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U.S. NAVAL VESSELS
(AUXILIARY AND AMPHIBIOUS SHIPS)
CONSTRUCTION COST MODEL

DRAFT FINAL REPORT

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Prepared by:
Gibbs & Cox, Inc.

Prepared for:
Naval Center for Cost Analysis

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GIBBS & COX, INC.
ARLINGTON, VA

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CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

ABSTRACT

This cost model for U.S. Naval auxiliary and amphibious type vessels provides a means of estimating basic construction costs with ship's characteristics information available at the end of the feasibility design stage.

The basic construction cost of a ship has been divided into a two-digit SWBS cost model structure, consisting of 24 cost groups, where ship subsystems with similar cost characteristics are grouped together. These characteristics form the basis for the cost estimating relationships (CER's) used to derive material costs in FY 86 dollars, and labor costs in manhours. Cost estimating worksheets are provided in the Appendices to facilitate use of this model.

1. INTRODUCTION

The purpose of this report is to update a procedure to estimate the basic construction cost of U.S. Naval auxiliaries and amphibious vessels.

The original model (Reference 1) was first developed by Gibbs & Cox, Inc. in 1983 and uses a two-digit SWBS (Ship Work Breakdown Structure) model structure to group costs according to ships' characteristics and costing information. The model uses ship characteristics available at the completion of feasibility design as independent variables for cost estimating relationships (CER's) that are based on return costs and cost estimates provided by shipyards, and from reports developed for NAVSEA. The CER's are used to estimate material costs in dollars and labor costs in manhours for each cost group. These individual cost group material and labor cost estimates are then summed in order to derive a total basic ship construction cost estimate.

The cost estimates produced from this model include shipyard costs of materials and labor for construction; design, except for detail design and engineering services; and construction services. Items that are not covered in the cost model include the acquisition of most government furnished equipment (GFE) in the areas of command, control, communications and weapons systems; Navy program support; integrated logistics support (ILS); crew training; preliminary and contract design; profit, etc.

Material costs and labor manhours have been divided into a two-digit breakdown that groups together ship subsystems with similar cost characteristics into 24 SWBS groups. This encompasses groups 100-900 of the U.S. Navy's SWBS. The ship and cost data for the various ships were broken down into the 24 SWBS groups and analyzed to determine best fit, representative CER's based on weight, length x beam, SHP, electric generating capacity, total ship volume, and ship complement. When appropriate, multiple CER's have been developed for individual cost groups to account for differences among the various ships systems.

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The original 1983 version of the model was developed with the support of cost estimators from the National Steel and Shipbuilding Company (NASSCO) and was based upon both actual return costs and cost estimates available at the time for representative auxiliary and amphibious vessels.

The current update was developed with the support of cost estimators from Bath Iron Works (BIW) and adds estimated cost data on the SWATH T-AGOS-19. In addition, the data base has been computerized, the data reanalyzed, and a new set of CER's developed. Material costs have also been updated to 1986 dollars and inflation factors provided that are consistent with current NAVSEA practice. Finally, the text of the report has been revised to reflect those changes and streamline the original report.

2. SHIP TYPES

2.1 Introduction

In order to develop this model, a number of different auxiliary and amphibious ship types were used. These ships represented those for which data was available. They are also considered to provide a sufficiently diverse sample of data to bound the range of auxiliary and amphibious ships and to provide a sufficient number of data points for developing CER's. The ships considered in this model are:

Auxiliary Ships		
	AD-41	Destroyer Tender
	AFS-6	Combat Store Ship
	AOR-7	Replenishment Oiler
	AO-180	Oiler
	T-AGOS-19	Ocean Surveillance Ship (SWATH)
	ASR-21	Submarine Rescue Ship
Amphibious Ships		
	LST-1179	Tank Landing Ship
	LST-1182	Tank Landing Ship
	LHA-1	Amphibious Assault Ship
	LPH-12	Amphibious Assault Ship
	LSD-41	Dock Landing Ship

A brief description of these ships is provided in the following sections. Additional information about the characteristics of these ships that was used in development of CER's is provided in Appendix C.

It should also be noted that for cost Group 2, Propulsion Plant, data points have been provided for the results of two conceptual studies for the T-AGX and 27K-SHP. The T-AGX is a multi-mission SWATH oceanographic research and surveillance ship. It is a forerunner of the T-AGOS-19 ship. The 27K-SHP is an estimate developed by NASSCO in the

original model for a 27,000 shaft horsepower twin medium speed diesel plant. The values used in the model for these data points are contained in Appendix C.

2.2 Auxiliary Ships

2.2.1 AD-41 Destroyer Tender - The AD-41 is a member of the first class of destroyer tenders built after World War II. The AD-41 was built at NASSCO and commissioned in May 1980. The cost data listed in this model for the AD-41 was provided by NASSCO (Reference 1). The AD-41's principal characteristics include:

Length (ft)	644
Beam (ft)	85
Draft (ft)	22.5
Displacement-Full Load (long tons)	20,224
Lightship (long tons)	13,290
Shaft Horsepower (SHP)	20,000
Main Engines	Steam-Geared turbine
No. of Shafts	1
Complement	1803

(Reference 2)

2.2.2 AFS-6 Combat Store Ship - The AFS-6 is a member of the "MARS" class combat store ships. The AFS-6 was built at NASSCO and commissioned in May 1969. The cost data used in this model for the AFS-6 was provided by NASSCO (Reference 1). The AFS-6 principal characteristics include:

Length (ft)	581
Beam (ft)	79
Draft (ft)	24
Shaft Horsepower (SHP)	22,000
Displacement-Full Load (long tons)	18,663
Lightship (long tons)	9,000
Main Engines	Steam-Geared turbine
No. of Shafts	1
Complement	486

Cargo Capacity (long tons of dry stores)	2625
(long tons of refrigerated stores)	1300
Aircraft	2 UH-46 Sea Knights

(Reference 2)

2.2.3 AOR-7 Replenishment Oiler - The AOR-7 is a member of the "WICHITA" class replenishment oilers. The AOR-7 was built by NASSCO and was commissioned in October 1976. The cost data used in this model for the AOR-7 was provided by NASSCO (Reference 1). The AOR-7's principal characteristics include:

Length (ft)	659
Beam (ft)	96
Draft (ft)	33
Displacement-Full Load (long tons)	37,000
Lightship (long tons)	12,850
Shaft Horsepower (SHP)	32,000
Main Engines	Steam-Geared Turbine
No. of Shafts	2
Complement	390
Aircraft	2 UH-46 Sea Knights (no hangar)
Cargo Capacity - barrels of liquid fuel	160,000
long tons of munitions	600
long tons of dry stores	200
long tons of refrigerated stores	100

(Reference 2)

2.2.4 AO-180 Oiler - The AO-180 is a "CIMARRON" class oiler. The AO-180 was built at Avondale Shipyards and commissioned in December 1982. The cost data listed in this model for the AO-180 is based on Reference (1). The AO-180's principal characteristics include:

Length (ft)	592

Beam (ft)	88
Draft (ft)	35
Displacement-Full Load (long tons)	26,110
Lightship (long tons)	8,256
Shaft Horsepower (SHP)	24,000
Main Engines	Steam-Geared Turbine
No. of Shafts	1
Complement	135

(Reference 2)

2.2.5 T-AGOS-19 Ocean Surveillance Ship (SWATH) - The T-AGOS-19 is a follow-on to the "STALWART" class of ocean surveillance ships. The ship is used for support for the SURTASS towed array surveillance system. The T-AGOS-19 is the first small waterplane area twin hulled (SWATH) vessel built for the class. The vessel is currently being built at McDermott, Inc. The T-AGOS-19's principal characteristics include:

Length (ft)	232
Beam (ft)	94
Draft (ft)	49
Displacement-Lightship (long tons)	2561
Main Engines	Diesel-Electric Drive
Shaft Horsepower (SHP)	2800
No. of Shafts	2
Complement	33

(Reference 4)

2.2.6 ASR-21 Submarine Rescue Ship - The ASR-21 is a member of the "PIGEON" class submarine rescue ships. This class are the first ships built for the role of surface support for deep submergence rescue vehicles and operational control for salvage operations. The ship is a twin hulled catamaran configuration. The ship was built at Alabama Drydock and Ship Building Company and was commissioned in April 1973. The cost data listed in this model is an estimate provided in Reference (1). The ASR-21's principal characteristics include:

Length (ft)	251
Beam (ft)	86
Draft (ft)	21
Displacement-Full Load (long tons)	3411
Shaft Horsepower (shp)	6000
Main Engines	Diesels
No. of Shafts	2
Complement	115

(Reference 2)

2.3. Amphibious Ships

2.3.1 LST's 1179 and 1182 Tank Landing Ships - The LST's-1179 and-1182 are members of the "NEWPORT" class tank landing ships. This class is the first class to use the over the bow ramp for unloading tanks and other heavy vehicles. The LST-1179 was built at Philadelphia Naval Shipyard and commissioned in June 1969. The LST-1182 was built by NASSCO and commissioned in November 1969. The cost data listed in this model for the LST-1182 was provided by NASSCO (Reference 1). The LST's 1179 and 1182's principal characteristics include:

Length (ft)	522
Beam (ft)	70
Draft (ft)	18
Displacement-Full Load (long tons)	8450
Lightweight (long tons)	4590
Shaft Horsepower (SHP)	16,000
Main Engines	Geared-Diesels
No. of Shafts	2
Complement	196
No. of Troops	400

Reference (2)

2.3.2 LHA-3 Amphibious Assault Ship - The LHA-3 is a member of the "TARAWA" class of multi-purpose amphibious assault ship. The LHA-3 has a flight deck below which is a split hangar. Below the hangar is a 268-foot x 78-foot floodable docking well. There is also a large garage for trucks and AFVs, troop berthing for a reinforced battalion and extensive medical facilities. The LHA-3 was built by Ingalls Shipbuilding Corporation and was commissioned in May 1976. The cost data listed in this model for the LHA-3 is based on an estimate provided in Reference (1). The LHA-3 principal characteristics include:

Length (ft)	820
Beam (ft)	106
Draft (ft)	26
Flight deck width (ft)	118
Displacement-Full Load (long tons)	39,300
Shaft Horse Power (SHP)	70,000
Main Engines	Steam-Geared Turbine
No. of Shafts	2
Complement	975
Troops	1703
Aircraft - CH-53 Sea Stallion Helicopters	19
or	
CH-46 Sea Knight Helicopters	26
Landing Craft - LCU 1610 Type	4
Storage - Vehicle petrol (gallons)	10,000
JP-5 Helicopter Fuel (gallons)	400,000
Vehicle Storage (sq ft)	33,730
Palletized Stores (cu. ft)	116,900
	(Reference 2)

2.3.3 LPH-2 Amphibious Assault Ships - The LPH-2 is a member of the "IWO JIMA" class amphibious ships. The "IWO JIMA" class was the first class of ships designed specifically to operate helicopters. The LPH-2 can carry a marine battalion landing team, its guns, vehicles, and equipment, plus a reinforced squadron of transport helicopters and personnel. The LPH-2 was built by Ingalls Shipbuilding Corporation and was commissioned in August 1961. The cost data listed in this model for the LPH-2 is based on an estimate in Reference (1). The LPH-2's principal characteristics include:

Length (ft)		602
Beam (ft)		84
Draft (ft)		26
Flight Deck Width (ft)		104
Displacement-Full Load (long tons)		18,042
Lightship (long tons)		11,000
Shaft Horsepower (SHP)		22,000
Main Engines		Steam-Geared Turbines
No. of Shafts		1
Complement		754
Troops		1746
Aircraft -	CH-46 Sea Knight Helicopters	20
	CH-53 Sea Stallion Helicopters	11
Storage -	Vehicle Petrol (gallons)	6500
	JP-5 Helicopter Fuel (gallons)	405,000
	Vehicle Storage (sq ft)	4,000
	Palletized Stores (cu ft)	37,400
		(Reference 2)

2.3.4 LSD-41 Dock Landing Ship - The LSD-41 is a member of the "MODIFIED WHIDBY ISLAND" class of dock landing ships. The LSD-41 has a 440 x 50 foot well deck. It was built by Lockheed Shipbuilding and Construction Company and was commissioned in May 1985. The cost data listed in this model for the LSD-41 is based on an estimate in Reference (4). The LSD-41's principal characteristics include:

Length (ft)		608
Beam (ft)		84
Draft (ft)		20
Displacement-Full Load (long tons)		15,726
Lightship (long tons)		11,125
Shaft Horsepower (shp)		41,600
Main Engines		Geared-Diesels
No. of Shafts		2
Complement		356
Troops		450
Aircraft-CH-53 Sea Stallion Helicopters		-
Landing Craft -	LCAC	4
	or	
	LCM-6	21
Cargo Capacity -	Marine Cargo (cu ft)	5000
	Vehicle Storage (sq. ft.)	12,500
		(Reference 2)

3. MODEL DESCRIPTION

3.1 Model Description

The original (1983) version of this model was developed to provide an improved and updated method of predicting ship construction costs by NCA. During this update of the model no attempt was made to change the model structure. Instead this update provides additional data points and revises CER's based on analysis of the revised data set.

The model develops basic construction costs only. These basic construction costs include construction, labor and material, and the shipyard's costs for design support, construction, engineering, and construction services. The model does not provide an estimate for plan costs, change orders, combat system GFE, or any escalation or growth factors.

The model is based on the two digit SWBS breakdown shown in Figure 3-1. Costs are subdivided into costs for materials in dollars and labor expenditures in manhours. Material costs include those materials purchased by the shipyard, such as steel, engines, generators, winches, pumps, lifeboats, and galley equipment. Labor costs include the man hours involved in the construction and assembly of raw materials and in the installation of equipment.

The shipyards have observed that their level of confidence in the costs is higher at the one digit level than at the two digit level. In certain cases it was not possible to accurately identify appropriate cost factors for a two digit group. In these cases the cost factors were estimated to produce a correct one-digit group cost total.

The data provides costs for representative subsystems installed on various auxiliary and amphibious vessels. The differences in these costs reflect differences in characteristics among the ships. If inflation is taken into account, a series of trend lines and algorithms can be developed that reflect relationships between these costs and ship's characteristics.

Anx Amph CCM 9/88

Figure 3-1 Two Digit Cost Model Structure

GROUP	Group Title	Group	Group Title
1	Hull Structure (Total)	5	Auxiliary Systems
1A	Structural Envelope/Subdivisions	5A	Environmental Systems
1B	Superstructure	5B	Fluid Systems
1C	Foundations	5C	Maneuvering Systems
1D	Structural Attachments	5D	Equipment Handling Systems
2	Propulsion Plant	6	Outfit and Furnishings
2A	Propulsion Energy Systems	6A	Hull Fittings
2B	Propulsion Transmission Systems	6B	Non-Structural Subdivisions
2C	Propulsion Gases (Intake and Exhaust) Systems	6C	Preservation
		6D	Ship Support
2D	Propulsion Service Systems	6E	Habitability
3	Electric Plant	7	Armament
3A	Electrical Power Generation		
3B	Electrical Power Distribution		
4	Command and Surveillance	8	Integration/Engineering
4A	Vehicle Command		
4B	Weapons Command	9	Ship Assembly and Support Services

Inflation primarily affects the material costs in dollars in this model. Labor costs are presented in manhours. Selection of a manhour rate by the model user will take inflation into account for labor. The material cost data, however, represents shipyard costs in dollars accumulated against a vessel from the contract award to the delivery date. These costs must be escalated from a point midpoint in the construction cycle to 1986 constant year dollars. This escalation was performed using the NAVSEA "Inflation Data Sheet" values for converting then-year dollars to constant year dollars in the following manner:

- 1986 Material Cost = Material Cost (Mid-point of Construction Date) x Inflation Factor

Inflation factors used are shown in Figure 3-2.

The cost data was analyzed by plotting the costs against various ship characteristics, i.e., cost group weight, ship's cubic number, length x beam, complement, SHP, installed electrical generation capacity in KW, and total ship volume to determine data fit, establish trends, and define CER's. A number of CER's were generated from the cost data for individual cost groups based on various ship's characteristics, and the best fit CER was selected for the model. If a number of characteristics showed a good fit, these CER's are also provided. Also, within individual independent variables within a cost group, a number of CER's were developed to account for different materials or systems involved.

Often individual or scattered groups of data are used to develop a CER. This treatment of data is different from the approach used in other models where outliers are not used on the presumption that they are not representative of the trend. This treatment of the data was considered necessary considering the limited number of candidate ships available for use in this model, which precluded obtaining a large number of data points for a cost group, and, more specifically, for each subsystem variation within a cost group. However, based on an analysis of the data by the shipyard estimators and Gibbs & Cox, Inc., the approach taken is considered sufficiently accurate for this model.

SHIPBUILDING ESCALATION FACTOR
(BUDGET YEAR TO CONSTANT DOLLAR YEAR)

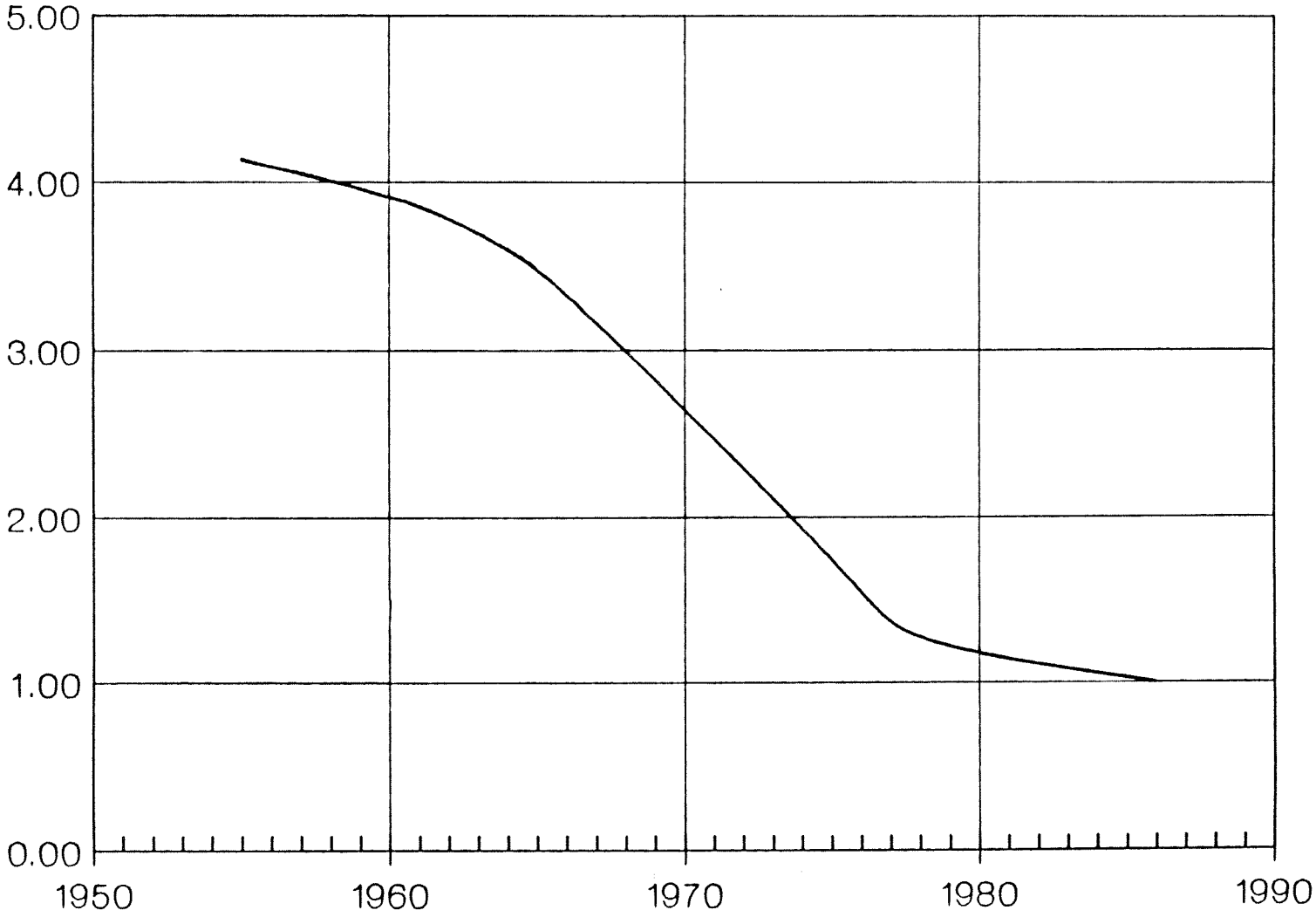


FIGURE 3-2

The independent variables against which cost or man hours were plotted in each group were arrived at through engineering judgement, taking into consideration the ship characteristics available during early stages of cost estimating and the fit of the data. The CER's provided in the model are all linear. This is based on the limited number of data points available and the generally good fit provided by the linear relationships. Nonlinear relationships have been investigated as part of this effort and are provided in Reference (5).

The CER's were developed using the least squares regression technique. The primary criteria for selection of a CER were the coefficient of determination, r^2, and the number of data points included in the equation. The coefficient of determination is a measure of the fit of the regression equation to the data points. An r^2 of 1.0 would indicate a perfect fit, implying that all data lie on the curve. An adjusted r^2 is provided for each CER which modifies the obtained r^2 by a factor based on the number of points used to derive the CER. In certain cases there was either too few points or too low a correlation to develop a meaningful adjusted r^2. In these cases the best fit algorithm was used and the adjusted r^2 is called "N/A-insufficient points".

This cost model does not include the government furnished equipment (GFE) associated with the combat system of the ship. Combat systems GFE is excluded for several reasons. Equipment in the combat system is extremely costly, compared to HM&E subsystems and, therefore, is usually acquired by the Navy in multi-ship lots. Costs are unique to the various combat system equipment and are driven by the complexity of the system, not usually by ships characteristics such as weight, etc. Also, equipment is selected for installation on ships in a variety of combinations depending upon the ship's mission requirements. For these reasons NCA uses other models available to estimate these GFE combat system costs. In this model installation costs of the combat suite that are incurred by the shipyard are included. Installation includes the material and labor costs for foundations, mounts, magazines and hoists, the supporting hydraulics, cables, and electrical systems and their testing. Cost groups that are most affected by GFE considerations are Groups 4B and 7.

Two means are available for estimating costs: graphs and mathematical relationships. Both the graphs and mathematical relationships

are provided for each one-digit and two-digit cost group. The mathematical relationships are provided as the CER's for the cost groups and reflect the trend lines shown on the graphs. The graphs permit the analyst to use his or her own judgement to adjust the estimate if the characteristics of the system being estimated are similar to that of a specific data point.

The data base contains two types of data points, actual adjusted return costs and estimated or derived costs. On the graphs the actual data points are marked by an "o" while estimated and derived points are marked by "*". Different line types are provided on the graphs where more than one relationship is presented.

A number of CER's have been derived for cost groups based on only a single data point. These CER's pass through that point, are linear, and have a slope based on the slope of the principal CER of that group.

Many of the 24 cost groups use weight as the independent variable. This assumes the availability of a three-digit weight estimate. When there is a lack of weight data for a particular cost group area, the alternative is to estimate the missing information. Appendix (C) is provided for this purpose to be used to compare the known data for the new ship to the average data for the model baseline ships.

In this update of the model, an additional parameter has been used to estimate costs. This parameter is total ship volume. Several cost groups failed to have good correlation with the other standard parameters, but demonstrated strong dependence on volume. Although total ship volume is not typically available during early stages of design, it is possible to estimate volume based on known ship characteristics and comparing these to known characteristics and volumes of other ships.

3.2 Procedure for Use of Model

Chapter 4 contains the descriptions and graphs for the two levels of detail that can be taken in the use of this model: one at the one-digit

level SWBS groups, and the other at the two-digit level SWBS groups. Each approach has an associated input data requirements work table, an output worksheet (Appendix A) for arriving at the cost estimate, and the requisite algorithms to perform the analysis.

3.2.1 One Digit Level Cost Model

The procedure for estimating ship construction costs at the one-digit level is as follows:

1. Determine the input parameters - estimated weights (in long tons), shaft horsepower, kilowatts, etc., as appropriate for each of the cost groups (Table A-1).

2. Select the one-digit level CER for material costs in Chapter 4 for each cost group. Determine the cost using the respective input parameter for that particular group. Record the cost on the worksheet (Table A-2). Repeat this process for each group until all material costs are obtained, then total.

3. Repeat step 2 for manhours of labor using the one-digit level CER's in Chapter 4.

4. On the worksheet, multiply the manhours by a manhour cost/hour for the year concerned. (The cost per manhour must be supplied by the user of the model.)

5. If the year for which material costs are being projected is not constant year 1986, then adjust the material costs by the escalation factor as described in Figure 3-2.

6. Determine SWBS Group 8 and 9 manhours and costs from Chapter 4 and make adjustments as appropriate, using the procedures described in steps 4 and 5.

7. Add the material cost to manhour cost to obtain the total basic construction cost.

3.2.2 Two-Digit Cost Model

The procedure for estimating ship construction costs at the two-digit level is as follows:

1. Determine the input parameters - estimated weights (in long tons), shaft horsepower, kilowatts, etc., as appropriate for each of the 24 cost groups (Table A-3).

2. Select the two-digit level CER for material costs in Chapter 4 for each cost group. Determine the cost using the respective input parameter for that particular group. Record the cost on the worksheet (Table A-4). Repeat this process for each group until all material costs are obtained, then total.

3. Repeat step 2 for manhours of labor using the two-digit level CERs in Chapter 4.

4. On the worksheet, multiply the manhours by a manhour cost/hour for the year concerned. (The cost per manhour must be supplied by the user of the model.)

5. If the year for which material costs are being projected is not constant year 1986, then adjust the material costs by the escalation factor as described in Figure 3-2.

6. Determine SWBS Group 8 and 9 manhours and costs from Chapter 4 and make adjustments, as appropriate, using the procedures described in steps 4 and 5.

7. Add the material cost to the manhour cost to obtain the total basic construction cost.

4. COST ESTIMATING RELATIONSHIPS

4.1 Introduction

The cost estimating relationships (CER's) are provided in two formats, equations and graphs of the data points and their trends.

The equations represent the best estimate of the trend lines shown. The equations used in this model are all linear. The graphical representations are provided to show the distribution of the data and to allow the model user to exercise discretion in selecting values based on similarities to specific ships used in the data base.

In the following sections the two digit SWBS groups are described and the CER's for the SWBS groups provided. Also, a short narrative is provided which discusses the characteristics of the ships that influence the selection of the CER's. The CER's are provided for both material in FY 1986 dollars and labor in manhours.

4.2 Group 1 - Hull Structure (Total)

This one digit SWBS Group includes the following four two digit SWBS Groups.

