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Appropriations: Transportation Subcommittee; by Elmer B. Staats,
Comptroller General.

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Various alternatives to expedite procurement of an icebreaker by the U.S. Coast Guard to replace the Westwind Icebreaker, which is becoming obsolete, were investigated. None of the alternatives examined appeared likely to reduce the time to award a contract for the icebreaker. The cost estimate developed by the Coast Guard during the initial planning phase appeared to be reasonable, and the estimating method was acceptable. However, the Coast Guard should provide a range of probable cost as well as the specific dollar estimate. (SC)



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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DECEMBER 1, 1978

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The Honorable ~~By the Office of~~ **By the Office of Congressional Relations.**
Chairman, Subcommittee on Transportation
and Related Agencies
Committee on Appropriations
United States Senate

The Honorable William Proxmire
United States Senate

As requested in your joint letter of August 16, 1978, we (1) analyzed various alternatives to expedite the U.S. Coast Guard procurement of an icebreaker to replace the Westwind Icebreaker and (2) evaluated Coast Guard's estimated cost to procure the replacement icebreaker.

We obtained the information in this report from discussions with Coast Guard, Maritime Administration, and Navy officials; naval architectural firms; and shipyard representatives and from a review of agency records. We considered various alternatives which the Coast Guard might use to expedite the remaining steps in the procurement process for the replacement breaker. We also reviewed the methodology and reasonableness of Coast Guard's cost estimate for the icebreaker which the Coast Guard developed during the initial planning phase.

We did not identify any alternatives that would likely reduce the time to award a contract for the icebreaker. The cost estimate developed by the Coast Guard during the initial planning phase appears reasonable and its estimating method is acceptable. However, along with the specific dollar estimate, the Coast Guard should provide a range of probable cost.

BACKGROUND ON THE
ICEBREAKER PROCUREMENT

The Congress directed the Coast Guard to proceed in the most expeditious manner to design an icebreaker to replace the Westwind, which is becoming obsolete. The Coast Guard was directed to be in a position to award a construction contract for the replacement vessel by December 31, 1980. The vessel's primary mission is to icebreak on the Great Lakes, but the vessel should also have the capacity to break ice in the Eastern Arctic.

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According to Coast Guard, a ship is designed in 4 stages--conceptual, preliminary, contract, and detailed design. These stages are defined as follows:

- Conceptual design involves studies to define a range of capable hull forms and propulsion plants with risk and preliminary cost analysis to compare alternatives. This stage is approximately 1 percent of the design effort.
- Preliminary design focuses on the most promising option developed during conceptual design phase to validate feasibility and determine final key dimensions and capabilities which would not be expected to change through ship acquisition. This stage provides budget level cost estimates and is approximately 7 percent of the design effort.
- Contract design expands on the preliminary design with detailed specifications and a limited number of drawings which enable a shipbuilder to prepare a responsive bid for the design and construction. The end product is a procurement package suitable for use in a fixed price bid and award transaction. This stage is approximately 12 percent of the design effort.
- Detailed design identifies specific equipment items for acquisition. Drawings and instructions for fabrication and installation of all materials and equipment necessary to construct the ship are prepared. It includes all the integration engineering and defines all testing required for each system of the ship. This stage is normally accomplished by the shipbuilder or his agent and represents approximately 80 percent of the design effort.

The Coast Guard has completed the conceptual design and expects to (1) complete the preliminary design by December 1978, (2) complete the contract design by April 1980 1/, and (3) award the contract by December 31, 1980. It estimates that the icebreaker will be constructed by

1/ Original estimated completion date was August 1980.

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December 1984. At the time of our review, the preliminary design phase was still in process. A more detailed discussion of the contract design phase and the contract award process follows.

The contract design is divided into four phases-- specification preparation, review, revision, and approval. During the specification preparation phase the Coast Guard lists the performance or physical characteristics which the equipment and/or system must meet. The Coast Guard also specifies the quality assurance requirements that the shipyard must follow. The Coast Guard writes the specifications to construct the icebreaker and develops the systems to demonstrate the adequacy and feasibility of the specifications. Some drawings of the proposed icebreaker are prepared at the completion of this phase.

