SHIP DESIGN AND NOISE CONTROL

GLOSTEN & NOISE CONTROL ENGINEERING

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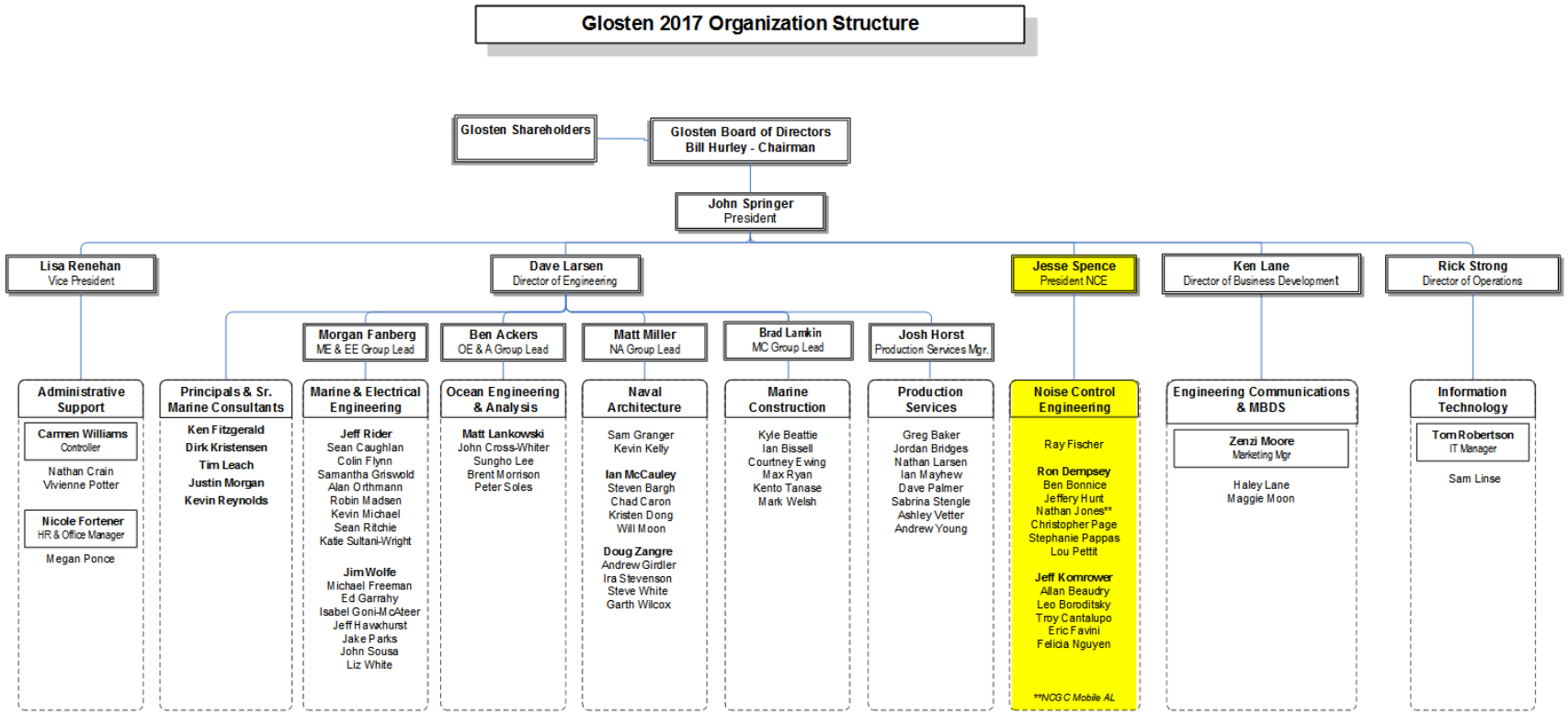


SHIP DESIGN AND NOISE CONTROL

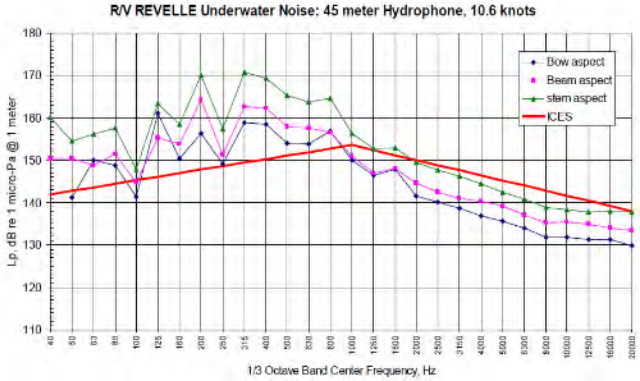
1. **Newbuild Basis of Design**
   - Evaluate mission requirements
   - Project-specific Basis of Design
2. **Preliminary & Contract Level Arrangements and Specifications**
   - Early design implementation of noise treatments and mitigations
3. **Post-delivery modifications and corrections**
   - Often 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 <u>project specific</u> 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