Group 1A - Structural Envelope/Subdivisions
Group 1B - Superstructure
Group 1C - Foundations
Group 1D - Structural Attachments

Material Costs - Two CER's are provided for material costs for Group 1, a steel deckhouse CER, and an aluminum deckhouse complex ship CER. Both CER's are based on Group 1 weight. The graph for Group 1 material costs is shown in Figure 4-1, and the CER's for Group 1 material costs are:

CER:	$ = 794(WT) + 149,600
Variable:	Group 1 WT (long tons)
Adjusted r^2:	.97 - 5 points
Application:	Ships with steel deckhouses

CER:	$ = 770 WT + 1,594,600
Variable:	Group 1 WT (long tons)
Adjusted r^2:	N/A - insufficient points
Application:	Ships with aluminum deckhouses or complex ships

Labor Costs - Four CER's are provided for labor costs for Group 1. Two are for costs based on Group 1 weight and two are for costs based on the ship's length x beam. In both cases CER's are provided for conventional auxiliary and amphibious ships, and for complex auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for Group 1 labor costs are shown in Figures 4-2 and 4-3, and the CER's for Group 1 labor costs are:

CER:	MH = 110(WT) + 33,200
Variable:	Group 1 WT in long tons
Adjusted r^2:	.82 - 5 points
Application:	Conventional ships

HULL STRUCTURE (TOTAL)
GROUP 1
MATERIALS COST

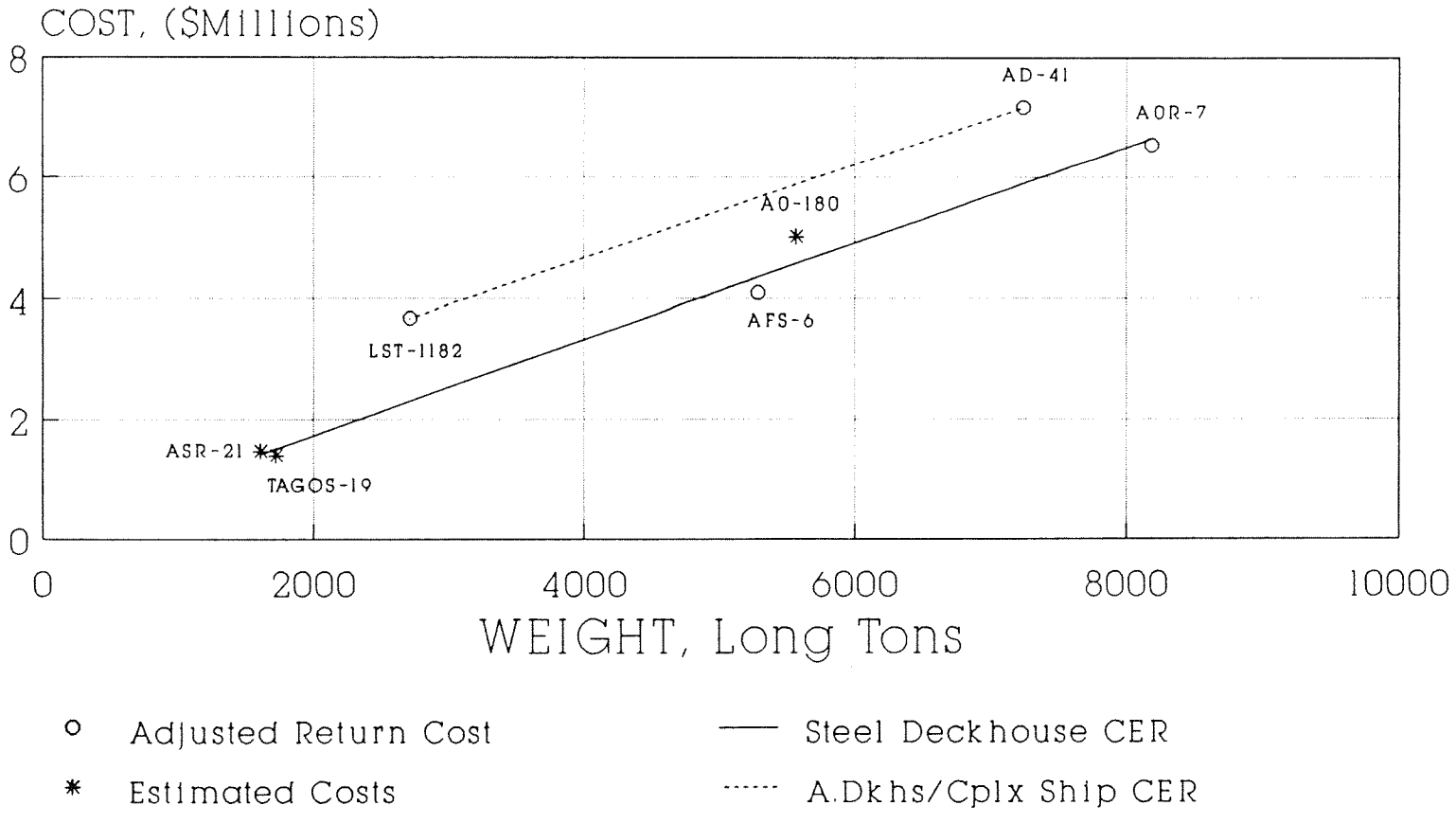


FIGURE 4-1

HULL STRUCTURE (TOTAL)
GROUP I
LABOR

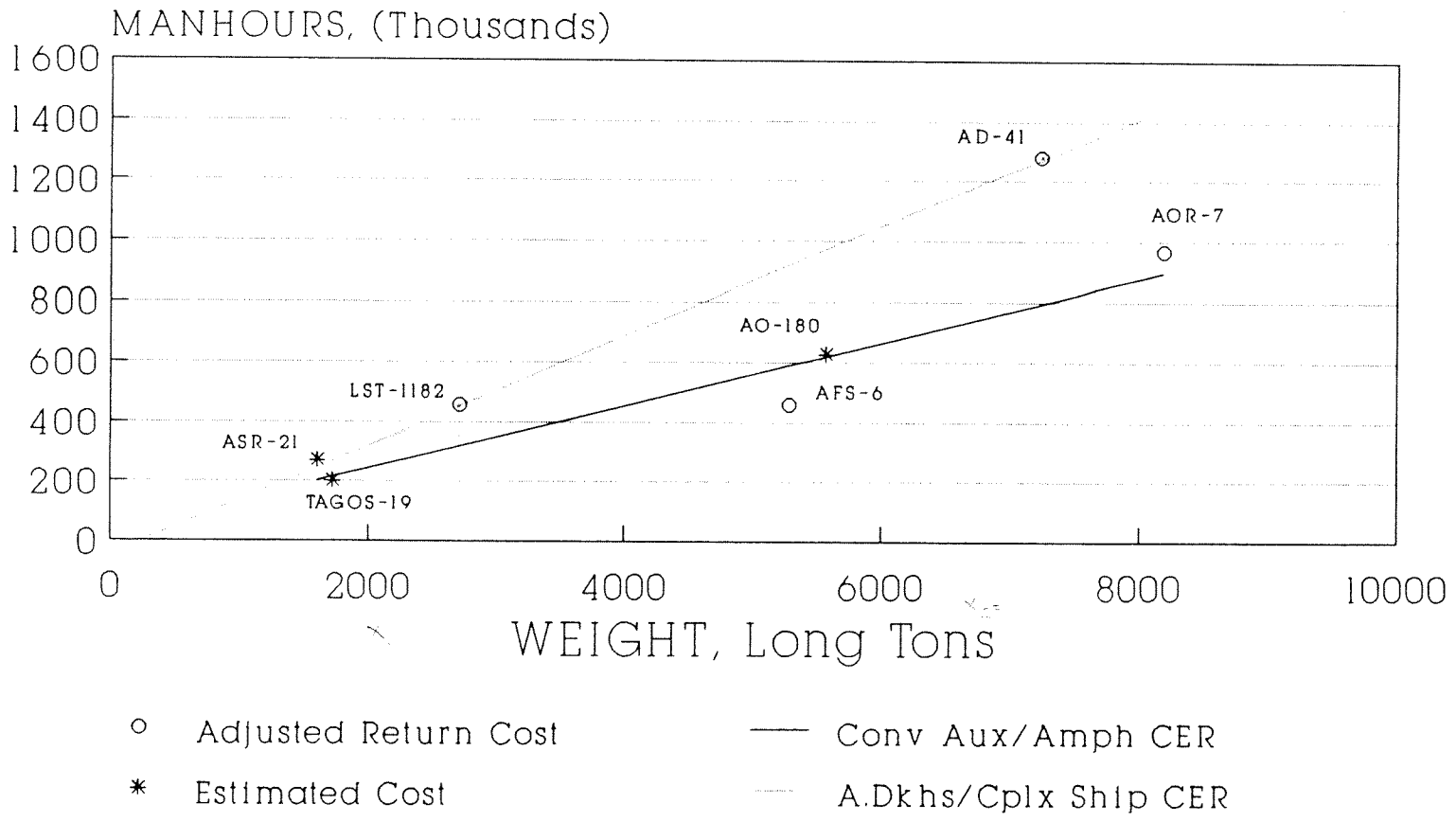


FIGURE 4-2

HULL STRUCTURE (TOTAL)
GROUP 1
LABOR

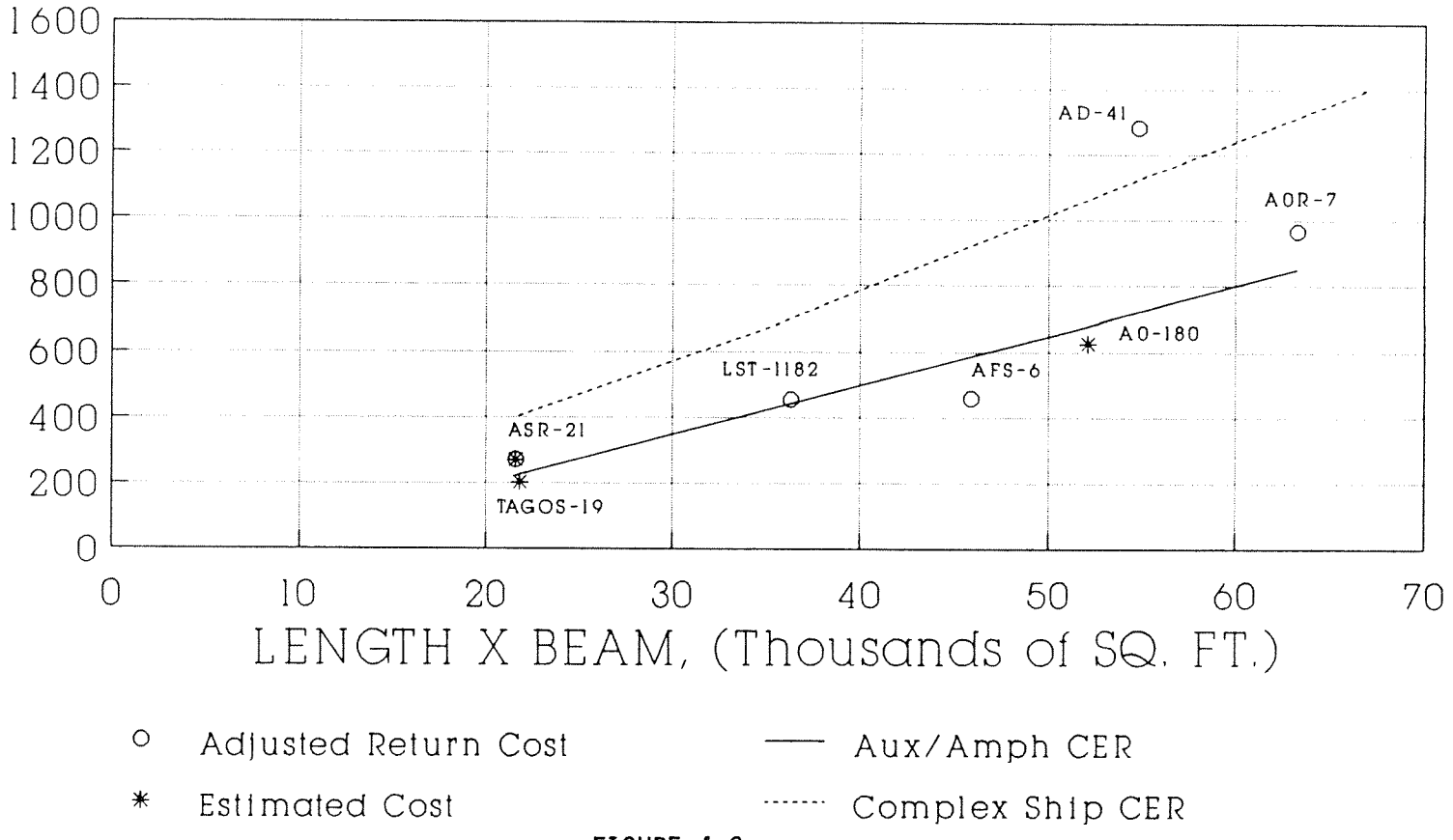


FIGURE 4-3

CER:	MH = 18 (WT) - 32,100
Variable:	Group 1 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Ships with aluminum deckhouse or complex ships

CER:	MH = 20 (LXB) - 100,700
Variable:	(LXB) in square feet
Adjusted r^2:	.79 - 6 points
Application:	Conventional ships

CER:	MH = 20 (LXB) - 88,000
Variable:	(LXB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

4.2.1 Group 1 A - Structural Envelope/Subdivisions

This group includes the shell plating, framing, structural bulkheads and decks.

Material Costs - A single CER is provided for material costs for Group 1A. This CER is based on Group 1A weight. The graph for Group 1A material costs is provided in Figure 4-4 and the CER for Group 1A material costs is as follows:

CER:	$ = 821 (WT) - 129,500
Variable:	Group 1A WT in long tons
Adjusted r^2:	.98 - 9 points
Application:	All ships

Labor Costs - Three CER's are provided for labor costs for Group 1A. All three are based on Group 1A weight. The three CER's are for conventional auxiliary and amphibious ships, complex auxiliary and amphibious ships, as exemplified by the AD-41, and amphibious ships, with

HULL STRUCTURAL ENVELOPE/SUBDIVISIONS
GROUP 1A
MATERIALS COSTS

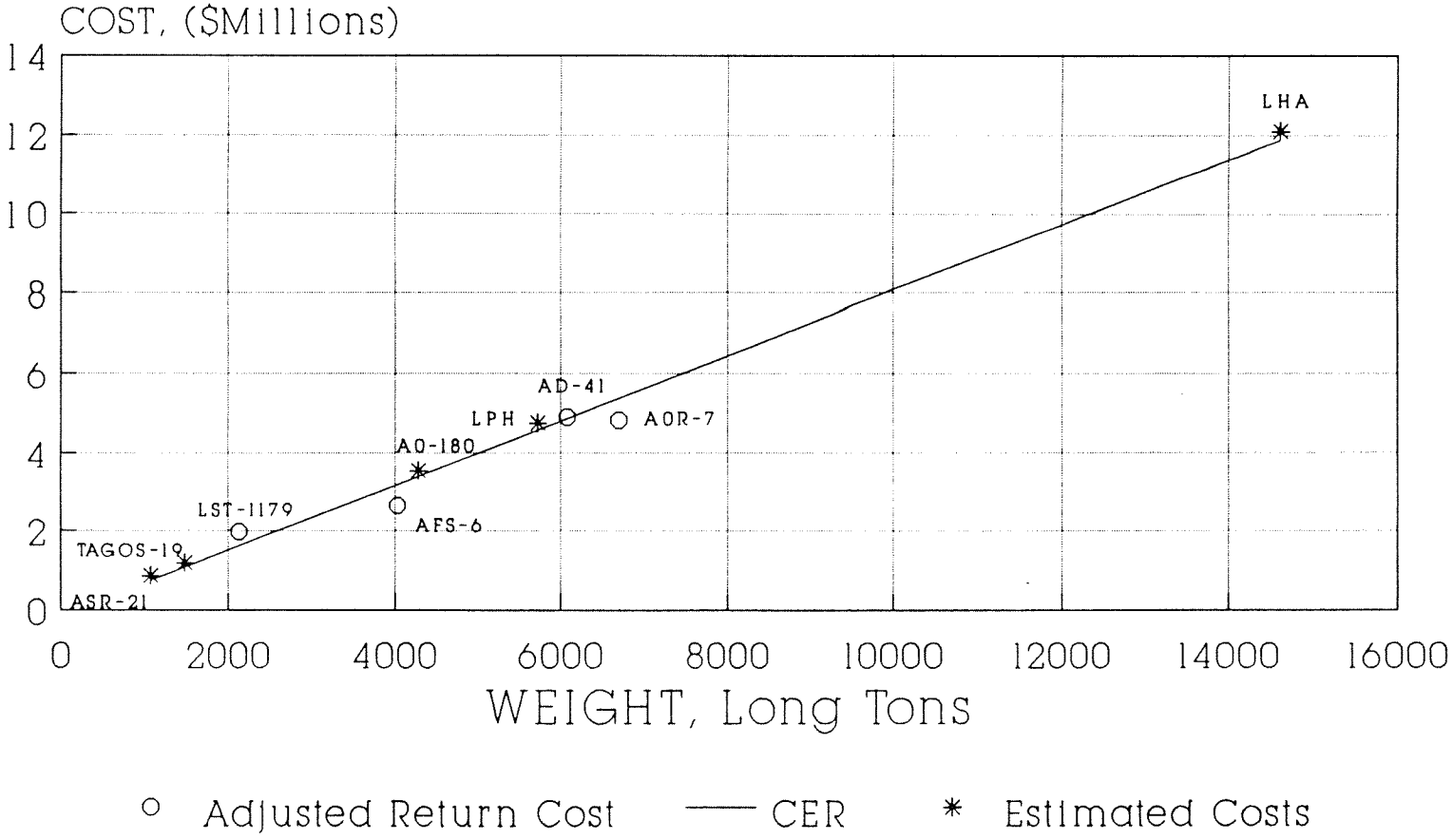


FIGURE 4-4

flight deck, such as LPH-12 and LHA-3. The graph for Group 1A labor costs is shown in Figure 4-5, and the CER's for Group 1A labor costs are as follows:

CER:	MH = 87 (WT) + 51,000
Variable:	Group 1A WT in long tons
Adjusted r^2:	.83 - 6 points
Application:	Conventional ships

CER:	MH = 143 (WT) + 83,500
Variable:	Group 1A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	MH = 100 (WT) + 157,400
Variable:	Group 1A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Flight deck ships

4.2.2 Group 1B Superstructure

This group includes the deckhouse structure and helicopter hangar, but does not include masts, stacks and macks.

Material Costs - Two CER's are provided for material costs for Group 1B. Both are based on Group 1B weights. One CER is for a steel deckhouse and one CER is for an aluminum deckhouse as exemplified by the LST-1182. The graph for Group 1B is shown in Figure 4-6, and the CER's for Group 1B material costs are as follows:

CER:	$ = 628 (WT) + 32,900
Variable:	Group 1B WT in long tons
Adjusted r^2:	.95 - 6 points
Application:	Steel deckhouse

STRUCTURAL ENVELOPE/SUBDIVISIONS
GROUP 1A
LABOR

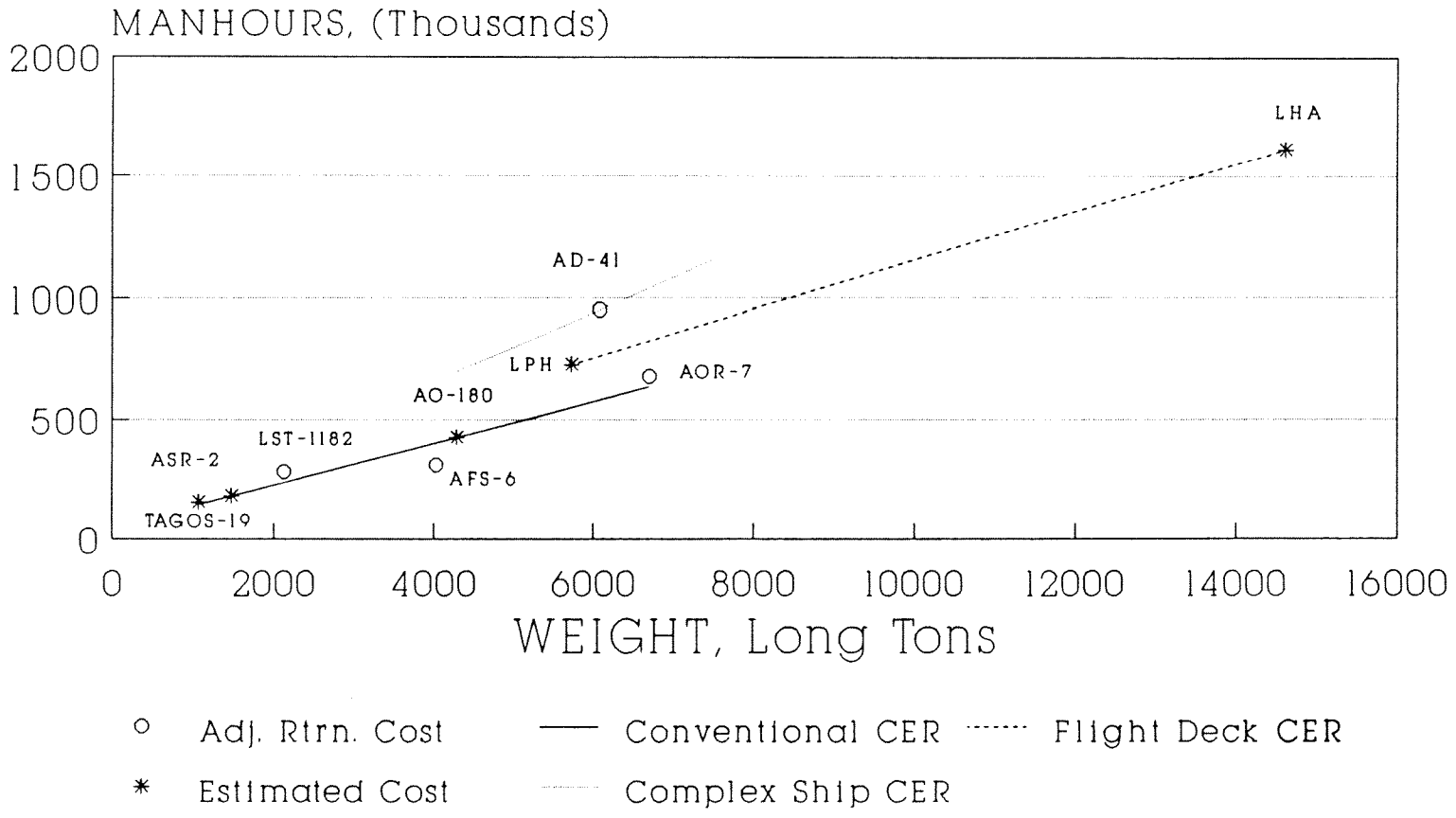


FIGURE 4-5

SUPERSTRUCTURE
GROUP 1B
MATERIALS COSTS

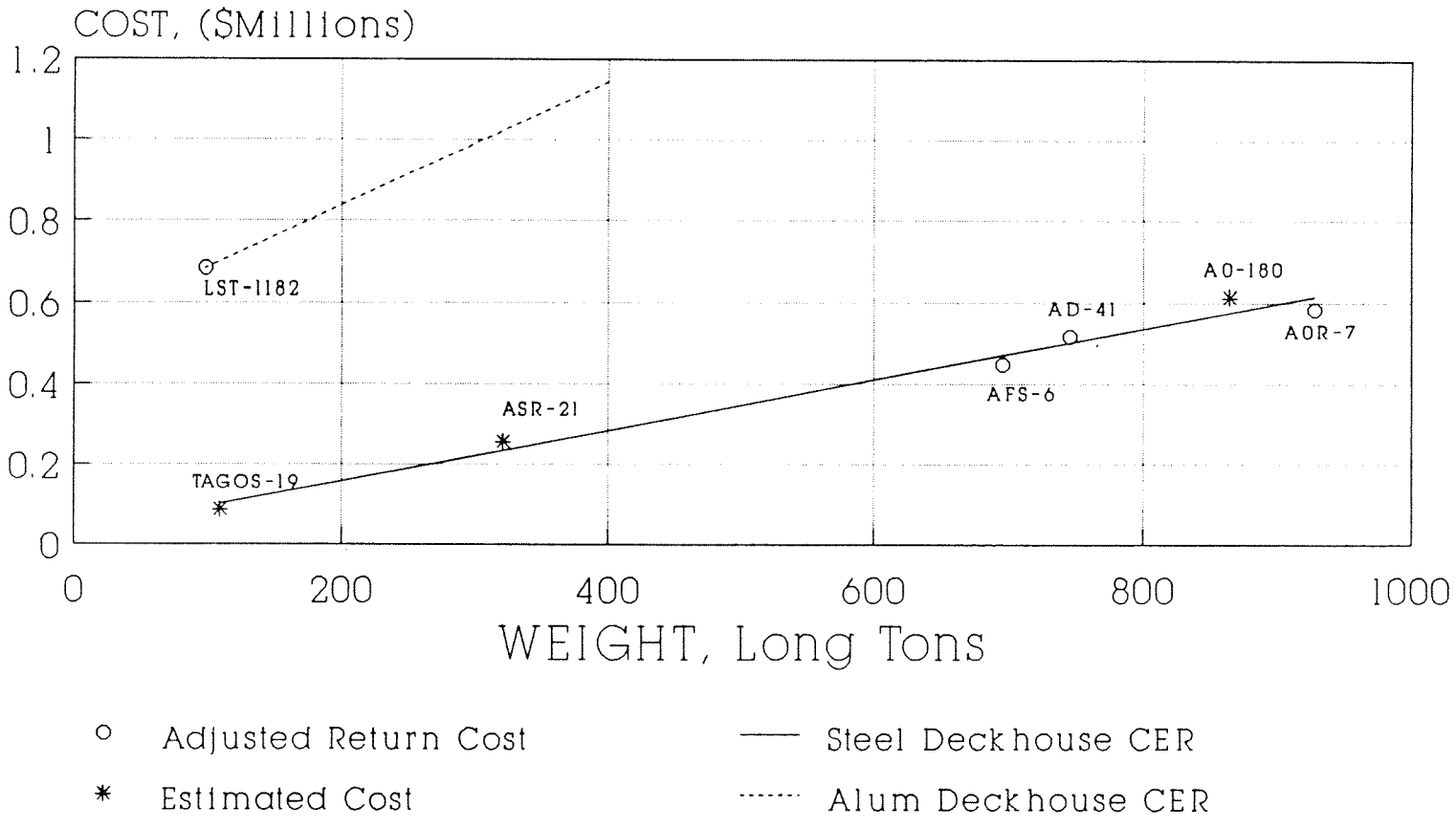


FIGURE 4-6

CER:	$ = 4,531 (WT) + 237,100
Variable:	Group 1B WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Aluminum deckhouse

Labor Costs - Two CER's are provided for labor costs for Group 1B. Both are based on Group 1B weights. The two CER's are for conventional superstructure and for aluminum or complex ship superstructure as exemplified by the LST-1182 and AD-41. The graph for Group 1B labor costs is shown in Figure 4-7 and the CER's for Group 1B labor costs are as follow:

CER:	MH = 120 (WT) - 2,200
Variable:	Group 1B WT in long tons
Adjusted r^2:	.63 - 5 points
Application:	Conventional superstructure

CER:	MH = 130 (WT) - 36,400
Variable:	Group 1B WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Aluminum or complex ship superstruture

4.2.3 Group 1C Foundations

This group includes the foundations for propulsion plant machinery, auxiliaries and other equipment.

Material Costs - Three CER's are provided for material costs for Group 1C. All three are based on Group 1C weights. The three CER's are for conventional auxiliary or amphibious ships, complex auxiliary or amphibious ships, as exemplified by AD-41, and commercial auxiliary and amphibious ships, (i.e., designed to purely commercial specifications) as exemplified by the T-AGOS-19. The graph for Group 1C material costs is shown in Figure 4-8 and the CER's for Group 1C material costs are:

SUPERSTRUCTURE
GROUP 1B
LABOR

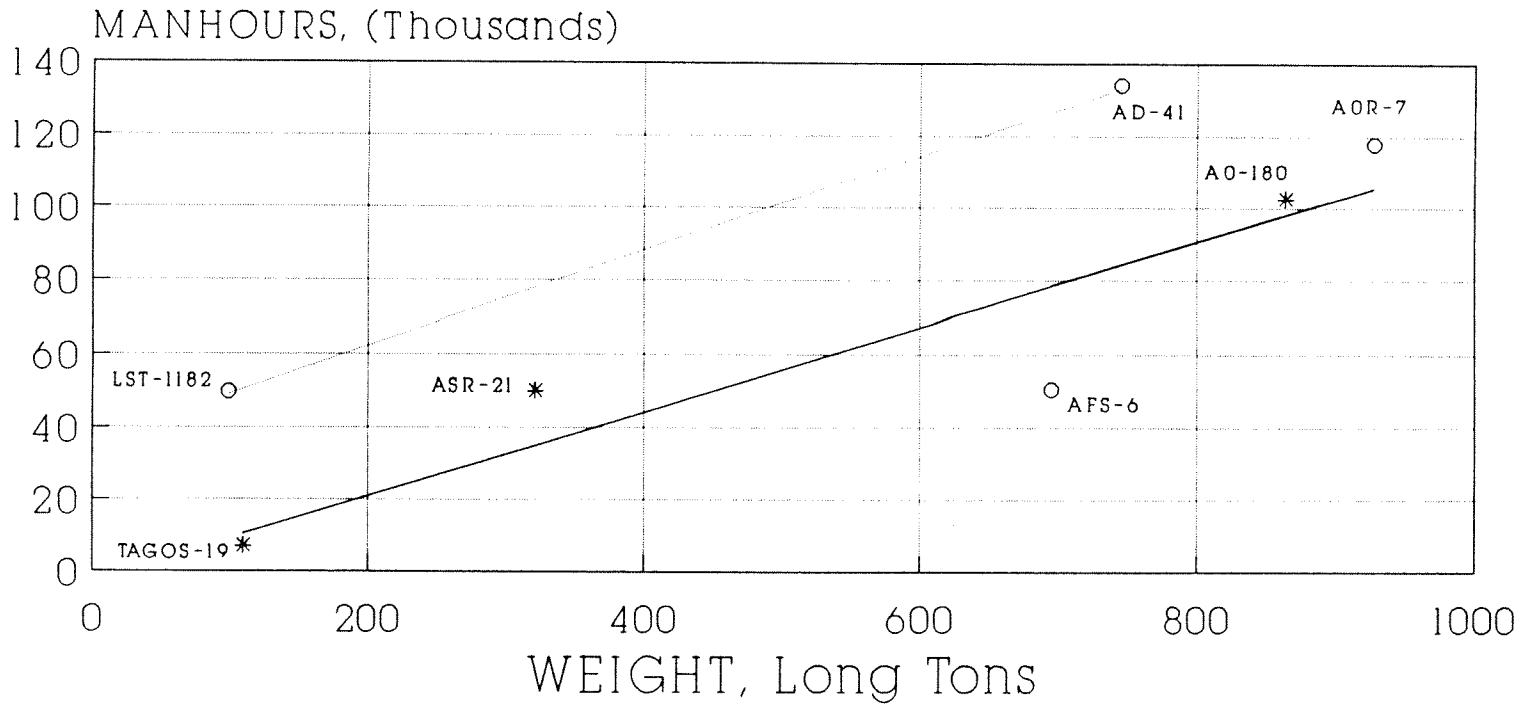


FIGURE 4-7

FOUNDATIONS
GROUP 1C
MATERIALS COST

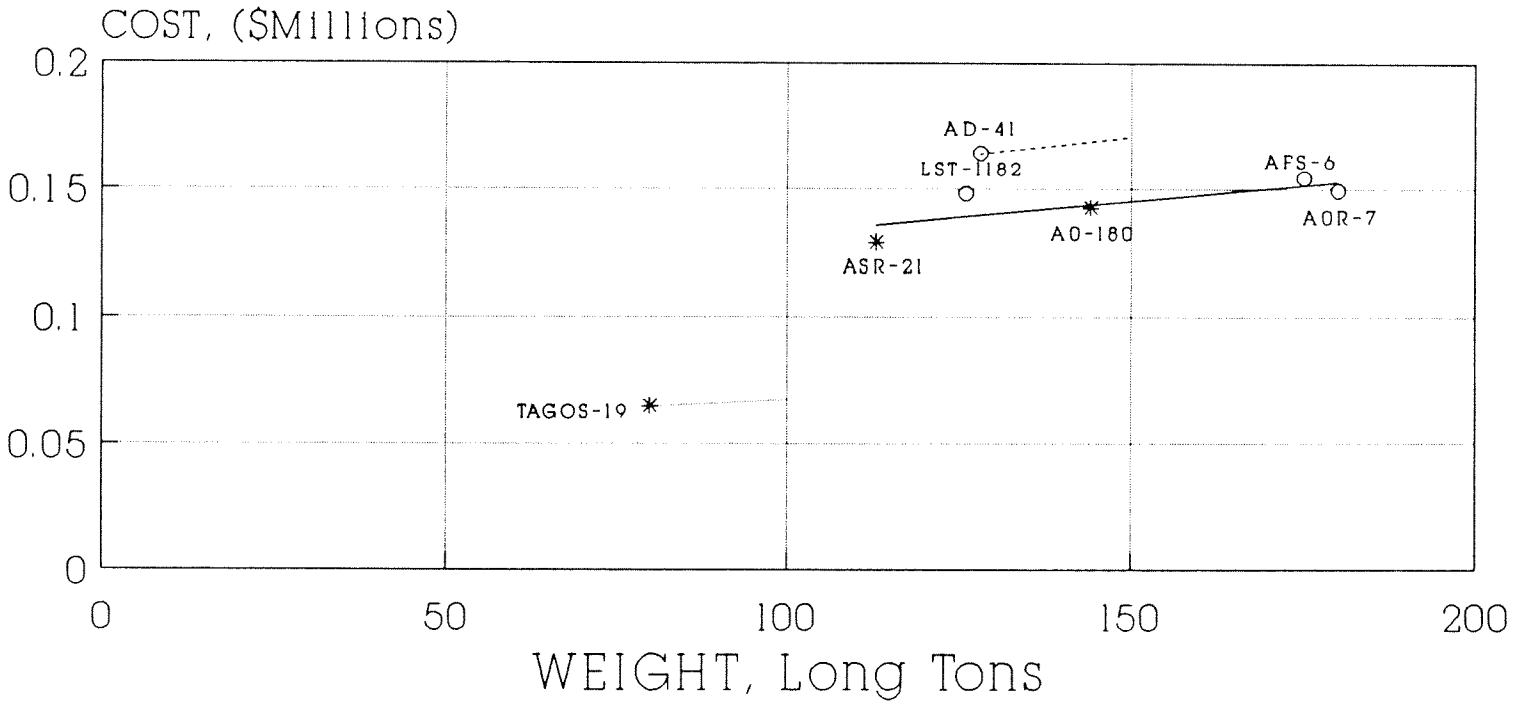


FIGURE 4-8

CER:	$ = 257 (WT) + 106,700
Variable:	Group 1C WT in long tons
Adjusted r2:	.16 - 5 points
Application:	Conventional ships

CER:	$ = 303 (WT) + 125,600
Variable:	Group 1C WT in long tons
Adjusted r2:	N/A - insufficient points
Application:	Complex ships

CER:	$ = 131 (WT) + 54,500
Variable:	Group 1C WT in long tons
Adjusted r2:	N/A - insufficient points
Application:	Commercial ships

Labor Costs - Two CER's are provided for labor costs for Group 1C. Both are based on Group 1C weights. One CER is for conventional auxiliary and amphibious ships and one is for complex auxiliary and amphibious ships as exemplified by the AD-41. The graph for Group 1C labor costs is shown in Figure 4-9, and the CER'S for Group 1C labor costs are as follows:

CER:	MH = 800 (WT) - 51,800
Variable:	Group 1C WT in long tons
Adjusted r2:	.92 - 5 points
Application:	Conventional ships

CER:	MH = 1,930 (WT) - 125,000
Variable:	Group 1D WT in long tons
Adjusted r2:	N/A - insufficient points
Application:	Complex ships

4.2.4 Group 1D - Structural Attachments

This group includes structural castings, forgings, doors, hatches, masts, towers, and sonar domes.

