Polar Research Vessel Project Review Meeting

ARVOC at MBARI

July 31 – August 1, 2003

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Moss Landing, CA

July 31 - August 1, 2003

Prepared by:

U.S. Maritime Administration

400 Seventh Street, SW

Washington, DC 20590

Polar Research Vessel Project Review Meeting
Agenda - Day 1

July 31, 2003

1:00	Welcoming remarks - Robin Ross
1:10	Introduction - Al Sutherland
1:30	Overview of the design process – Dick Voelker
1:45	Initial science and operational requirements – Skip Owen
2:15	Results from special technical studies – Alex Iyerusalimskiy and Dick Voelker
2:45	Break
3:00	Continue with results from special technical studies
4:00	PRV design results – Alex Iyerusalimskiy
5:00	Adjourn for the day

Polar Research Vessel Project Review Meeting
Agenda - Day 2

August 1, 2003

8:30	PRV cost estimate for construction – Alex Iyerusalimskiy
9:00	PRV web site – Paul Olsgaard
9:15	Next phase of the design effort – Dick Voelker
10:00	Break
10:30	Summary remarks and discussion – Al Sutherland
12:00	Lunch
1:00	Additional time margin for presentation and discussion
1:50	Closing remarks – Robin Ross
2:00	MBARI presentations on AUV/ROV operations - Steve Etchemendy
2:45	Break
3:00	Visit ZEPHYR and WESTERN FLYER – Steve Etchemendy
5:00	Adjourn

Welcoming Remarks

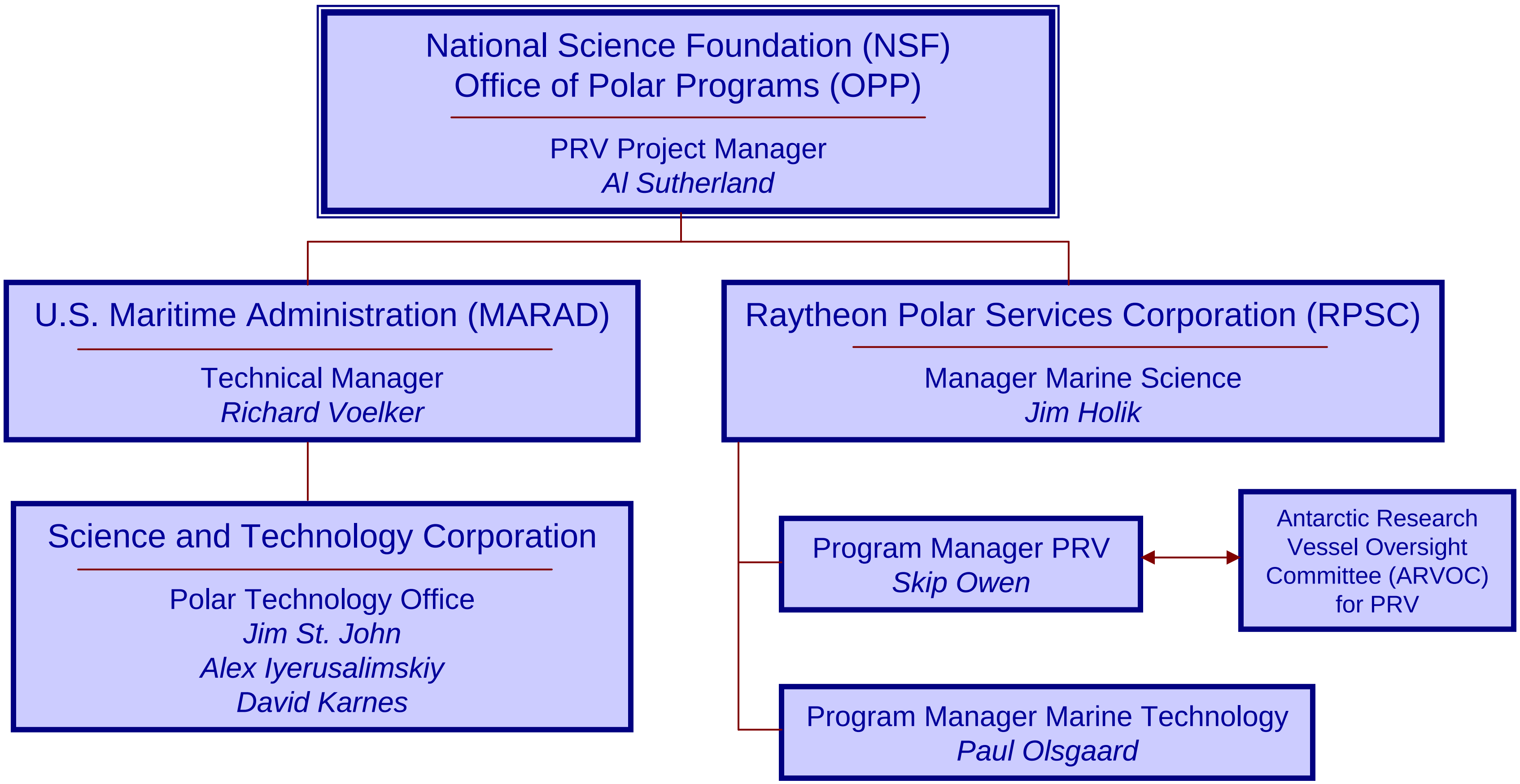
Introductory Remarks

Overview of the
Project Organization and
Design Process

Overview of the Project Organization and Design Process

- Project organization for PRV
- Relationship between organizations
- Current statement of work
- PRV design spiral
- Relationship of special technical studies to design spiral
- Overview of feasibility-level design spiral

Project Organization for Polar Research Vessel (PRV)



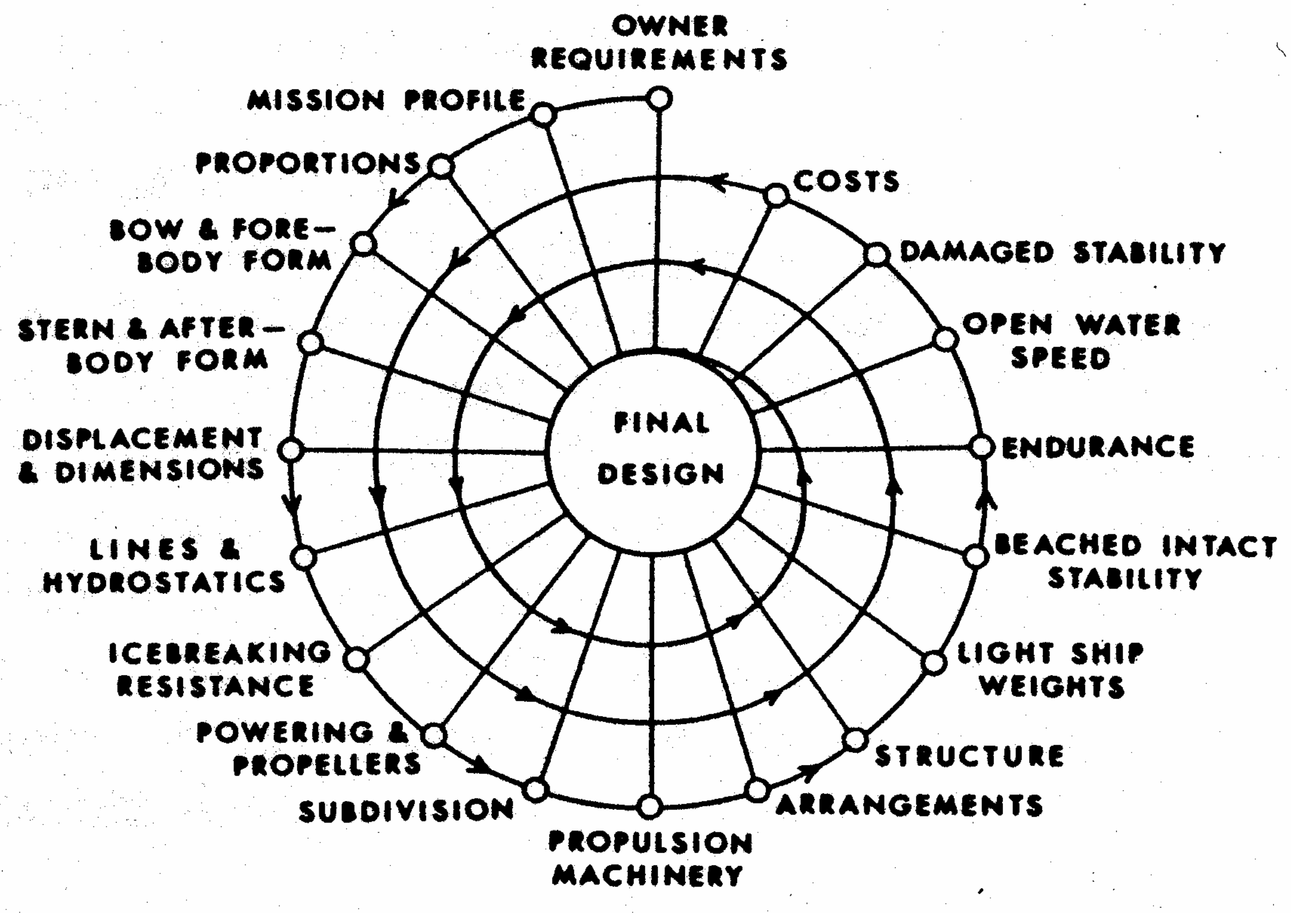
Relationship Between Organizations

- NSF
  - Directs project activities
- MARAD
  - Provides technical and shipbuilding expertise
  - Develops vessel conceptual design and cost
  - Supports RPSC in procurement activities
- RPSC
  - Manages the procurement process
  - Signs contract for vessel charter
  - Accepts delivery of vessel

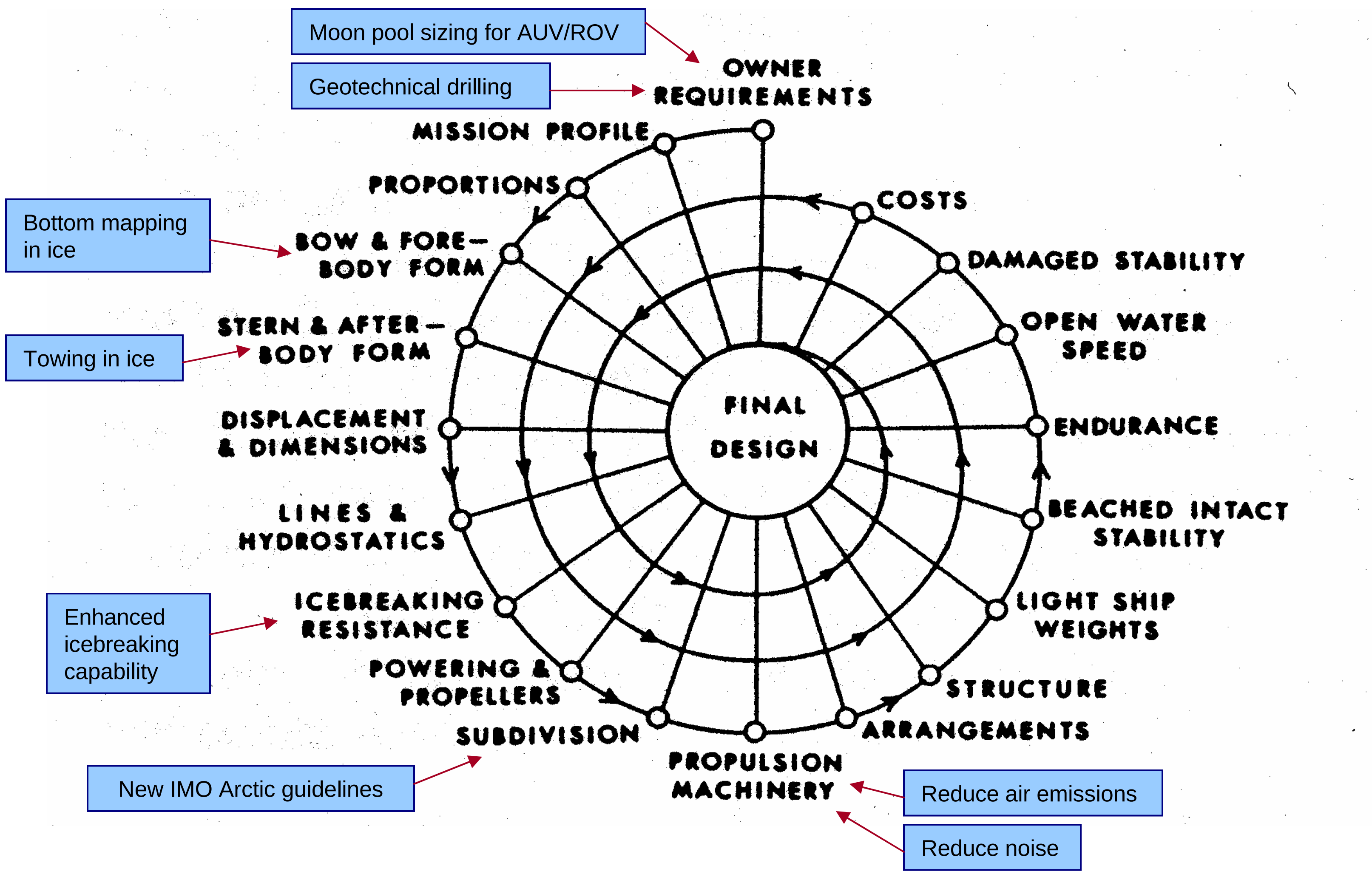
Current Statement of Work

- Translate an initial set of science and operational requirements into design criteria taking into account the experience gained by U.S. and foreign vessels engaged in polar research
- Conduct a number of special studies to properly understand the full implications of these requirements
- Perform a feasibility-level ship design in sufficient detail to arrive at a ship size, general arrangement drawings and a vessel cost estimate
- Deliver copies of special studies, vessel plans and characteristics, technical specifications, cost estimate and design history

