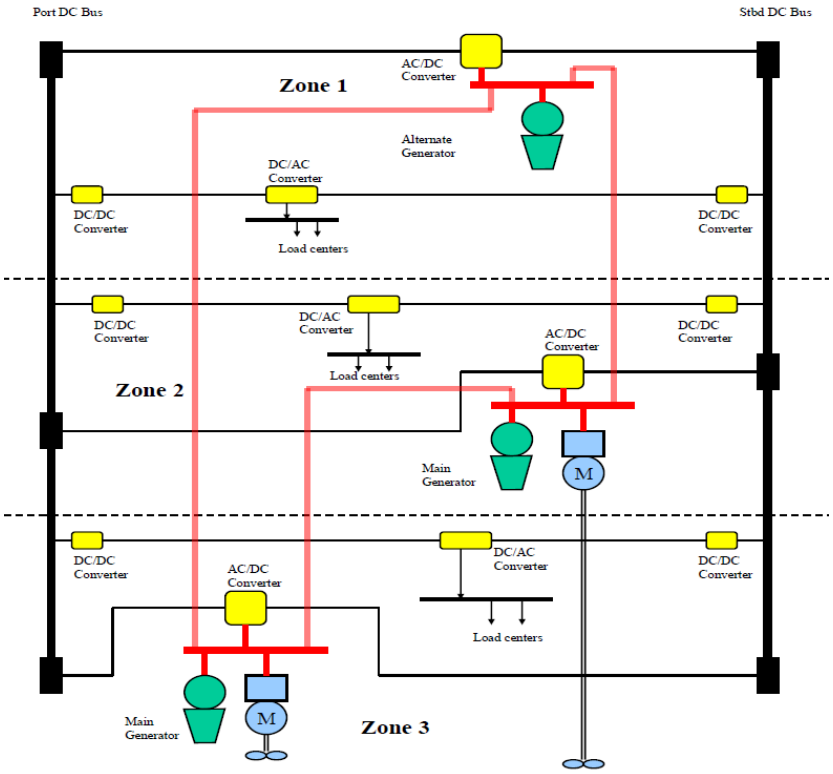
AMSC N/A AREA SESS

- Low Voltage
  - 28 V (MIL-STD-704) note 1
  - 155 V (MIL-STD-1399-390)
  - 270 V (MIL-STD-704) note 1
  - 375 V
  - 650 V
- High Voltage
  - 1 kV
  - 6 kV
  - 12 kV
  - 18 kV

Note 1: for interfaces with vehicles and systems designed for vehicles or modules

Power Systems Architectures

- More emphasis on
  - Zonal distribution systems
  - Mixed high voltage and low voltage distribution
- Less emphasis on 400 Hz distribution
  - Recommends considering Point-of-Use power conversion: Integrated Power Node Center (IPNC) for example



Margin and Service Life Allowance

- Margin
  - Accounts for uncertainty during design and construction
- Service Life Allowance
  - Accounts for growth in electrical load due to modernization and equipment degradation during the ship's service life
- Criteria have been adjusted and reworded to account for lessons learned

Quality of Service

- Quality of Service directly addresses the reliability of the power system
- Classify loads by the duration of power interruptions they can withstand
  - Un-interruptible
  - Short-term Interrupt
  - Long-term Interrupt
- Previously, loads requiring un-interruptible power were required to provide their own UPS
  - Resulted in maintenance burden on ship's force
  - Functionality may now be provided by the Power System
- Two-tiered load shed strategy
  - Initially based on QOS
  - If power not restored within a set period of time, switch to a mission priority based load shed strategy

USNS Navajo tows USS Belleau Wood

Sizing Generator Sets and Energy Storage

- Previously, criteria based on traditional ship service distribution systems
- New criteria includes consideration for integrated power systems and energy storage

Sept 9, 2013: onboard USS Ramage (DDG 61)