FOUNDATIONS
GROUP 1C
LABOR

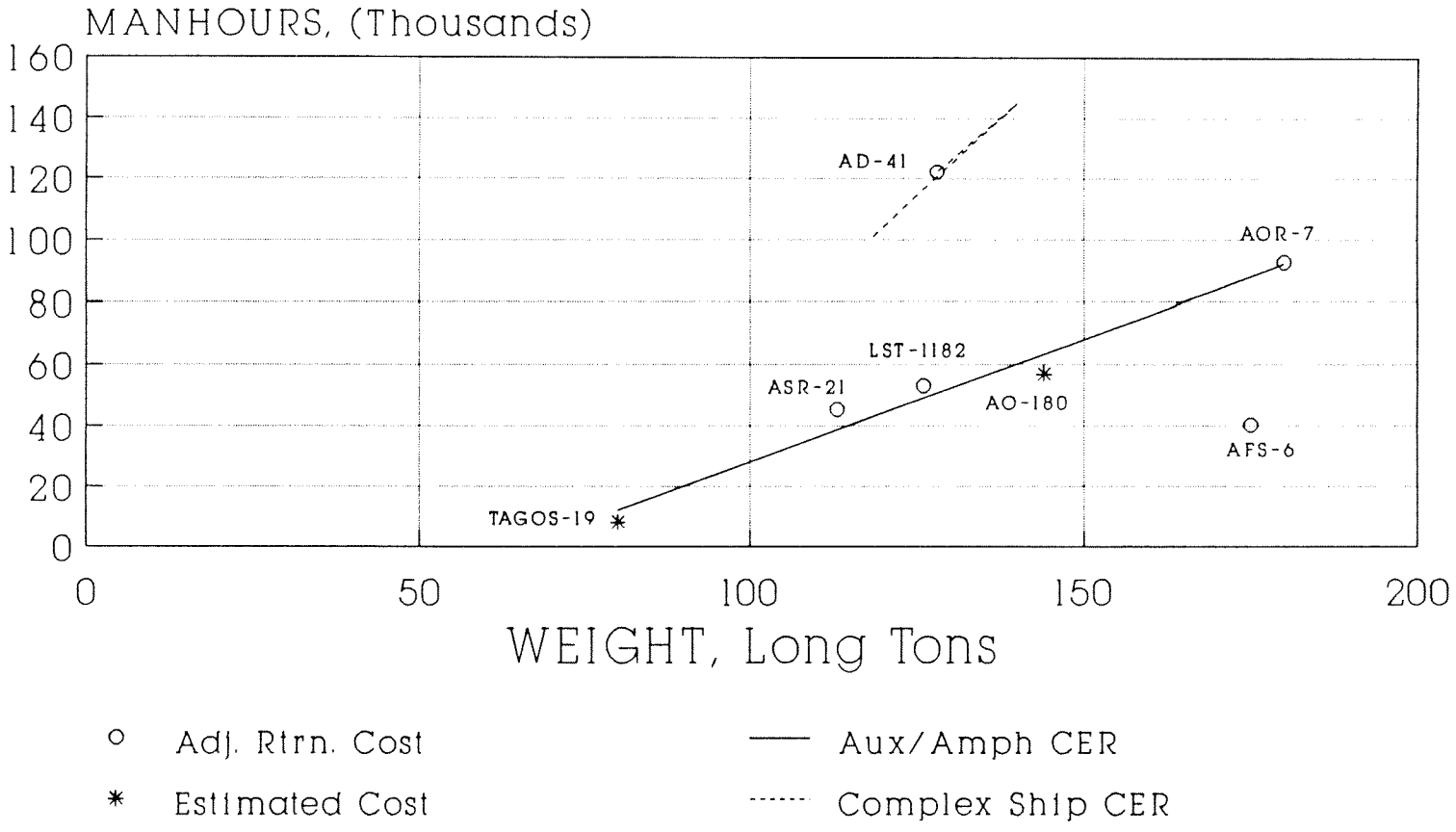


FIGURE 4-9

Material Costs - Two CER's are provided for material costs for Group 1D. Both are based on Group 1D weights. One is for conventional structural attachments and one is for complex structural attachments such as those that would be found on a tender (AD-41). The graph for Group 1D material costs is shown in Figure 4-10 and the CER's for Group 1D material costs are as follows:

CER:	$ = 2550 (WT) - 39,500
Variable:	Group 1D WT in long tons
Adjusted r^2:	.95 - 6 points
Application:	Conventional structural attachments

CER:	$ = 602 (WT) - 93,300
Variable:	Group 1D WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex structural attachments

Labor Costs - Two CER's are provided for labor costs for Group 1D. Both are based on Group 1D weights. One is for conventional auxiliary and amphibious ships and one is for complex auxiliary and amphibious ships, as exemplified by the AD-41. The graph for Group 1D labor costs is shown in Figure 4-11 and the CER's for Group 1D labor costs are as follows:

CER:	MH = 187 (WT) - 1,900
Variable:	Group 1D WT in long tons
Adjusted r^2:	.83 - 6 points
Application:	Conventional ships

CER:	MH = 274 (WT) - 2,800
Variable:	Group 1D WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

STRUCTURAL ATTACHMENTS
GROUP 1D
MATERIALS COST

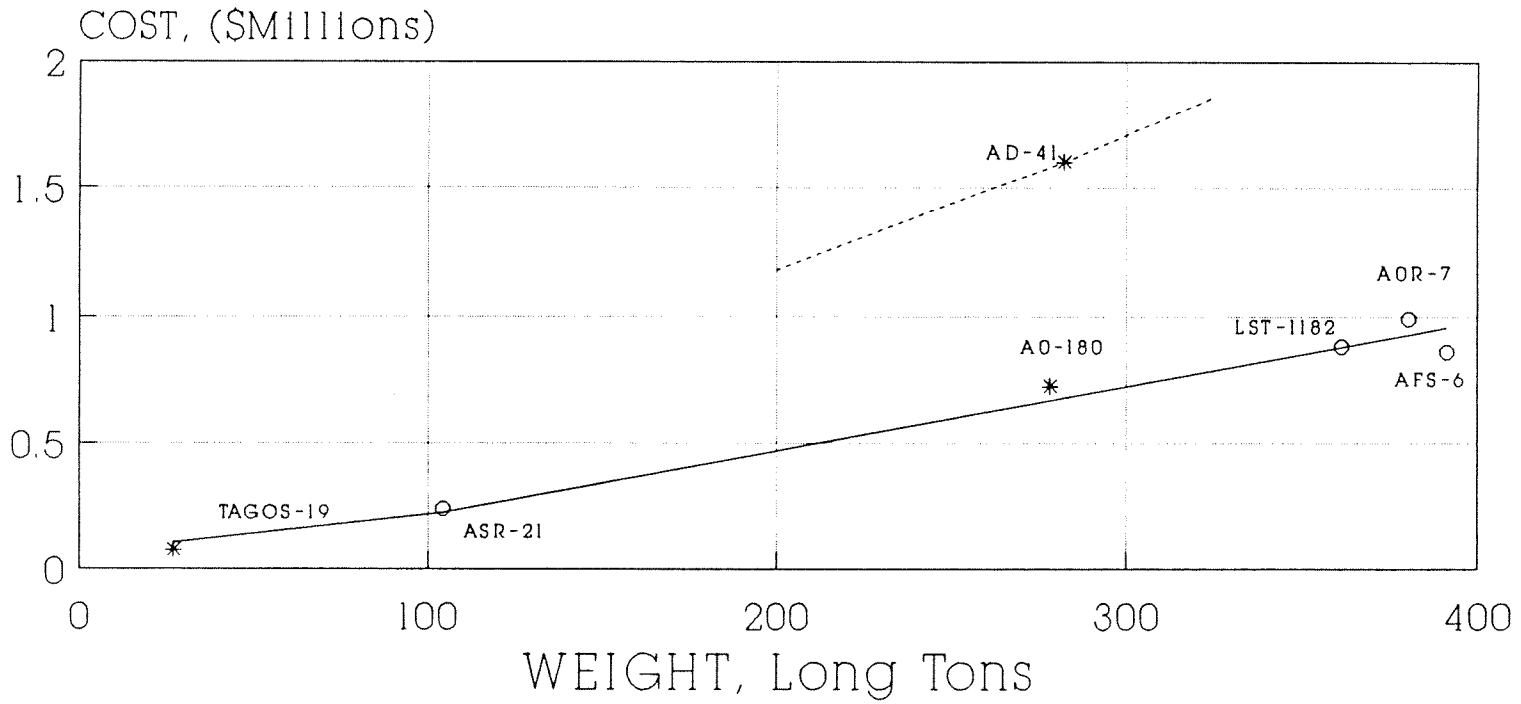


FIGURE 4-10

STRUCTURAL ATTACHMENTS
GROUP 1D
LABOR

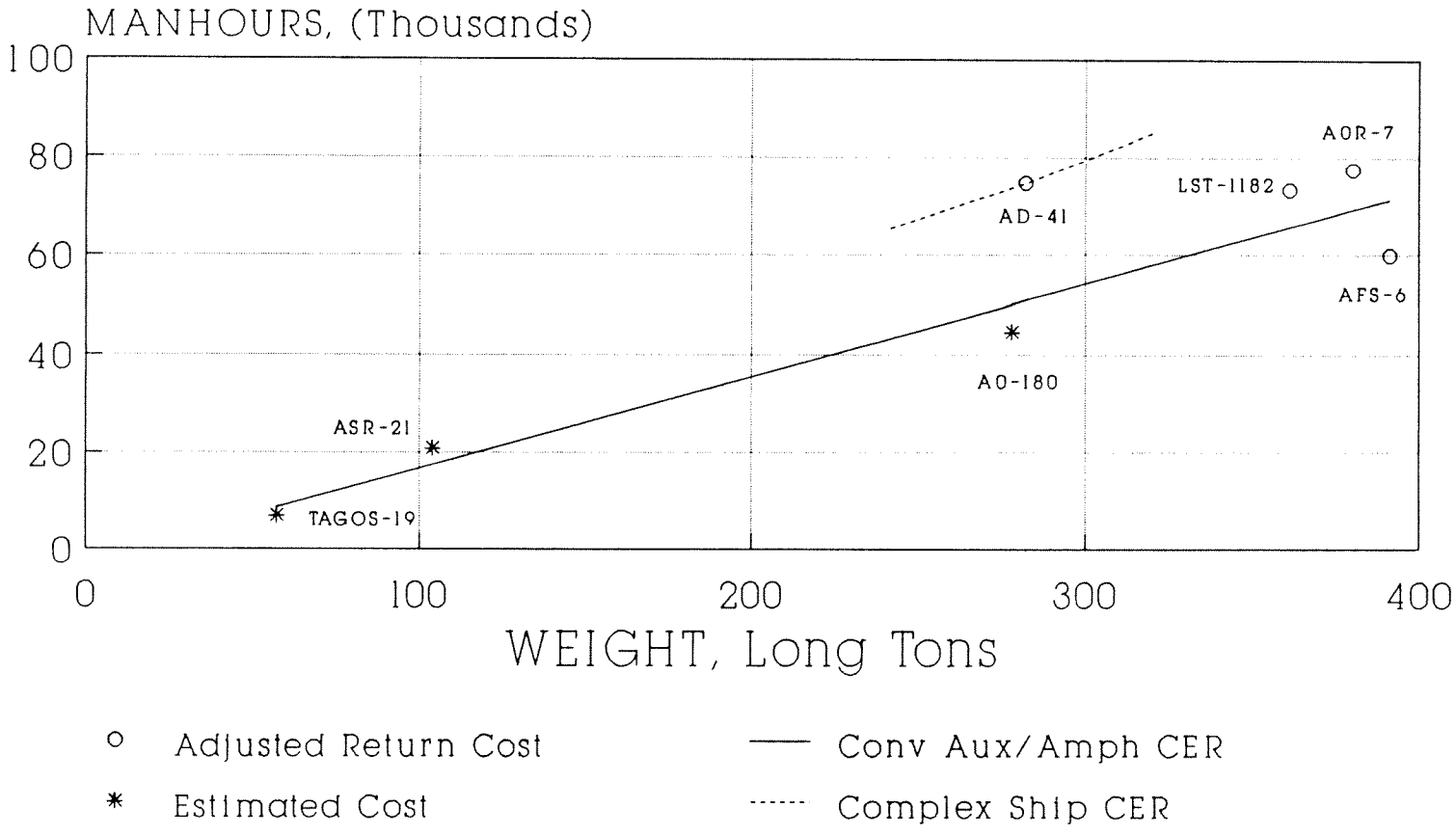


FIGURE 4-11

4.3 Group 2 - Propulsion Plant

This one digit SWBS Group includes the following four two digit SWBS Groups:

Group 2A - Propulsion Energy Systems
Group 2B - Propulsion Train Systems
Group 2C - Propulsion Gases Systems
Group 2D - Propulsion Service Systems

Material Costs - Six CER's are provided for material costs for Group 2. Three are based on Group 2 weights, and three are based on total shaft horsepower. In each case, the three CER's are for steam geared turbines, geared diesel or diesel electric drive powered ships. The graphs for Group 2 material costs are shown in Figures 4-12 and 4-13 and the CER's for Group 2 material costs are:

CER:	$ = 5,890 (WT) + 4,718,200
Variable:	Group 2 WT in long tons
Adjusted r^2:	.39 - 4 points
Application:	Steam geared turbine

CER:	$ = 29,500 (WT) - 3,313,200
Variable:	Group 2 WT in long tons
Adjusted r^2:	.99 - 3 points
Application:	Geared diesel

CER:	$ = 230 (WT) - 2,004,100
Variable:	Group 2 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Diesel electrical drive

CER:	$ = 264 (SHP) + 2,310,000
Variable:	Shaft horsepower
Adjusted r^2:	.74 - 4 points
Application:	Steam geared turbine

PROPULSION PLANT
GROUP 2
MATERIALS COSTS

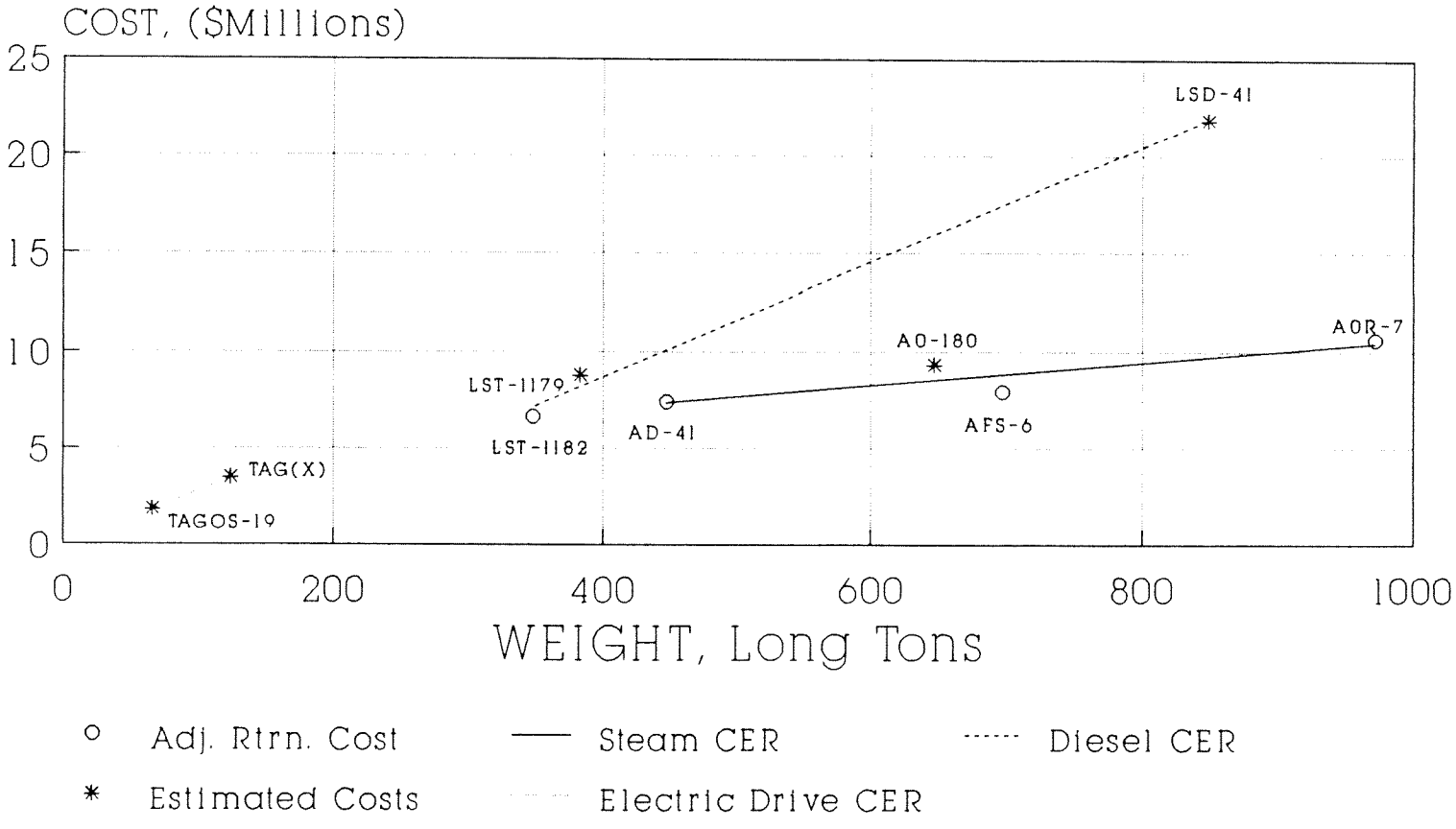


FIGURE 4-12

PROPULSION SYSTEMS
GROUP 2
MATERIALS COST

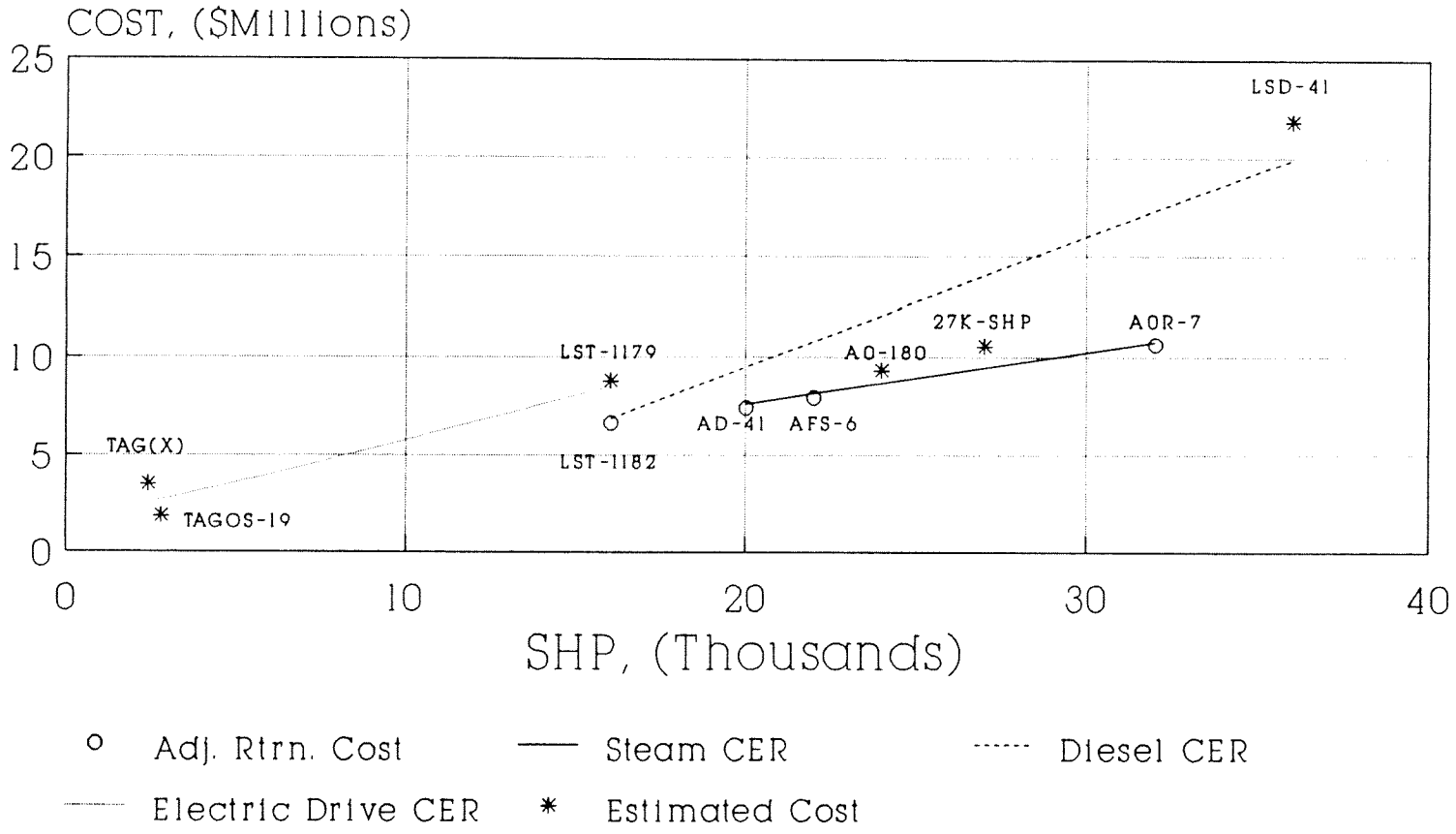


FIGURE 4-13

CER:	$ = 651 (SHP) - 3,544,900
Variable:	Shaft horsepower
Adjusted r^2:	.61 - 4 points
Application:	Geared diesel

CER:	$ = 229 (SHP) + 2,004,100
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Application:	Diesel-electric drive

Labor Costs - Six CER's are provided for labor costs for Group 2. Three are based on Group 2 weight, and three are based on total shaft horsepower. In each case the three CER's are for steam geared turbines, geared diesel or diesel electric drive ships, or ships with double steam forced draft blowers as exemplified by the AD-41. The graphs for Group 2 labor costs are shown in Figures 4-14 and 4-15, and the CER's for Group 2 labor costs are:

CER:	MH = 206 (WT) - 20,700
Variable:	Group 2 WT in long tons
Adjusted r^2:	.73 - 3 points
Application:	Steam geared turbine

CER:	MH = 77 (WT) + 25,600
Variable:	Group 2 WT in long tons
Adjusted r^2:	N/A-insufficient points Application: Geared diesel or diesel-electric drive

CER:	MH = 180 (WT) - 96,000
Variable:	Group 2 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Double steam forced draft blowers

CER:	MH = 7 (SHP) -45,400
Variable:	Shaft horsepower
Adjusted r^2:	.99 - 3 points
Application:	Steam geared turbine