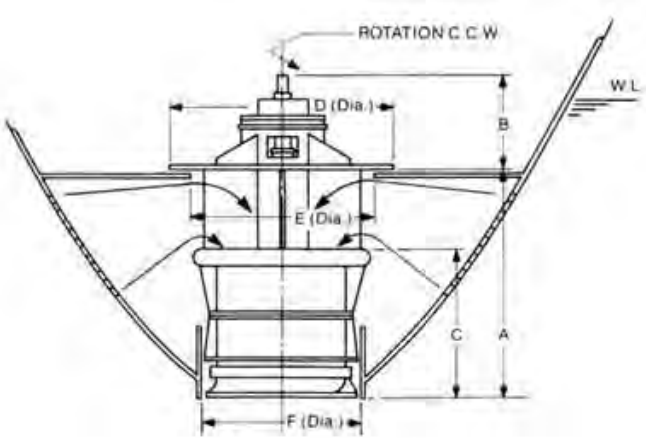
- Propeller cavitation during dynamic positioning

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



NOISE AND VIBRATION CONTROL - PLANNING

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

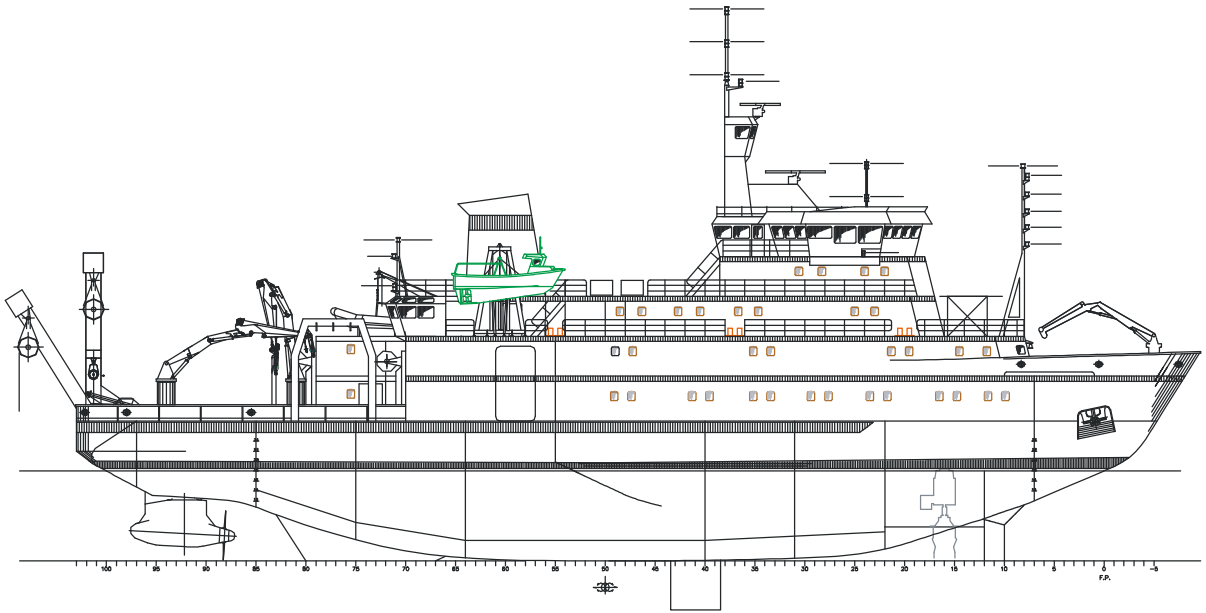
Sea Trials

- 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

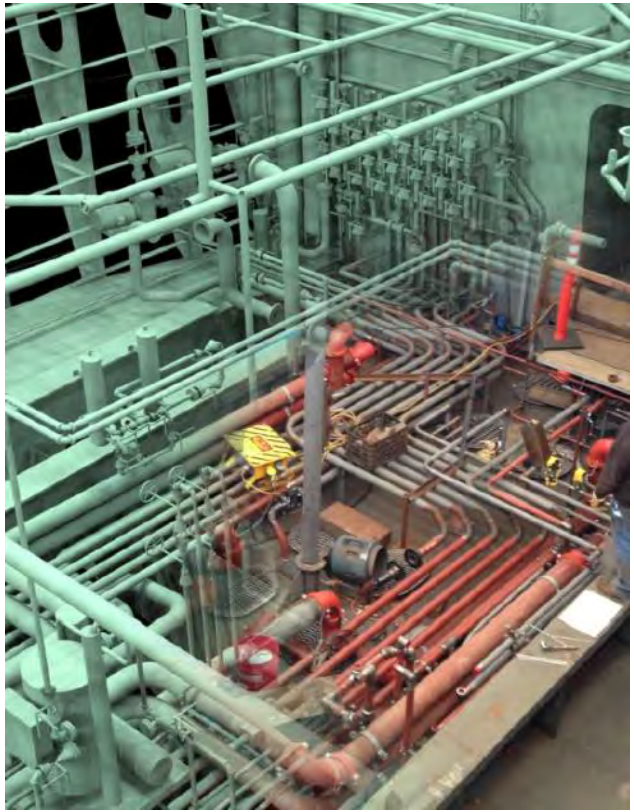
Goals of Analysis:

- *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

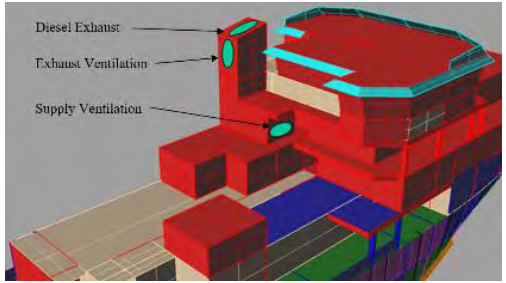
Successful design

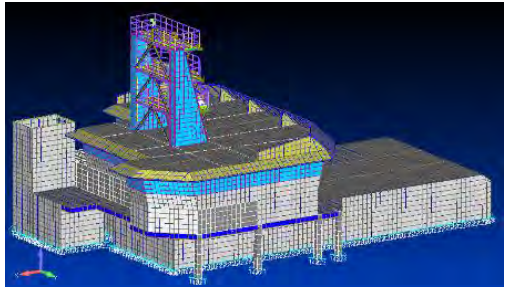
- Requires planning and follow-through
- Must start at early stages.
- Requires coordination between acoustic expert, naval architects, and shipyard

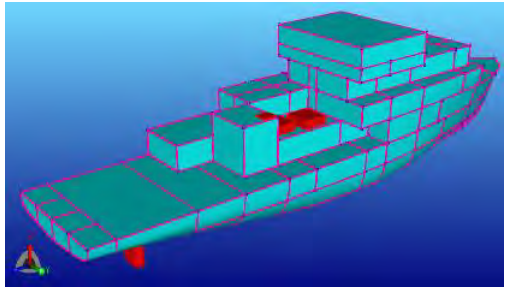
OCEAN CLASS AGOR DESIGN

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



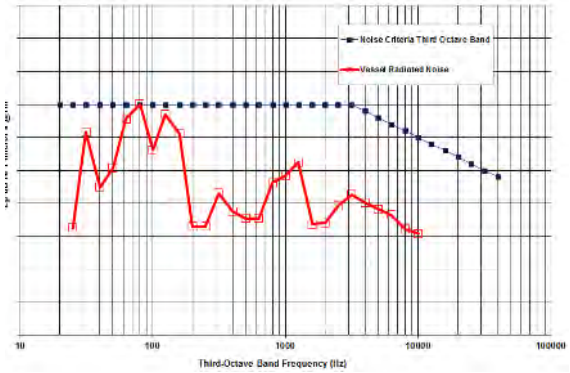


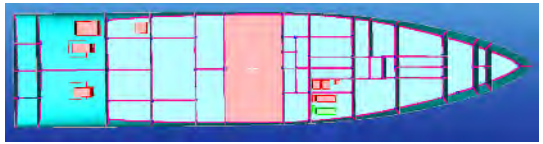


OCEAN CLASS AGOR DESIGN

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

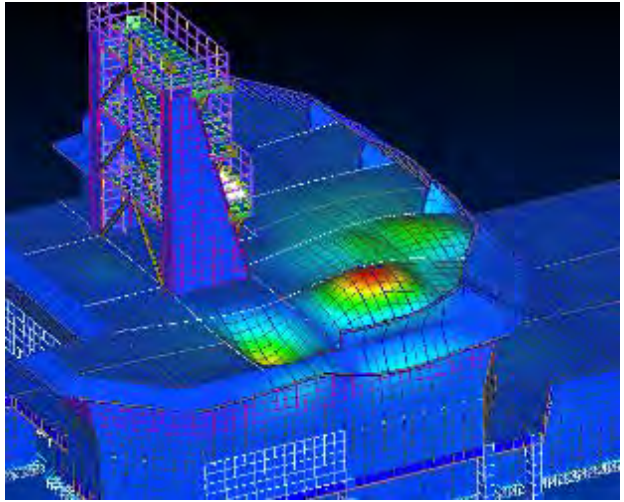


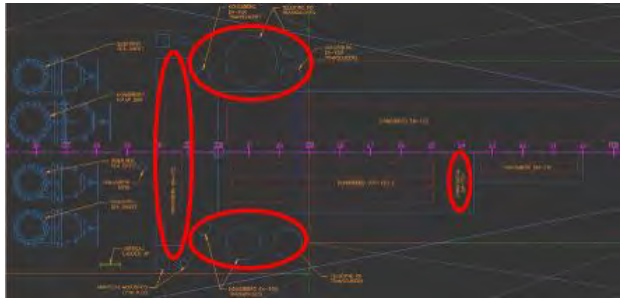


OCEAN CLASS AGOR DESIGN

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.

