Energy Efficient Operations of Warships
Perspective of the Indian Navy

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- Drivers for Change
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Introduction

- Current global scenario
  - Climate change concerns
  - Environment sustainability
- India’s climate change goals
  - Intended Nationally Determined Contribution
    - Core Principle: Sustainable Development
- Implementation requires all-inclusive efforts
Introduction

- Indian Navy: Aligned to the national mission
  - Global maritime force
    - Blue water capabilities
    - 200 ship Fleet by 2027
  - Green Initiatives Program (2014)
    - Energy and resource efficient
    - Environmentally responsible
  - IN Environment Conservation Roadmap
    - Reduce
    - Diversify
    - Clean technologies

Green Footprint to blue water capabilities
Drivers for Change

- **Drivers**
  - Global climate change concerns
  - Alignment with national policy
  - Reduce running costs
  - Enhanced operational reach

- **Emerging challenges**
  - High CAPEX – Planned acquisitions/ship building program
  - Availability of mature technology
  - Cultural issues – traditional warship practices

- **Implementation**
  - Acquisition
  - Fleet procedures
  - Behavioral changes
IN ‘Go Green’ Objectives

- **Fleet**
  - Design
    - Efficient
  - Operations
    - Optimize
  - Maintenance
    - Sustain

- **Shore**

**IN Green Initiatives**

Directorate of Marine Engineering
Overall IN ‘Go Green’ Philosophy

IN Green Initiatives

Fleet
Design
- Acquisition
- Retrofit

Operations
- Doctrine
- Fleet Plans
- Fleet Operations

Maintenance
- Condition Monitoring
- Corrective Maintenance

Shore
Cultural Shift
O&M: Current Practices

- Operations Monitoring
  - EEF–running hours based (indirect approach)

- Condition Monitoring
  - Fuel consumption trials – comparison to CST figures
  - Engine health monitoring

- Monitoring Mechanism
  - Maintenance of Logs: manual logs, returns, post analysis by INSMA
    - Advantages
      - Simplicity – low crew training
      - Low cost
    - Limitations
      - No hull health monitoring
      - Data collation and analysis: manual
IN ‘Go Green’ Enablers

IN Green Initiatives

Fleet

Design
- Hull
- Propulsion & PG
- Optimization

Operations
- Modelling Scenarios
- Staff Requirements
- Operational Profile

Maintenance
- Monitoring
- Data Sharing
- Decision Making

Technology
- Identification
- Development
- Insertion
Ship, Hull and Propulsor Design

- Increase hull efficiency
  - Bow, Stern End Bulb
  - Stern flap
  - Propeller Boss Cap Fins
  - Against bio-fouling
    - Hull paint schemes
    - Propeller coatings

- Trim Optimization

- Fleet & Ship Operations Management
  - Voyage Planning
  - Weather Routing

- Technology insertion applicability for retrofit
  - Applicable

Images courtesy of NAVSEA, USA
Propulsion and PG Design

- Enhance Overall Plant Efficiency
  - Over complete range of Operating Profile
  - Target
    - Engine Efficiency
    - Plant Efficiency
      - Recuperation
      - Integrated plants
        - All Electric
        - Hybrid

- Technology insertion applicability for retrofit
  - Applicable for Hybrid Plant in limited cases
Design Requirements & Optimization

- Design stage optimization
  - Ship efficiency: inherent design objective
    - High endurance
    - Low running cost

- Choice of propulsion and electric power plants
  - Conventional, Hybrid or All Electric
  - Optimized Staff Requirements
    - Conditioned for modern role
    - Consider top speed requirement carefully
    - Realistic operational profile
  - Through Life Cost: Acquisition vs Running Cost
Design Optimization

- Multipoint Design Point vs Single Design Point Optimization
  - Design variables: independent cycle parameters
  - Multiple combinations of design variables gives: CDS
    - Comprises of numerous candidate cycles
  - Constraints
    - Technology limits
    - Performance limits

- MDP allows many design points to be included in the analysis
  - Ensures that all performance requirements met at all design points
Monitoring Operations

- Energy Efficient Operations
  - Baselining of Energy Requirements
    - Capture data–class of ship wise
    - Analyze and establish ‘Baseline Levels’
      - Existing ships
      - Future acquisitions
  - Monitor Energy Consumption
    - Intelligent dashboard: Real time monitoring and management tool
      - Ship Level
      - Fleet Level
Monitoring Indices

Energy Efficiency Design Index

\[
\text{EEDI} = \frac{\text{FOC} \times C}{\text{Capacity} \times V_s}
\]

(g/ton-mile)

Energy Efficiency Operational Indicator

\[
\text{EEOI} = \frac{\text{Fuel (ave.)} \times C}{\text{Cargo} \times \text{Distance}}
\]

(g/ton-mile)
Conclusion

- IN developing a strong ‘Green Program’ for its fleets

- Many indirect benefits of the program
  - Lower running costs
  - Higher endurance
  - Better engine and plant health

- Synergy: need of the hour
  - IN: Open to partnerships in developing
    - Design optimization tools
    - Ship and Fleet Energy Dashboards
    - Trim optimization tool
    - Hull fouling measurement system
Questions
Thank You