PROPULSION PLANT
GROUP 2
LABOR

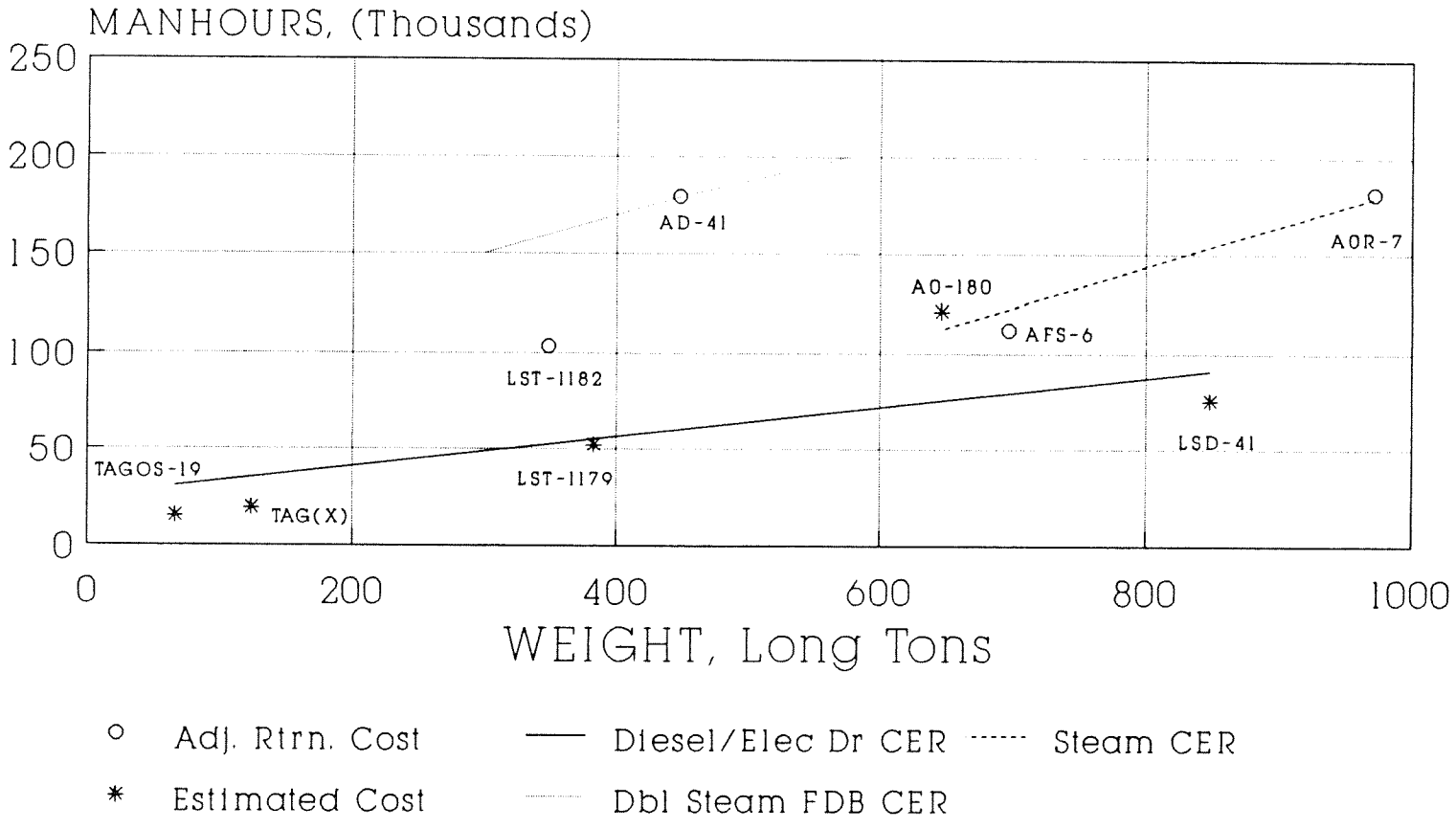


FIGURE 4-14

PROPULSION PLANT
GROUP 2
LABOR

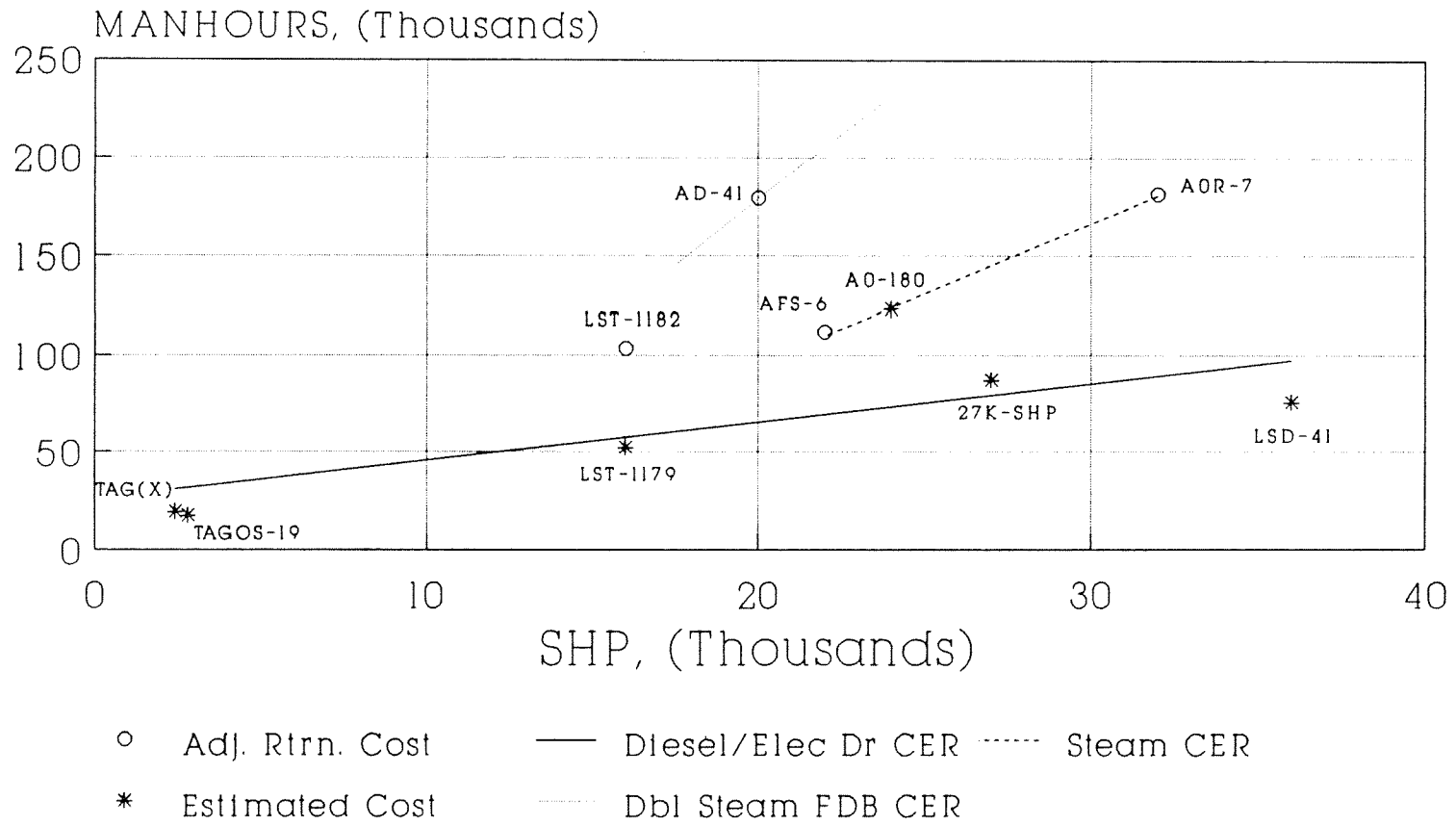


FIGURE 4-15

CER:	MH = 2 (SHP) + 26,100
Variable:	Shaft horsepower
Adjusted r^2:	.10 - 6 points
Application:	Geared diesel or diesel electric drive

CER:	MH = 13 (SHP) - 84,900
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Application:	Double steam f.d. blowers

4.3.1 Group 2A - Propulsion Energy Systems

This group includes propulsion boilers, turbines, reduction gears, fuel and condensate systems, auxiliary propulsion devices, etc.

Material Costs- Four CER's are provided for material costs for Group 2A. Two are based on Group 2A weight and two are based on total shaft horsepower. In each case, the CER's are for steam geared turbines, and geared diesel ships. The graphs for Group 2A material costs are shown in Figures 4-16 and 4-17, and the CER's for Group 2A material costs are:

CER:	$ = 7,270 (WT) + 2,648,400
Variable:	Group 2A WT in long tons
Adjusted r^2:	.61 - 4 points
Application:	Steam geared turbine

CER:	$ = 23,550 (WT) + 65,800
Variable:	Group 2A WT in long tons
Adjusted r^2:	1.0 - 5 points
Application:	Diesel powered

CER:	$ = 171 (SHP) + 1,704,200
Variable:	Shaft horsepower
Adjusted r^2:	.88 - 4 points
Application:	Steam geared turbine

PROPULSION ENERGY SYSTEMS
GROUP 2A
MATERIALS COST

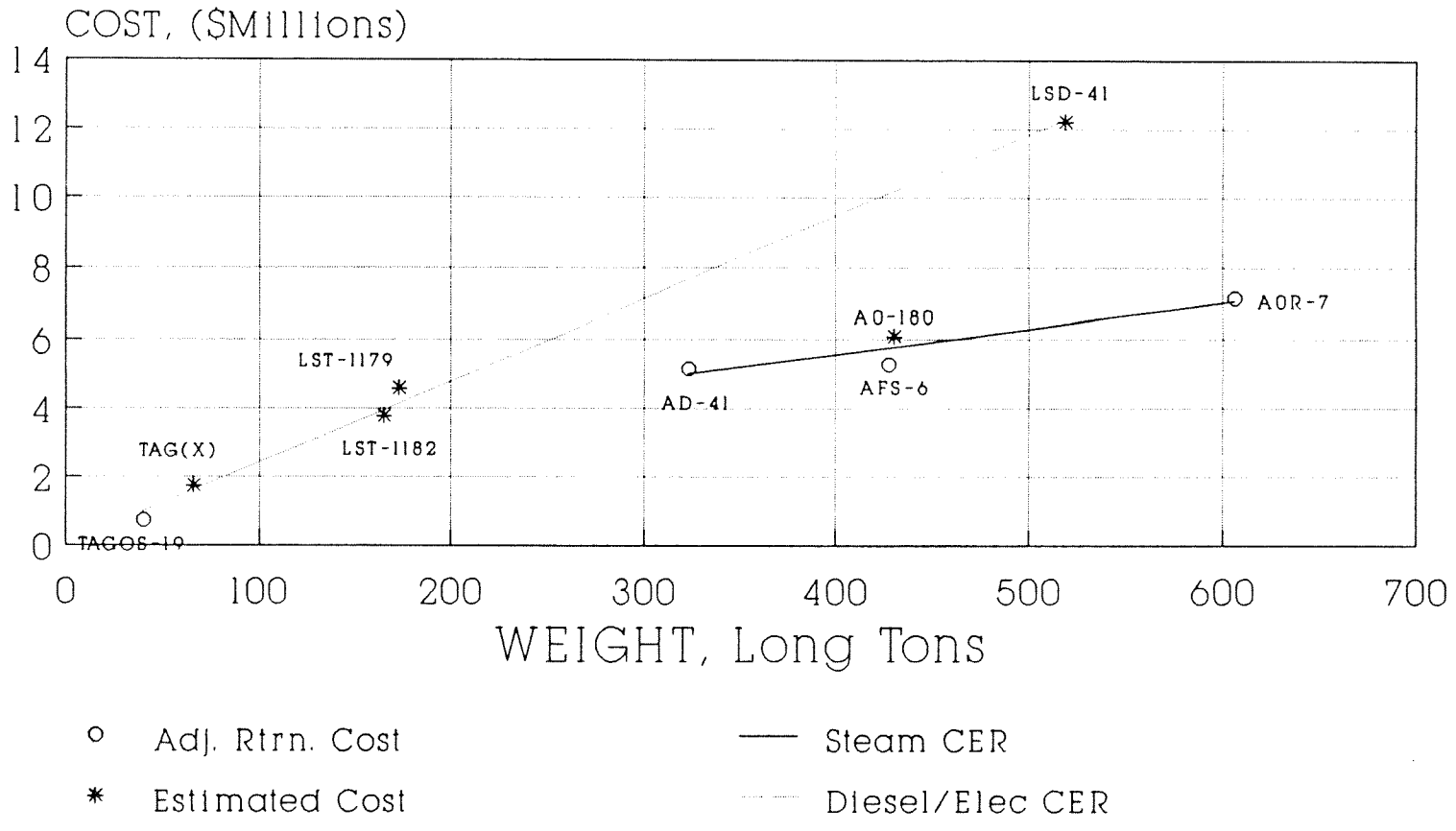


FIGURE 4-16

PROPULSION ENERGY SYSTEMS
GROUP 2A
MATERIALS COST

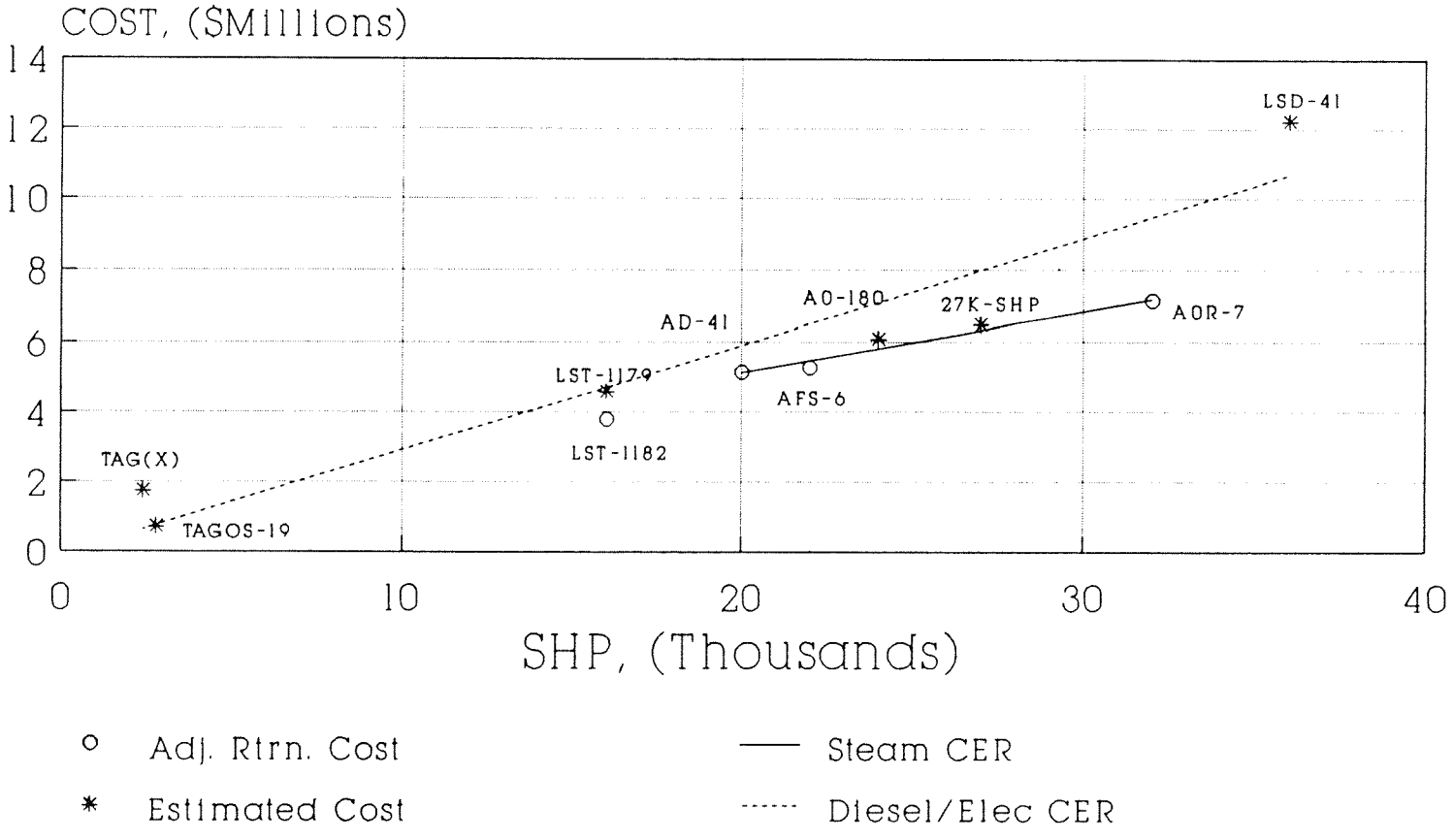


FIGURE 4-17

CER:	$ = 300 (SHP) - 70,200
Variable:	Shaft horsepower
Adjusted r^2:	.80 - 5 points
Application:	Diesel powered

Labor Costs - Four CER's are provided for labor costs for Group 2A. Two are based on Group 2A weights and two are based on total shaft horsepower. In each case the two CER's are for steam geared turbine, and geared diesel or diesel electric drive powered ships. The graphs for Group 2A labor costs are shown in Figures 4-18 and 4-19 and the CER's for Group 2A labor costs are:

CER:	MH = 79 (WT) + 33,100
Variable:	Group 2A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Steam geared turbine

CER:	MH = 29 (WT) + 3,400
Variable:	Group 2A WT in long tons
Adjusted r^2:	.16 - 5 points
Application:	Geared diesel or diesel electric drive powered

CER:	MH = 2 (SHP) + 14,100
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Application:	Steam geared turbine

CER:	MH = 0.4 (SHP) + 2,400
Variable:	Shaft horsepower
Adjusted r^2:	.53 - 6 points
Application:	Diesel or electric drive powered

4.3.2 Group 2B - Propulsion Train Systems

This group includes shafting, shaft bearings, propulsors, etc.

PROPULSION ENERGY SYSTEMS
GROUP 2A
LABOR

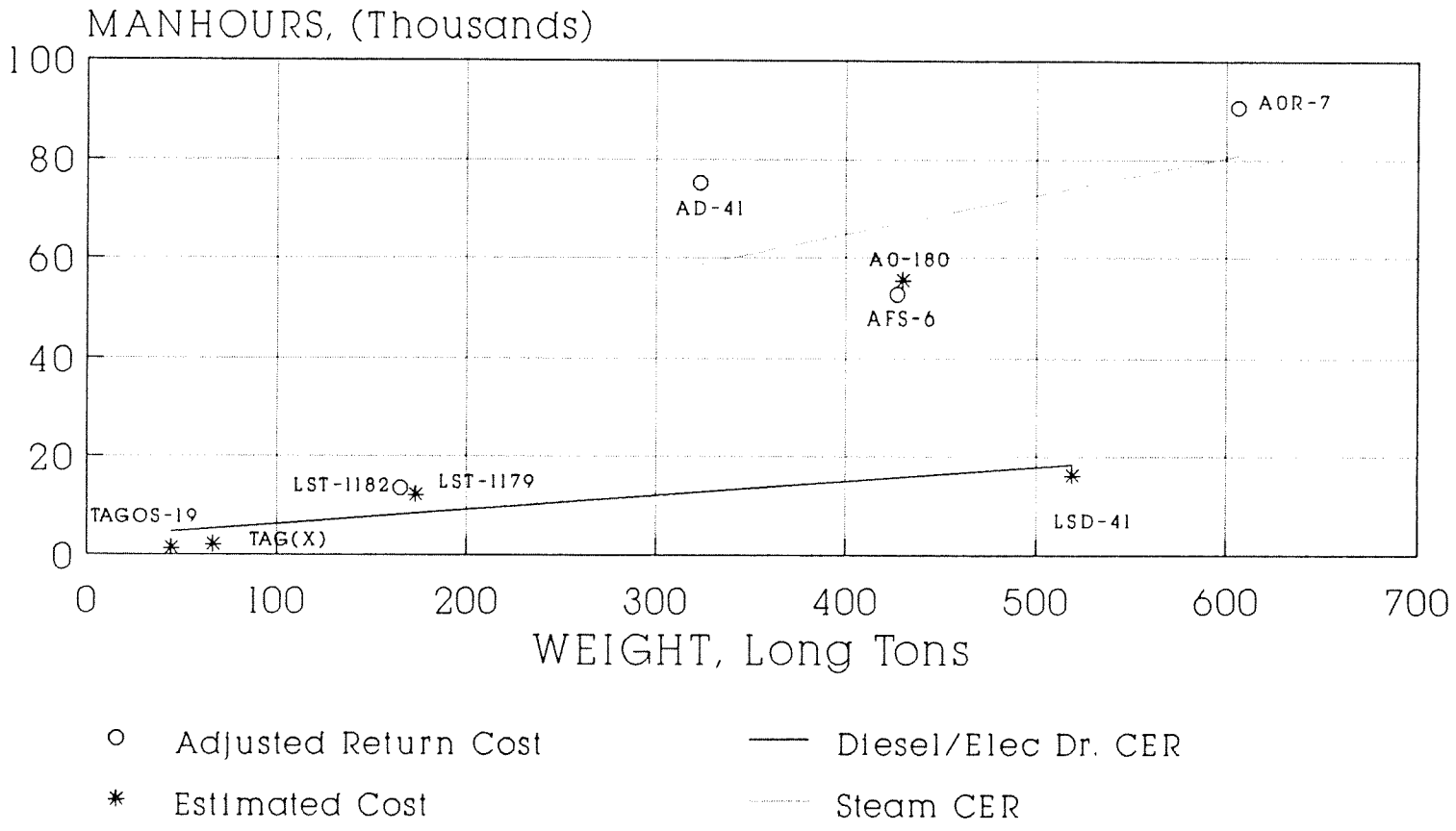


FIGURE 4-18

PROPULSION ENERGY SYSTEMS
GROUP 2A
LABOR

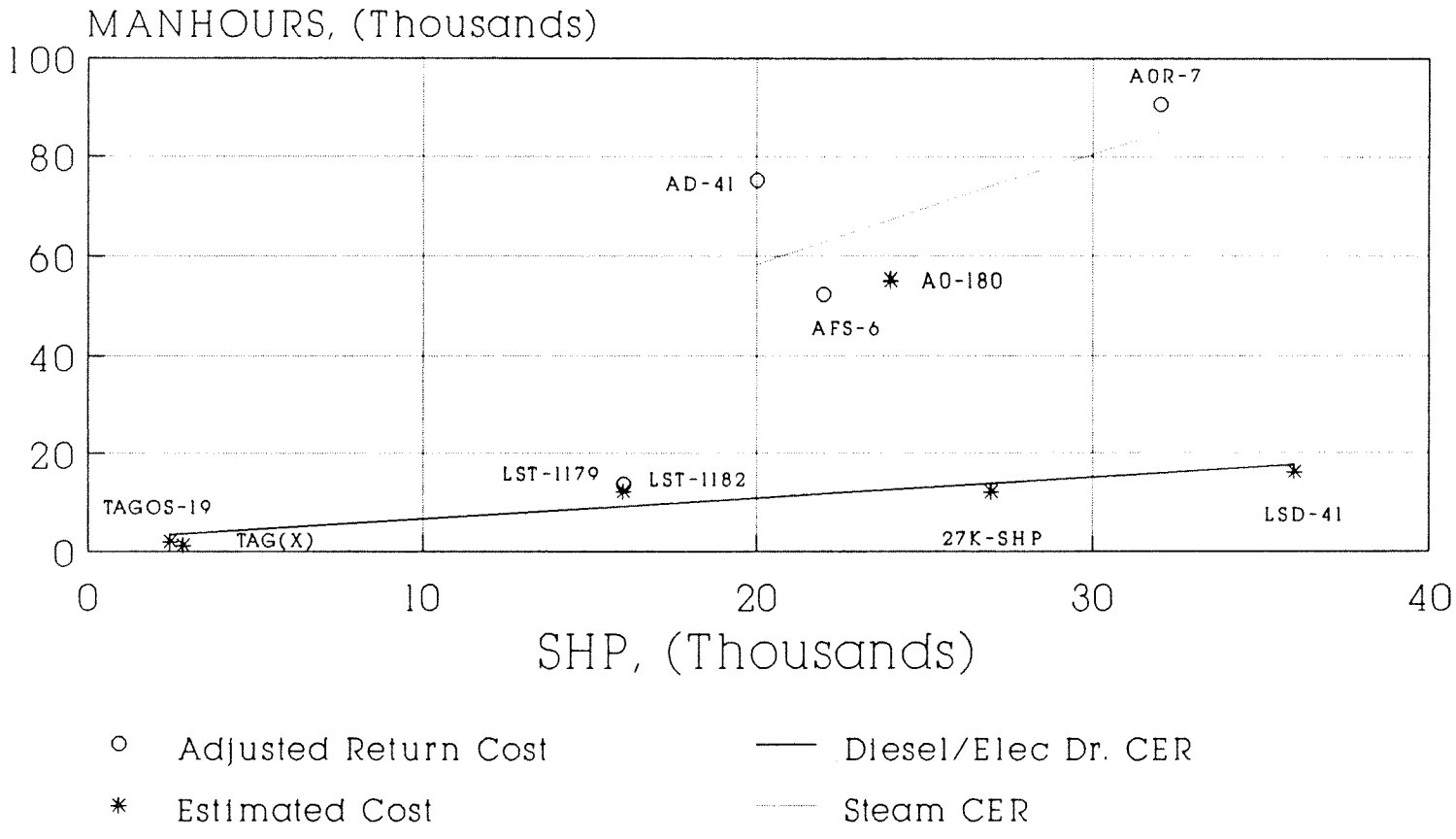


FIGURE 4-19

Material Costs - Four CER's are provided for material costs for Group 2B. Two are based on Group 2B weight and two are based on total shaft horsepower. In each case, the two CER's are for fixed pitch propellers and controllable pitch propellers. The graphs for Group 2B material costs are shown in Figures 4-20 and 4-21 and the CER's for Group 2B material costs are:

CER:	$ = 2,670 (WT) + 492,700
Variable:	Group 2B WT in long tons
Adjusted r^2:	.31 - 8 points
Application:	Fixed pitch propellers

CER:	$ = 24,114 (WT) - 160,500
Variable:	Group 2B WT in long tons
Adjusted r^2:	.88 - 3 points
Application:	Controllable pitch propellers

CER:	$ = 20 (SHP) + 470,000
Variable:	Shaft horsepower
Adjusted r^2:	.10 - 6 points
Application:	Fixed pitch propeller

CER:	$ = 57 (SHP) + 891,400
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Application:	Controllable pitch propeller

Labor Costs - Four CER's are provided for labor costs for Group 2B. Two are based on Group 2B weights and two are based on total shaft horsepower. The CER's are for fixed pitch and controllable pitch propellers. The graphs for Group 2B labor costs are shown in Figure 4-22 and 4-23, and the CER's for Group 2B labor costs are:

CER:	MH = 50 (WT) + 3,400
Variable:	Group 2B WT in long tons
Adjusted r^2:	.46 - 7 points
Application:	Fixed pitch propeller