POST-CONSTRUCTION

Significant efforts are needed to create a quiet vessel

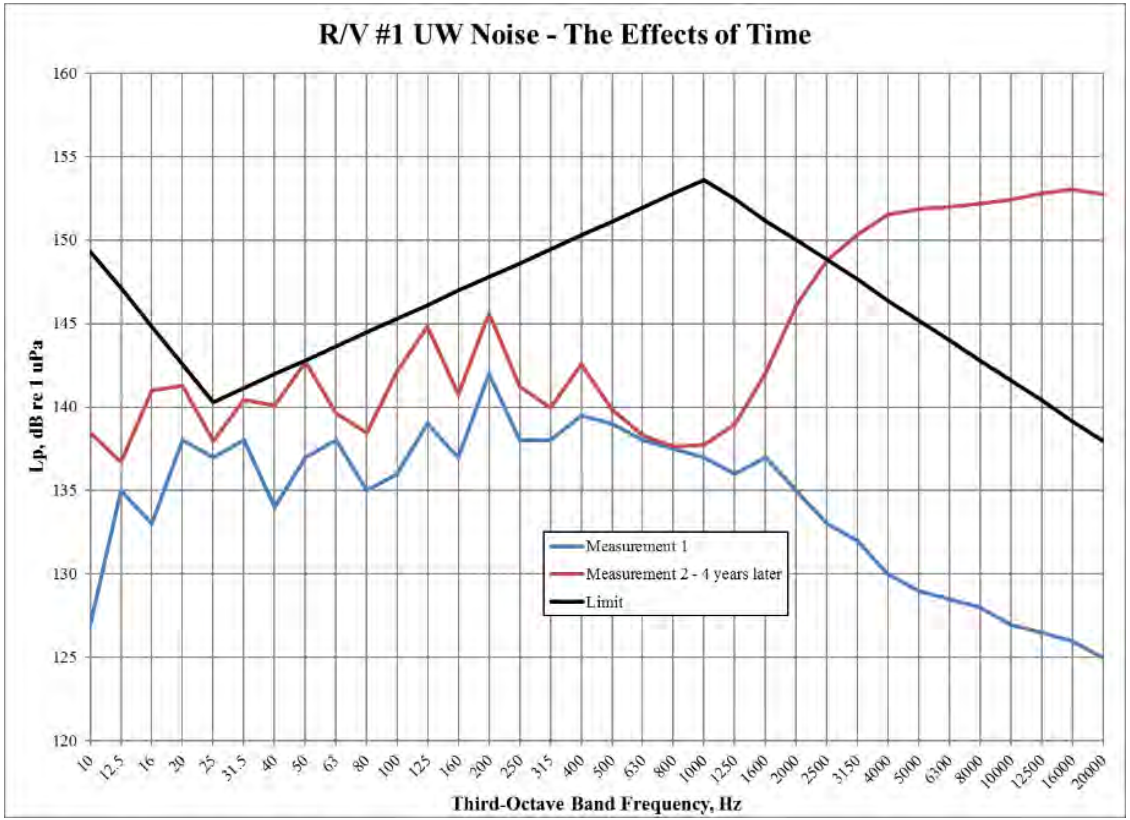
- Wouldn't it be nice to keep it that way?

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?

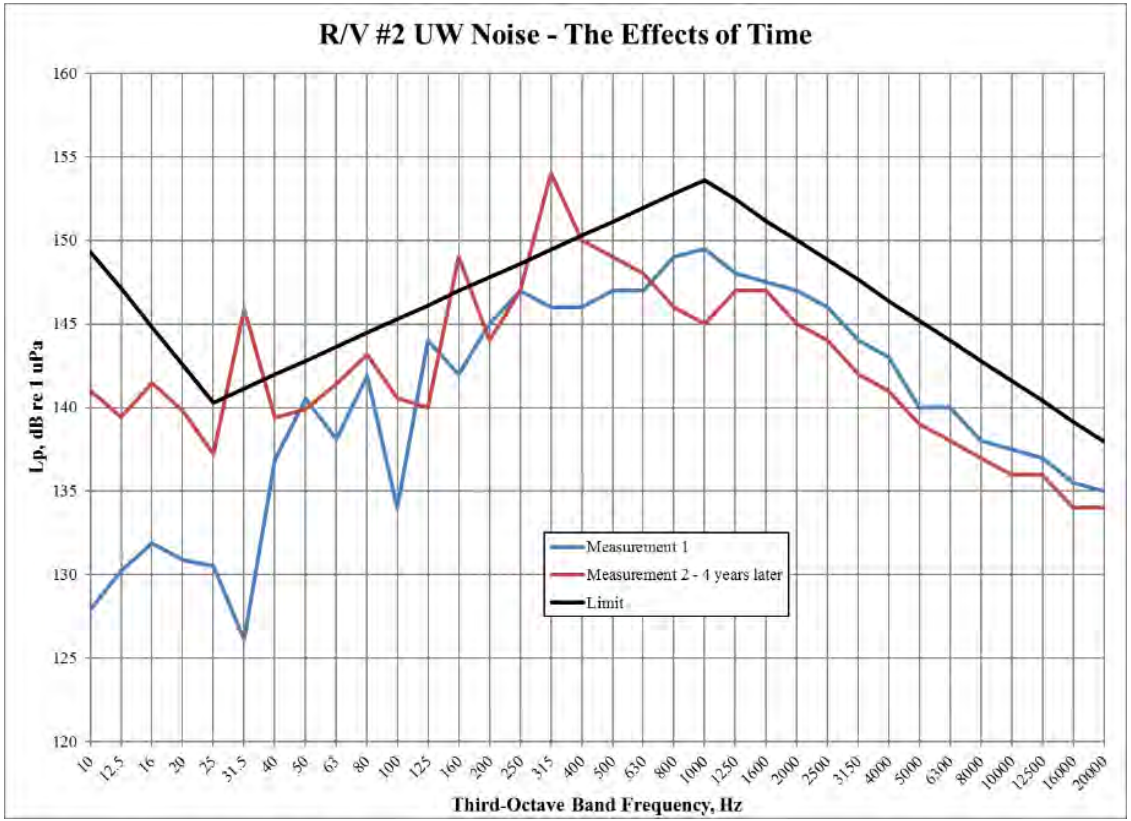
NOISE VS. TIME – WHO WILL WIN?