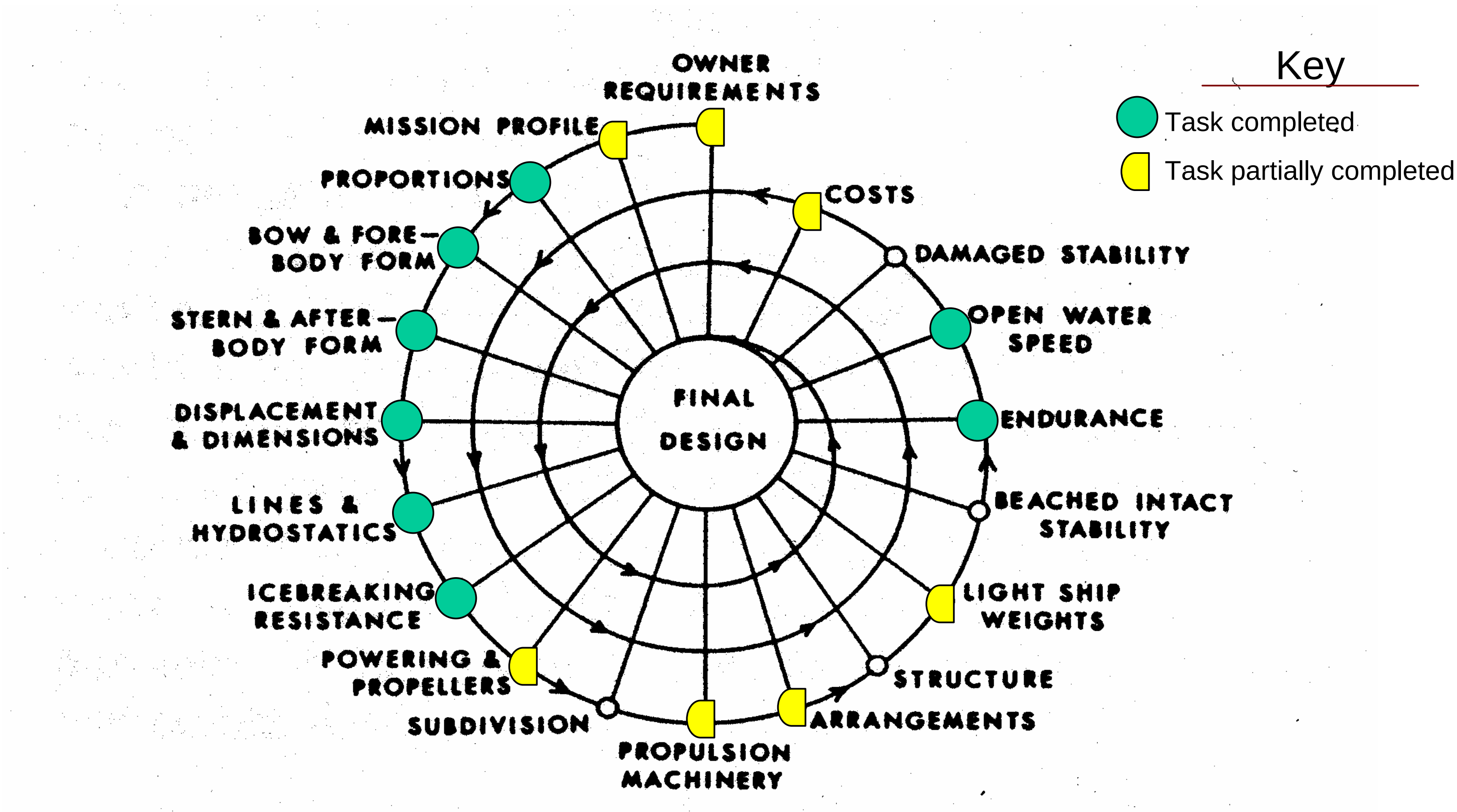
PRV Design Spiral



Special Technical Studies



Overview of Feasibility-Level Design Cycle



Overview of the Project Organization and Design Process

Initial Science and Operational Requirements

- How the PRV procurement activity is different from the NBP
- Information resources
- Science and operational requirements provided to design team
- Examples of science and operational requirements needing further clarification

How the PRV Procurement Activity is Different from the NBP

- NBP procurement had limited design guidance in the RFP technical specifications and bidders were to submit competing designs at all levels of detail including science spaces.

- The PRV procurement will contain significantly more details in the specification, including a conceptual design of the vessel and guidance drawings of laboratory spaces that reflect the preferences of the science community.

Information Resources

- Two Science Workshops
  - Antarctic Oceanography Planning Workshop, Final Report, June 25-26, 2002
  - Antarctic Marine Geology and Geophysics Planning Workshop, Final Report March 23-24, 2002
- NBP procurement specifications as modified during refit, about 2000
- ARV design, 1994
- ARRV design, 2001
- Data base of research vessels

Science and Operational Requirements Provided to Design Team

- Acoustic profiling including bottom mapping during icebreaking
- Towing of nets and instruments from the stern during icebreaking
- Conduct of AUV/ROV operations from a moon pool
- Geotechnical drilling through a moon pool
- Acoustically quiet
- Comply with IMO guidelines for Arctic vessels
- Accommodations for 50 scientists
- 80-day endurance
- Reduced air emissions from diesels and incinerator
- Enhanced icebreaking capability
- Helicopter hangar

Examples of Science and Operational Requirements Needing Further Clarification

- Icebreaking capability
  - a definite ice thickness
  - representative route and time of year
- Operational requirement for geotechnical drilling
  - dynamic station keeping requirement (sea state and duration)
  - limits of lateral movement
- Number of boats, size, seaworthiness, method of launch and recovery

Examples of Science and Operational Requirements Needing Further Clarification

- Requirement for moon pool
  - size
  - associated support space and equipment
- Endurance
  - current 80-day endurance based on 12kt open water speed
  - need representative mission profiles in ice to verify sufficiency
- Vessel performance in open water
  - open water transit and maximum speed
  - sea keeping requirements

Examples of Science and Operational Requirements Needing Further Clarification

- Acoustically quiet
  - seismic
  - bio-acoustic systems
  - passive listening
  - additional
- Other examples
  - need for handicap accessible throughout science and habitability spaces – per ARV design
  - need for elevated medical support/assistance

Results from
Special Technical Studies

Results from Special Technical Studies

- Approach
- Listing of special design studies
- Results from each study

Approach

- Special studies to examine key issues
- Studies have a major effect on ship size, capability and cost
- Outcome of this project is
  - Size of the ship and layout – initial level
  - Key science capabilities incorporated in the design
  - Drawings to illustrate the concepts

Listing of Special Design Studies

- Establish requirements and impact on the ship for:
  - Improved towing in ice
  - Improved bathymetry in ice
  - Geotechnical drilling
  - Moon pool
  - Icebreaking capability
  - IMO Arctic Guidelines
  - Improved acoustic environment
  - Reduced exhaust emissions

Improve Towing in Ice

Towing in Ice

- Several concepts have had some practical application

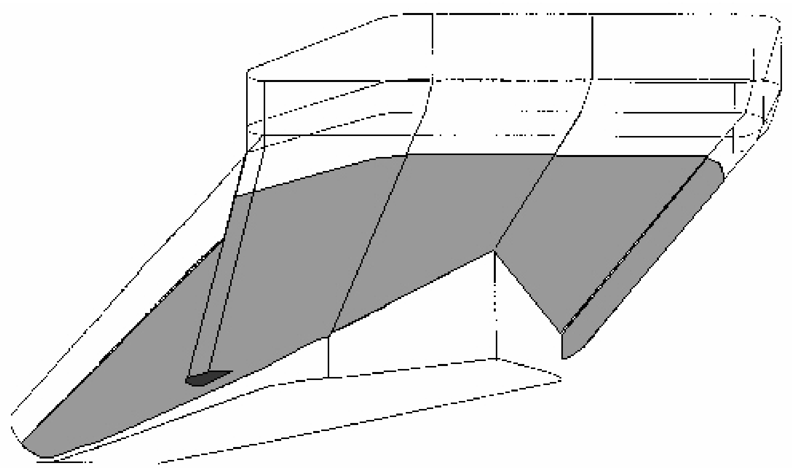
- Conclusions based on experience and test results to date

Towing in Ice

- Potential methods to improve towing in ice
  - Reducing ice concentration or clearing the ice in the ship's track
    - Using non-conventional hull form
    - Using auxiliary devices for ice management
    - Using non-conventional propulsion system
  - Reducing the risk of contact between the ice and towed equipment by using special devices and stern arrangements

Towing in Ice

Non-conventional Hull Form



Icebreaker ODEN ice-removing wedge

Towing in Ice

Non-Conventional Hull Form

Icebreaker ODEN Track

Conventional Icebreaker Track

Ice concentration is approximately the same

Towing in Ice

Auxiliary Clearing Devices

- Dozens of methods invented
- Several were built
- Most popular: hydrodynamic devices
  - Air-bubbling systems
  - Water-wash systems
- Reduction of ice concentration in ship’s track was very limited:
  - Up to 5%-10% in very light ice conditions

Towing in Ice

Non-Conventional Propulsion Systems

Azimuthal propulsors

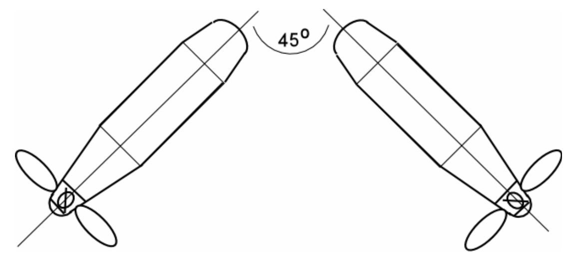
Azipod

Aquamaster

Towing in Ice

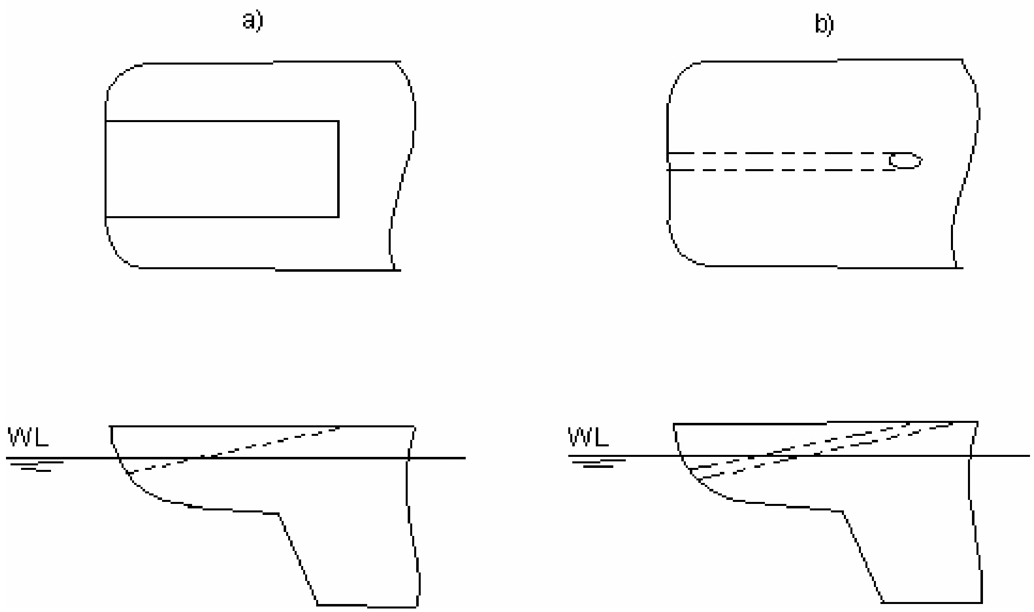
Non-Conventional Propulsion Systems

- Thrusters angle from 10^0 to 90^0 can reduce the ice concentration in the ship's track by 10% to 80%
- Effect is limited to 10% to 40% of design icebreaking capability at speeds of 3 to 4 knots



Towing in Ice - Stern Arrangements

- Special stern ramp similar to those used on fishing boats: Figure a)
- Channel or tube for the towing line: Figure b)
- Specific stern arrangements will not affect the ship design overall



Towing in Ice - Conclusions

- Clearing the ship's track remains a technical challenge
- No successful example is known to date
- All methods are very limited but most efficient is the use of azimuthal propulsors
- Combination of azimuthal thrusters and stern arrangements may result in safer and more reliable towing in ice

Improve Bathymetry in Ice

Bathymetry in Ice

- Background
  - Visit to AWI in Bremerhaven, Germany
  - Draw heavily on experience of Dr. Schenke (POLARSTERN and HEALY)
  - Design team experience (NBP and POLARSTERN)

POLARSTERN Experience

- POLARSTERN built in 1982. Original bottom mapping system did not work in ice because placement was too far aft, and fiberglass window structure was inadequate.
- New system was installed in 1989 and was placed closer to the bow; flared sides to trap bubble sweep down; and with titanium windows. Gathering good data since refit.
- 1991 IAOE – Bathymetry to North Pole, Lomonosov Ridge
- Weddell Sea – 12 kt in 80% concentration of thick FY ice and continuous icebreaking in thin FY ice
- Open water – 10 kt in deep ocean
- Excellent data for over 13 years in ice