PROPULSION TRAIN SYSTEMS
GROUP 2B
MATERIALS COST

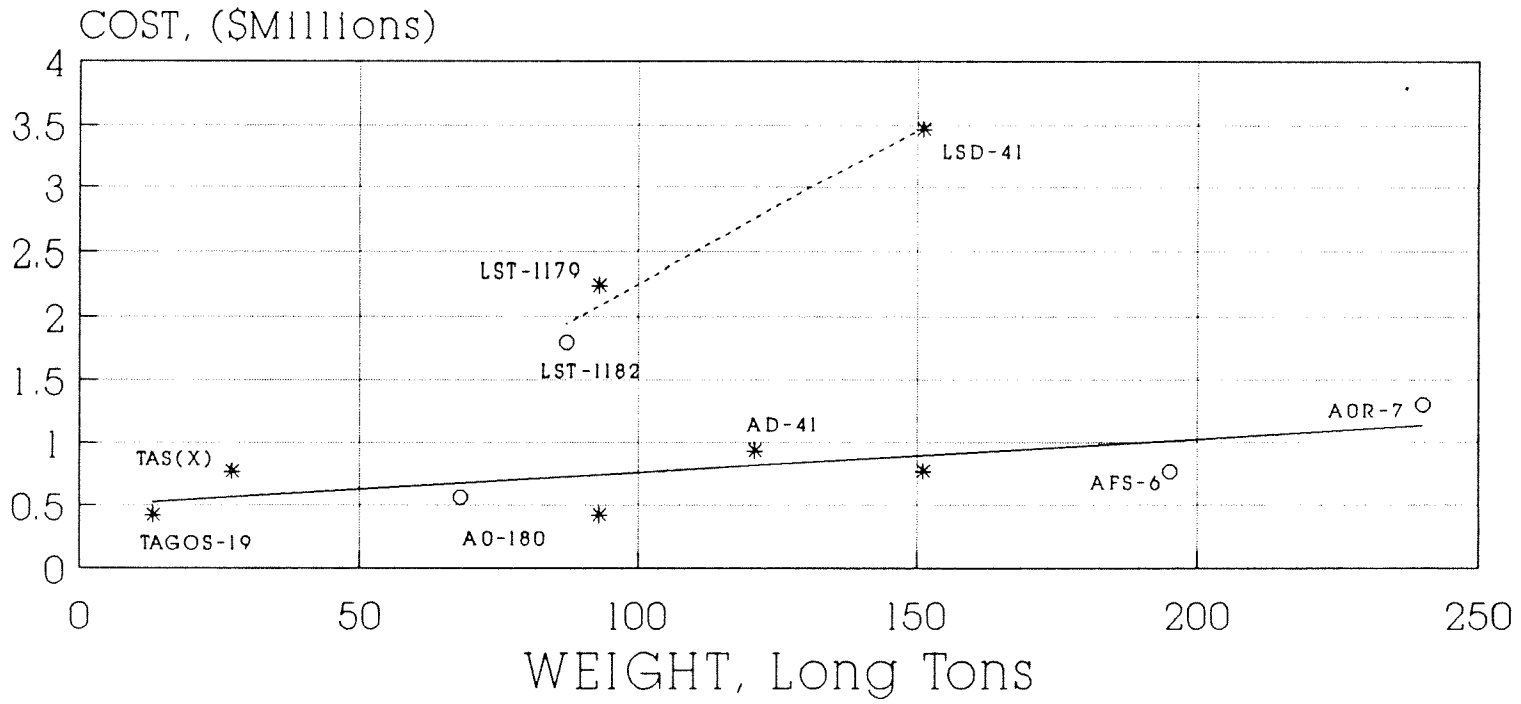


FIGURE 4-20

PROPULSION TRAIN SYSTEMS
GROUP 2B
MATERIALS COST

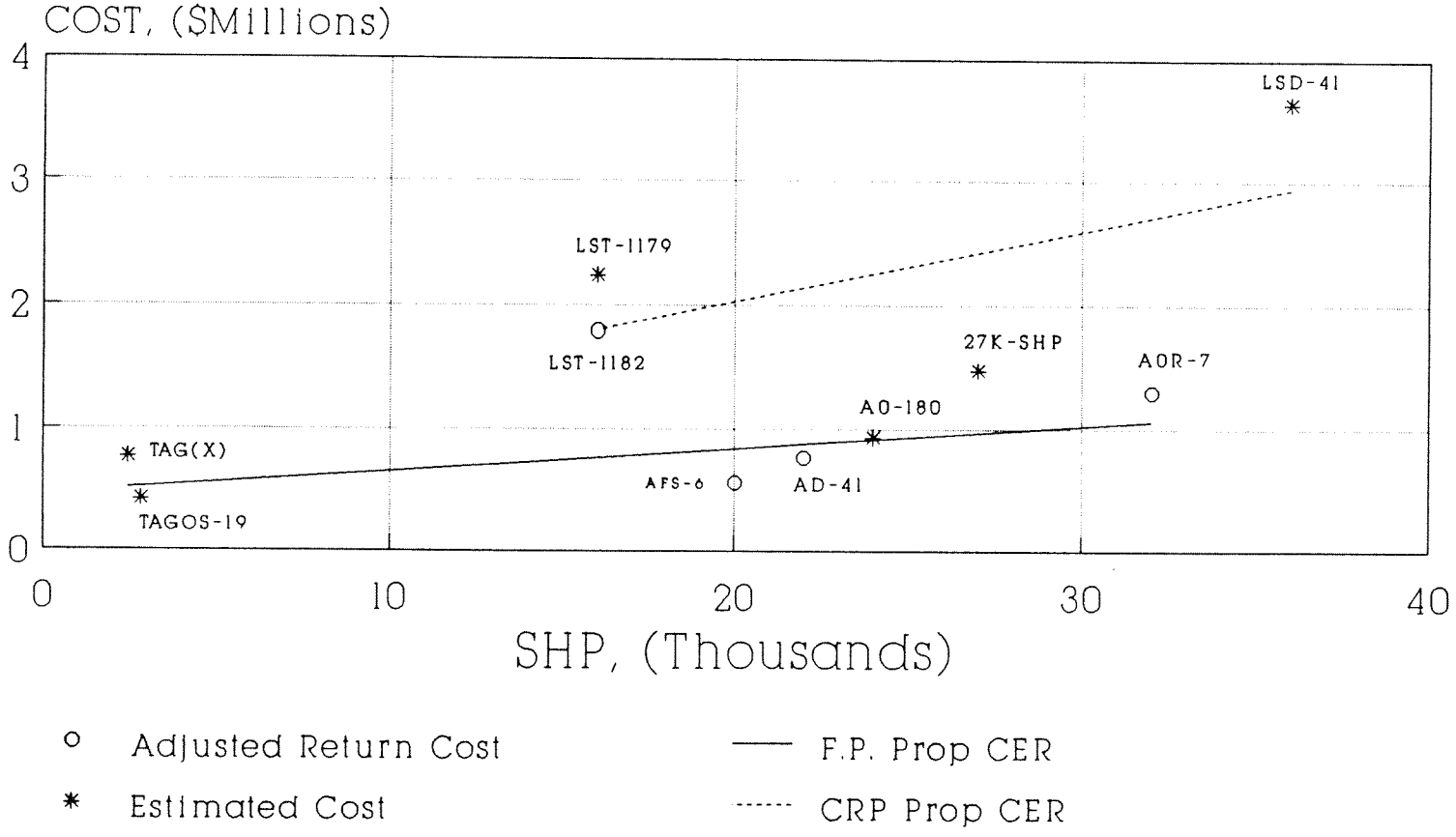


FIGURE 4-21

PROPULSION TRAIN SYSTEMS
GROUP 2B
LABOR

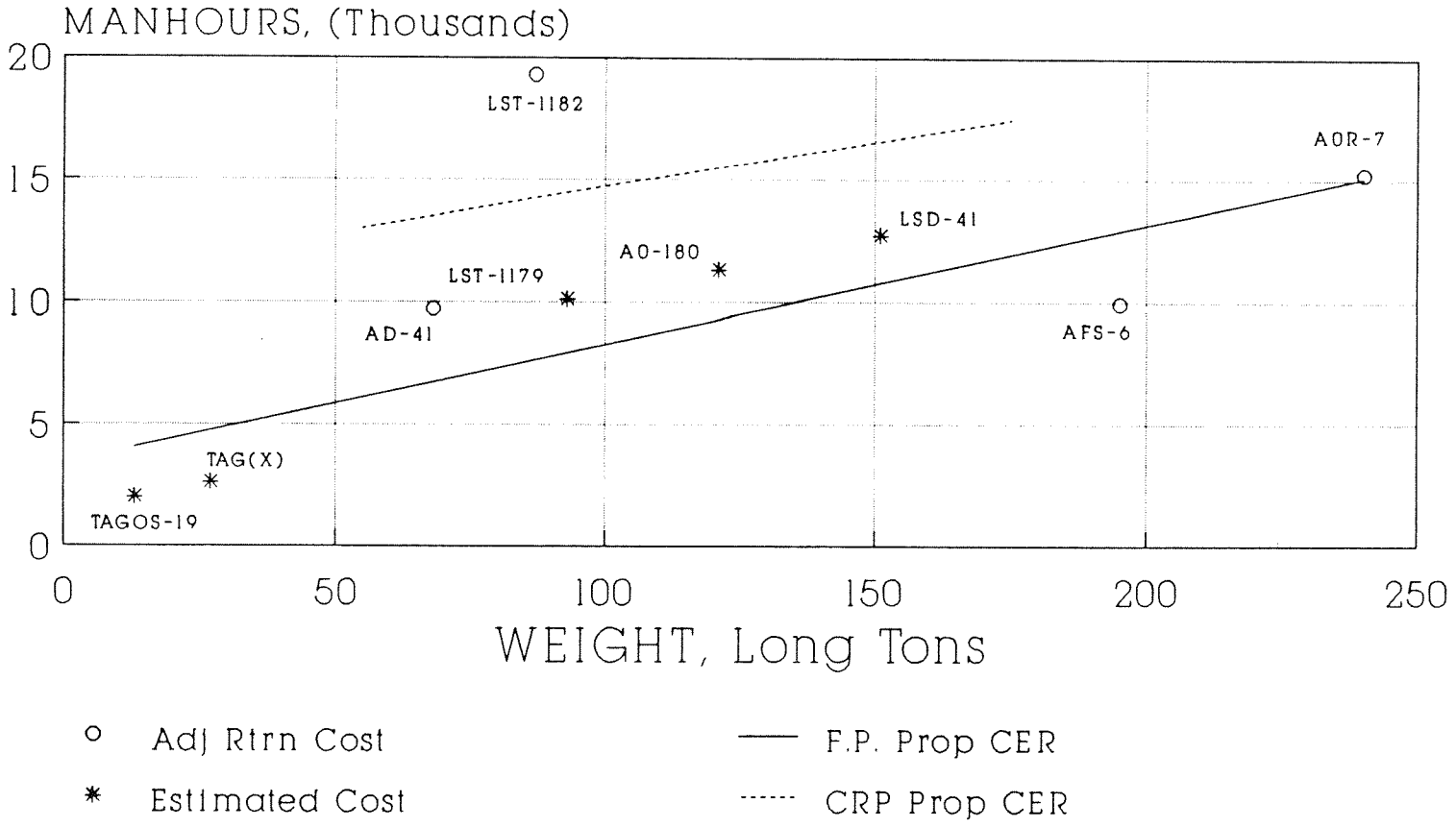


FIGURE 4-22

PROPULSION TRAIN SYSTEMS
GROUP 2B
LABOR

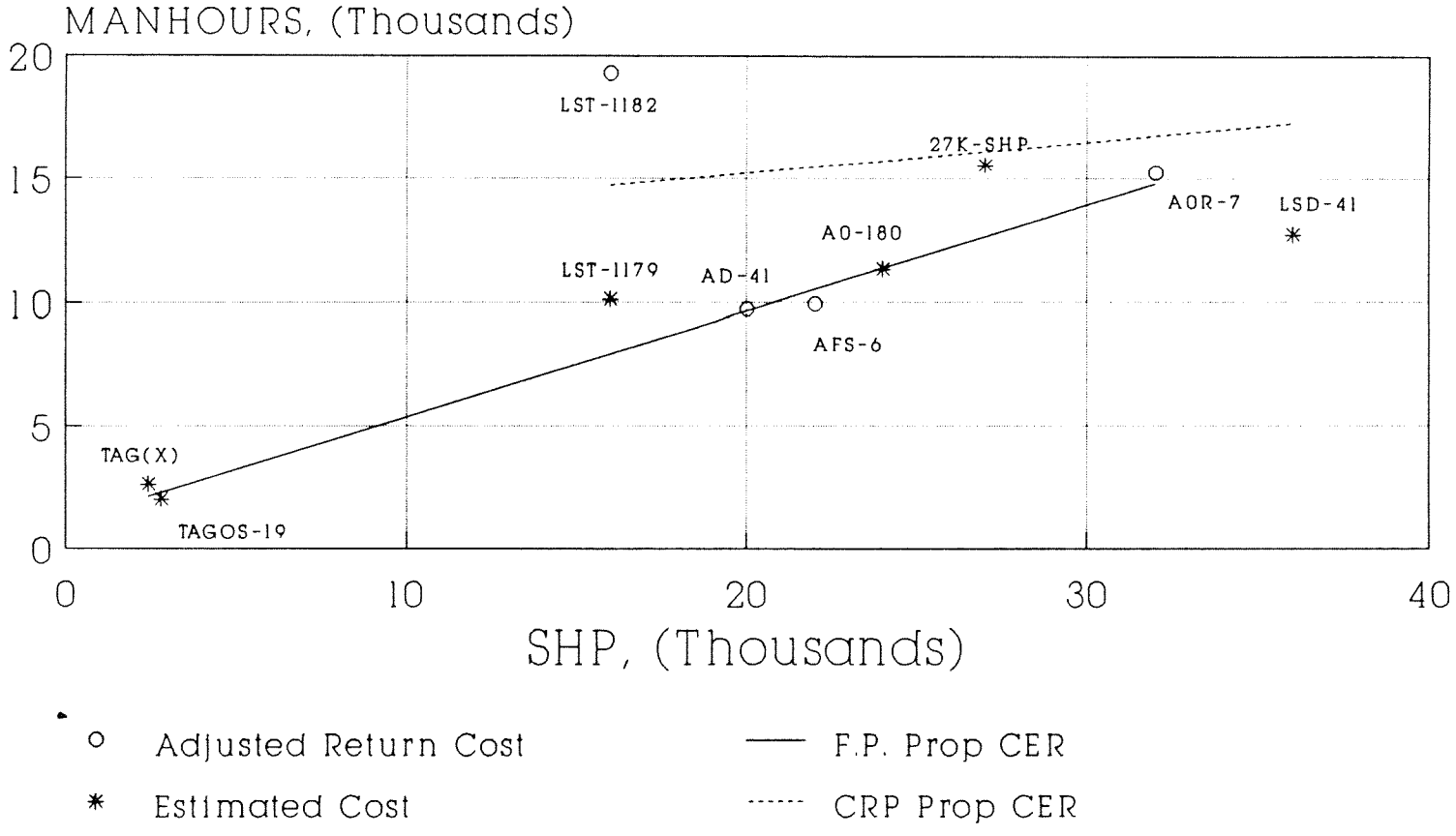


FIGURE 4-23

CER:	MH = 40 (WT) +11,000
Variable:	Group 2B WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Controllable pitch propeller

CER:	MH = .43 (SHP) + 1,100
Variable:	Shaft horsepower
Adjusted r^2:	.98 - 6 points
Application:	Fixed pitch propeller

CER:	MH = .13 (SHP) + 12,600
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Applications:	Controllable pitch propellers

4.3.3 - Group 2C - Propulsion Gases Systems

This group includes the combustion air system, uptakes, etc.

Material Costs - Two CER's are provided for material costs for Group 2C. One is based on Group 2C weight and one is based on shaft horsepower. The graphs for Group 2C material costs are shown in Figures 4-24 and 4-25 and the CER's for Group 2C material costs are:

CER:	$ = 13,380 (WT) + 1,000
Variable:	Group 2C WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	All ships

CER:	$ = 20 (SHP) + 10,300
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Application:	All ships

PROPULSION GASES SYSTEMS
GROUP 2C
MATERIALS COSTS

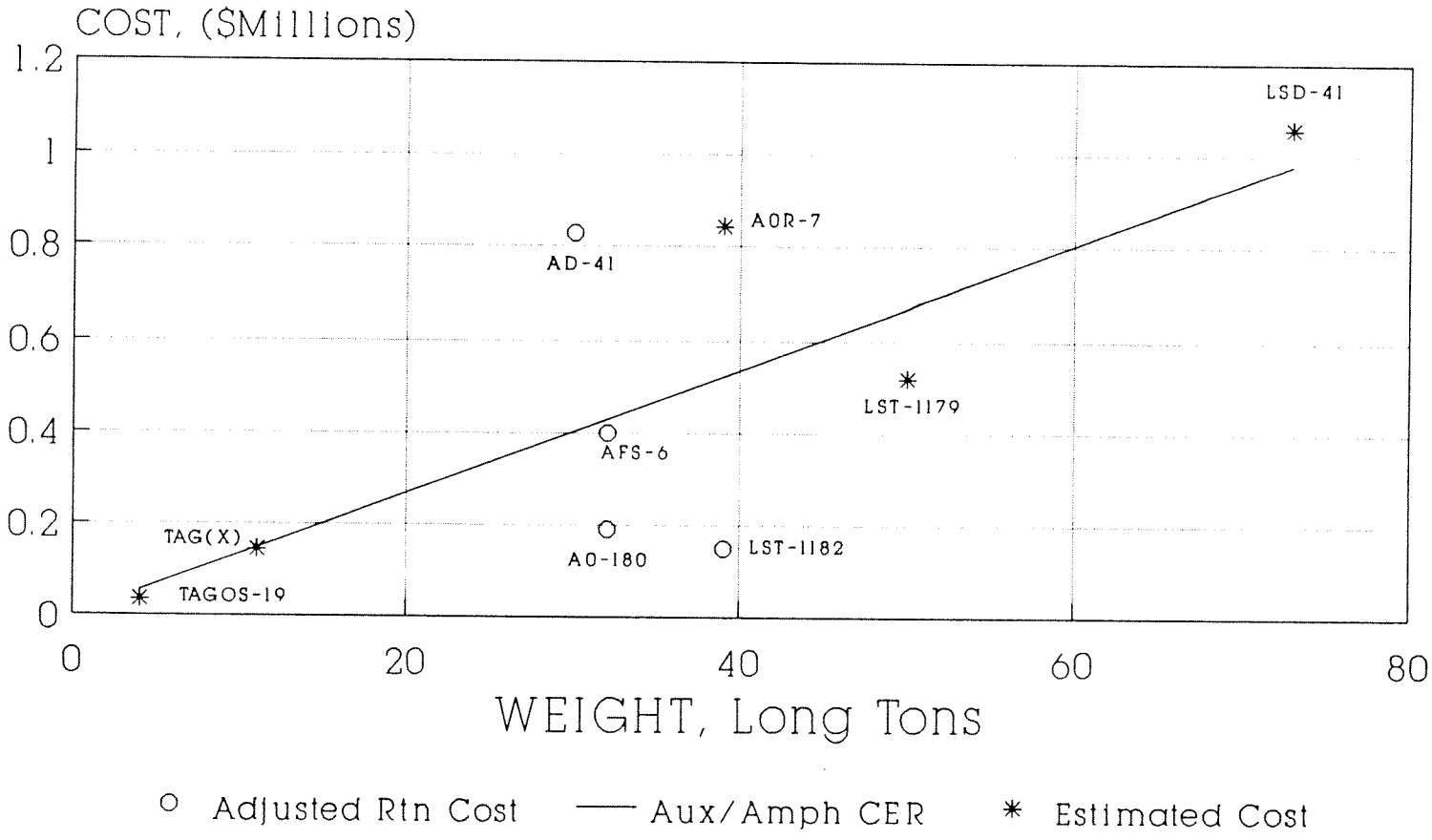


FIGURE 4-24

PROPULSION GASES SYSTEMS
GROUP 2C
MATERIALS COST

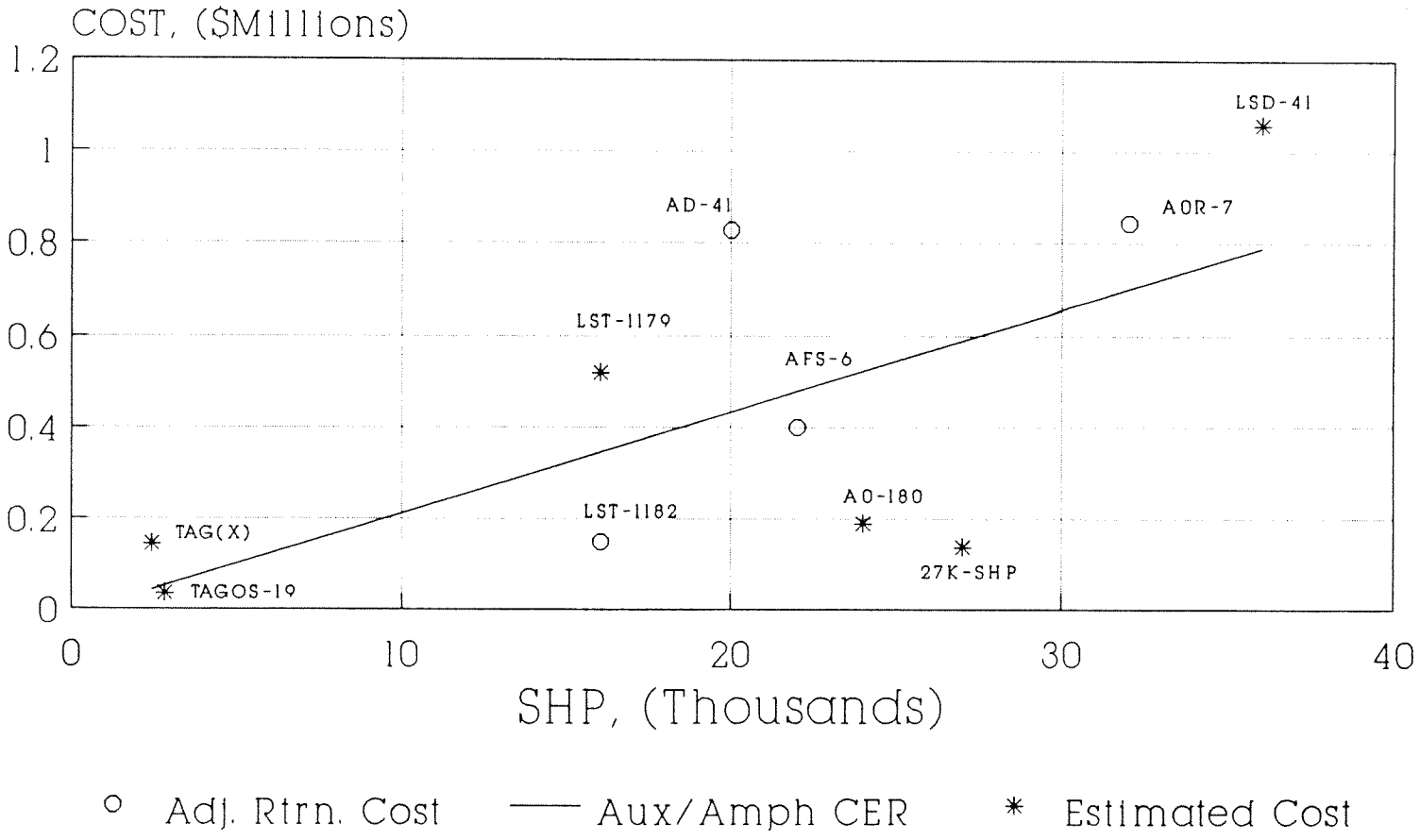


FIGURE 4-25

Labor Costs - Two CER's are provided for labor costs for Group 2C. Both are based on total shaft horsepower and are for the following conditions: steam geared turbine and geared diesel. The graph for Group 2C labor costs is shown in Figure 4-26 and the CER's for Group 2C labor costs are:

CER:	MH = 0.4 (SHP) + 1,200
Variable:	Shaft horsepower
Adjusted r^2:	.84 - 3 points
Application:	Steam geared turbine

CER:	MH = 0.4 (SHP) + 3,800
Variable:	Shaft horsepower
Adjusted r^2:	.04 - 6 points
Application:	Geared diesel

4.3.4 Group 2D Propulsion Service Systems

This group includes control systems, seawater circulating and cooling system, high pressure steam drain system, fuel service, and lube oil systems.

Material Costs - Four CER's are provided for material costs for Group 2D. Two are based on Group 2D weight and two on total shaft horsepower. In each case, the two CER's are for steam geared turbine and geared diesel ships. It should be noted that propulsion control systems costs are not included in this cost group. The graphs for Group 2D material costs are shown in Figures 4-27 and 4-28 and the CER's for Group 2D material costs are:

CER:	$ = 10,032 WT + 513,300
Variable:	Group 2D WT in long tons
Adjusted r^2:	.53 - 4 points
Application:	Steam geared turbine

CER:	$ = 24,221 WT + 57,700
Variable:	Group 2D WT in long tons
Adjusted r^2:	.68 - 5 points
Application:	Geared diesel

PROPULSION GASES SYSTEMS
GROUP 2C
LABOR

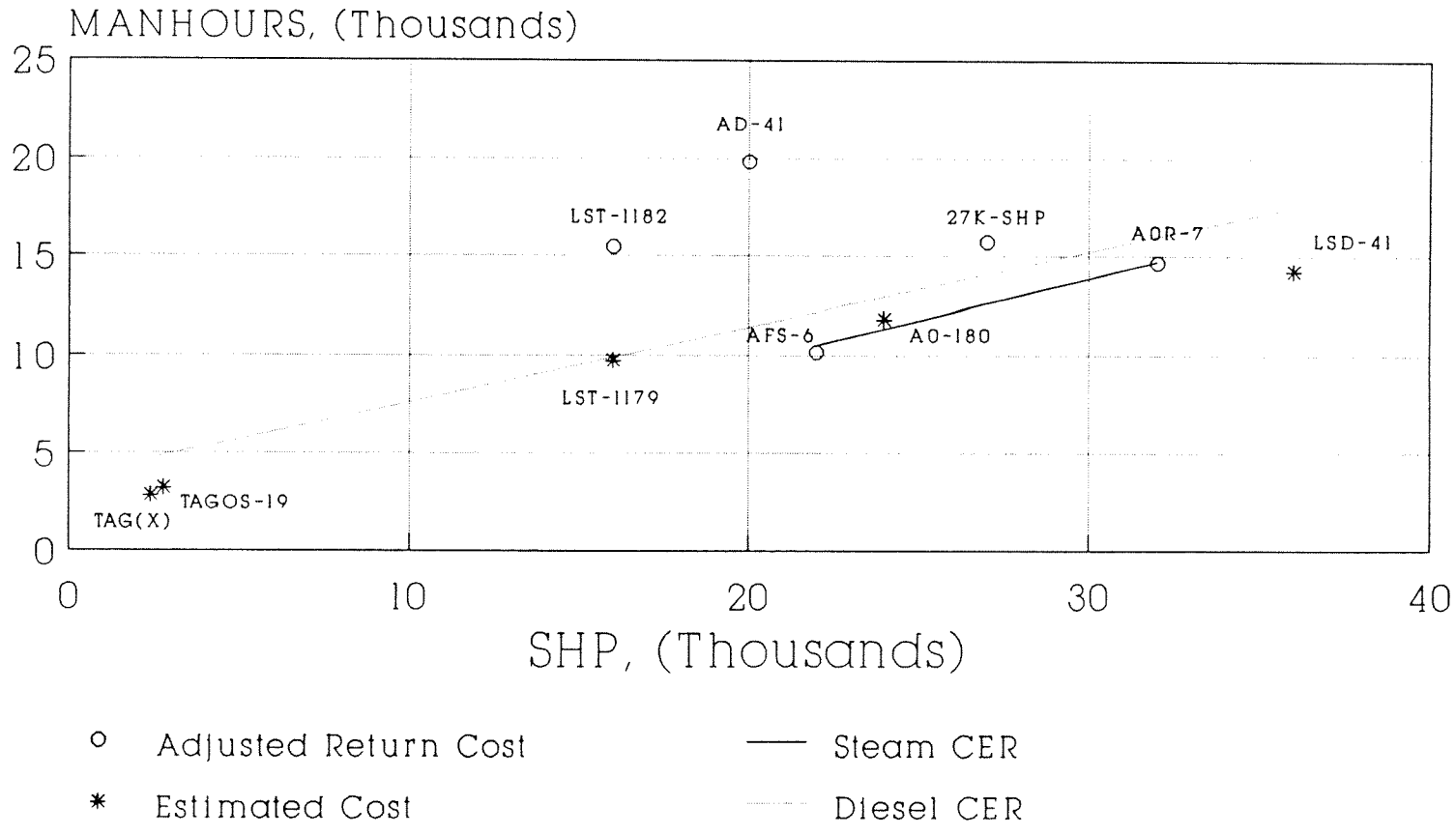
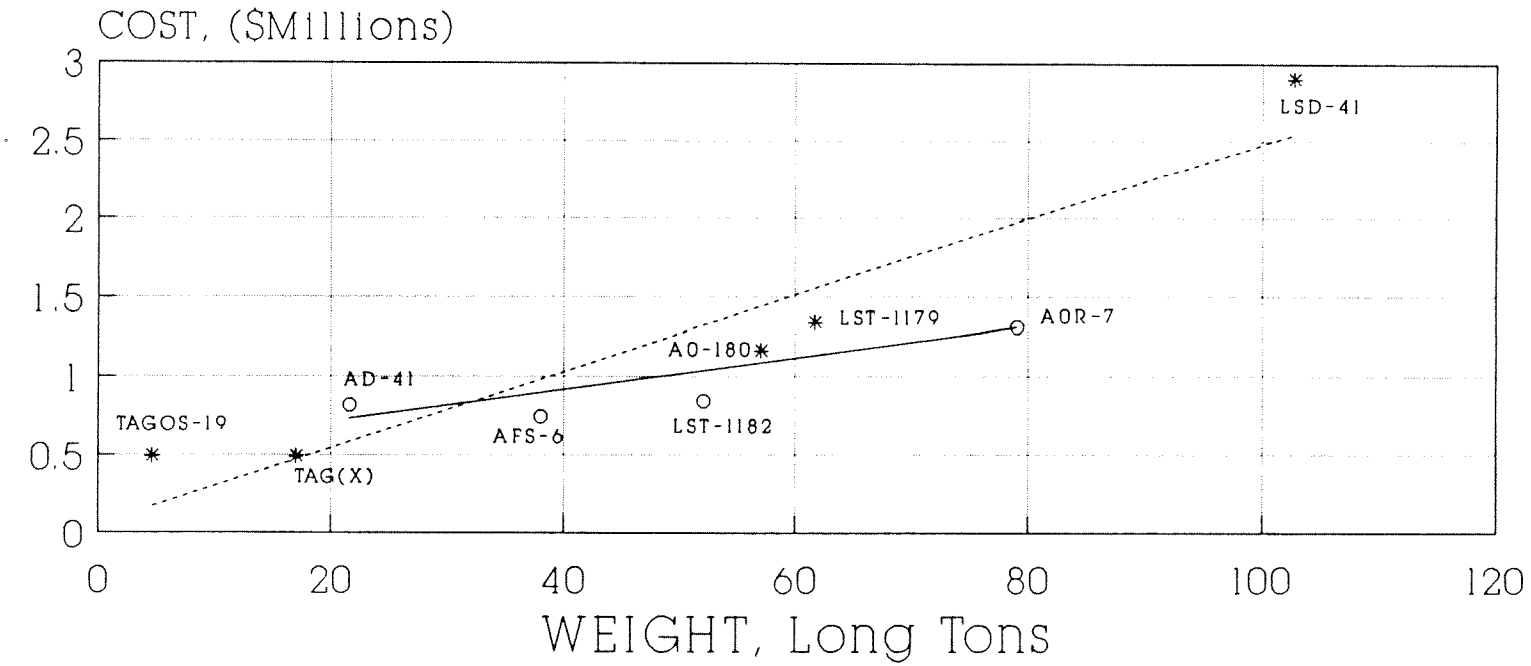