During the specification review phase the Chief, Design Branch, and the Design Project Officer review the specifications and drawings. They are assisted by supervisors of the technical staff who prepared them. When possible, some review is also accomplished during the specification phase. In addition to the above review, experienced technical officers who were not involved in the specification phase will review the specifications. In addition, the Coast Guard plans to have an experienced naval architectural firm independently review the specifications.

During the revision phase, the Coast Guard assesses the comments generated during the review phase. After changes are incorporated, the specifications are checked for accuracy. The final phase--approval--consists of a series of briefings to review the icebreaker requirements and to describe the specifications that will be provided.

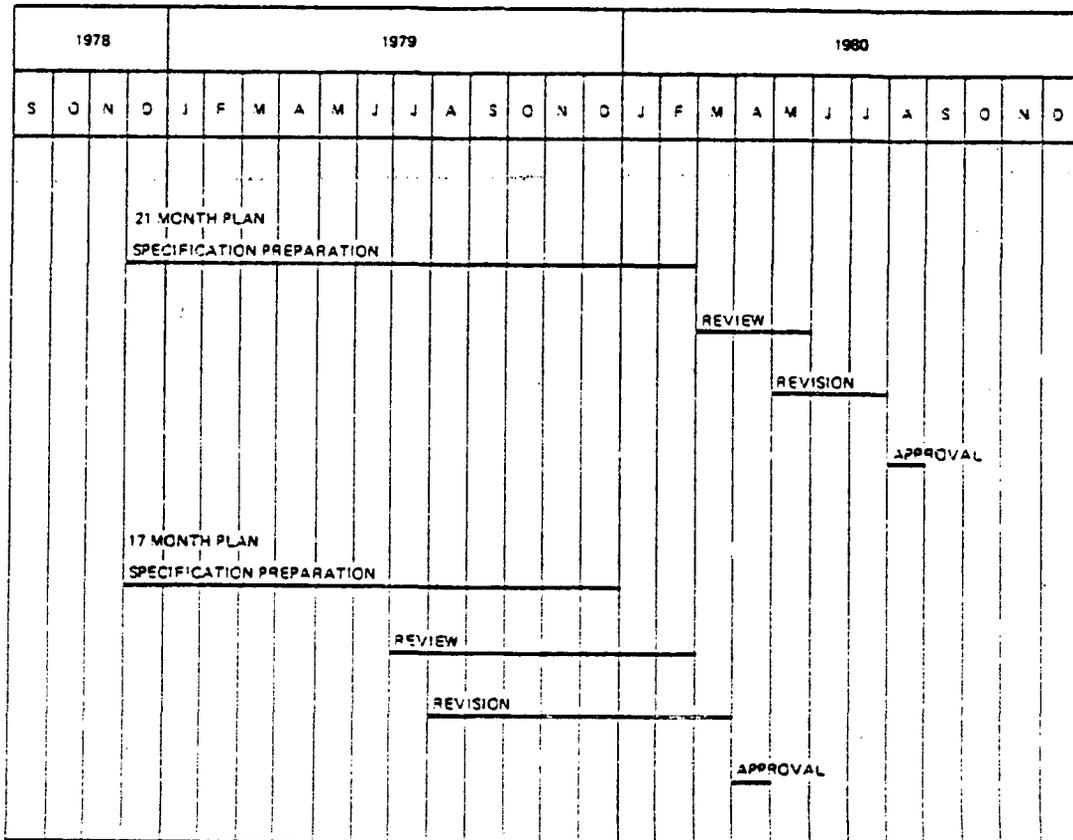
The Coast Guard originally estimated that the contract design would require 21 months--15 for specification preparation, 3 for review, 3 for revisions (of which 1 month will be done concurrently with the review), and 1 for approval. The Congress directed the Coast Guard to be in a position to award a contract by December 31, 1980. To help accomplish this directive the Coast Guard has reduced the contract design phase by 4 months. It anticipates reducing the specification preparation from 15 to 13 months by assigning an additional technically trained officer with design review

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experience and judiciously using overtime. An additional 2 months will be saved by having concurrent rather than sequential reviews. See the following table for the revised 17-month schedule for the contract design completion date.