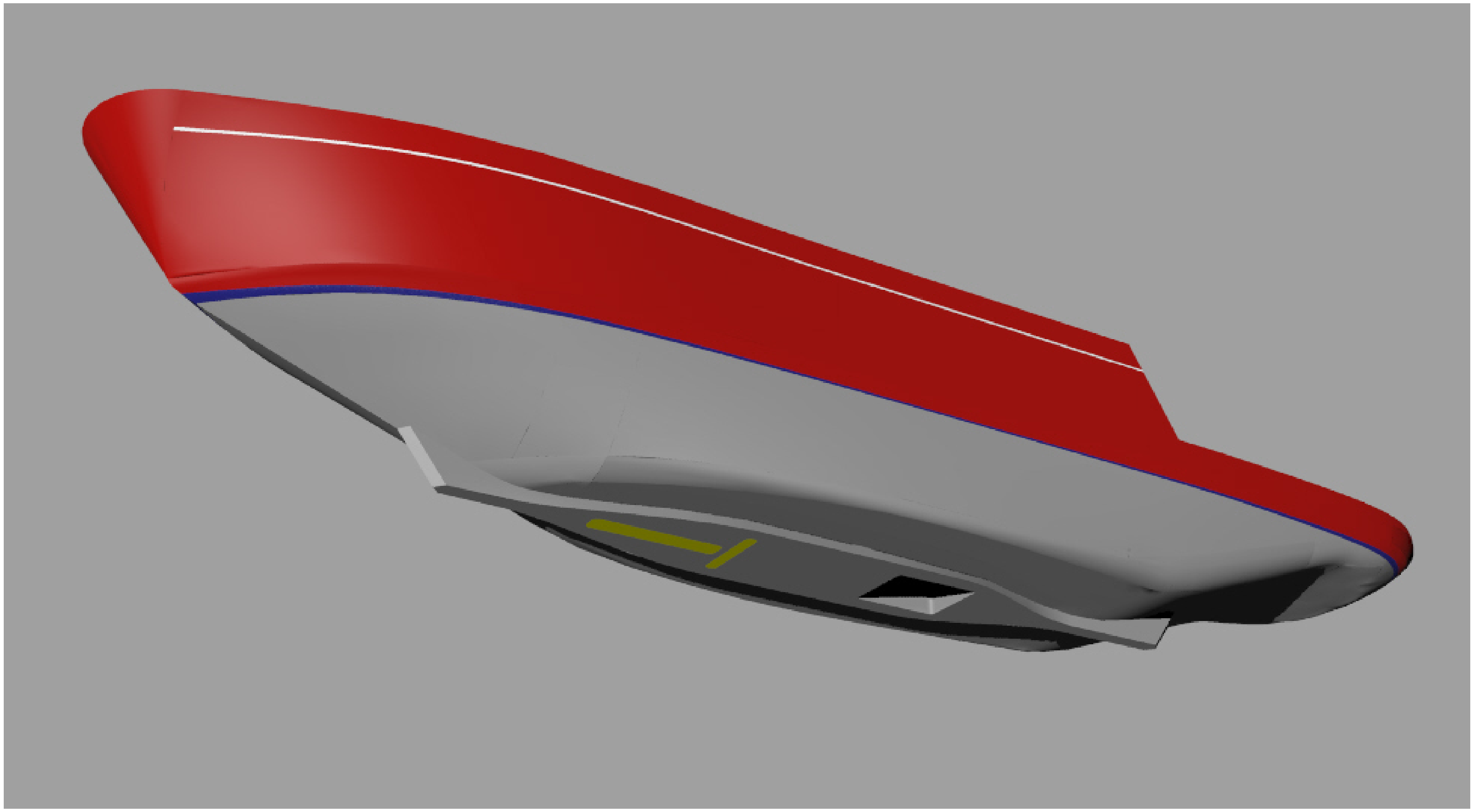
Other Ship Experience

- NBP had operational problems with original system, also bubble sweep down problems, not used in ice. New system performs better in open water, not tried yet in ice?
- HESPERUS and JAMES CLARK ROSS lack ability to achieve speed for large-scale mapping in thick FY ice.
- HEALY system performs well at higher speeds; poorer performance at low speeds and stationary attributable to Motion Measurement System (MMS) and not bathymetric system. Recent Arctic data compared well with POLARSTERN data.

Bathymetry - Conclusions

- Bubble sweep down is a bigger problem than ice pieces and can be handled with a box keel with reverse flared sides
- Deep draft is an advantage for both bubble sweep down and ice
- Vessel should have sufficient capability to move at 10 to 12 kt in thick first year ice of up to 80% concentration
- Proper bow form and stern form can guide ice around arrays to some extent, as shown in next slide

Proposed Solution for PRV



Geotechnical Drilling

Geotechnical Drilling

- Visit to BOTNICA
- Visit to AWI in Bremerhaven
- Discussion with NSF and RPSC on Shaldril program

Visit to BOTNICA

- Finnish icebreaker designed to be chartered for oil support in the summer
- Used for ROV work, well-intervention and drilling
- Removable drill rig 160 tonne, about 34 m off the deck, removable
- Drilling rig never used, only intended for use in open water

Visit to AWI

- Planning a new drill ship for year-round work in the Arctic Ocean
- Drilling in the summer and other science missions during the rest of the year
- Large drilling rig – few details currently available
- Comment was made that the drilling dominates the layout of the ship

ShalDril

- 40 ft high, 13 ft wide, portable in 7 containers
- On NBP, ShalDril will be used through a 6 ft diameter moon pool off centerline on the after deck
- ShalDril system used as representative drilling system for PRV

Guidelines for Drilling

- Use ShalDril as representative drilling system for PRV
- Moon pool is needed for other science requirements - located in an ideal location on the ship for drilling
- Rig over the moon pool and enclosed
- Part of system is permanently installed in the vessel and the remaining part is portable.
- Provide access from deck for drill pipe and access forward to labs for cores to be handled
- Bow thruster in the hull for station keeping in open water

Moon Pool

Moon Pool

- Support for:
  - ROVs, AUVs, CTD/rosette, biomass, diving, drilling
- Background
  - Visit to BOTNICA
  - Visit to AWI in Bremerhaven
  - Discussions with NSF and RPSC
  - Research on other ships with moon pools

Moon Pools for ROVs

- BOTNICA
  - 6.5 m square (21.3 ft)
  - Series of about 0.5 m diameter holes in a secondary bulkhead in the moon pool to dampen waves
  - Typical supply boat afterdeck – plenty of room for working and maintaining ROVs, though not sheltered

- Other Ships
  - Commercial vessels range from 4 m to 6.5 m square range
  - Planned German drillship 4 by 5 m and 6 by 8 m moon pools
  - Large French Victor ROV, 2 by 2 by 4 m (AWI)

PRV Moon Pool Considerations

- 6.1 m long by 4.9 m wide (20 ft by 16 ft)
- Initially sized by CTD rosette and AUV, hook height, and motion criteria for the ship with about 3 ft of margin
- Maximum dimensions were taken as 5 ft width (rosette) and 10 ft length (AUV), excluding ROVs
- ROV capability was considered later, and it was assumed there would be captured launch and recovery (no ship motions)
- Moon pool size considered representative and a small increase in size will have low impact on vessel design

PRV Moon Pool Considerations

- Must be on vessel centerline and longitudinal center of gravity for station keeping and motions
- Large covered workspace around moon pool
- Room for ROV winches and maintenance
- Workshop close by
- Good crane support for maintenance and moving packages
- Can be combined with Baltic room
- Control room and science data collection area overlook moon pool, one deck up

Icebreaking Capability

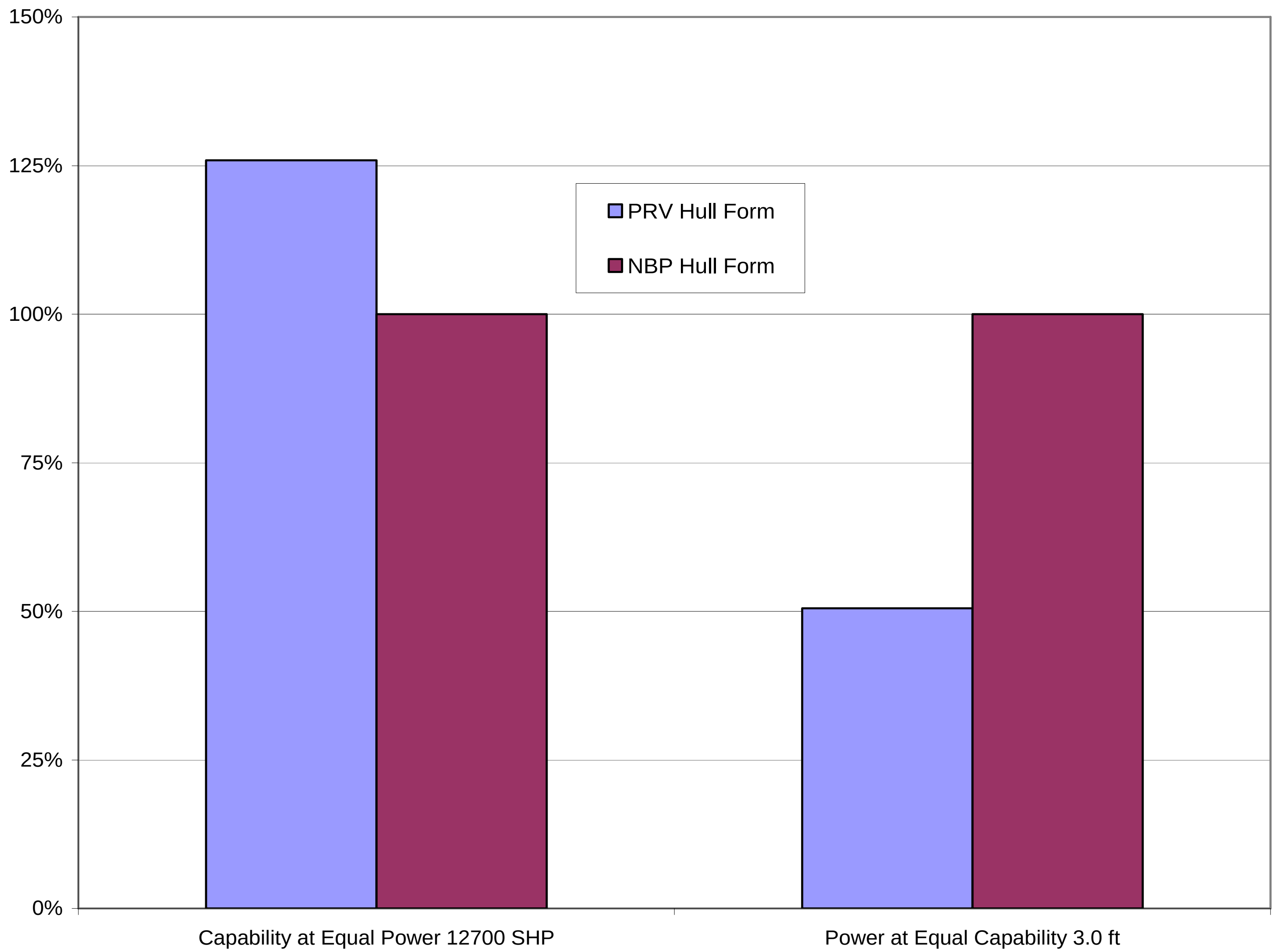
Icebreaking Capability and Power Plant Selection

- Icebreaking Capability
  - Increased capability translated into 4.5 ft level winter first year ice at 3 kt
  - Suitable for Arctic operations
  - Significant increased performance over NBP (3+ ft)
- Power Plant Alternatives
  - Direct drive diesel vs common bus AC Electric
  - Conventional shafting vs azimuthal propulsors
  - Open propellers vs nozzles

Hull Form Design

- Improve icebreaking performance
- Low open water resistance
- Maintain NBP good seakeeping performance
  - Same roll and pitch, acceleration limits in 16 ft significant wave height
  - Same slamming limit (minimal)
  - Improve deck wetness (increase freeboard)