FIGURE 4-26

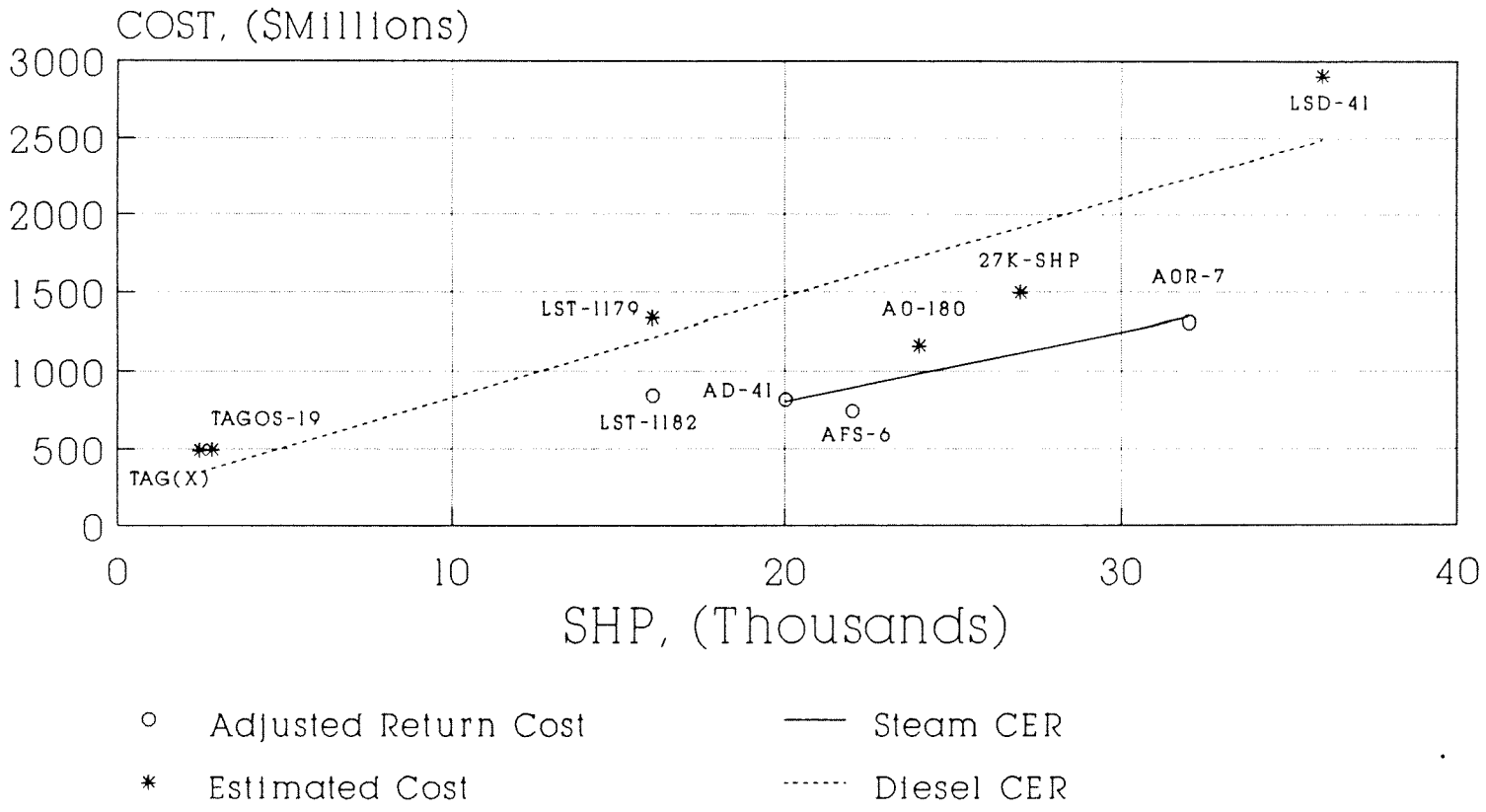
PROPULSION SERVICE SYSTEMS
GROUP 2D
MATERIALS COSTS



Cost and Weight of Control System Subtracted from all Ships

FIGURE 4-27

PROPULSION SERVICE SYSTEMS
GROUP 2D
MATERIALS COST



Cost of Control Systems Subtracted from All Ships

FIGURE 4-28

CER:	$ = 45 (SHP) - 88,200
Variable:	Shaft horsepower
Adjusted r^2:	.32 - 4 points
Application:	Steam geared turbine

CER:	$ = 64 (SHP) + 190,400
Variable:	Shaft horsepower
Adjusted r^2:	.70 - 6 points
Application:	Geared diesel

Labor Costs - Four CER's are provided for labor costs for Group 2D. Two are based on Group 2D weights and two are based on total shaft horsepower. In each case the CER's are for the following conditions: steam geared turbine and geared diesel ships. The graphs for the Group 2D labor costs are shown in Figures 4-29 and 4-30 and the CER's for the Group 2D labor costs are:

CER:	MH = 754 (WT) - 4,300
Variable:	Group 2D WT in long tons
Adjusted r^2:	.96 - 3 points
Application:	Steam geared turbine

CER:	MH = 270 (WT) + 6,600
Variable:	Group 2D WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Geared diesel

CER:	MH = 3 (SHP) - 35,600
Variable:	Shaft horsepower
Adjusted r^2:	.88 - 3 points
Application:	Steam geared turbine

CER:	MH = 0.9 (SHP) - 8,000
Variable:	Shaft horsepower
Adjusted r^2:	N/A - insufficient points
Application:	Geared diesel

PROPULSION SERVICE SYSTEM
GROUP 2D
LABOR

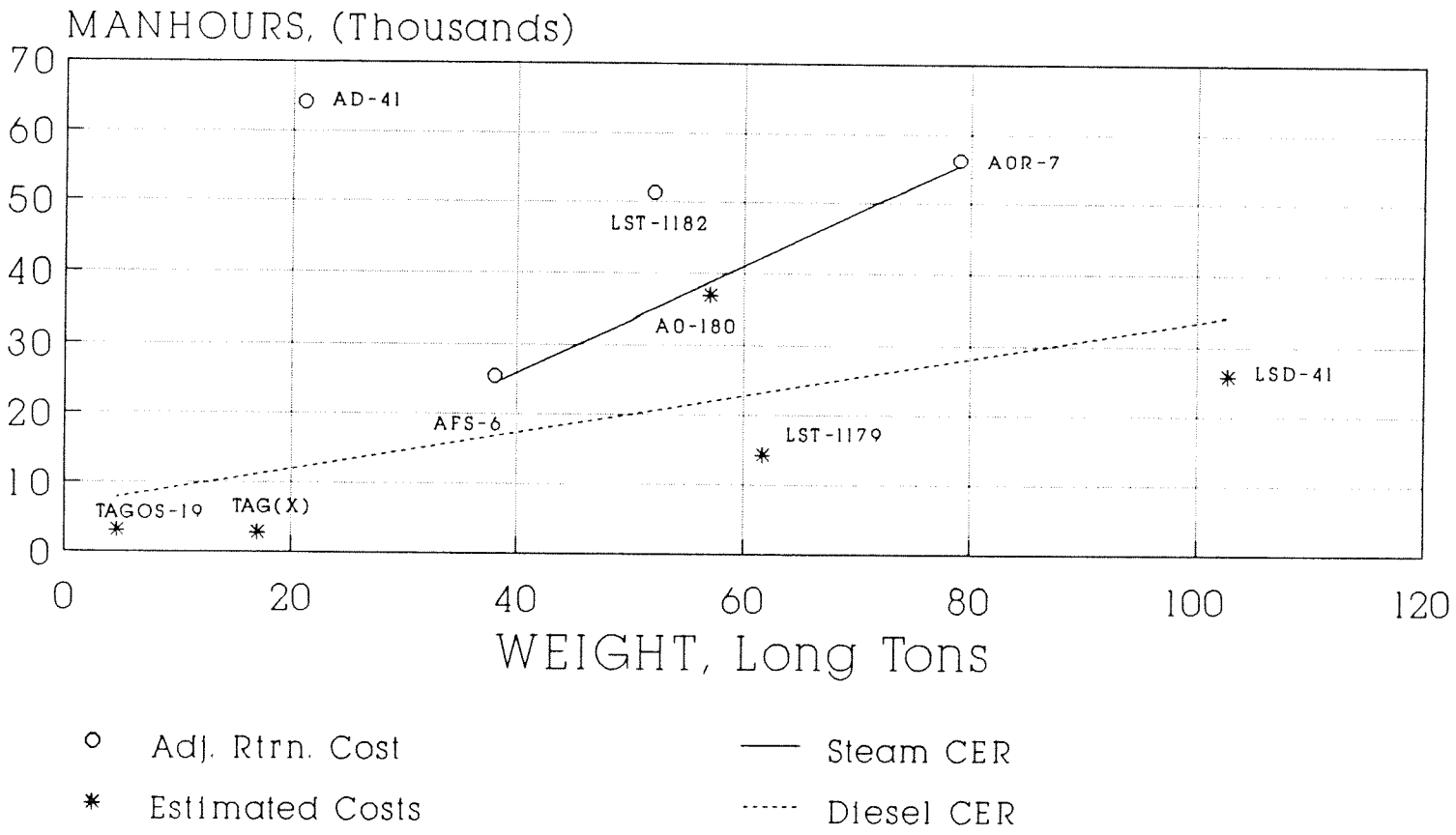


FIGURE 4-29

PROPULSION SERVICE SYSTEMS
GROUP 2D
LABOR

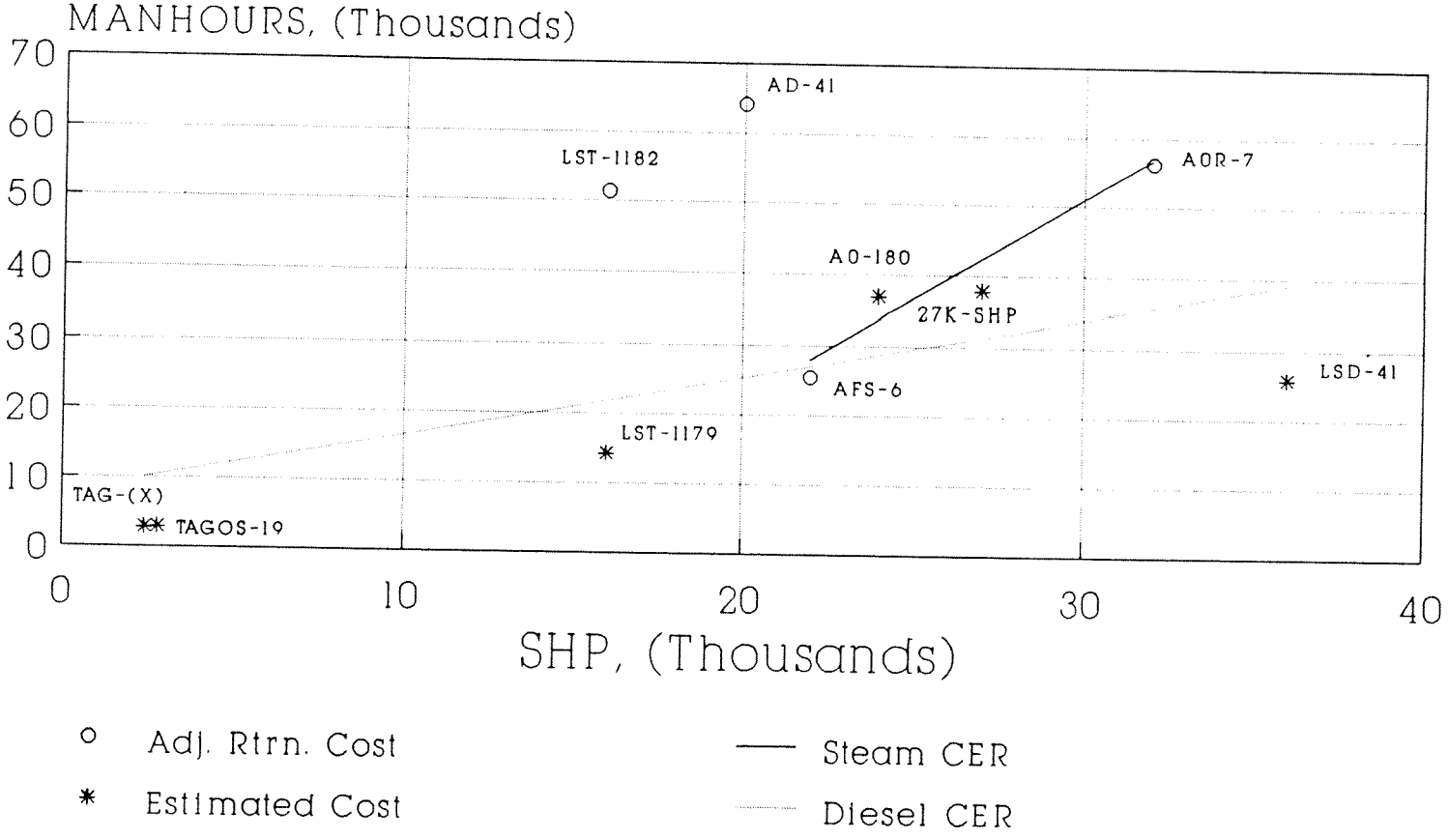


FIGURE 4-30

4.4 Group 3 - Electric Plant

This one digit SWBS Group includes the following two digit SWBS Groups:

Group 3A - Electrical Power Generation
Group 3B - Electrical Power Distribution

Material Costs - Four CER's are provided for material costs for Group 3. Two are based on Group 3 weight and two are based on the total installed generating capacity. In each case, the two CER's are for the following conditions: conventional auxiliary and amphibious ships, and commercial auxiliary and amphibious ships. The commercial ships use commercial design standards, equipment and material as opposed to military specifications. The graphs for the Group 3 material costs are shown in Figures 4-31 and 4-32 and the CER's for Group 3 material costs are:

CER:	$ = 7,435 (WT) + 4,108,100
Variable:	Group 3 WT in long tons
Adjusted r^2:	.55 - 5 points
Application:	Conventional ships

CER:	$ = 2,780 (WT) + 1,583,000
Variable:	Group 3 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Commercial ships

CER:	$ = 281 (KW) + 4,077,800
Variable:	Generating capacity in Kilowatts
Adjusted r^2:	.70 - 6 points
Application:	Conventional ships

CER:	$ = 113 (KW) + 1,632,400
Variable:	Generating capacity in Kilowatts
Adjusted r^2:	N/A - insufficient points
Application:	Commercial ships

ELECTRIC PLANT
GROUP 3
MATERIALS COST

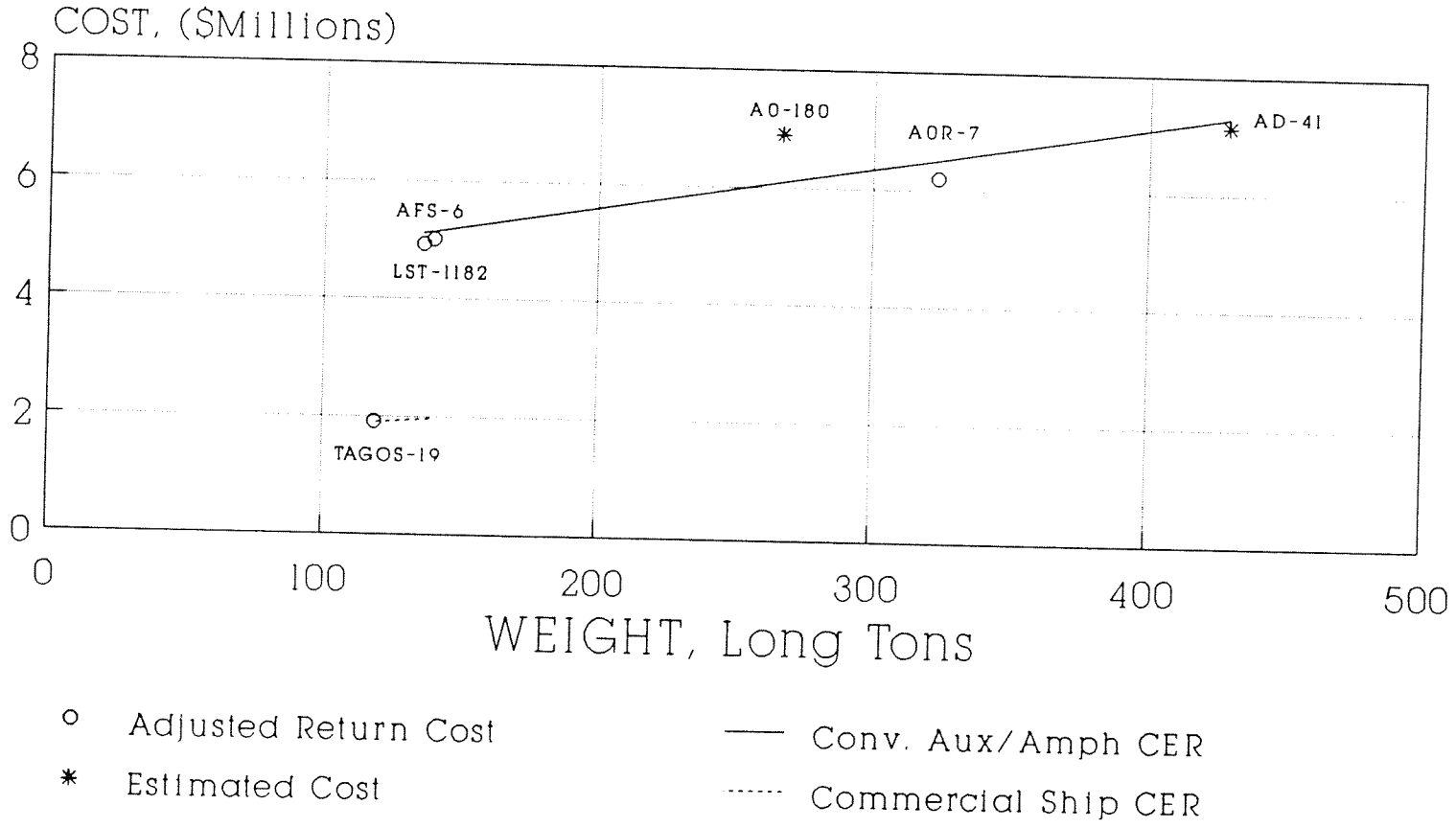


FIGURE 4-31

ELECTRIC PLANT
GROUP 3
MATERIALS COST

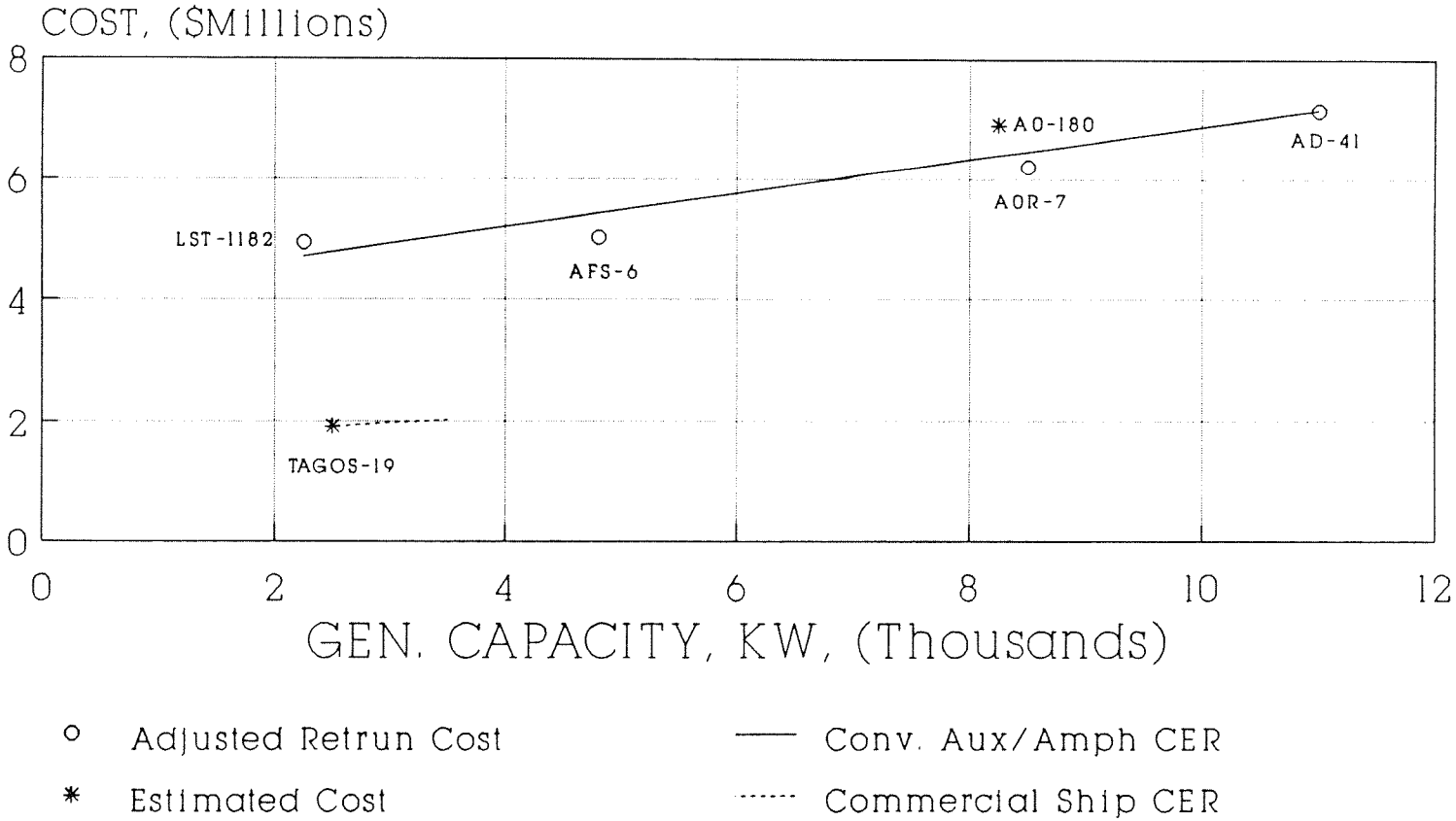


FIGURE 4-32

Labor Costs - Two CER's are provided for labor costs for Group 3. One is based on Group 3 weight and one is based on total installed generating capacity. The graphs for the Group 3 labor costs are shown in Figures 4-33 and 4-34 and the CER's for the Group 3 labor costs are:

CER:	MH = 903 (WT) - 78,000
Variable:	Group 3 WT in long tons
Adjusted r^2:	.77 - 6 points
Application:	All ships

CER:	MH = 30 (KW) - 54,200
Variable:	Installed generating capacity in Kilowatts
Adjusted r^2:	.61 - 6 points
Application:	All ships

4.4.1 Group 3A-Electric Plant

This group includes ship service power generation, emergency generators, power conversion equipment, diesel and turbine support systems.

Material Costs - Two CER's are provided for material costs for Group 3A. One is based on Group 3A weight and one on total installed generating capacity. The graphs for Group 3A are shown in Figures 4-35 and 4-36, and the CER's for Group 3A material costs are:

CER:	$ = 21,432 (WT) + 207,900
Variable:	Group 3A WT in long tons
Adjusted r^2:	.60 - 6 points
Application:	All ships

CER:	$ = 267 (KW) + 626,200
Variable:	Generating capacity in Kilowatts
Adjusted r^2:	.90 - 6 ships
Application:	All ships