After the contract design is completed, the Coast Guard will prepare an invitation for bid to enable the shipyards to bid on the icebreaker's design and construction. The Coast Guard estimates 9 months for this phase. The Coast Guard requires this time to (1) prepare the invitation (2 months), (2) allow the shipyards to respond (4 months), and (3) review the bids and award a contract for construction (3 months). However, Coast Guard will prepare part of the invitation during the contract design phase. This will result in this being completed by December 1980--8 months after the contract design phase is finished.

CONTRACT DESIGN PHASE



SOURCE: U.S. COAST GUARD

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ANALYSIS OF ALTERNATIVES
TO EXPEDITE THE
ICEBREAKER PROCUREMENT

The Coast Guard may not be able to reduce the time needed to procure the vessel, based on (1) our analysis of the Coast Guard estimated time to complete contract and detailed design and to construct the icebreaker, and (2) discussions with Navy, Maritime Administration, 6 architectural firm and 13 shipyard officials. Our analysis did not identify any reasonable approach to reduce the 17-month contract design phase. However, most naval architectural firms and shipyard officials believed that the 17-month period is excessive and that the design could be completed in less time. Most architectural firms believed that the Coast Guard would take more time because of staffing limitations. Also, most believed that the vessel could be constructed in 3 years, a year less than the Coast Guard anticipates.

In our analysis we considered the following alternatives available to the Coast Guard:

- Having a naval architectural firm perform the contract design phase as compared to Coast Guard doing it in-house.
- Requesting shipyards to prepare the design based on the preliminary design.
- Buying an "off-the-shelf" icebreaker.
- Reducing the time to prepare an invitation for bid and award a construction contract.
- Reducing the time to construct the icebreaker.

Use of naval architectural firms

The Coast Guard plans to complete the contract design phase with its own personnel in 17 months. As indicated in the following table, most naval architectural firms and shipyards with design capability said to us that they could complete the contract design for the icebreaker, including Coast Guard review, in less than 17 months--the average time was 12 months. Six architectural firms and two shipyards estimated the cost of the contract design. The cost estimates ranged between \$250,000 and \$1,300,000, with an average cost of \$800,000.

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	Number estimating contract design	Estimated months to do contract design		
		<u>6 to 11</u>	<u>12 to 16</u>	<u>17</u>
Naval archi- tectual firms	6	2	4	-
Shipyards	<u>10</u>	<u>5</u>	<u>1</u>	<u>4</u>
Total	<u>16</u>	<u>7</u>	<u>5</u>	<u>4</u>

In order for the Coast Guard to engage a firm to perform all or part of this phase, bids or offers would have to be solicited. In our opinion, following Federal procurement requirements would not reduce the time needed to complete the contract design. A competitive solicitation and award process when combined with the design period would not be completed in less than 17 months. In order for such approaches to save time, the bid or proposal preparation, solicitation, and award would have to be completed in 5 months if the contract design phase was completed in 12 months (the average). Navy and Maritime Administration officials believed that the Coast Guard would not save time by engaging a naval architectural firm to perform the contract design. One naval architectural firm and Maritime Administration official stated that Coast Guard naval architects are experts in icebreaker technology, and therefore, the Coast Guard can do the best job designing this vessel.

Some naval architectural firms and shipyard officials said that they could complete the contract design in less time because they have more available staff. A Coast Guard official stated, however, that additional design staff would not reduce the 17-month period because such staff would have to become familiar with the planning already completed for the icebreaker.