Icebreaking Comparison

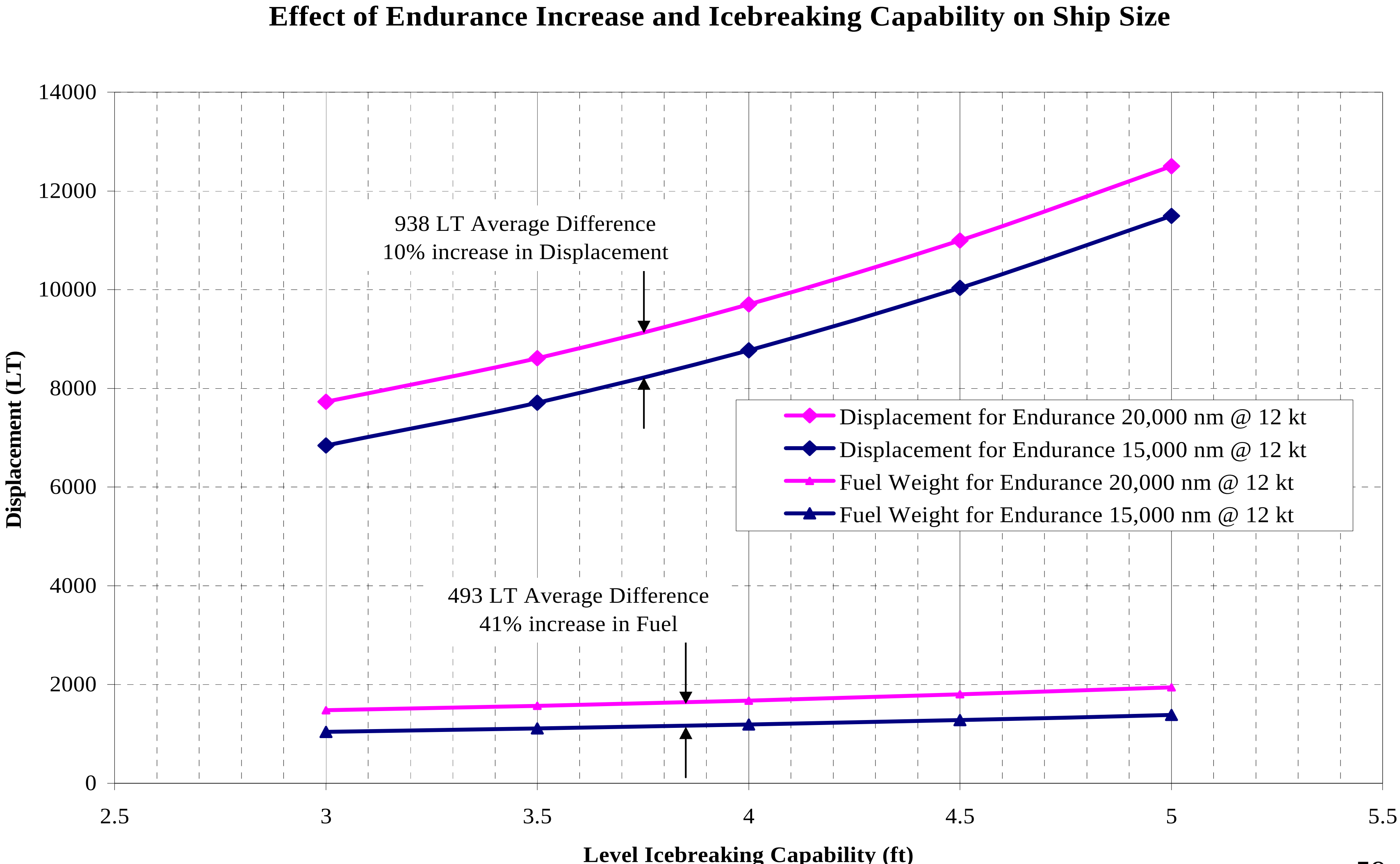


Icebreaking Capability

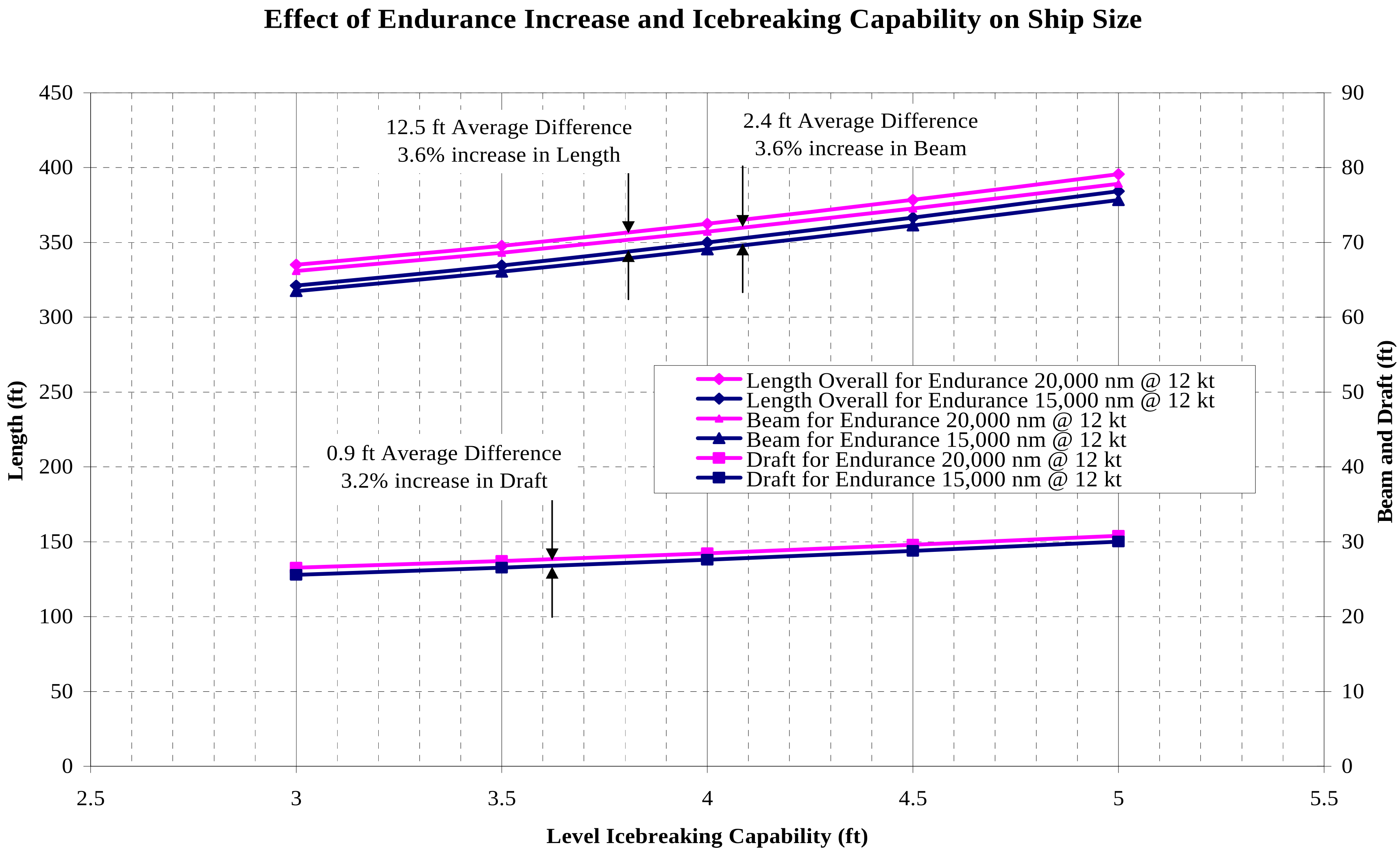
Approach Used in the Design

- Increased icebreaking means more power and therefore a larger ship
- Designed the ship for each increment of capability
- Developed a design synthesis model to calculate the important parameters of the design – weights, hydrostatics and ship size, propeller design, open water performance, endurance, and icebreaking performance for a given hull shape
- Investigated endurance, NBP and +33%
- Achieved design solutions through constrained nonlinear optimization techniques

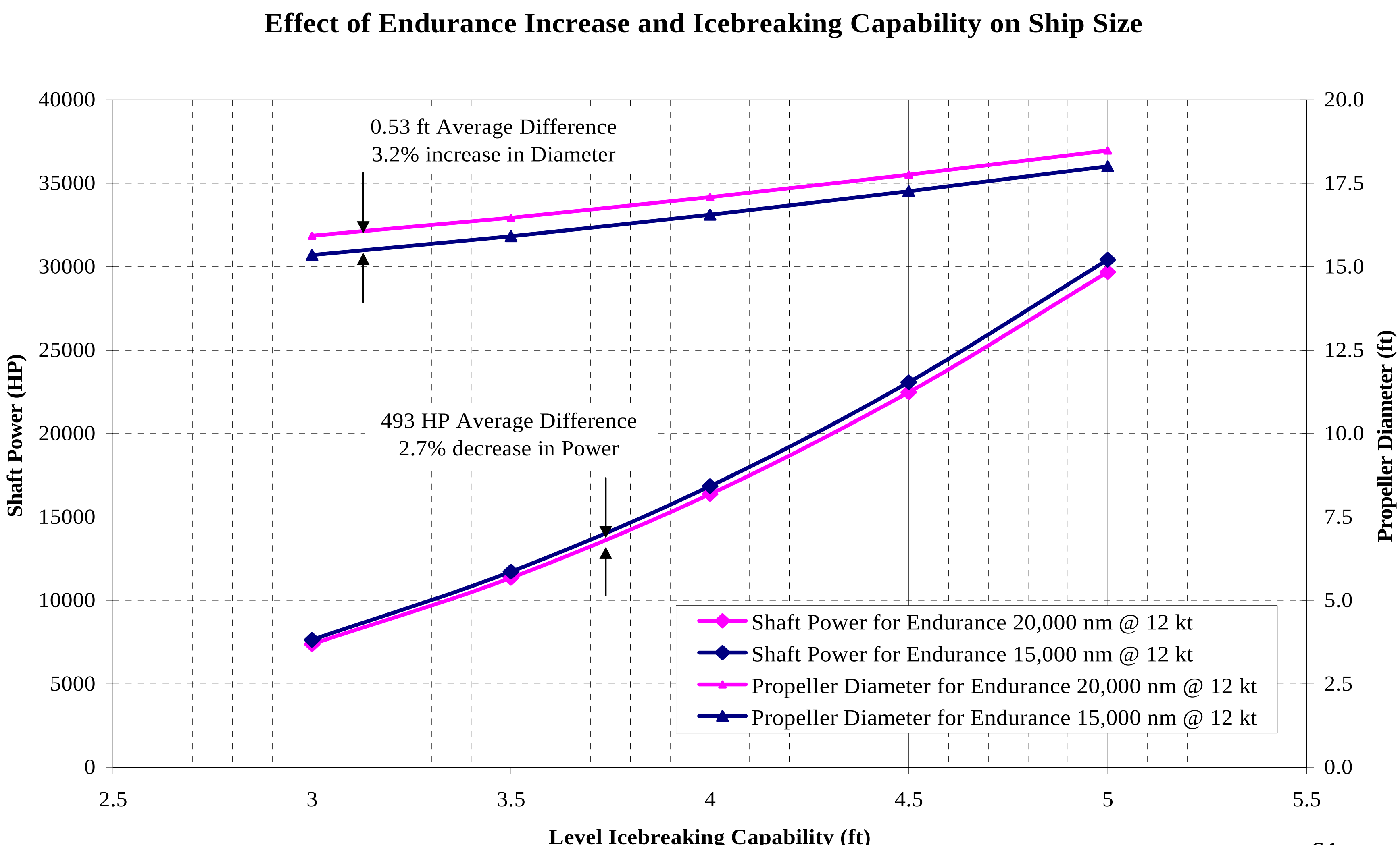
Synthesis Model Results - Size



Synthesis Model Results – L,B,T



Synthesis Model Results – Power



NBP vs PRV Comparison

	NBP	PRV	
Length	308	378	ft
Beam	60	74.5	ft
Draft	22.4	29.6	ft
Freeboard	8.6	11.0	ft
Displacement	6,800	11,000	LT
Total Installed Power	19,200	29,500	HP
Shaft Power	12,600	22,500	HP
Propeller Diameter	13.1	17.8	ft
Endurance @ 12 kt	15,000	20,000	nm

Power Plant Selection

- Direct drive diesel hard to fit into a ship with large moon pool – electric plant more flexible
- Diesel-generators can be “floated” on isolation mounts for low noise/vibration
- Torque characteristics of electric plant better suited to ice operation – no propeller stalling
- Large open props produce high thrust for icebreaking and low noise at low rpm cruising speed – noise radiate in all directions. Nozzles direct noise forward and aft.
- Azimuthal propulsors give great maneuverability in ice and station keeping

Power Plant Selection

- Electric Z-drive systems provide less Electro-Magnetic Interference (EMI) in the water
- Trade-off between high thrust nozzle Z-drive and large open propeller should be considered in future iterations – noise, EMI, icebreaking, endurance
- Some manufacturers of azimuthal propulsion
  - ABB Azipod AB
  - Rolls-Royce AB Kristenhamn (MERMAID)
  - Rolls-Royce OY AB (Ulstein Aquamaster)
  - Schottel/Siemens

Ice Class Consideration
(American Bureau of Shipping)

- NBP is ABS A2
- PRV may encounter more old ice (multiyear) based on mission requirements
- ABS A3 or Polar Class 3 is more appropriate
- ABS rules recommend ABS Ice Class A3 for unescorted operation in Arctic offshore shelf and escorted operation in the Central Arctic Basin.

