SHIP DESIGN AND NOISE CONTROL

GLOSTEN & NOISE CONTROL ENGINEERING
SHIP DESIGN AND NOISE CONTROL

1. Newbuild Basis of Design
   • Evaluate mission requirements
   • Project-specific Basis of Design

2. Preliminary & Contract Level Arrangements and Specifications
   • Early design implementation of noise treatments and mitigations

3. Post-delivery modifications and corrections
   • Often technically challenging
   • Added post-delivery risks: Feasibility, Cost and Schedule
NEWBUILD BASIS OF DESIGN

EXAMPLE: Sikuliaq UWRN requirements

Balancing Performance & Cost

• Cost considerations
  – Azipods VS Z-drives
  – Double isolation VS conventional mounts

• ICES 209 VS Existing fleet UWRN performance
  – Revelle UWRN testing for noise contributors
  – Develop a project specific design basis

• ICES 209 baseline with allowable exceedances
  – Frequency bands
  – Vessel speeds
CONTRACT & FUNCTIONAL DESIGN

EXAMPLE: Ocean Class Research Vessel

Vessel Design by Glosten
Noise Design input by NCE

• Areas requiring noise treatment
• Equipment requiring vibration isolation
• Staterooms locations
• Arrangement of public and private spaces
• Arrangement of fan room locations, inlets, exhaust plenums
MODIFICATIONS AND CORRECTIONS

EXAMPLE: Atlantis and Revelle bow thruster habitability

Habitability noise problem
- Propeller cavitation during dynamic positioning

Multi-disciplinary treatment
- Noise control treatments in the seachest and structure
- Modified thruster intakes: flow velocities, flow clearances, air injection, foundation faring
- Modified propeller

Multi-disciplinary team
- Neil Brown, NCE, Bird-Johnson, SIO, WHOI, Glosten
Success requires attention throughout the design and construction phases. If noise and vibration are not addressed early, problems are likely:

- Options for mitigation will be limited
- Solutions more costly
- More treatments will be required
- Compromises become the only option

Proper procedure is costly, but not as costly as alternatives.
WHAT “BAD” LOOKS LIKE

EXAMPLE: 75 m Specialty Cruise Vessel

Concept/Preliminary/Contract Design
• Identified noise goal
• Higher than standard IMO regulation

Detailed Design
• Performed noise analysis
• Predicted high noise due to propeller cavitation
WHAT “BAD” LOOKS LIKE

Construction

• Some noise control materials installed
• Other options rejected
• No construction inspections

Sea Trials

• Noise excesses, per the predictions
• Owner decided noise limit is too high
• Looking to reduce noise by 20+ dB in some compartments
• Expenses, limited options, compromises
A BETTER APPROACH

Concept Design

• Identify appropriate specification
– What are the goals?
– What’s appropriate for this vessel type?
– What are passenger and crew expectations?
– Where might issues lie in noise/vibration criterion?
– Will machinery selection affect noise/vibration goals?
A BETTER APPROACH

Preliminary/Contract Design

• Perform analyses!
  – Difficulties
    • Time consuming calculations
    • Evolving vessel design information
  – Current methods allow for faster assessment
    • New modeling tools
    • Ability to work with estimated inputs

Goals of Analysis:

• Identify
  – Problem areas,
  – Arrangements that will minimize need for controls
  – Low noise equipment
  – Mitigation strategies.

• Provide expectations for future phases
A BETTER APPROACH

Detail Design

• Update analyses as design develops
• Ensure overall approach will work
  – Make adjustments as needed
• Identify and design noise critical features
  – Resilient mounts
  – Insulation details
  – Damping/floating floor details
  – Pipe hangers
  – Flexible couplings
  – Etc.
A BETTER APPROACH

Construction

• Training of key shipyard personnel
  – What to look for
  – What to be aware of
  – How to prevent rework

• Inspections of critical components
  – Identify and correct possible deficiencies

• Opportunities:
  – Testing of critical machinery components when available
  – Tests of treatment effectiveness
  – Tests to validate models and make adjustments
A BETTER APPROACH

Successful design

• Requires planning and follow-through
• Must start at early stages.
• Requires coordination between acoustic expert, naval architects, and shipyard
OCEAN CLASS AGOR DESIGN