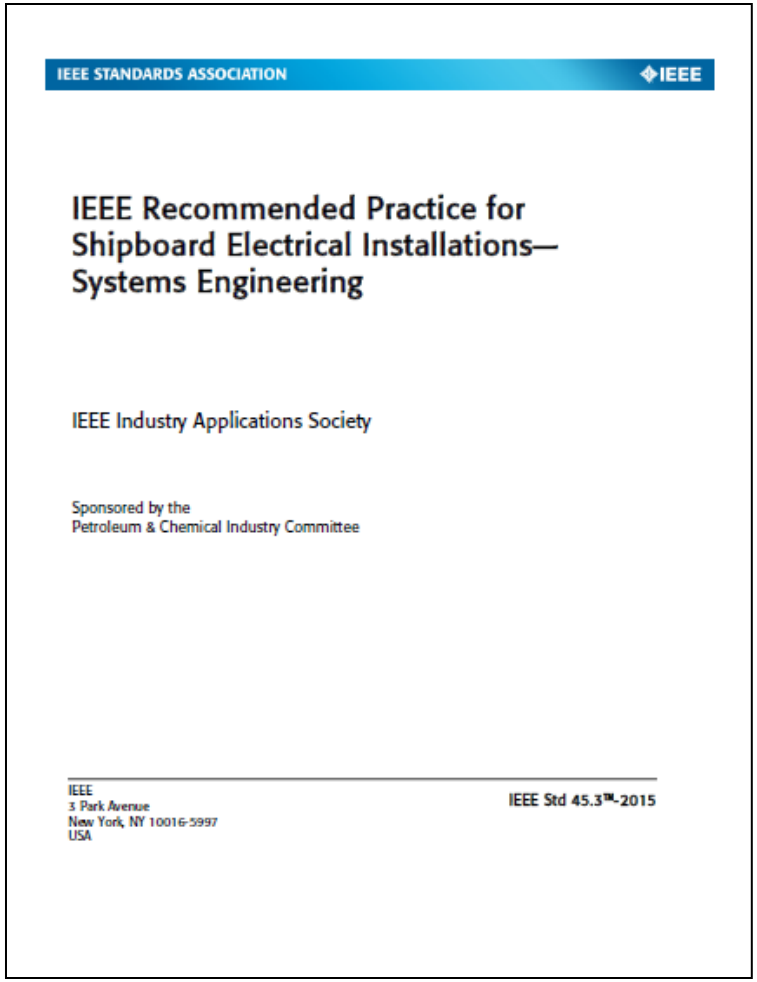
Survivability

- Updated direction and guidance for survivable power systems
- Zonal Distribution Systems addresses:
  - Vulnerability through zonal survivability
  - Recoverability through compartment survivability (including casualty power)

March 6, 2008: USS Blue Ridge (LCC 19)

Analysis

- Electric Power Load Analysis
- Load Flow Analysis
- Transient Analysis
- Fault Current Analysis and Protective Device Coordination Study
- Harmonic and Non-Fundamental Frequency Analysis
- Stability Analysis
- Electromagnetic Interference (EMI) Analysis
- Reliability Analysis
- QOS Analysis
- Vulnerability and Recoverability Analysis
- Arc Flash Analysis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IEEE Recommended Practice for Shipboard Electrical Installations—Systems Engineering

IEEE Industry Applications Society

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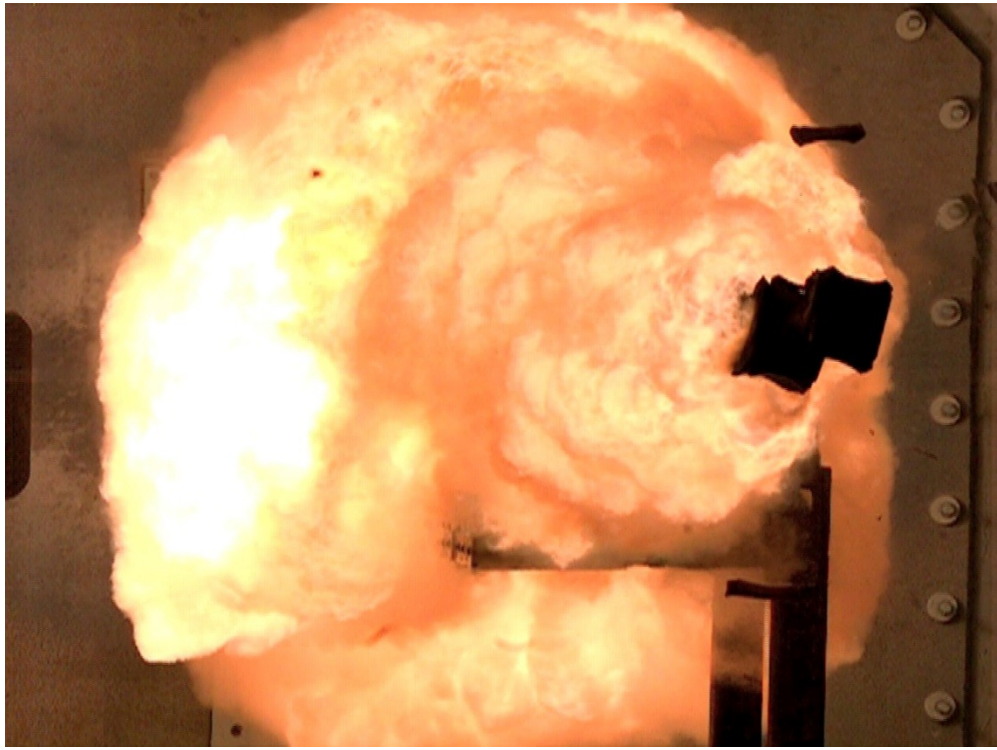
USA

IEEE Std 45.3™-2015

Future Work

- HV DC (MVDC) systems
- HV power system protection, including arc fault detection
- HV Cable
- HV shore power
- HV casualty power
- Podded Propulsion
- Harmonic filters and active power filters
- Braking resistors
- Fuel Cells
- Health Monitoring Systems
- Essential Lighting technologies
- Analysis methods
- Pulse power support
- Update references
- Update margin and service life allowance policy



Summary

- T9300-AF-PRO-020 Rev 1 is a major update to the base document developed in 1992
- Reflects lessons learned up through DDG 1000
- Needs additional work to prepare us for upcoming electric weapons and MVDC systems
- Additional gaps have been identified