IMO Arctic Guidelines

IMO Arctic Guidelines

Compartmentation

- IMO Guideline work in harmony with the Class selected for the vessel and additional requirements on design
- No pollutants should be carried against the shell in areas at significant risk of ice impact
- Require a cofferdam of a depth of at least 0.76 m (2.5 ft) between tanks with fuel and the shell
- Required to have a double bottom through the length from the collision bulkhead to the aftpeak bulkhead

IMO Arctic Guidelines

Compartmentation

- Damage can occur of 4.5% of length fwd of max beam and 1.5% aft – 2 compartment standard
- Hull volumes in PRV checked for adequate volumes and margins for cofferdams and all tankage
- Intact and damaged stability and compartmentation studied in the next round of the design – not expected to pose a problem

IMO Arctic Guidelines

Other Requirements

- IMO guidelines cover cold weather operation – many items included in NBP technical specification
- Some cold weather specifications could be eliminated by invoking IMO guidelines
- Others, such as sea spray icing, are currently more stringent in NBP specifications and should remain
- Need a careful comparison when preparing the technical specification

Improve Acoustic Performance

Acoustic Performance Considerations

- Acceptable acoustic performance is a requirement of a modern research vessel
- Acoustic performance can be divided into three primary areas:
  - Underwater Radiated Noise
  - Sonar Self-Noise
  - Airborne (habitability) Noise
- Acoustic requirements will be determined by:
  - Specific scientific criteria
  - Tradeoffs with other mission requirements
  - Cost considerations
- Some acoustic requirements may have a significant impact on the overall design and need to be identified early in the design process

Approach to Noise Control

Typical steps:

- Define requirements
- Identify noise sources
- Model noise system and establish “noise budget”
- Specify treatments in order to meet “noise budget”
- Monitor construction
- Test and trials
  - Identify failures
  - Propose remedies

Requirements Definition

- “Hard” Requirements:
  - Regulatory
  - Invoke particular scientific standard
- “Soft” Requirements:
  - Dependent of cost and other tradeoffs
  - Iterative as design progresses
- How to define requirements?
  - “Performance based”
  - Specify acoustic treatments to mitigate noise
  - Combination
- Procurement Approach - the greater the contractor risk, such as a performance-based specification, the higher the vessel cost

Noise and the Design Process

Some aspects of noise control must be considered at the earliest design stages - others can wail until well into the design spiral.

- Early stage impacts include:
  - Selection of machinery type
  - Hull form development and principal propeller characteristics
  - Arrangement to locate sonar away from noise sources
  - Arrangement to locate accommodations away from noise sources
- Later stage impacts include:
  - Sound insulation
  - Mounting of individual pieces of equipment
  - Hull form details around sonar location

Design Considerations
Underwater Radiated Noise

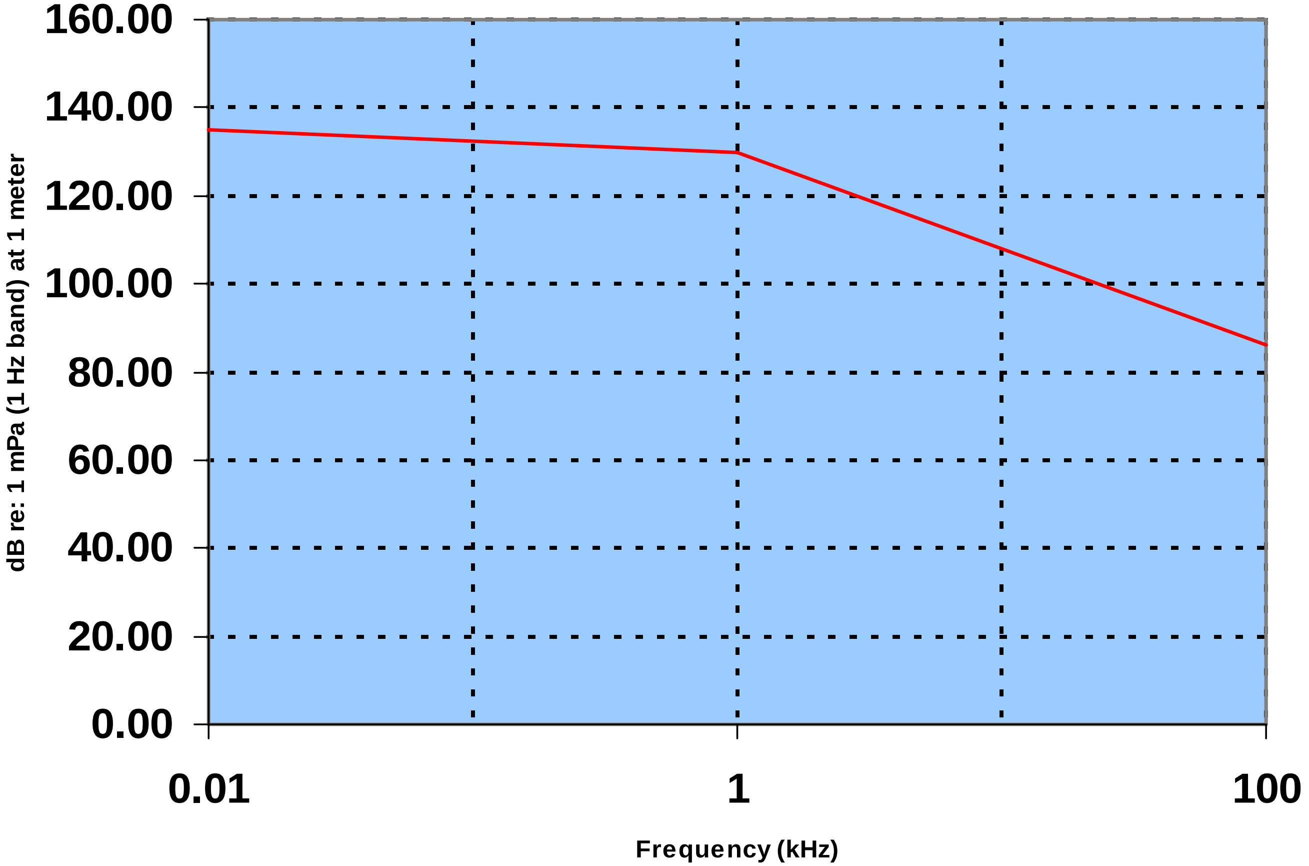
Standard for fisheries research is the ICES curve - requires need military quietness. Standard is at defined speed of 11 knots.

- Design Impacts:
  - Diesel electric propulsion
  - Raft mounted main engines
  - Insulation of machinery space
  - Resilient mounting of piping and auxiliary machinery
  - Careful hull form and propeller design - model tests required
  - Difficult to meet with AC power
  - Difficult to meet with podded propellers

Most design impacts must be considered at earliest stages of design

- Alternatives to ICES might include:
  - Meeting ICES noise levels at speed less than 11 knots
  - Meeting ICES noise levels only at certain frequencies
  - Noise goal somewhat higher than ICES levels
  - Specifying cost-reasonable treatments and accepting results

ICES Underwater Radiated Noise Standard



Design Considerations
Sonar Self-Noise

Requirements established in conjunction with sonar vendor considering sonar mission. Usually expressed in ability to detect certain size target at particular distance with specified conditions of vessel speed and sea state

- Early stage design impacts:
  - Locating sonar away from noise sources
  - Hull form design to avoid local flow noise in region of sonar location (air bubble sweep down)

- Other sonar self-noise design features include:
  - Resilient mounting of piping and ducting locally around sonar

Design Considerations Airborne (Habitability) Noise

Noise requirements defined by U.S. Coast Guard and IMO

- Early stage design impacts include:
  - Locating noise sensitive areas (such as accommodations) away from noise sources (such as machinery space, ice breaking belt, roll stabilization tank, etc.)
  - Selection of HVAC system characteristics

- Other airborne noise design features include:
  - Noise insulation
  - Noise absorbing materials such as overhead panels, carpeting, etc.

Suggestions for Next Design Cycle

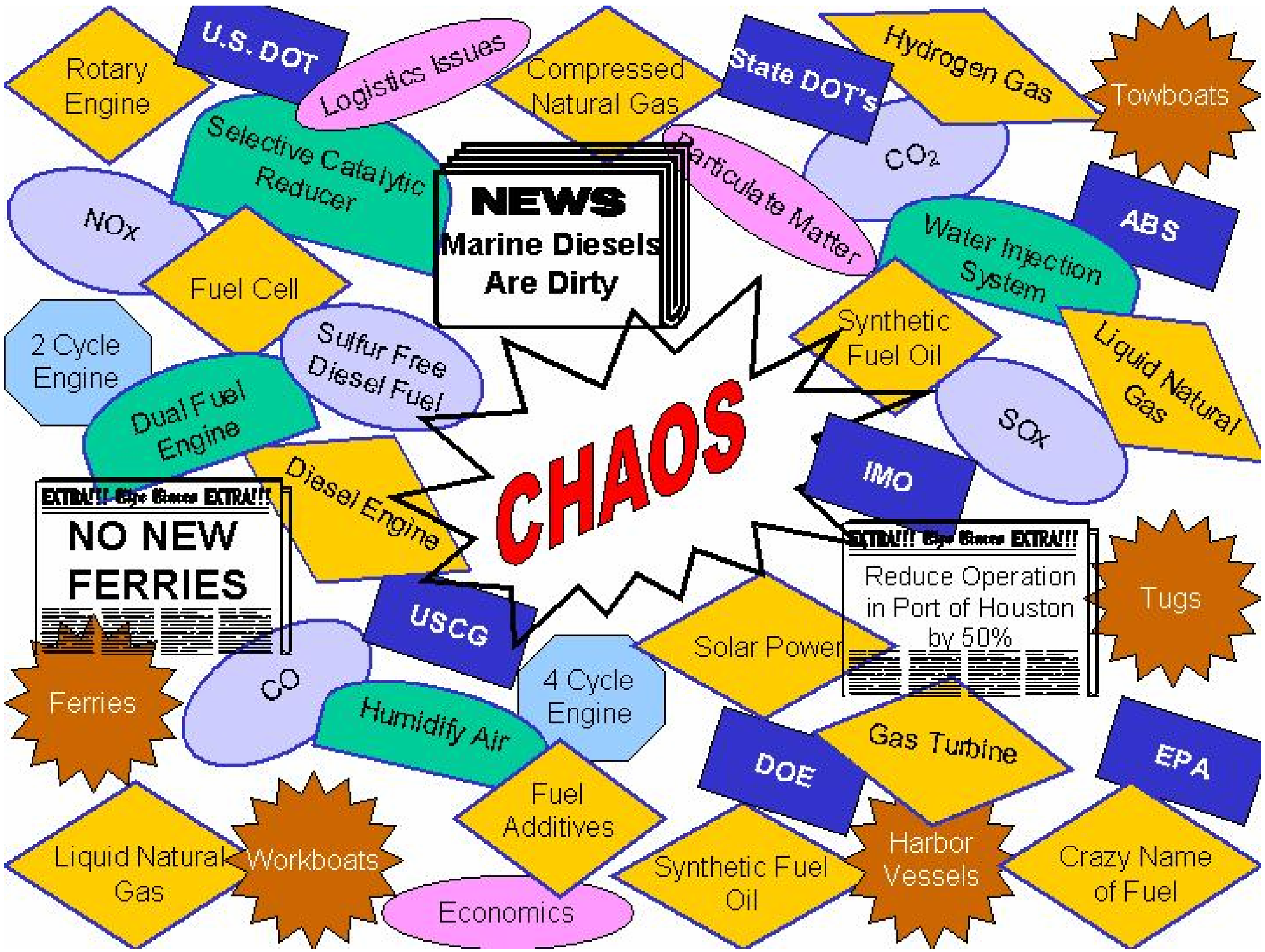
- Define Requirements
  - Determine if noise levels on NBP (and other vessels is acceptable, marginal, or unacceptable)
  - Science sensors and equipment
- Identify noise sources requiring investigation
  - Podded propulsion system
  - Diesel engines
  - Auxiliary machinery; pumps, compressors, ventilation system, hydraulic system, etc.
- Evaluate procurement alternatives re: noise
  - Performance
  - Treatments
  - Combination

Reduce Exhaust Emissions

Approach for Reducing Diesel Engine Exhaust Emissions

- Diesel engine exhaust issues
- Technology overview
- Emission reduction technologies
- Cost for emission reduction
- Summary
- Possible PRV diesel emission goals

Diesel Engine Exhaust Issues



Technology Overview

- Technology selected must be supplied or be approved by engine manufacturer
- Technology is evolving rapidly
- Technology must be logistically supportable

Emission Reduction Technologies

- Direct water injection (DWI)
- Combustion air humidification
- Fuel-water emulsion (FWE)
- Selective catalytic reduction (SCR)
- Common rail fuel injection
- Electronic engine controls

Typical Costs for Emission Reduction

Technology	Units	SCR	SCR	DWI 70% H_2O	WFE 30% H_2O
NOx Reductions	%	40%	90%	50%	20%
Capital Costs	US$/kW	$35	$45	$35	$3.0
Total operational costs	US$/MWh	$2.5	$7.5	$2.7	$1.2

Summary

- EPA will require that marine engines in 2007 achieve a 30% reduction in Oxides of Nitrogen (NO_x) and Total Hydrocarbons (THC) compared to older engines
- Additional emissions reduction technology is available

Technology	Emission	Overall Reduction
SCR	NO_x + HC	93%
FWE+Air Humid	NO_x + HC	82%
Direct Water Inject. (DWI)	NO_x + HC	72%
Fuel-Water Emulsion (FWE)	NO_x + HC	51%
Emission Tuning	NO_x + HC	37%
Particulate Trap	Particulate	90%

Possible Diesel Emission Goal for PRV

Achieve 90% reduction in Oxides of Nitrogen (NO_x), Total Hydrocarbon (THC) and Particulate Matter (PM) with 2007 diesel engines and state-of-the-art emission reduction technology .... compared to 1990 diesel engines (NBP)