Considerations for airborne noise, vibration, underwater noise, sonar self-noise

• Efforts began at preliminary design
• Early modeling of noise and vibration
• Updated models, predictions, and recommendations as the design evolved
• Worked closely with Naval Architect and Shipyard to identify optimized solutions that work for all parties
  – Early meetings to discuss overall design
  – Frequent communication through stages of modeling, recommendations, design updates, etc.
  – Follow-up meetings at key design stages
OCEAN CLASS AGOR DESIGN

Key design aspects included:

• Optimized General Arrangement
  – Compartment locations re-arranged
  – Equipment locations changed

• Quiet bow thrusters
  – Two small thrusters vs. one large thruster
  – No cavitation expected under steady state operation

• Quiet Propellers – delayed cavitation inception (above 11 knots)

• Z-drive gears
  – High quality gears to reduce gear mesh noise

• Diesel Generators
  – Selected for low noise and vibration
Key design aspects included:

- **Stiff mast design**
  - Designed to push natural frequencies above full speed propeller blade rate

- **Optimized hull form**
  - Minimizes bubble sweepdown effects on sonar performance

- **Flush Mounted Transducers**
  - Minimize flow noise

- **Isolation mounted equipment**
  - Major and auxiliary equipment

- **Insulation and damping where needed**
  - Efforts were employed to minimize extent of treatments
OCEAN CLASS AGOR DESIGN

Results.....

It would have been awesome.
Significant efforts are needed to create a quiet vessel

- Wouldn’t it be nice to keep it that way?

After delivery, underwater radiated noise is not static

- Outfitting changes to vessel, ‘wear and tear’, and many other factors can influence noise

How strong is your assumption of a quiet vessel?
Example 1:

- RV built to meet stringent UW noise goal
- Measurement 1
  - Meets requirement with ‘room to spare’ at sea trials
- Measurement 2
  - 4 years later, significant cavitation exists, higher machinery noise
NOISE VS. TIME – WHO WILL WIN?

Example 2:

- RV built to meet stringent UW noise goal
- Measurement 1
  - Meets requirement at sea trials
- Measurement 2
  - 4 years later, higher machinery noise, exceeds noise limit
Vessels built to incorporate many low-noise technologies

- Low noise is not only about treatment selection
- Also requires an understanding from the crew
  - Maintenance
  - Operation

Do not turn your back on noise, or else the previous efforts will not matter!

Periodic underwater noise ‘check-ins’ can be used as a monitoring and diagnostic tool
UNDERWATER RADIATED NOISE TEST

What does it look like?
UNDERWATER RADIATED NOISE TEST

What does it look like?
BASIC OUTLINE

- Multiple hydrophones
- Multiple depths
- Known distance
- Calculate ‘source level’
THE TEST COURSE
MEASUREMENT OPTIONS

• Permanent ranging facilities
• Bottom moored hydrophone with a support vessel
• Surface supported hydrophone with a support vessel
• Near shore measurements
• And more….
PERMANENT RANGING FACILITY

Pros
– The ‘gold standard’ in noise measurements
– Very quiet locations – low background
– Accurate noise and distance

Cons
– Expensive
– Scheduling issues
– Remote Locations
– Military owned
– Many people required
– Noise deficiencies are relayed between shore and vessel
– Increased challenge for real-time troubleshooting
– Test results can take months
ACOUSTIC MEASUREMENT BUOY

Pros

• Low cost
• Short setup time
• Quality measurements
• Flexibility for test location
• Can be deployed from vessel under test
• Results can be obtained quickly
  – All personnel on test vessel
  – Simplifies diagnostics
• No support vessel noise

Cons

• Wave motion may influence results
• Increased complexity of distance measurement
BUOY ACOUSTIC MEASUREMENT SYSTEM (BAMS)

- Portable underwater noise measurement system
- Shipped and deployed anywhere in the world
- Autonomous acoustic recording
- Automated distance measurements
- Real-time communications
- Immediate feedback
**BAMS ACCURACY**

Comparison of Permanent Range and NCE BAMS UWRN Data

![Graph showing comparison of permanent range and NCE BAMS UWRN data. The graph includes two lines: one for the test facility with a permanently moored array and another for the NCE BAMS system. The y-axis represents sound pressure level (dB), and the x-axis represents frequency (Hz). The graph highlights different machinery lineup.]
QUESTIONS / DISCUSSION

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PROPRIETARY INFORMATION