ELECTRIC PLANT
GROUP 3
LABOR

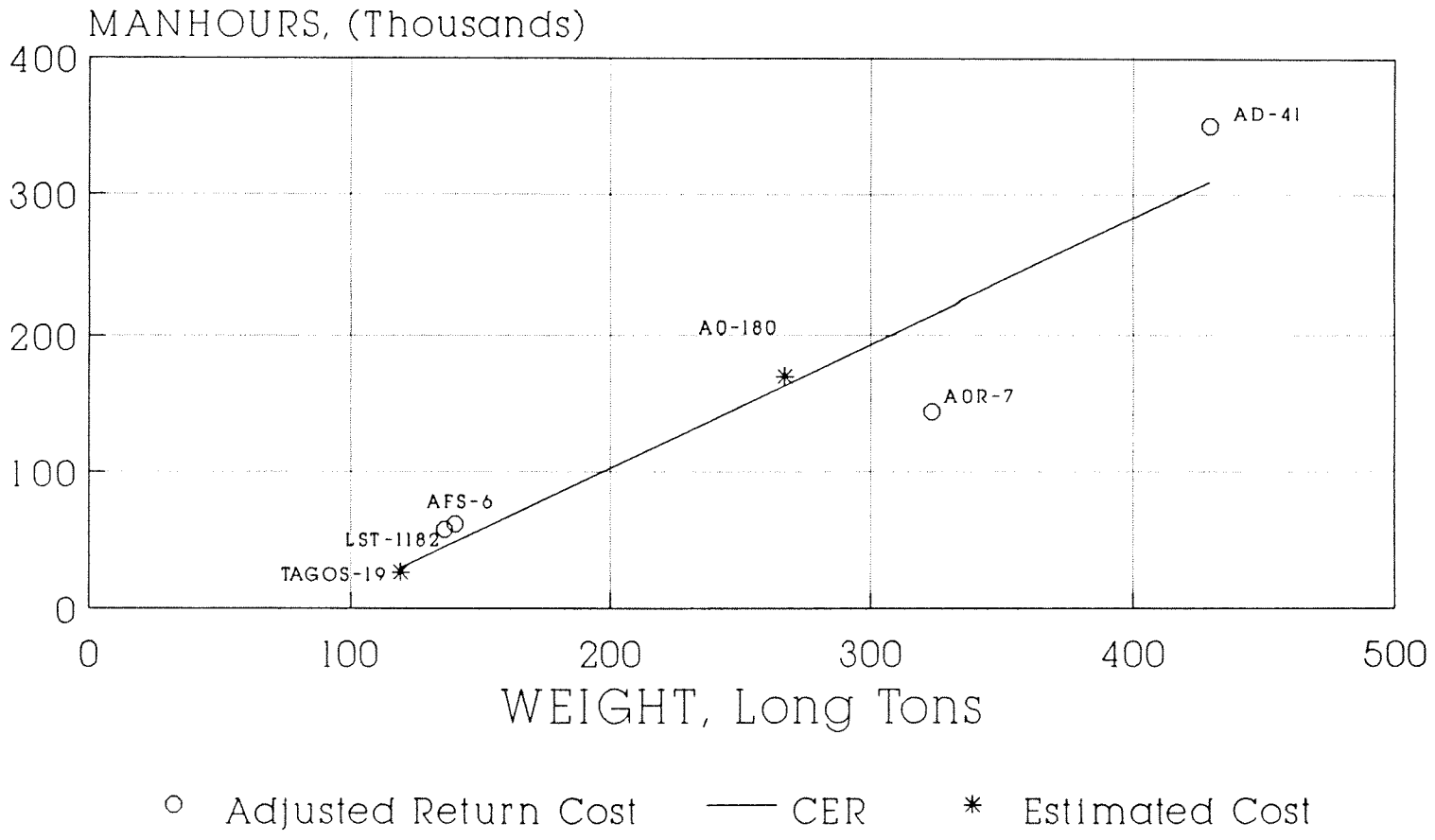


FIGURE 4-33

ELECTRIC PLANT
GROUP 3
LABOR

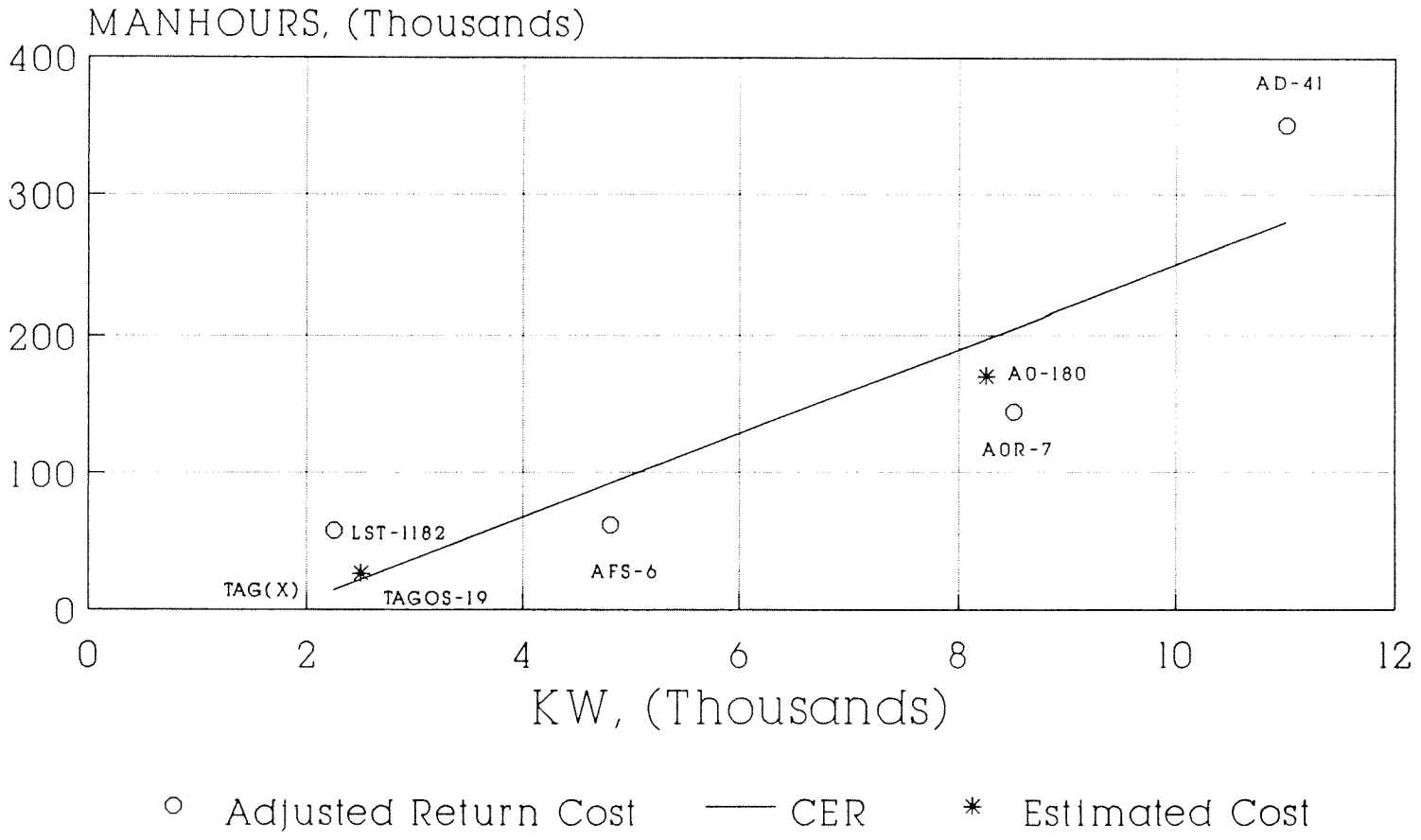


FIGURE 4-34

ELECTRICAL POWER GENERATION
GROUP 3A
MATERIALS COST

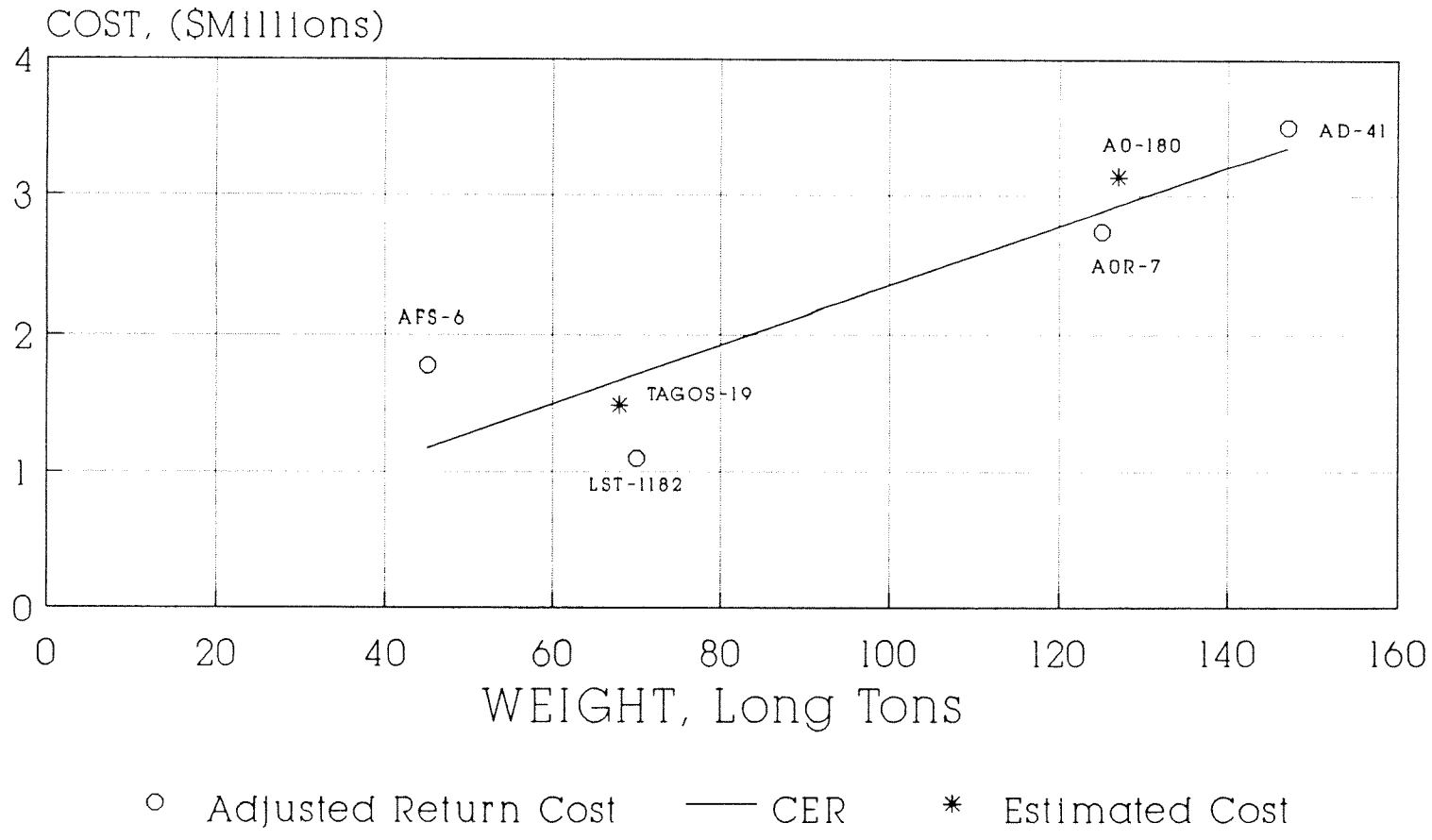


FIGURE 4-35

ELECTRICAL POWER GENERATION
GROUP 3A
MATERIALS COST

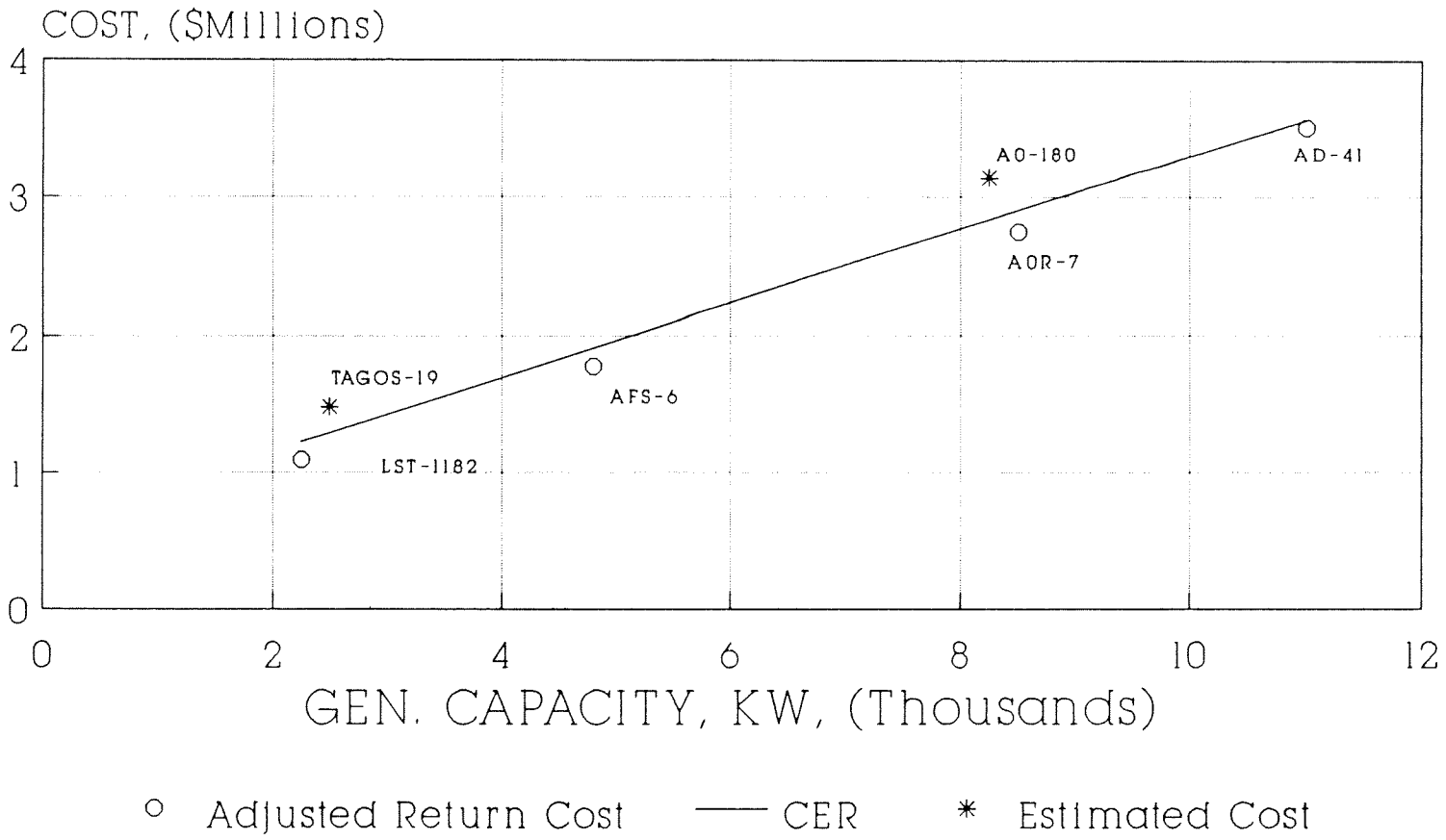


FIGURE 4-36

Labor Costs - Four CER's are provided for labor costs for Group 3A. Two are based on Group 3A weight and two are based on total installed generating capacity. The CER's are for the following conditions: steam turbine generators, diesel generators. The graphs for Group 3A labor costs are shown in Figures 4-37 and 4-38 and the CER's for Group 3A labor costs are:

CER:	MH = 34 (WT) - 2,800
Variable:	Group 3A WT in long tons
Adjusted r^2:	.41 - 3 points
Application:	Steam turbine generators
CER:	MH = 40 (WT) - 500
Variable:	Group 3A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Diesel generators
CER:	MH = .29 (KW) - 900
Variable:	Installed generating capacity in Kilowatts
Adjusted r^2:	.73 - 3 points
Application:	Steam turbine generators
CER:	MH = .13 (KW) + 1,300
Variable:	Installed generating capacity in Kilowatts
Adjusted r^2:	N/A - insufficient points
Application:	Diesel generators

4.4.2 Group 3B-Electrical Power Distribution

This group includes lighting distribution and fixtures

Material Costs - Four CER's are provided for material costs for Group 3B. Two are based on Group 3B weights and two are based on total ship's volume. In both cases the two CER's are for conventional auxiliary and amphibious ships and commercial auxiliary and amphibious ships. The graphs for Group 3B material costs are shown in Figures 4-39 and 4-40 and the CER's for Group 3B material costs are:

ELECTRICAL POWER GENERATION
GROUP 3A
LABOR

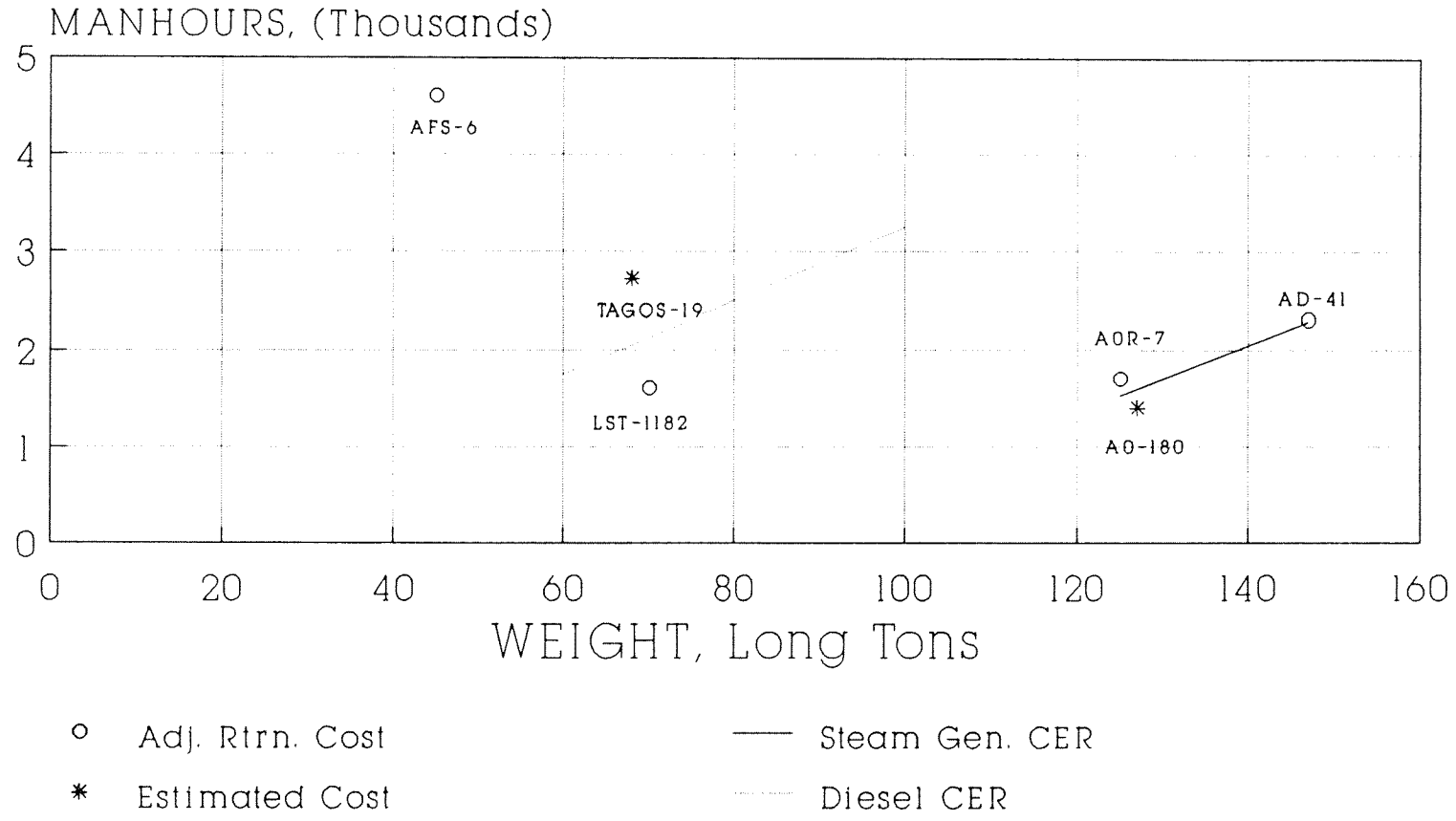


FIGURE 4-37

ELECTRICAL POWER GENERATION
GROUP 3A
LABOR

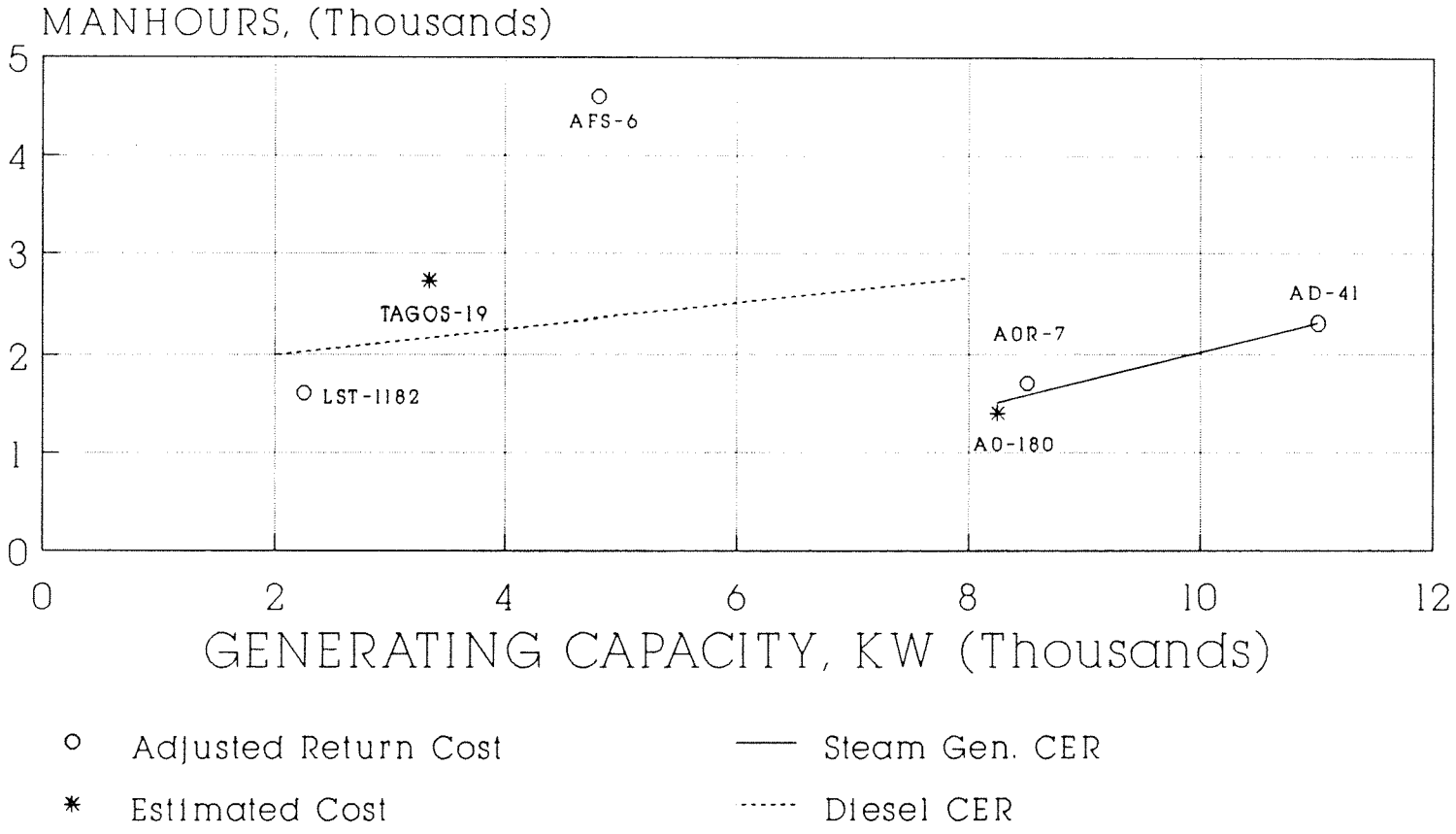


FIGURE 4-38

ELECTRICAL POWER DISTRIBUTION
GROUP 3B
MATERIALS COST

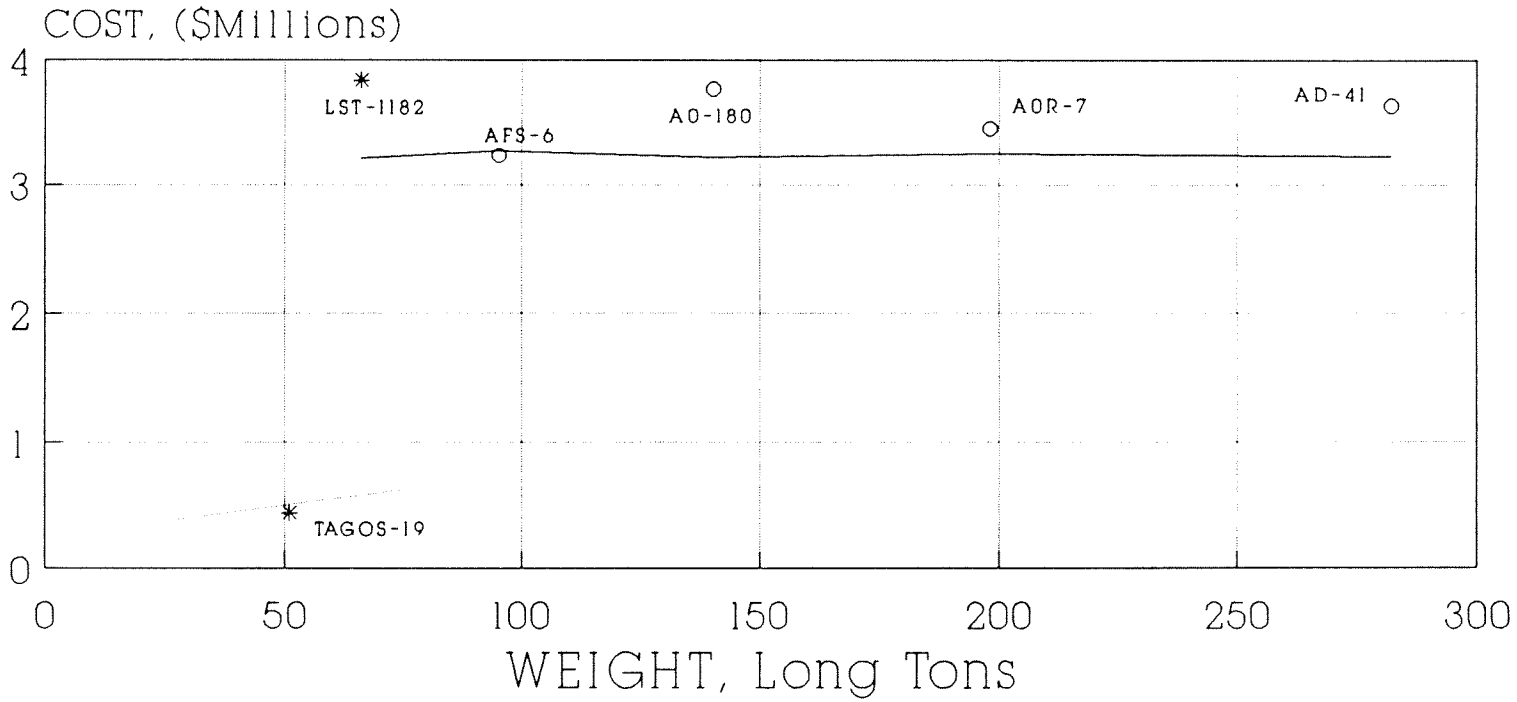


FIGURE 4-39

ELECTRICAL POWER DISTRIBUTION
GROUP 3B
MATERIALS COST

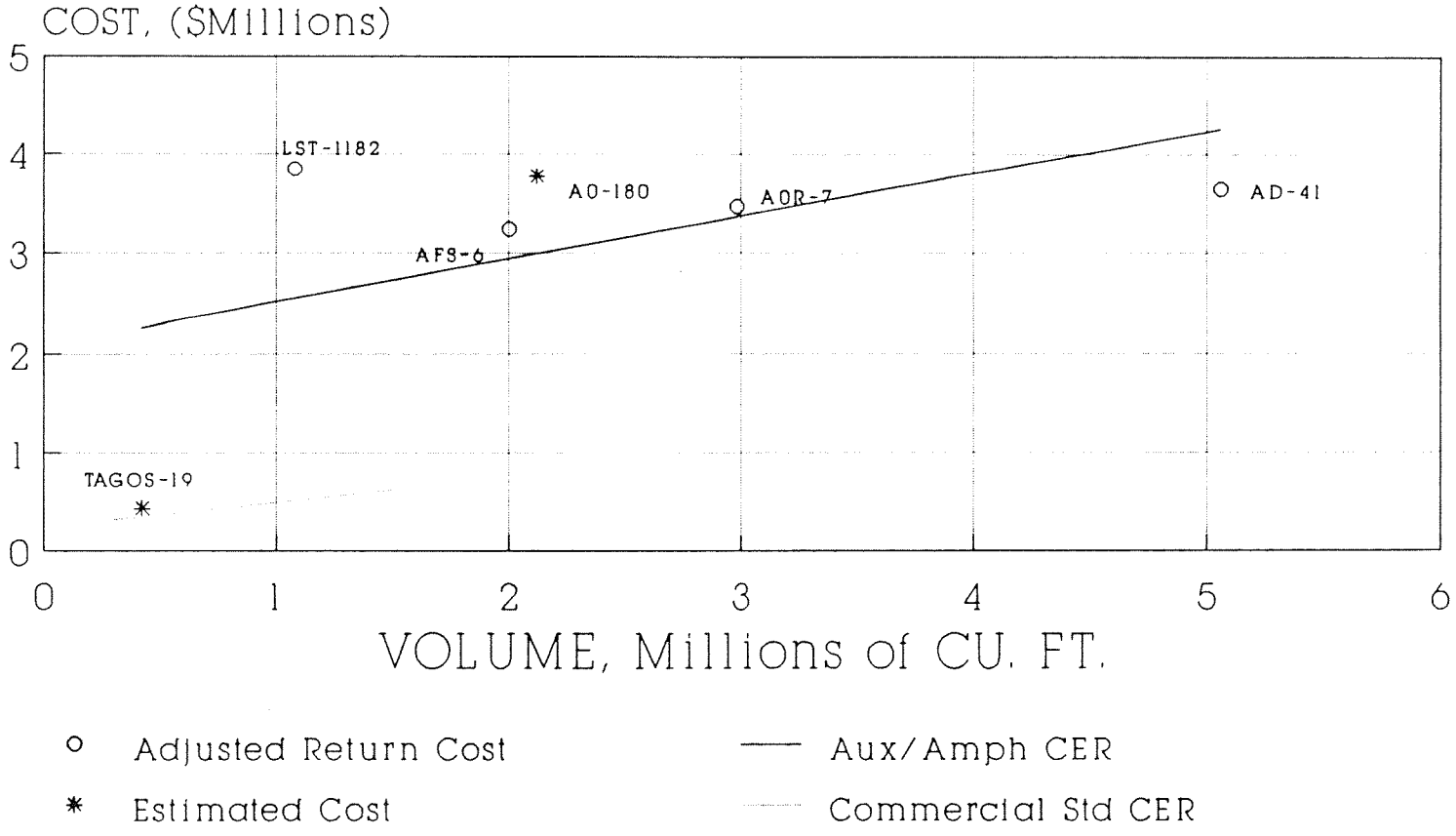


FIGURE 4-40

CER	=	$ = 7,025 (WT) + 2,086,100
Variable	=	Group 3B WT in long tons
Adjusted r^2	=	N/A - insufficient points
Application	=	Conventional ships

CER	=	$ = 5 (WT) + 300
Variable	=	Group 3B WT in long tons
Adjusted r^2	=	N/A - insufficient points
Application	=	Commercial ships

CER	=	$ = 0.43 (VOL) + 2,082,600
Variable	=	Total ship's volume in cubic feet
Adjusted r^2	=	N/A-insufficient points
Application	=	Conventional ships

CER	=	$ = 250 (VOL) + 300
Variable	=	Total ship's volume in cubic feet
Adjusted r^2	=	N/A - insufficient points
Application	=	Commercial ships

Labor Costs - Two CER's are provided for labor costs for Group 3B. One is based on Group 3B weight and one is based on total ship's volume. The graphs for Group 3B labor costs are shown in Figures 4-41 and 4-42 and the CER's for Group 3B labor costs are:

CER	=	MH = 1,285 (WT) - 45,700
Variable	=	Group 3B WT in long tons
Adjusted r^2	=	.77 - 6 points
Application	=	All ships

CER	=	MH = .07 (VOL) - 25,600
Variable	=	Total ship's volume in cubic feet
Adjusted r^2	=	.74 - 6 points
Application	=	All ships

ELECTRICAL POWER DISTRIBUTION
GROUP 3B
LABOR

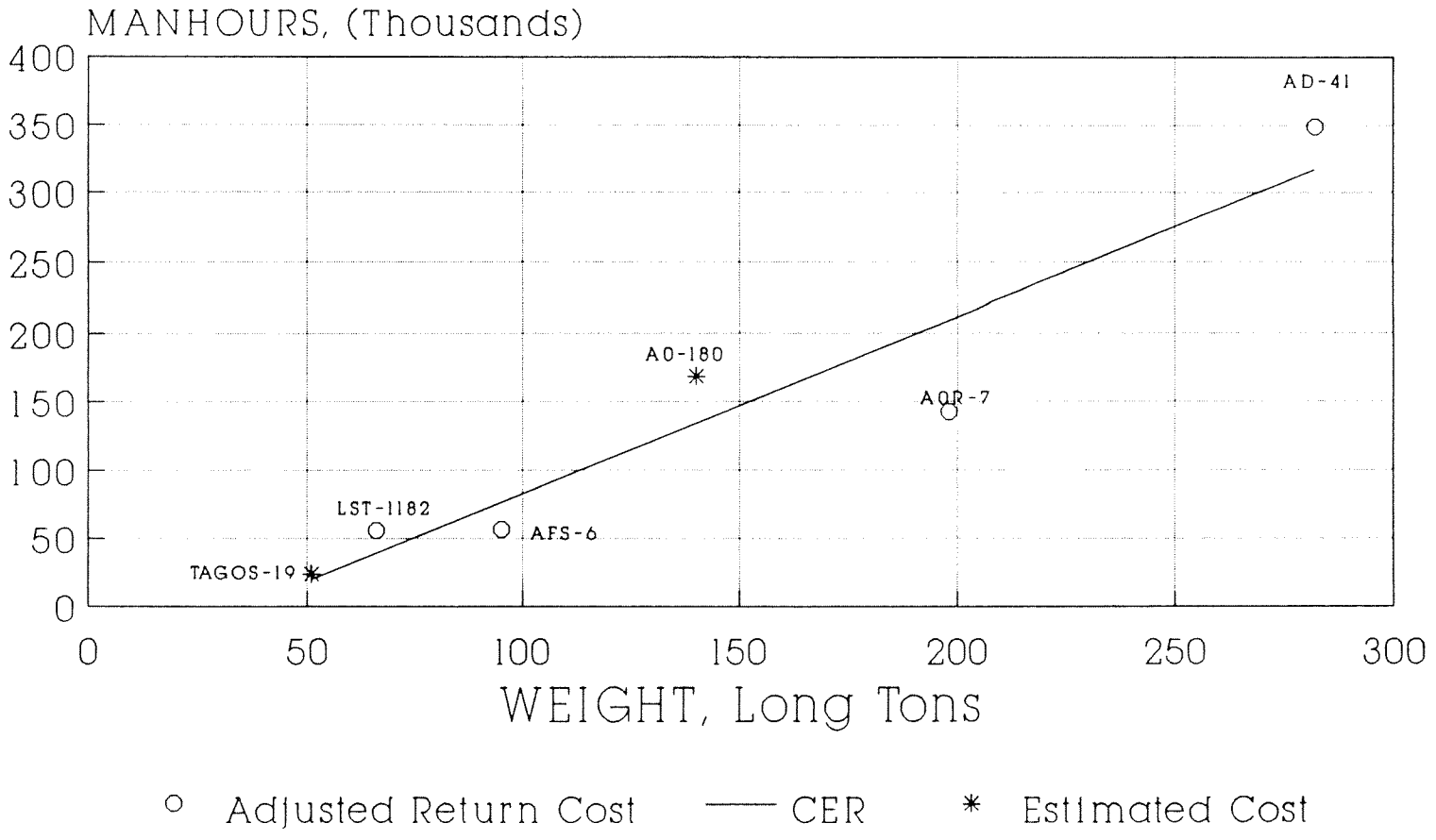


FIGURE 4-41

ELECTRICAL POWER DISTRIBUTION
GROUP 3B
LABOR

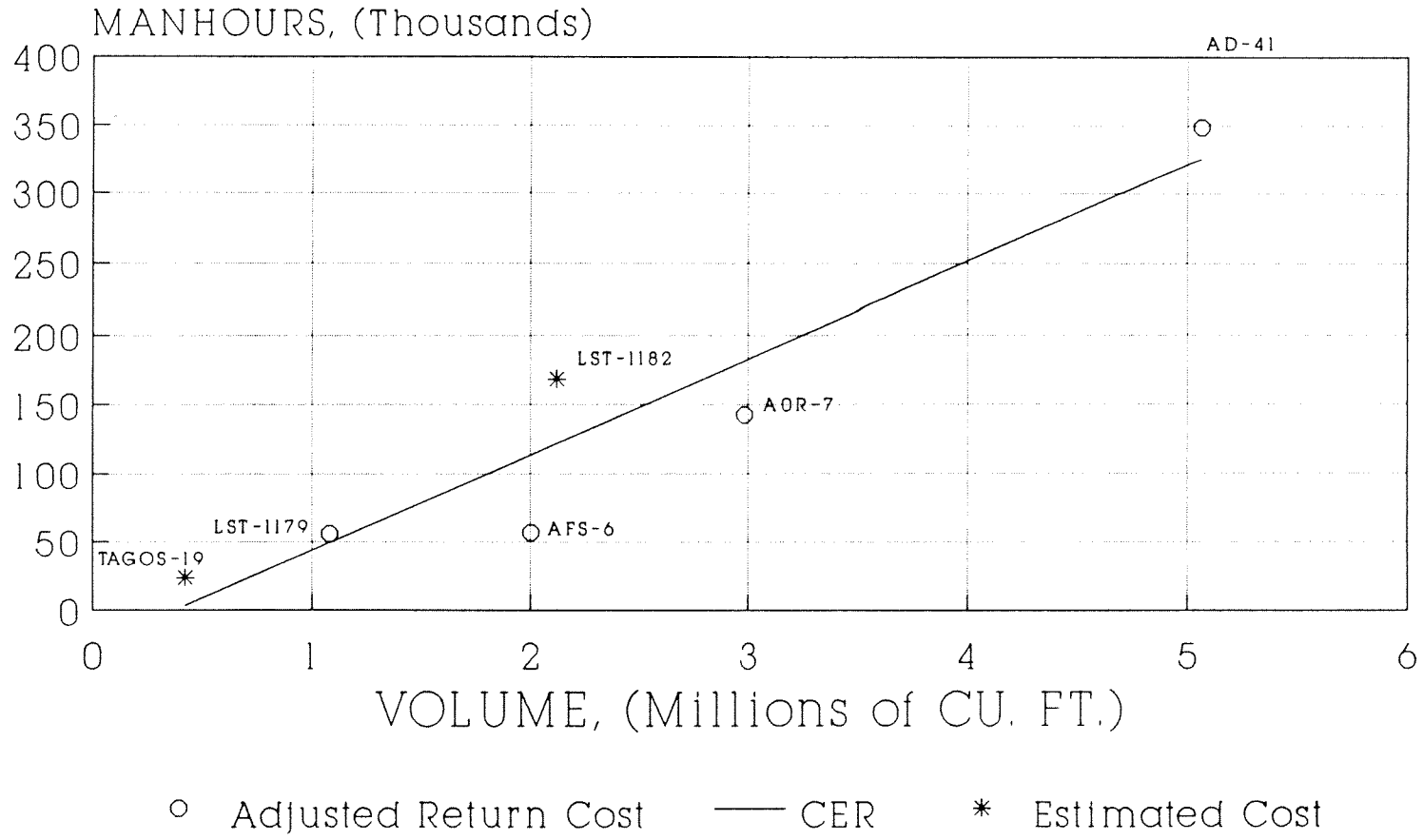


FIGURE 4-42

4.5 Group 4 - Command and Surveillance

This one digit SWBS Group includes the following two two digit SWBS Groups:

Group 4A - Vehicle Command
Group 4B - Weapons Command

Material Costs - No discernible CER could be identified that established a trend for Group 4. As such, a consistent value of $ = $1.1 million should be used for estimating Group 4 material costs for all ships. The graph for Group 4 material costs versus Group 4 weight is shown in Figure 4-43.