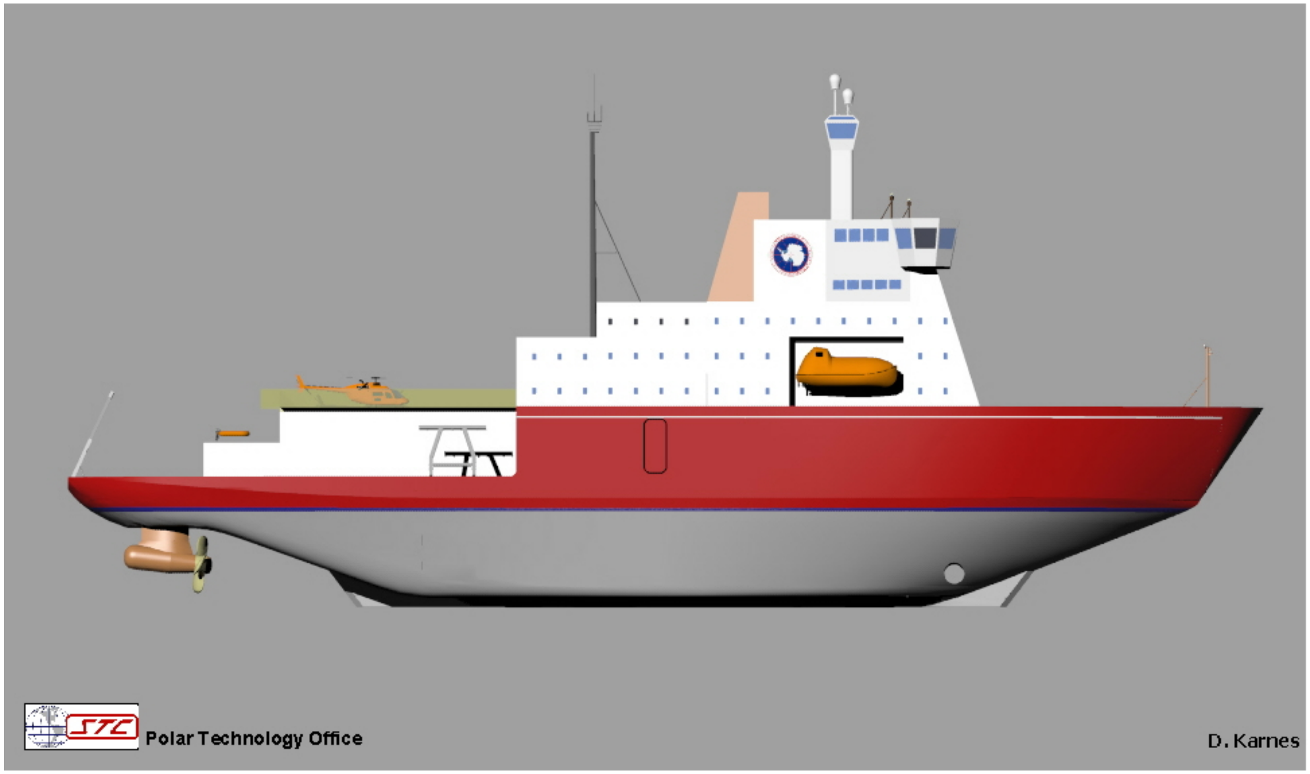
PRV Design Study

PRV Design Study

- Rendering of PRV
- PRV principal characteristics
- PRV power plant
- PRV performance
- PRV ice classification
- PRV science features
- Underwater view of box keel
- Head-on view of box keel
- Features of main deck and 01 level
- Drawing of main deck and 01 level
- Baltic/Moon pool arrangement
- Comparison of Laboratory Spaces – NBP and PRV
- Additional views of PRV

Rendering of PRV

PRV Principal Characteristics



LOA	378.4 ft	Draft	26.6 ft
LWL	340.9 ft	Displacement	11,000 LT
Beam	74.5 ft		

PRV Power Plant

- Diesel-Electric Propulsion Plant
  - Four Main Diesel-Generators Sets
    - 2 X 8046 HP
    - 2 X 6785 HP
    - Total Brake Power at MCR (100%) 29600 HP (22 MW)
  - Common Bus/Integrated Electric System
  - AC-AC
  - Frequency Converters
  - One Harbor Diesel-Generator Set
  - One Emergency Diesel-Generator Set
- Azimuthal Twin Screw Propulsion
  - Two Electric (AC) Azimuthal Podded Propulsion Units
    - 2 X 11200 HP (2 X 8.4 MW)
  - Electro-Hydraulic or Electric Steering Gear and Remote Control System
  - Open Fixed Pitch Propellers
    - Diameter 17.76 ft
    - 4 Blades
    - Stainless Steel
    - 112 RPM at icebreaking
- Bow Thruster

PRV Performance

• Level Icebreaking Capability @ 3 kt	4.5 ft
• Maximum Open Water Speed	18.5 kt
• Endurance Speed	12.0 kt
• Endurance	80 days/20,000 miles
• Crew	22
• Total Complement	80
• Ice Class	ABS A3 (IMO Guide – PC3)

Ice Classification

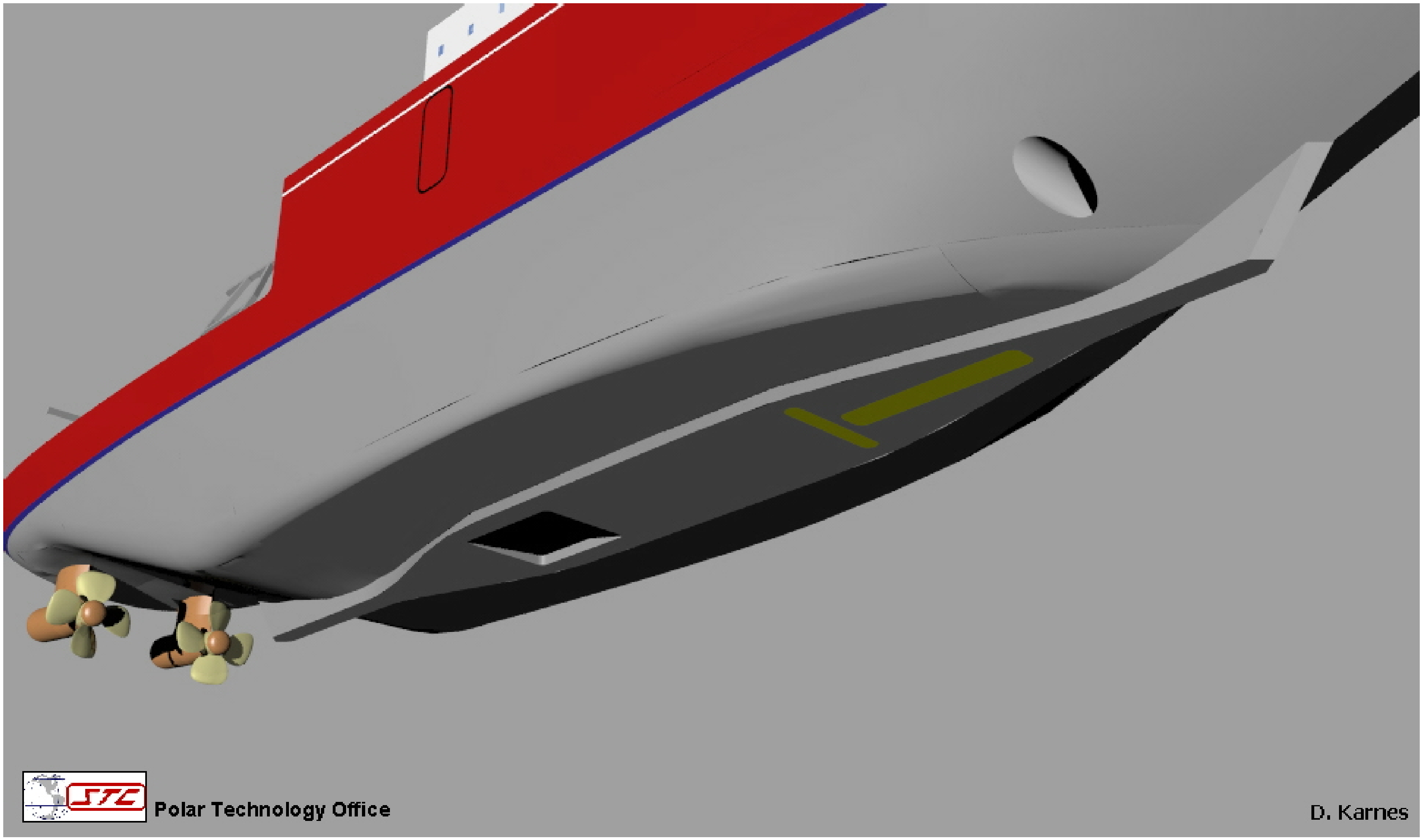
(American Bureau of Shipping)

Location	ABS A2	ABS A3
Arctic Offshore Shelf	Independently August through October	Independently July through December
Central Arctic Basin	Independent operation not allowed Escort by A4 or Higher, July through November	Independently July through September for short term, short distance Escort by A4 or higher, July through November
Antarctic	Independently March through April NBP operates independently all year in first-year ice	Independently February through May PRV can operate independently all year in first-year ice and enter areas with second year ice

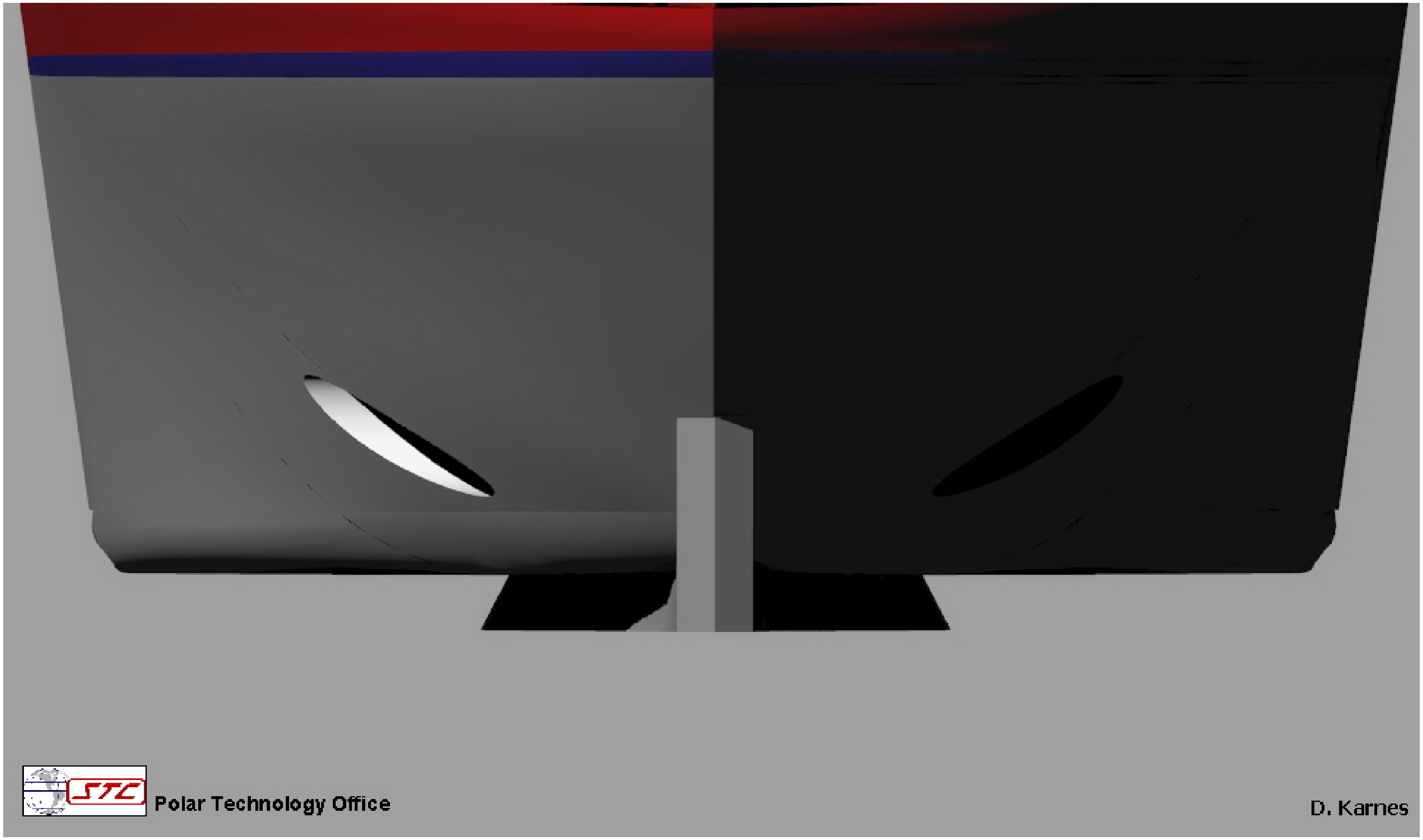
PRV Science Features

- Bottom mapping during icebreaking
- Enclosed geotechnical drilling capability
- Moon pool (completely enclosed)
  - AUV/ROV
  - Diving
  - CTD rosette
  - OBS
- Traditional set of A-frames, winches, cranes
- Enhanced towing in ice
- Accommodation for 50 scientists
- Helicopter complex (deck, hangar, elevator)
- Clear view aft from starboard pilot house control station
- Inter-deck science/cargo elevator
- Box keel sized suitable for growth in sensors