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

WHAT HAPPENED?

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

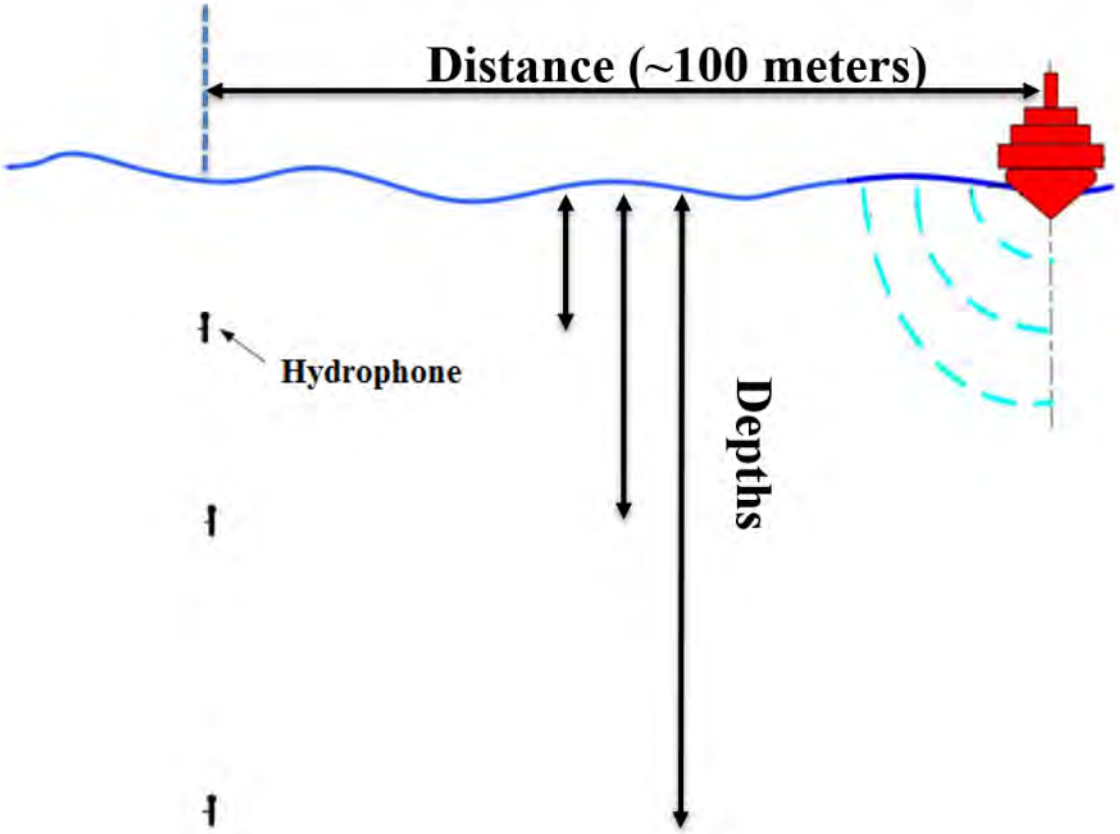
What does it look like?