In our opinion, even if the Coast Guard could hire additional design staff in time to assist in the contract design phase they would probably not be able to reduce the 17-month period. The additional staff would most likely be unfamiliar with the Coast Guard and icebreaker design, and therefore require some training before making effective and/or significant contributions to the design work.

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Contract for the icebreaker on
the basis of the preliminary design

Based upon our analysis and discussion with Navy, Maritime Administration, and shipyard officials, we believe the Coast Guard would not reduce the time to obtain the icebreaker if they solicited bids based on the preliminary design phase. Also, purchasing the vessel after completing the preliminary design could result in the Coast Guard's not obtaining the best vessel to meet its needs.

The Coast Guard considered using the approach of having shipyards prepare an icebreaker design based on its requirements for such a vessel (2-step option). However, the Coast Guard estimated that such an approach would increase the total time to procure the vessel by 7 months, as compared to its planned approach of doing the contract design phase in-house and then soliciting bids. According to the Coast Guard, the additional time would be needed by (1) the Coast Guard to prepare the vessel requirements, (2) the shipyards to prepare their designs to respond to the solicitation, and (3) the Coast Guard to review the designs and contract award.

Navy and Maritime Administration officials also stated that the Coast Guard would not save time by contracting for the icebreaker based on the preliminary design. They too expressed concern that the Coast Guard might not obtain a vessel satisfactory to its needs, because the shipyards would prepare the icebreaker design based on less Coast Guard supplied information than if the contract design was prepared by the Coast Guard. This could result in shipyards making trade-offs between competing designs and operational requirements which might not precisely reflect Coast Guard needs. A Maritime official added that under this procurement method less understanding exists between the Coast Guard and shipyard which can increase the number of changes occurring during construction.

Most shipyard officials told us that they prefer the Coast Guard to develop the contract design. In addition, some shipyard officials expressed a reluctance to incur the design costs in order to respond to a solicitation for one vessel. Navy and Maritime Administration officials also expressed similar views that shipyards would be reluctant to respond to such a solicitation.

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Buy an off-the-shelf
icebreaker

Of the Navy, Maritime Administration, 13 naval architectural firm, and 6 shipyard officials that we talked with only one naval architectural firm stated that an off-the-shelf (previously designed) icebreaker could meet Coast Guard's requirements. An official of this firm stated that it has a recently designed, multimission icebreaker that could meet Coast Guard's requirements as defined in the conceptual design. The firm official recognizes that its design would need modifications to meet all of Coast Guard's icebreaker requirements. However, the official believed that the modifications would be minor because the vessel can operate in the Great Lakes and North Arctic and is about the same size as the icebreaker specified in Coast Guard's conceptual design. Some architectural firms believed that the modifications either would be major or not significantly reduce the time to complete contract design phase.

Coast Guard officials said that the existing vessel does not meet their mission requirements. They said that the design would require major modifications if it could be used. Specifically the existing designed vessel provides for (1) one small helicopter as compared with Coast Guard's need for two larger ones, (2) crew accommodation for 75 people as compared with Coast Guard's need for 160, and (3) less fuel carrying capability (650 tons). They also said that their defense requirements necessitate (1) major communications equipment changes and (2) armament provision, not adequately included in existing design. These factors will require Coast Guard to obtain a larger and heavier vessel. In our opinion modifying the existing design would not reduce the time the Coast Guard will need to complete the contract design.

Reduce time to award
the icebreaker contract

As previously discussed, the Coast Guard estimates that the preparation of the invitation for bid, the response by the shipyards, and the contract award ^{1/} will take 9 months. In our opinion this estimate appears realistic. However, if a bid protest should occur, more time will be needed to award the contract. While some naval architectural firms and shipyard officials believed that the 9 months was too long, they did not have any suggestions to shorten the time period and still maintain competition.

^{1/} This includes the survey audit of the shipyard constructing the vessel.