Underwater View of Box Keel



Head-On View of Box Keel

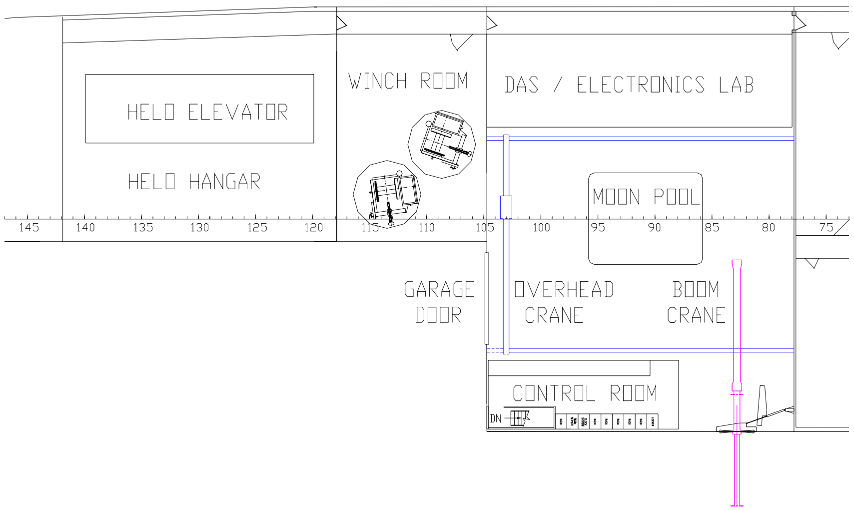


Features of Main Deck and 01 Level

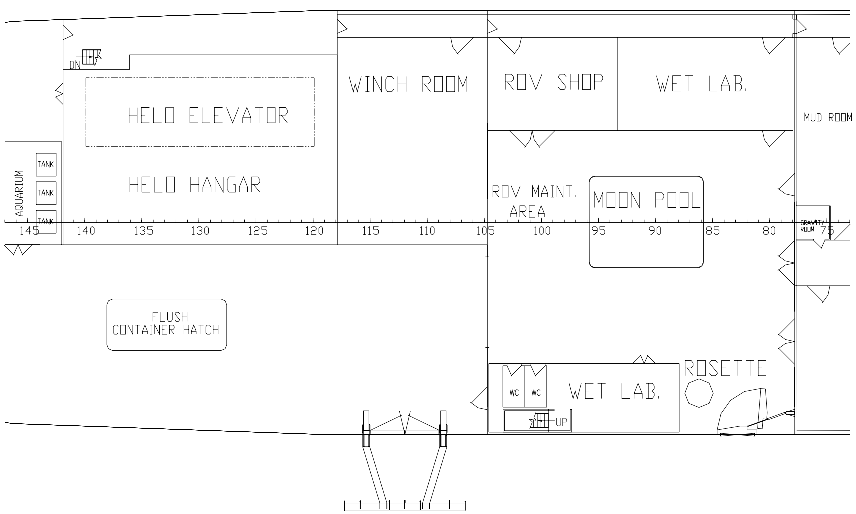
- Combined moon pool and Baltic room with 22 ft deck height
- Control room overlooks moon pool and boom crane
- 8 ft-wide corridor through laboratory spaces
- Garage door between Baltic room and starboard-side deck
- Removable lower section of geo-tech drill rig
- 01 Level winches service moon pool, starboard A-frame and boom crane
- Dedicated microscope room

Place holder for drawing

Baltic/Moon Pool Arrangement



01 LEVEL



MAIN DECK

Comparison of Laboratory Spaces NBP and PRV

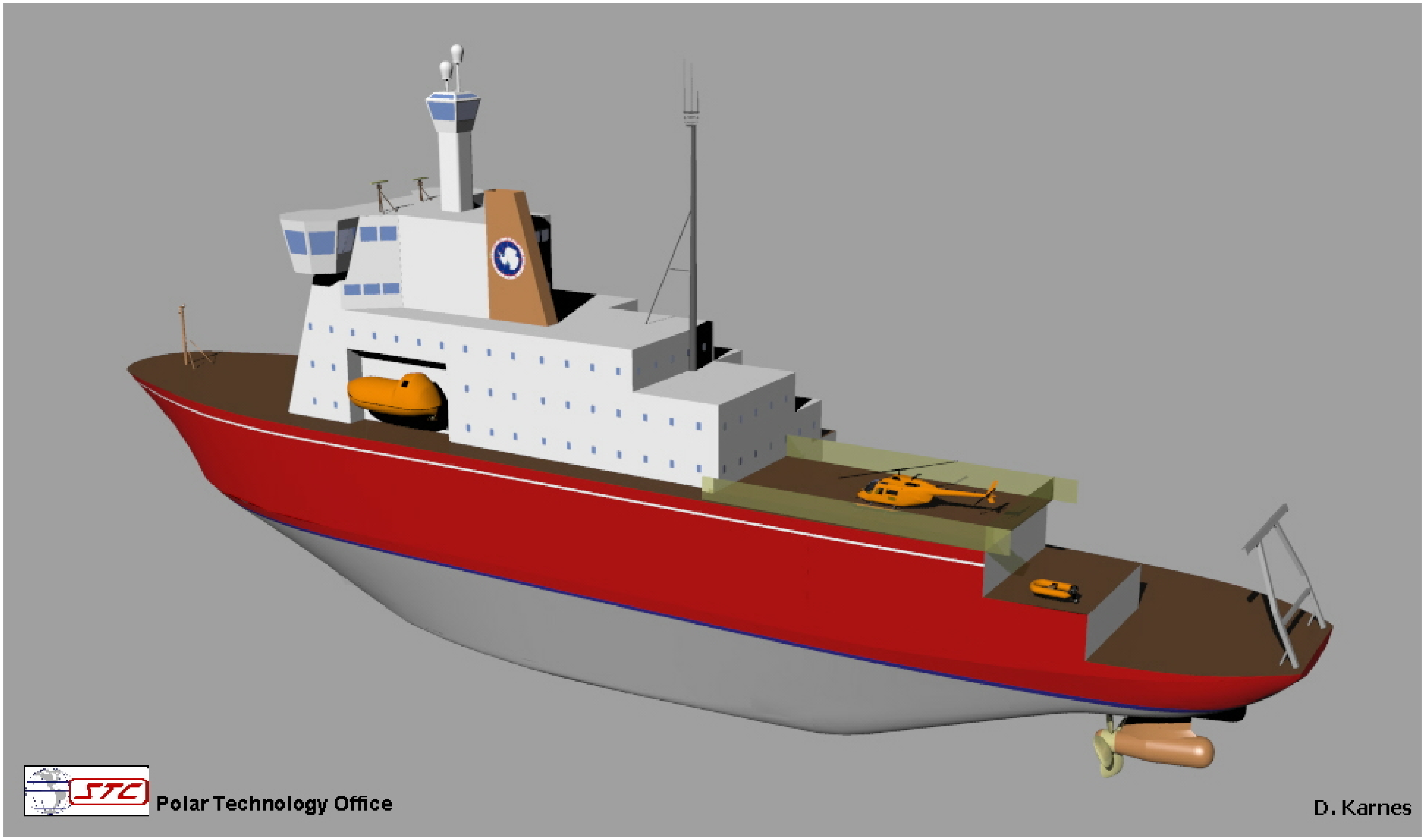
Laboratory Space	NBP (ft^2)	PRV (ft^2)	Percent Increase
Dry Lab (main)	1121	2234	99
Data Acquisition System / Electronics Lab	1261	3520	179
Hydro Lab	445	792	78
Bio Lab	524	885	69
Computer Lab / LAN office / Electronic storage	883	1936	119
Wet Lab	380	763	101
Baltic Room / Moon Pool	660	2424	267
Aquarium Lab	288	270	-6
Science Refrigerator / Coolers	152	224	47
Science Storage	505	1548	207
Workshop	142	231	63
Open workdeck	4062	5411	33

Additional Views of PRV

- Starboard view of stern quarter
- Port view of stern quarter

Starboard View of Stern Quarter

Port View of Stern Quarter



PRV Cost Estimate for Construction

PRV Cost Estimate for Construction

- Cost estimating procedures
- Cost estimate for NBP today
- Cost estimate for PRV
- Comparison of Costs NBP to PRV
- Some comparisons of NBP to PRV
- Effect of increasing endurance and icebreaking capability on ship size

Cost Estimating Procedures

- No universal method for estimating vessel cost at initial design stage
- Several Alternative methods
  - Use initial weight estimates for different weight groups for cost per ton multipliers for materials and labor
  - Use the Glosten Associates cost formulation based on regression of research vessels incorporating cubic number and horsepower (developed for ARV)

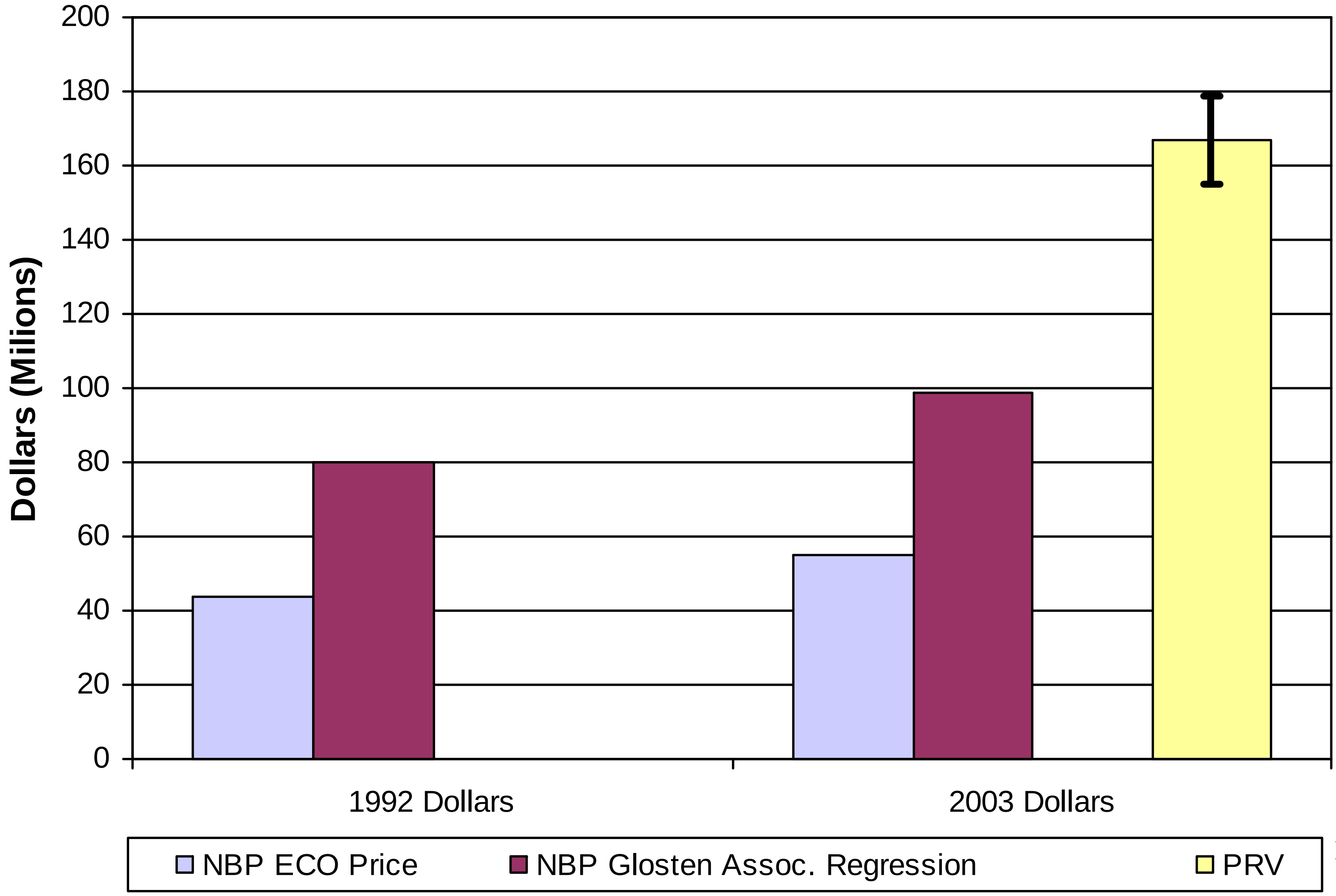
Cost Estimate for NBP Today

- Cost of construction vice price
- Cost of NBP from ECO in 1992 dollars was estimated at $44 million
- Cost of NBP based on Glosten Associates for the 1992 formulation for the ARV was $80 million based on regression of vessel costs
- Cost escalation factor from 1992 to 2003 is 1.238 and is based on 11 years of producer price index for shipbuilding and repair industry
- Cost of NBP in 2003 dollars
  - $55 million based on ECO estimate
  - $99 million based on Glosten estimate

Cost Estimate for PRV

- Cost estimate has been developed for a vessel that is at an initial design stage
- The range of cost is projected to be \$155 - \$179 million based on 2003 dollars based on calculations by Science and Technology Corporation and the U.S. Maritime Administration