UNDERWATER RADIATED NOISE TEST

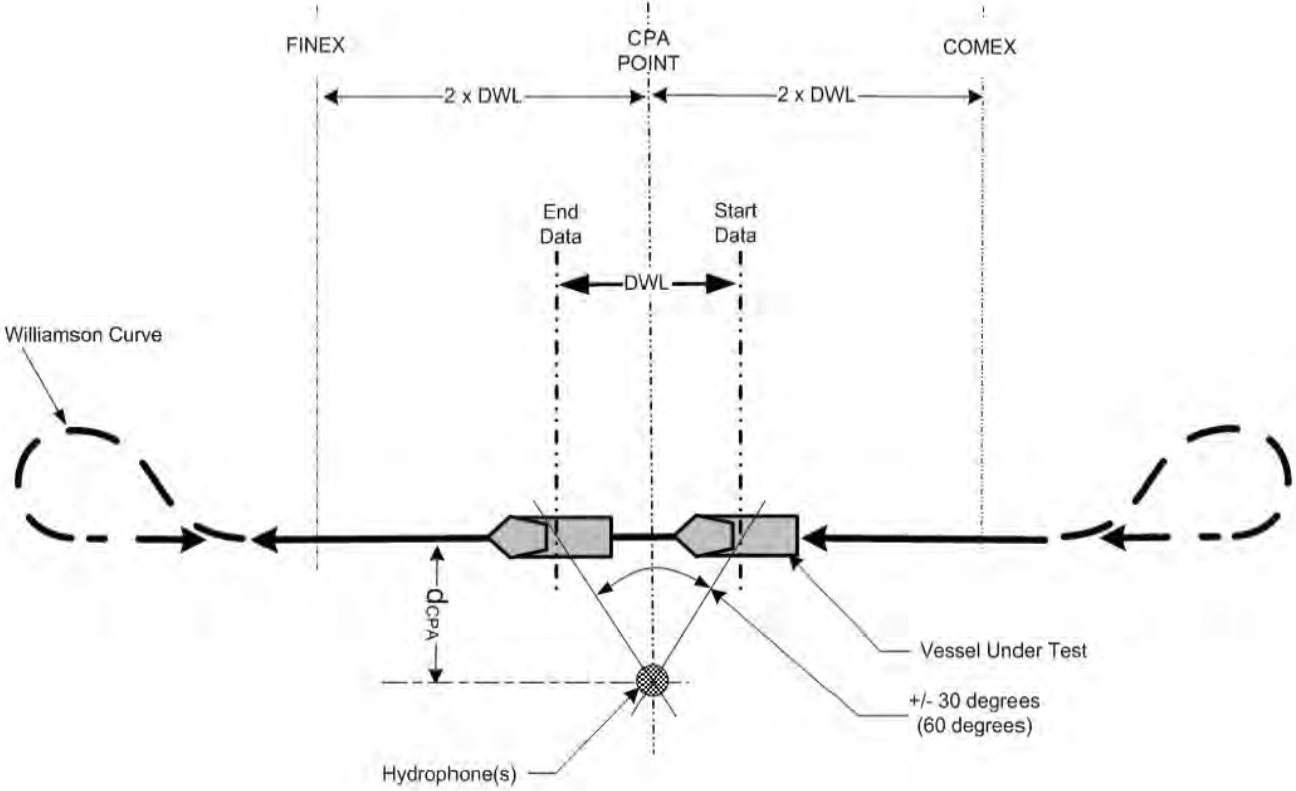
What does it look like?

BASIC OUTLINE

- Multiple hydrophones
- Multiple depths
- Known distance
- Calculate ‘source level’