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Reduce construction time

The Coast Guard estimated that the icebreaker construction would require 4 years. This estimate was based on a telephone survey of potential shipbuilders. Most naval architectural firm and shipyard officials told us that the vessel could be constructed in 3 years. The 3-year estimate was based on the same procurement method as the 4-year estimate. We were unable to validate the reasonableness of the estimates provided either to the Coast Guard or to us. However, it should be recognized that these are estimates at best, and the Coast Guard has limited control over the shipyard's actual construction time. Such factors as lead time for special procurement items 1/ (e.g., engines), weather, labor, and shipyard construction schedule at time of award limit Coast Guard's control.

Data on construction of similar vessels is not available. However, two recently purchased Coast Guard icebreakers, which are larger and more complex than the Westwind replacement, required about 5 years for detailed design and construction. Navy officials stated that 4 years to do the detailed design and construct this vessel is a reasonable estimate.

Conclusion

If the Coast Guard maintains its planning schedule for the replacement icebreaker, then the construction contract will be awarded by December 31, 1980, and construction will be completed by December 1984. The December 31, 1980, date complies with the congressional directive for contract award.

We concur with Coast Guard's approach in purchasing the icebreaker. We did not identify any alternatives that would likely reduce the time to award a contract for the icebreaker.

1/ We considered having Coast Guard procure long lead items prior to contract award. The Coast Guard would be liable to the constructing shipyard for damages from untimely delivered or inadequate equipment. Shipyard officials did not recommend this approach because it is inefficient. Because of potential Coast Guard liabilities, we do not recommend this approach for this vessel.

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ICEBEAKER COST ESTIMATE

We believe that, based on available data as of March 1977, the Coast Guard's cost estimate for the icebreaker to replace the Westwind is reasonable, and the estimating method is acceptable. However, the Coast Guard should provide a range of probable cost in addition to the specific dollar or single point estimate. Using such a specific dollar amount assumes a certainty that does not exist. ^{1/} The Coast Guard recognizes that the amount is an estimate and will change.

As part of the conceptual design phase the Coast Guard estimated in March 1977, the contract cost of the icebreaker to replace the Westwind to be \$99.6 million in June 1981 --\$86.6 million for the contract costs and \$13 million for related Coast Guard costs. A description of the cost estimating model follows.

Based upon general vessel characteristics, such as the ship's draft, power, speed, and size (length, width), Coast Guard officials estimate the icebreaker's displacement (of water) or vessel weight. Based on the conceptual design, the Coast Guard estimates the weight to be 5,100 long tons. Using historical data of similar size Navy and Coast Guard vessels, Coast Guard officials are further able to estimate the weight of the seven groups--hull structure, propulsion (engine, propellers, gears, shaft), electric plant and generator, communications equipment, auxiliary systems (e.g., pumps, ventilation system), outfitting and furnishings (e.g., ladders, medical and laundry space, riggings and canvas, and armament)--the sum of which comprise the icebreaker's weight. For example, the hull weight is based on the estimated volume of the hull.

^{1/} See our prior report, "A Range of Cost Measuring Risk and Uncertainty In Major Programs--An Aid to Decisionmaking," PSAD-78-12, dated Feb. 2, 1978, for additional discussion on the need to provide a cost range.

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The estimated weights for each of the seven groups are used to determine the related direct labor, ^{1/} overhead, and material costs. The Coast Guard determines these costs for the seven groups by using mathematical relationships which relate each group's weight to labor and material cost. The Coast Guard develops the mathematical relationships based on vessels of similar size and type. These mathematical relationships are updated periodically as data of construction costs from other vessels become available.

For example, the estimated weight of the hull structure can be related to the labor man-hours for its construction. The man-hour estimates are multiplied by the wage rate. This results in the estimated wage cost for direct labor for the hull structure. The direct labor costs are developed from data provided by the Bureau of Labor Statistics. An overhead percentage, based on Bureau data and Coast Guard experience is applied to the hull's direct labor cost estimate to determine overhead cost. The estimate for direct material cost is based upon estimated hull weight, using mathematical relationships similar to those developed for labor costs.