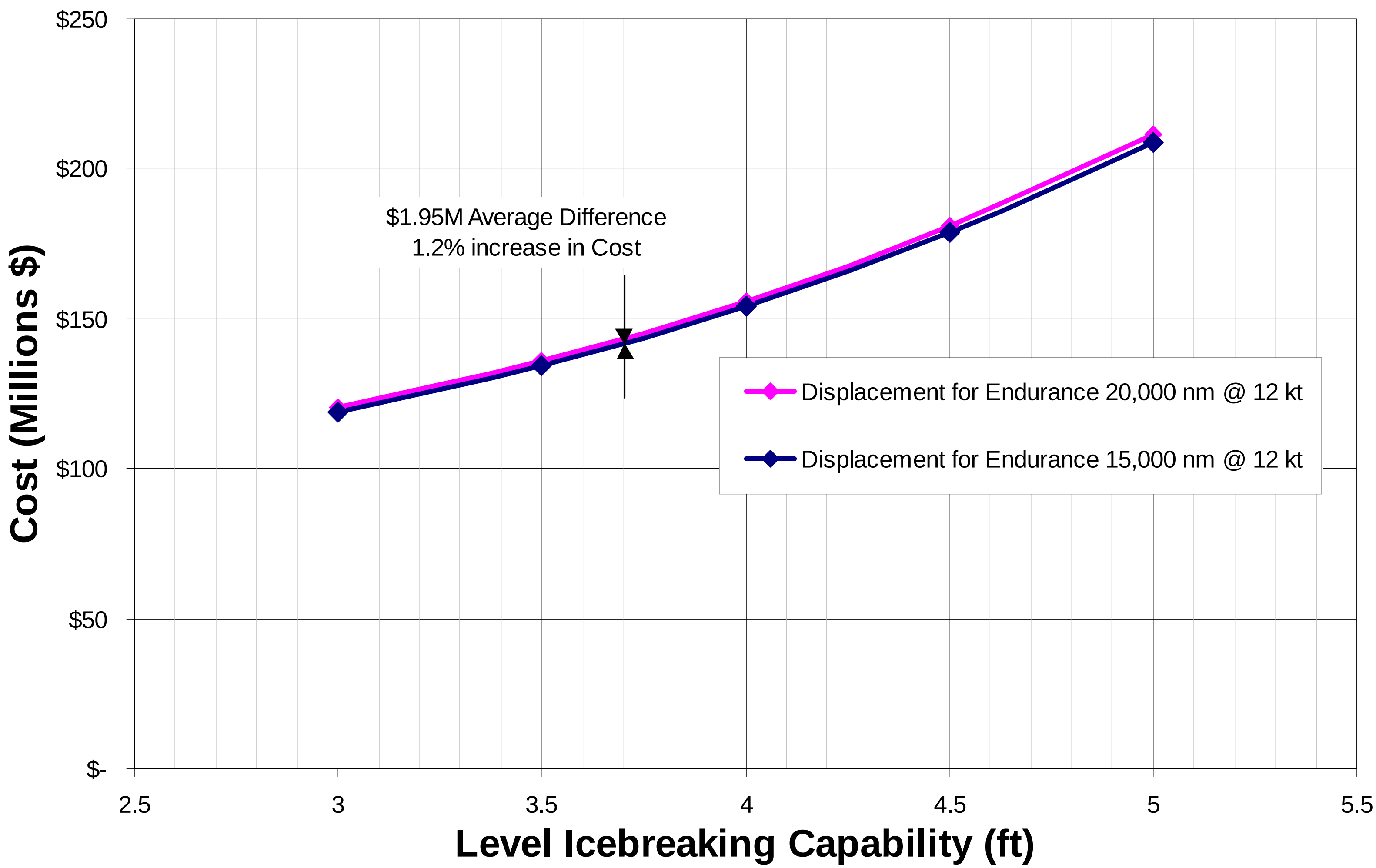
Cost Comparison for NBP and PRV



Some Comparison of NBP and PRV

	NBP	PRV	Increase
Displacement (LT)	6,800	11,000	62%
Shaft Power (HP)	12,600	22,500	79%
Icebreaking capability (ft)	3	4.5	50%
Total lab space (sq ft)	5,714	13,048	128%
Accommodations for scientists	38	50	32%
Endurance (NM)	15,000	20,000	33%
Cost ($ millions)	99	167	69%

Effect of Increasing Endurance and Icebreaking Capability on Ship Size



PRV Web Site

PRV Web Site

- PRV Home Page
- PRV Feedback Form
- PRV Feedback: View Comments
- PRV Feedback: Response to Comment

www.polar.org/science/marine/prv

PRV Home Page

PRV Feedback Form

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PRV Feedback Form

Updated June 17, 2003

Marine Home
PRV Feedback Form
Log In

* Name: Doctor Ocean

* E-mail: Doctor@Ocean.net

* Phone: 555-555-5555

* Institution/Organization: Ocean University

* Subject: Lab Fume Hoods

Technical/Lab Specification Section # (if available): X.Y.Z

View RVIB technical specifications (pdf)
View RVIB Lab specifications (pdf)

* Comment:

The lab fume hoods should be capable of exchanging 1 million cfm vs. 1,000 cfm.

PRV Feedback: View Comment

PRV Feedback: Response to Comment

Next Phase of the Design Effort

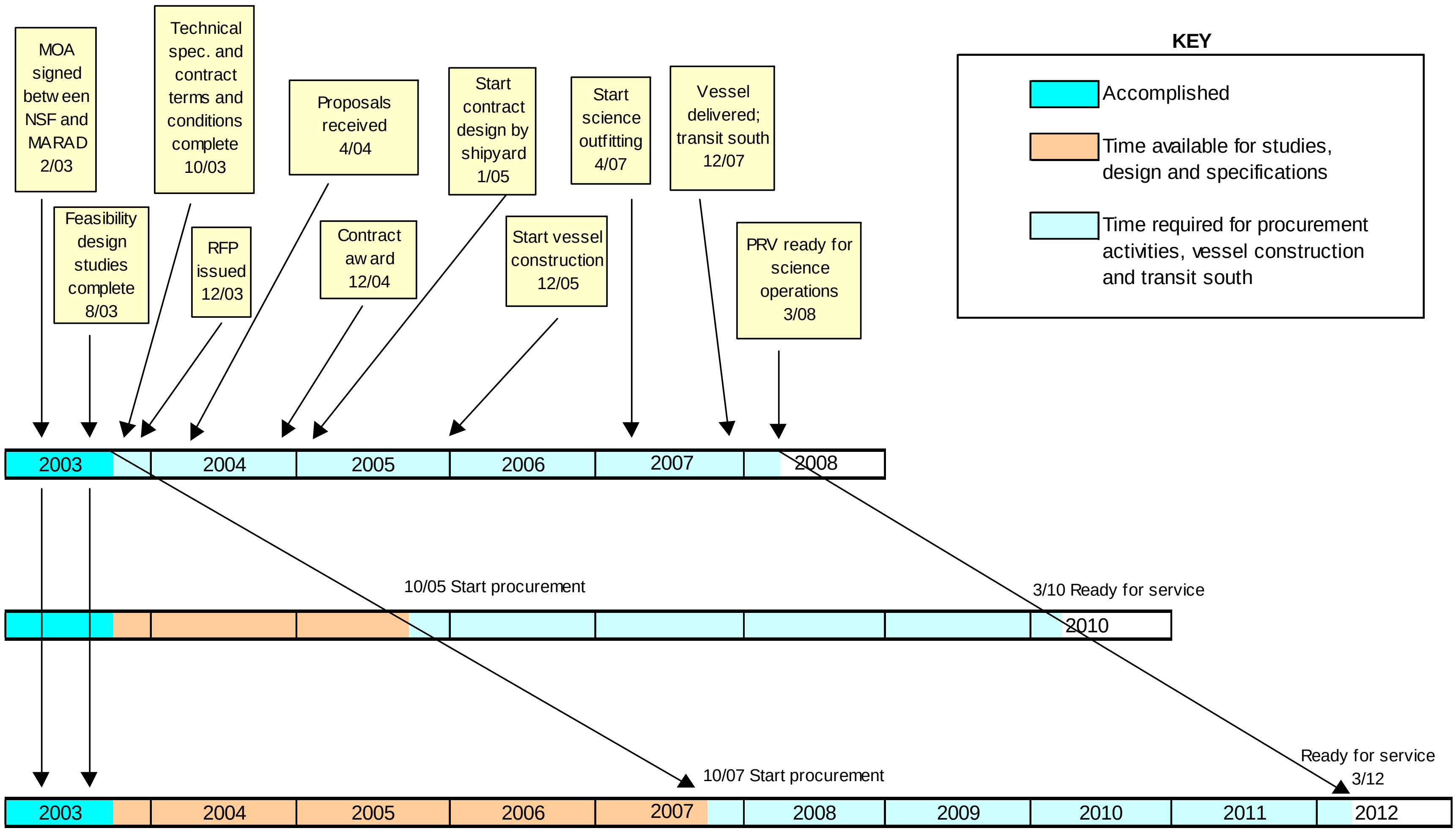
Next Phase of the Design Effort

- Management of documentation
- Procurement timeline and alternatives
- Possible future PRV design activities

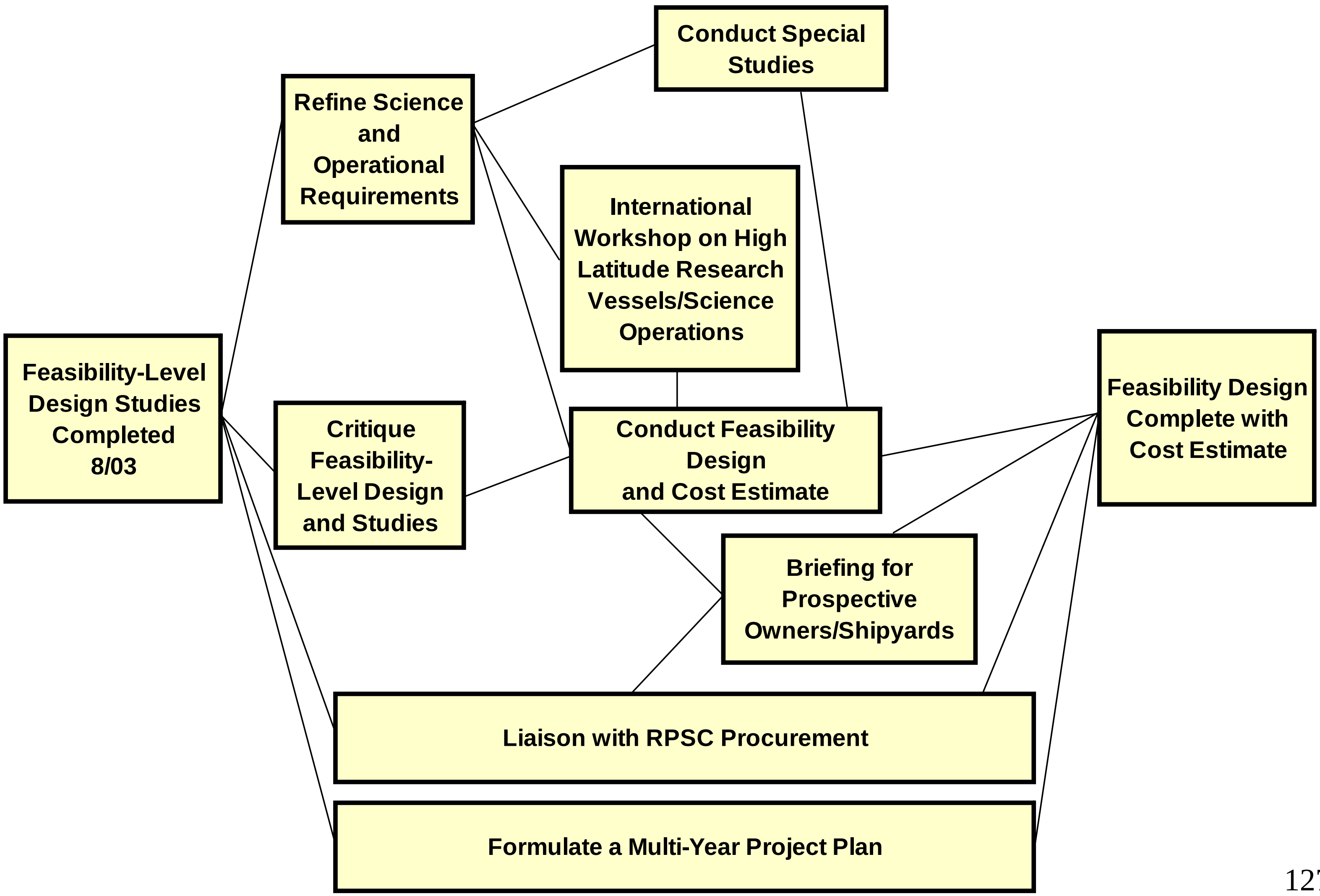
Management of Documents

- Historical files and references
- PRV studies and reports
- RFP technical specifications
- Vessel guidance drawings
- ARVOC presentations
- PRV newsletters
  - Seeking articles for next newsletter

Procurement Timeline Alternatives
(Calendar Years)



Possible Future PRV Design Activities



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Summary Remarks and Discussion

Closing Remarks

MBARI Presentation and Visit to ZEPHYR and WESTERN FLYER

Acronyms

ADCP	Acoustic Doppler Current Profiler
ARV	Arctic Research Vessel
ARRV	Alaska Region Research Vessel
ARVOC	Antarctic Research Vessel Oversight Committee
AUV	Autonomous Underwater Vehicle
AWI	Alfred Wegener Institute for Polar and Marine Research
CTD	Conductivity, Temperature, Depth
FY	First Year (ice)
IMO	International Maritime Organization
MARAD	Maritime Administration

MBARI	Monterey Bay Aquarium Research Institute
MMS	Motion Measurement System
MOA	Memorandum of Agreement
NMREC	National Maritime Resource and Education Center
NSF	National Science Foundation
PRV	Polar Research Vessel
RFP	Request for Proposal
ROV	Remotely Operated Vehicle
RPSC	Raytheon Polar Services Company
STC	Science and Technology Corporation

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NATIONAL SCIENCE FOUNDATION