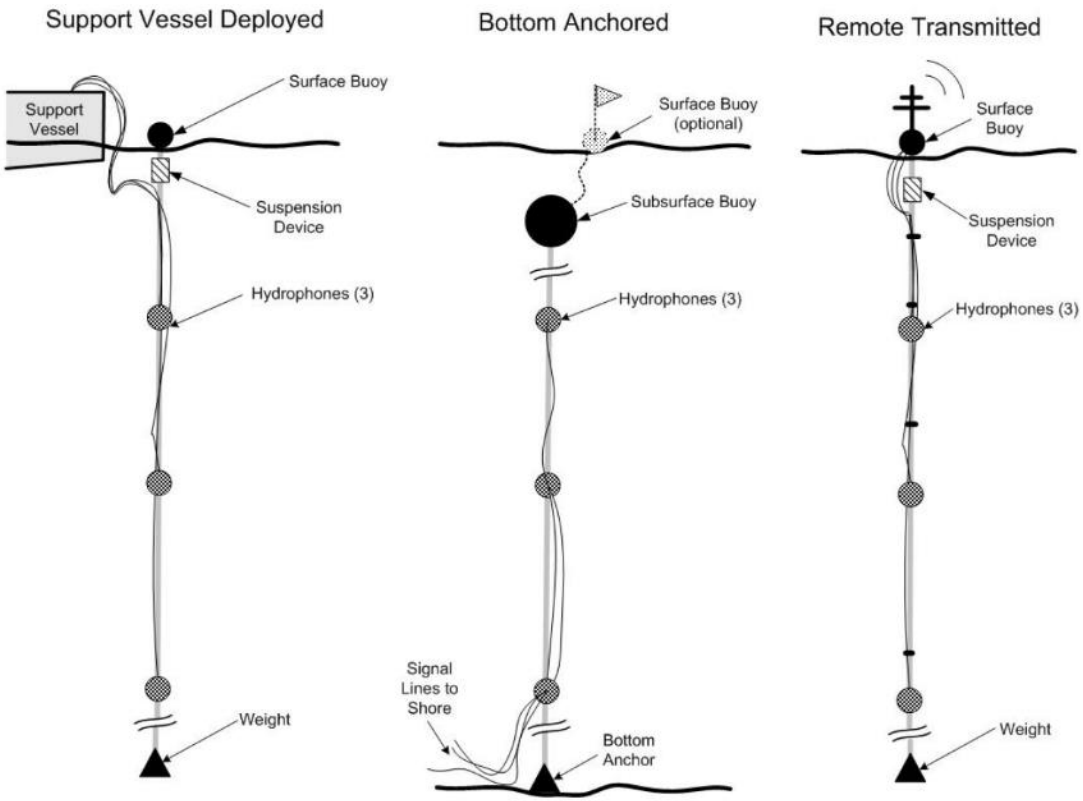


THE TEST COURSE



MEASUREMENT OPTIONS

- Permanent ranging facilities
- Bottom moored hydrophone with a support vessel
- Surface supported hydrophone with a support vessel
- Near shore measurements
- And more….