The three amounts--direct labor, overhead, and direct material--determine the total estimated hull structure cost. This technique is used to develop the costs for the six other groups. For some of the groups weight estimates are not used to develop cost estimates. These groups contain mostly equipment (e.g., electronics) and therefore manufacturer's price lists are used to estimate costs.

In addition to the seven groups noted above, the Coast Guard estimates the cost for the design and engineering services, and construction services. The estimates for the direct costs of these two services are determined by applying percentages to total estimated direct labor for the first seven groups and total estimated material costs for the first seven groups. Overhead for these two services is developed by applying a percentage to the services' computed direct labor costs. All overhead percentages are based upon Bureau data accumulated for the Navy.

^{1/} Direct labor is labor expended directly on the vessel's material.

The sum of the estimated costs for the seven groups and two services provides Coast Guard with an estimate of the icebreaker's total cost. A profit percentage for the contractor, based on Navy and Coast Guard construction experience, is added to the cost. The Coast Guard estimated the icebreaker's cost, including profit, to be about \$56.4 million in March 1977.

The \$56.4 million conceptual design estimate is increased to recognize inflation 1/ from March 1977 to the estimated contract award date and escalation 2/ of cost during construction (4 years). The estimated inflation percentage is based upon Navy and Coast Guard forecasts and the cost escalation during construction is also based on Navy and Coast Guard forecast data. This data is generated from the Bureau's index for ship construction. The Coast Guard estimated the contract cost to be \$86.6 million in June 1981.

Based on historical experience, the Coast Guard expects to incur \$13 million for related costs to the contract. These costs include spare parts, contract modifications, self-insurance, and costs of contract administration. This brings the total estimate for the icebreaker to \$99.6 million.

Coast Guard officials, when discussing these amounts with us, emphasized that they are only estimates and are based on data available in March 1977. As the icebreaker design becomes more fixed, and as it progresses through the other phases to eventual construction, the cost estimate should improve and become more reliable. The preliminary design phase, scheduled to be completed in December 1978, will contain a more refined cost estimate because more specifics about the icebreaker will be known.

Coast Guard officials said that the vessel weight has increased during preliminary design and that weight estimates and the corresponding cost estimates will change as the design is refined. For example, the Coast Guard recognizes that the overhead percentage has increased. Based upon historical data of similar size ships, their analysis showed an approximate 20-percent increase in weight from the

1/ Persistent rise in the general level of average prices.

2/ The increase in contract costs encompassing other factors and inflation.

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preliminary design to actual construction. Since the Coast Guard recognizes such increases occur, its weight and cost estimates should reflect these increases. This can be accomplished by providing an estimated cost range, as well as a specific dollar estimate.

Conclusion

The cost estimate developed by the Coast Guard during the conceptual design phase appears reasonable, and the estimating method is acceptable. However, cost estimating is more art than science, and thus, cost estimates are not statements of fact but rather judgments of the procurement cost. These judgments are made in the face of many uncertainties (e.g., inflation, labor and material costs) and risks (e.g., equipment availability) inherent in procurement. A range of probable procurement cost, in addition to a specific dollar estimate, while not solving all problems that can affect the cost estimate, will bring before management and other decisionmakers information on major areas of probable risk and uncertainty and their potential impact on the procurement cost if these events should occur.

Recommendations

A range of potential procurement cost for the icebreaker will provide this Subcommittee, as well as others, useful information for its deliberations on the planned icebreaker. Therefore, we recommend that the Subcommittee require that the Commandant, U.S. Coast Guard, submit an analysis of the uncertainties affecting the procurement for this icebreaker, to include:

- An identification of significant uncertainties that could cause deviations in the estimated procurement cost.
- A range of potential cost around the dollar estimate reflecting the potential cost changes.
- A statement of the likelihood of the actual cost exceeding certain predetermined levels.

The information in this report was discussed informally with agency officials who concurred in its accuracy.