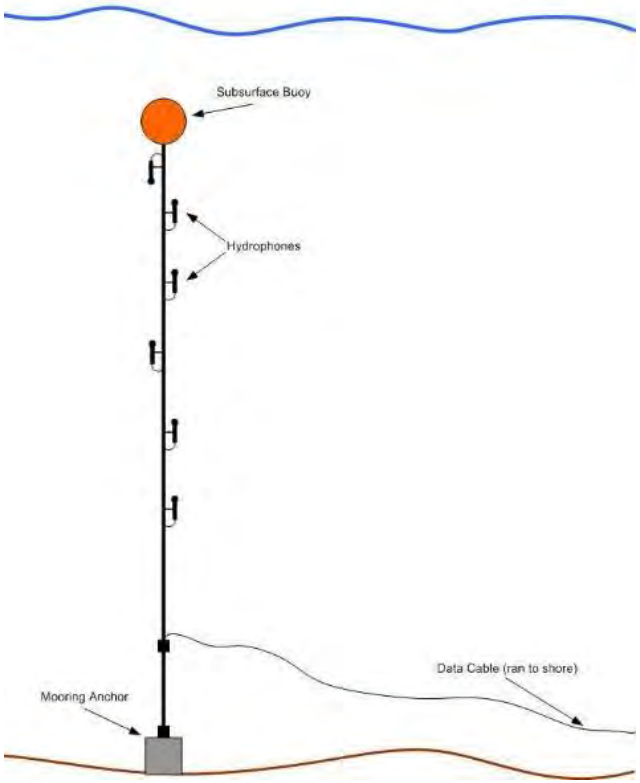
PERMANENT RANGING FACILITY

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



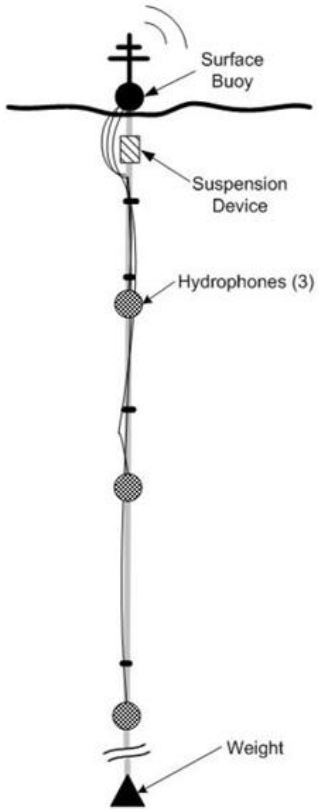
ACOUSTIC MEASUREMENT BUOY

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

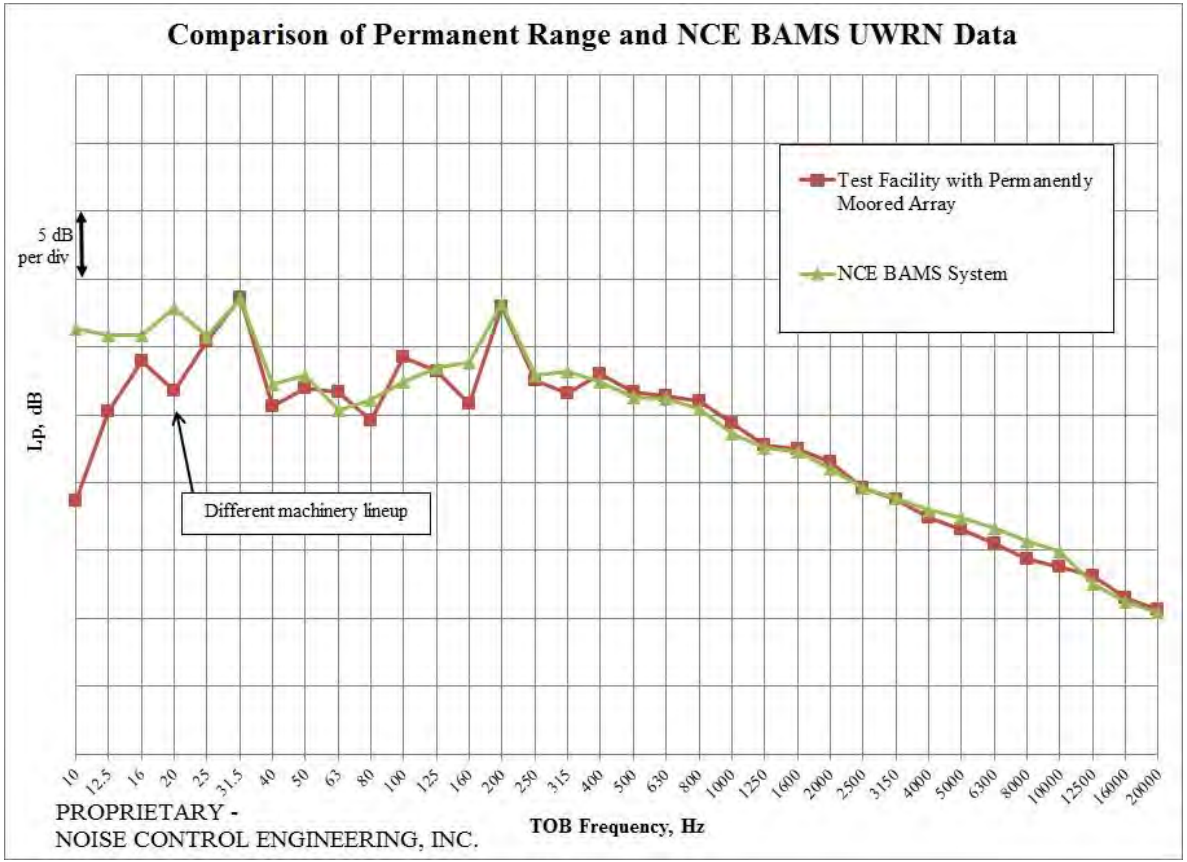
- Wave motion may influence results
- Increased complexity of distance measurement



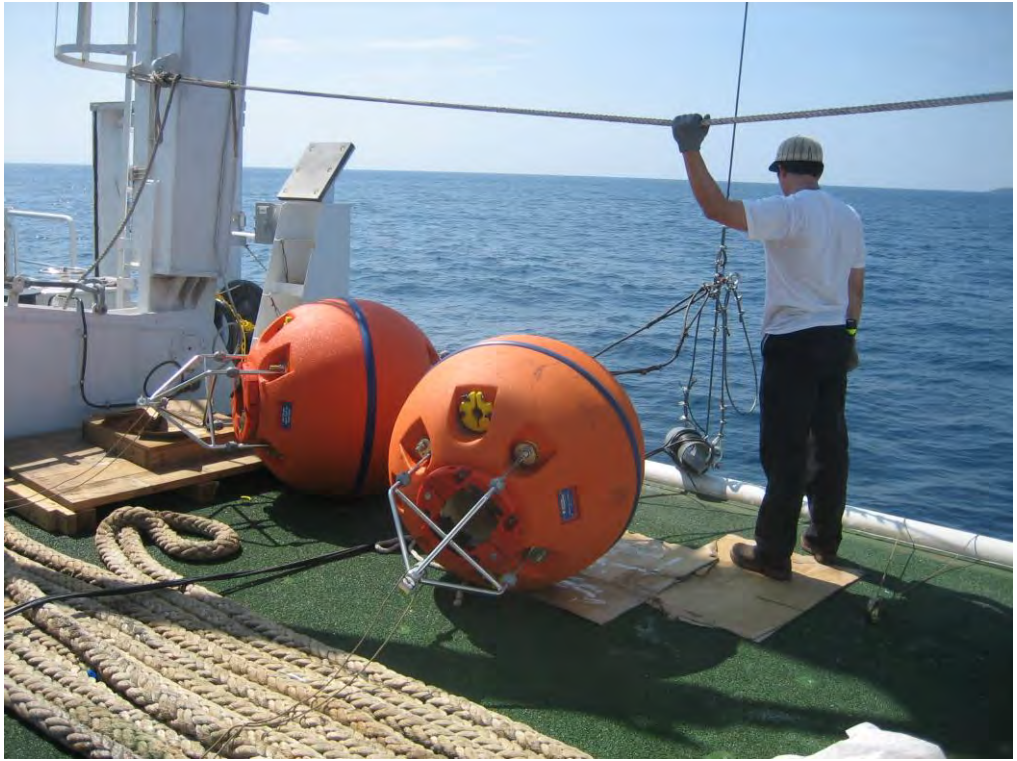
BUOY ACOUSTIC MEASUREMENT SYSTEM (BAMS)

- 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



QUESTIONS / DISCUSSION



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