Labor Costs - A single CER is provided for labor costs for Group 4. This CER is based on total ship volume. The graph for the Group 4 labor costs is shown in Figure 4-44 and the CER for Group 4 labor costs is:

CER:	MH = 0.012 (VOL) - 24,800
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.21 - 6 points
Application:	All ships

4.5.1 Group 4A - Vehicle Command

This group includes navigation equipment, interior communication, and countermeasure systems such as degaussing.

Material Costs - Two CER's are provided for material costs for Group 4A. One is for costs based on Group 4A weight and one is for costs based on total ship volume. The graphs for Group 4A material costs are shown in Figures 4-45 and 4-46 and the CER's for Group 4A material costs are:

COMMAND AND SURVEILLANCE
GROUP 4
MATERIALS COST

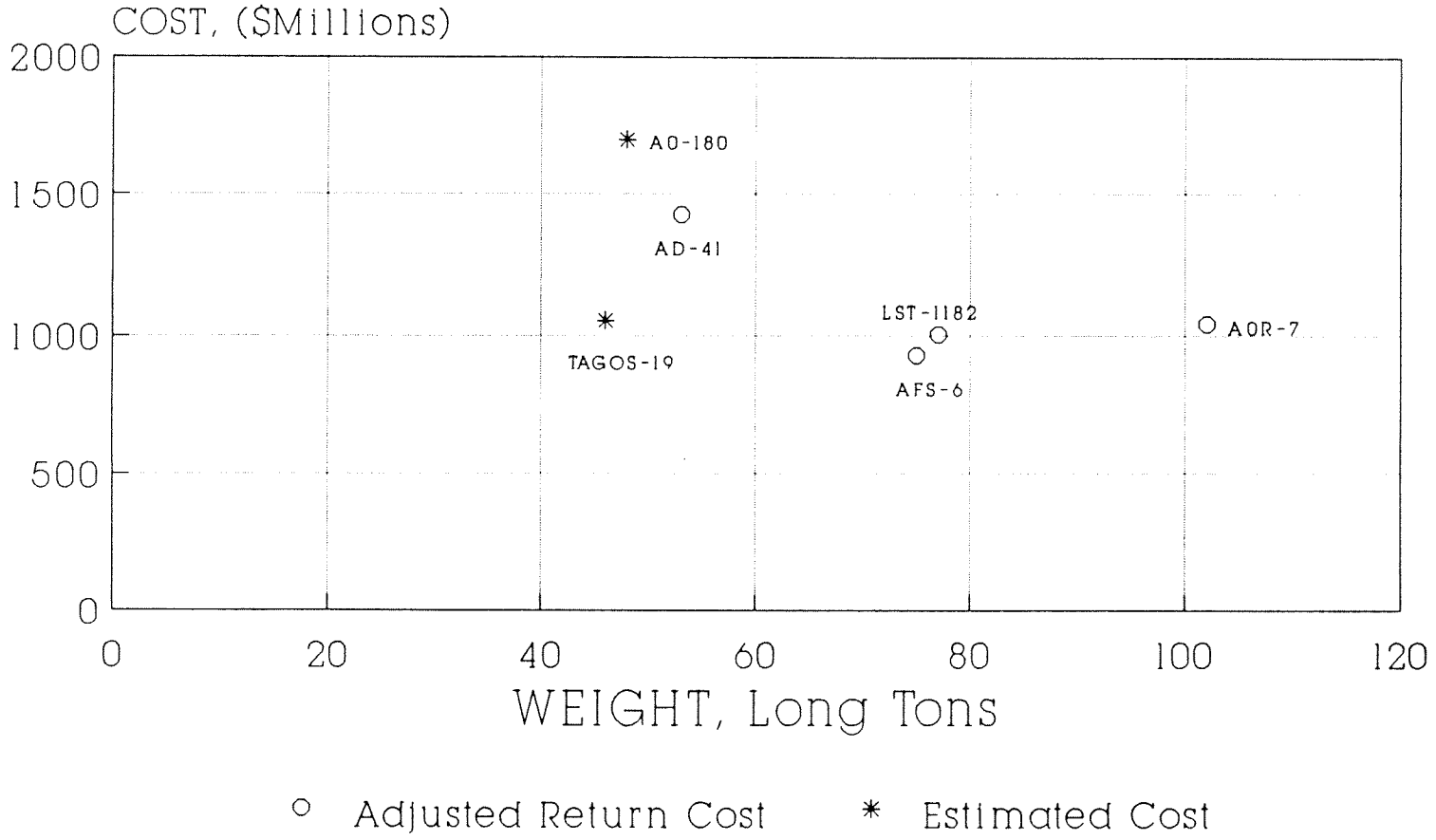


FIGURE 4-43

COMMAND AND SURVEILLANCE
GROUP 4
LABOR

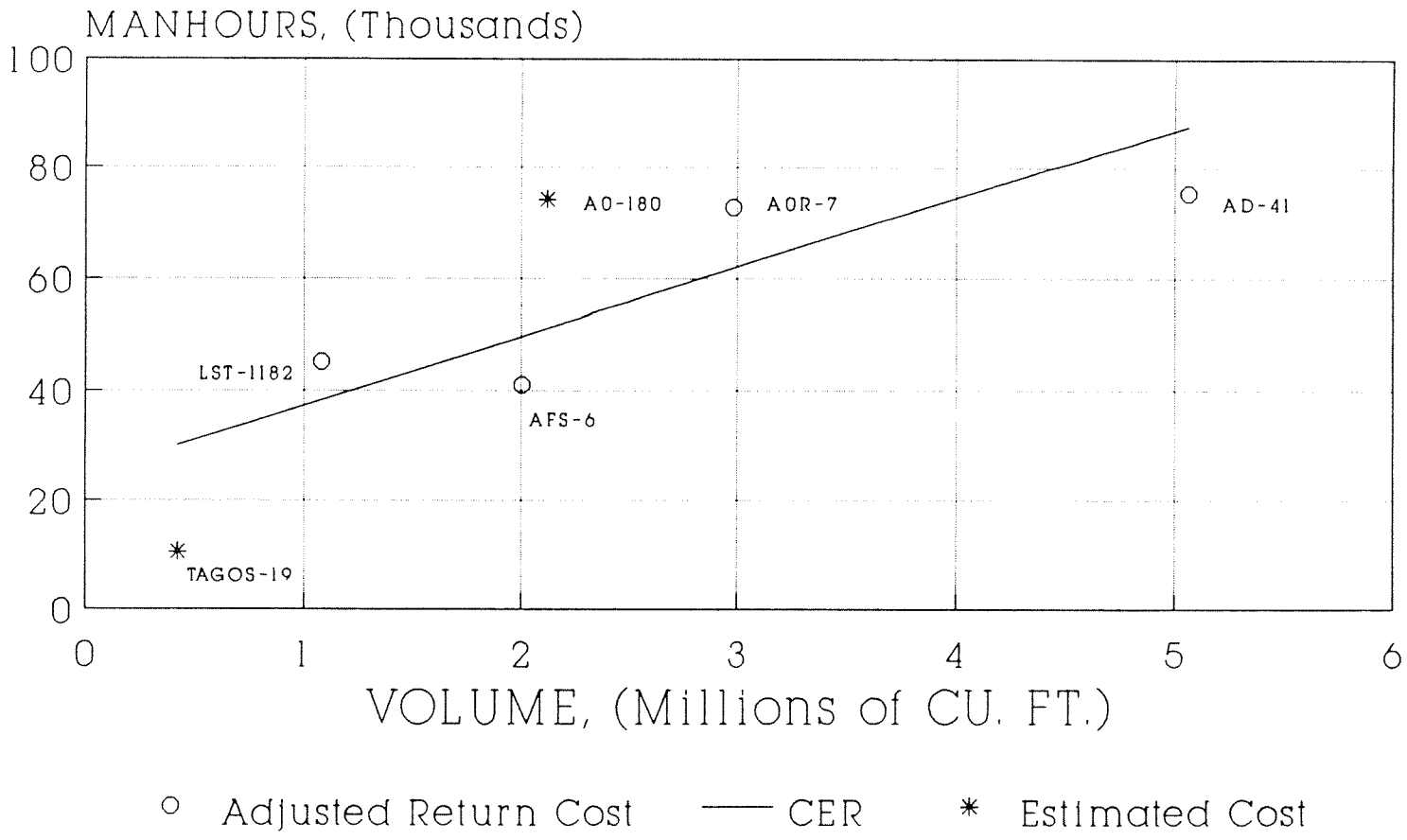
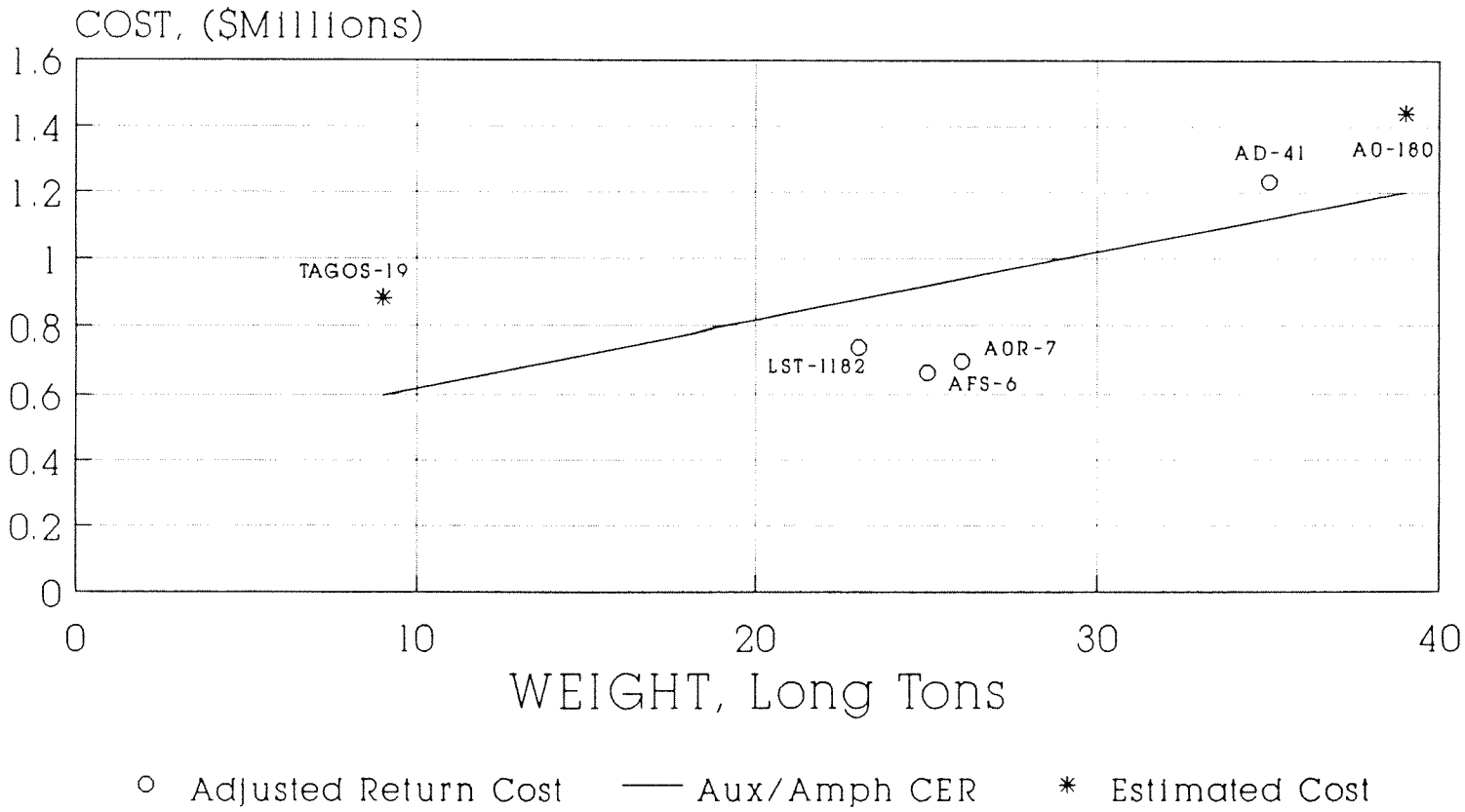


FIGURE 4-44

VEHICLE COMMAND
GROUP 4A
MATERIALS COST



Weight and Cost for Degaussing System
Subtracted from LST-1182, AFS-6, AOR-7

FIGURE 4-45

VEHICLE COMMAND
GROUP 4A
MATERIALS COST

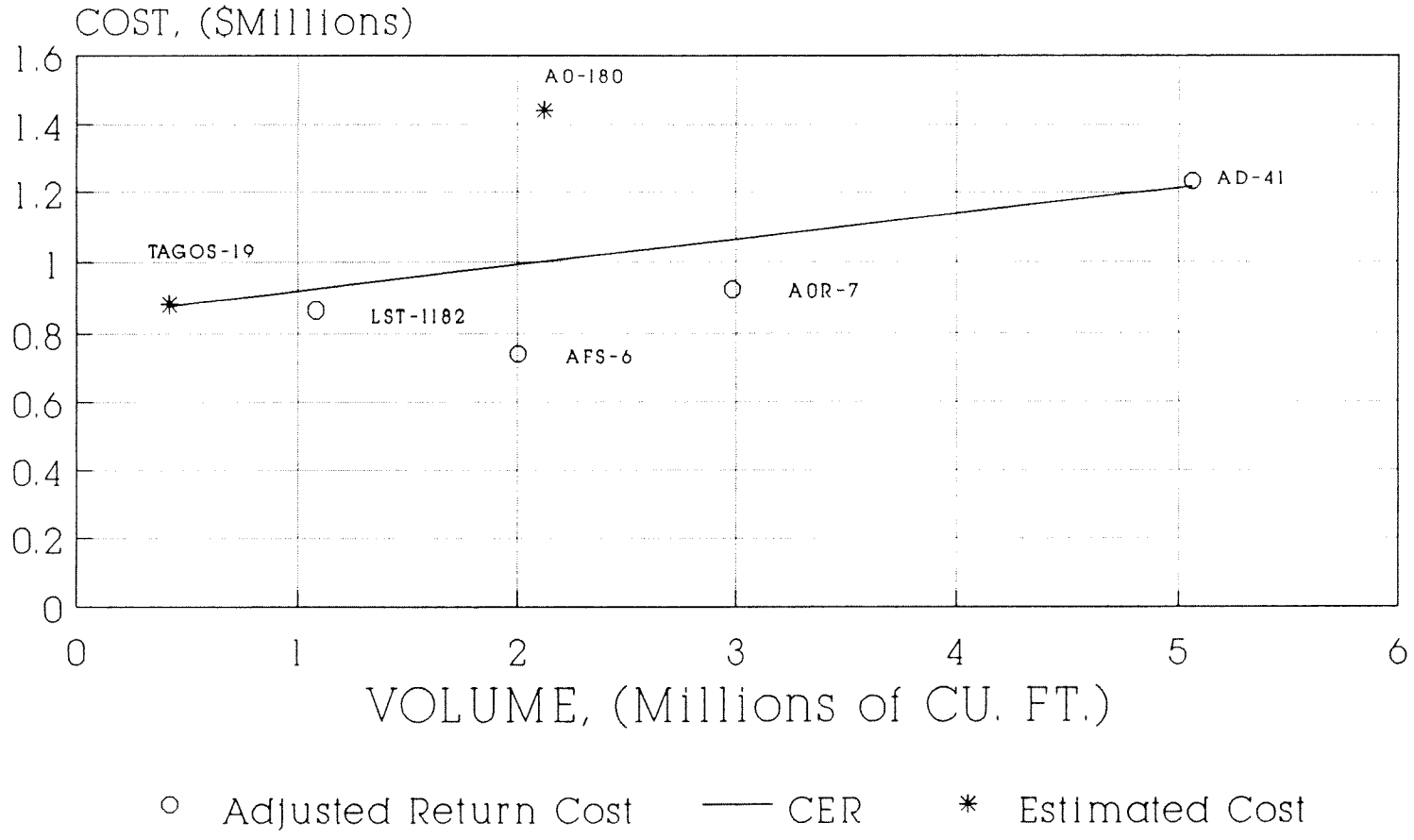


FIGURE 4-46

CER:		$= 20,060 (WT) - 417,000
Variable:		Group 4A WT in long tons
Adjusted r^2:		N/A - insufficient points
Application:		All ships

CER	=	$ = .074 (VOL) + 884,700
Variable	=	Total ship's volume in cubic feet
Adjusted r^2	=	N/A - insufficient points
Application	=	All ships

Labor Costs - Two CER's are provided for labor costs for Group 4A. One is based on Group 4A weight and one on total ship's volume. The graphs for Group 4A labor costs are shown in Figures 4-47 and 4-48 and the CER's for Group 4A labor costs are:

CER	=	MH = 1951 (WT) - 13,000
Variable	=	Group 4A WT in long tons
Adjusted r^2	=	.64 - 6 points
Application	=	All ships

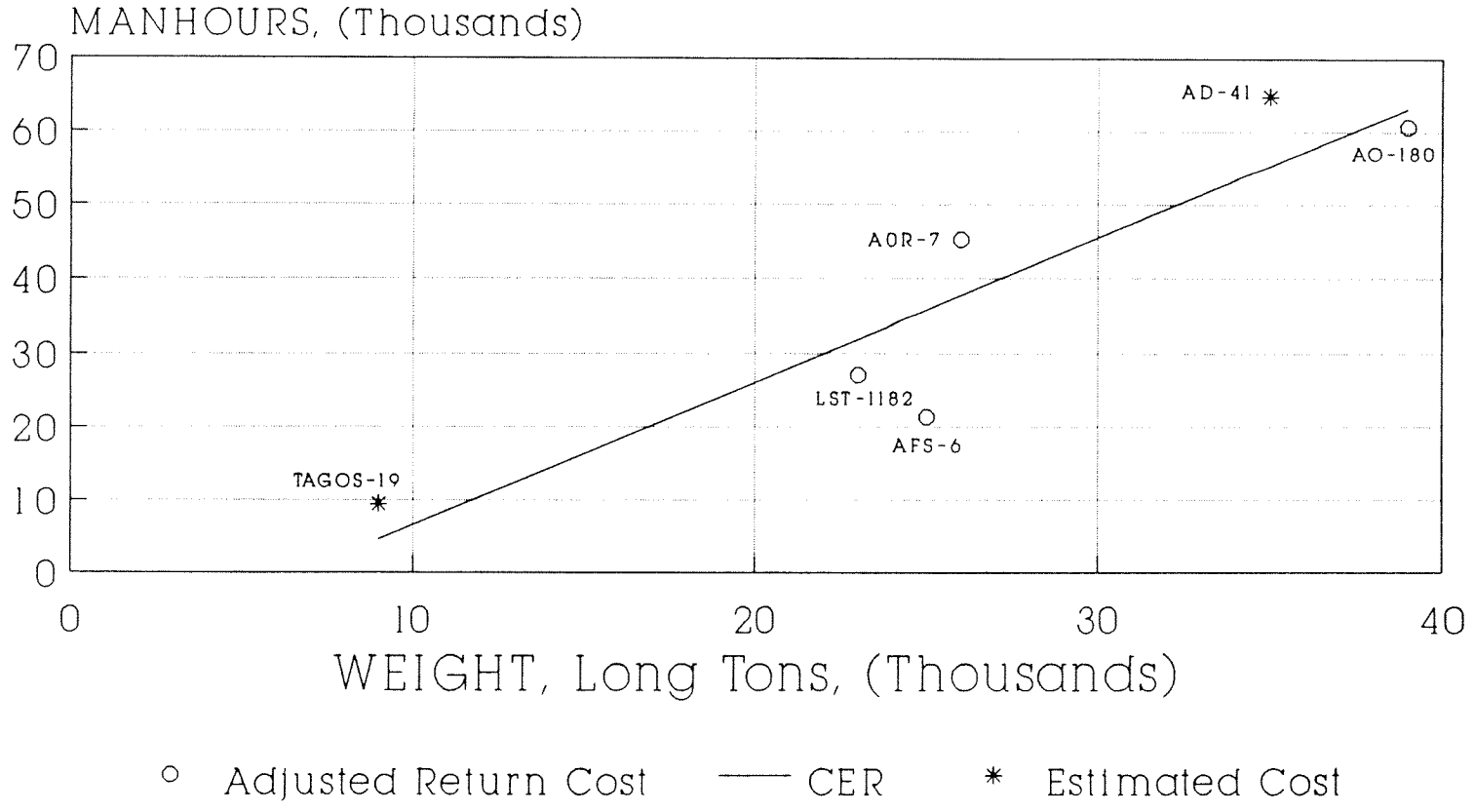
CER	=	MH = .011 (VOL) + 12,700
Variable	=	Total ship's volume in cubic feet
Adjusted r^2	=	.28 - 6 points
Application	=	All ships

4.5.2 Group 4B - Weapons Command

This group includes the installation costs for fire control systems, electronic countermeasures, radar and sonar.

Material Costs - No discernible CER would be identified which established a trend for Group 4B. As such, a constant value of $ = 190,000 should be used for estimating Group 4B costs for all ships. The data distribution for Group 4B material costs versus Group 4B weight is shown in Figure 4-49.

VEHICLE COMMAND
GROUP 4A
LABOR



Labor and Weight of Degaussing Systems are Subtracted for LST-1182, AFS-6 and AOR-7

FIGURE 4-47

VEHICLE COMMAND
GROUP 4A
LABOR

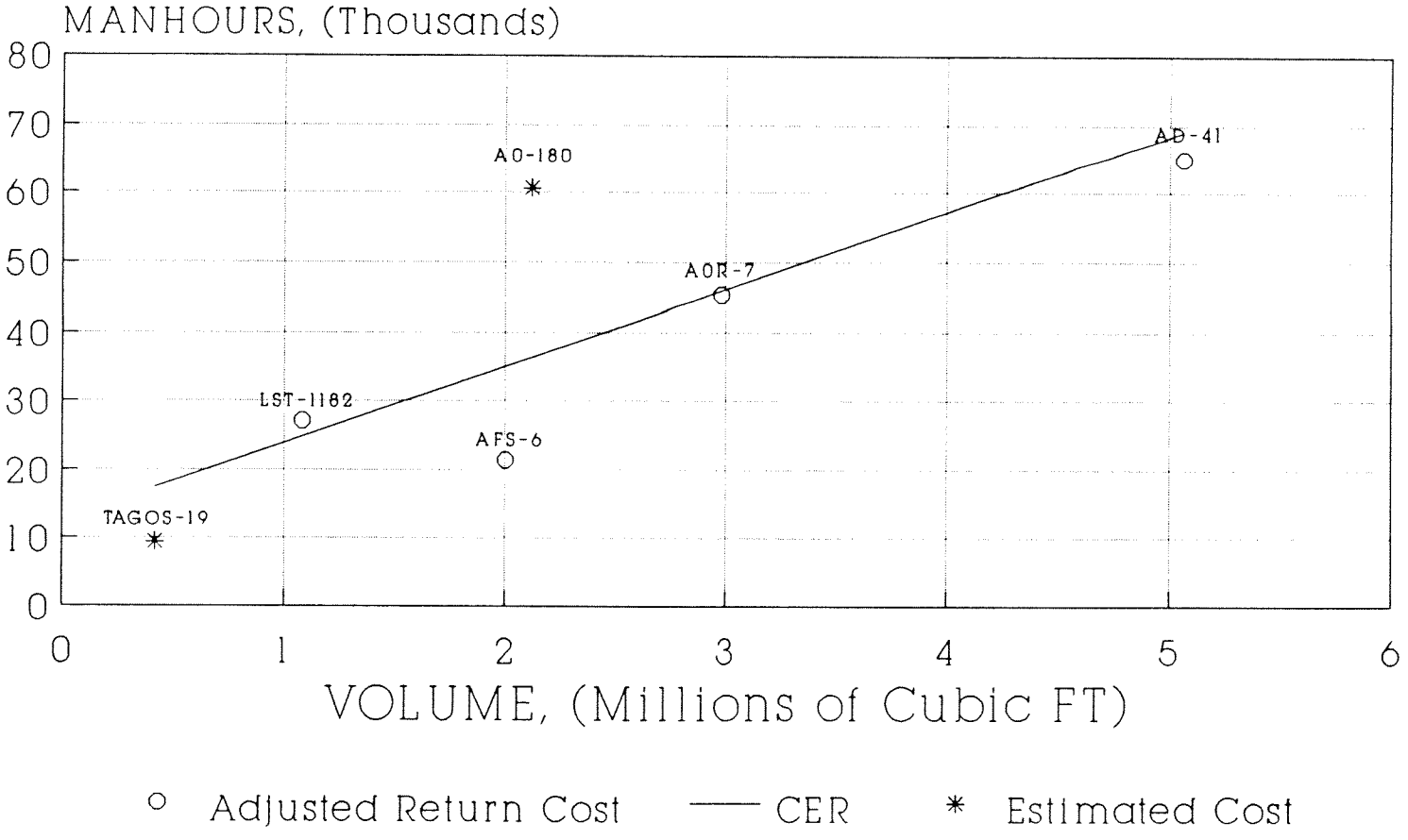
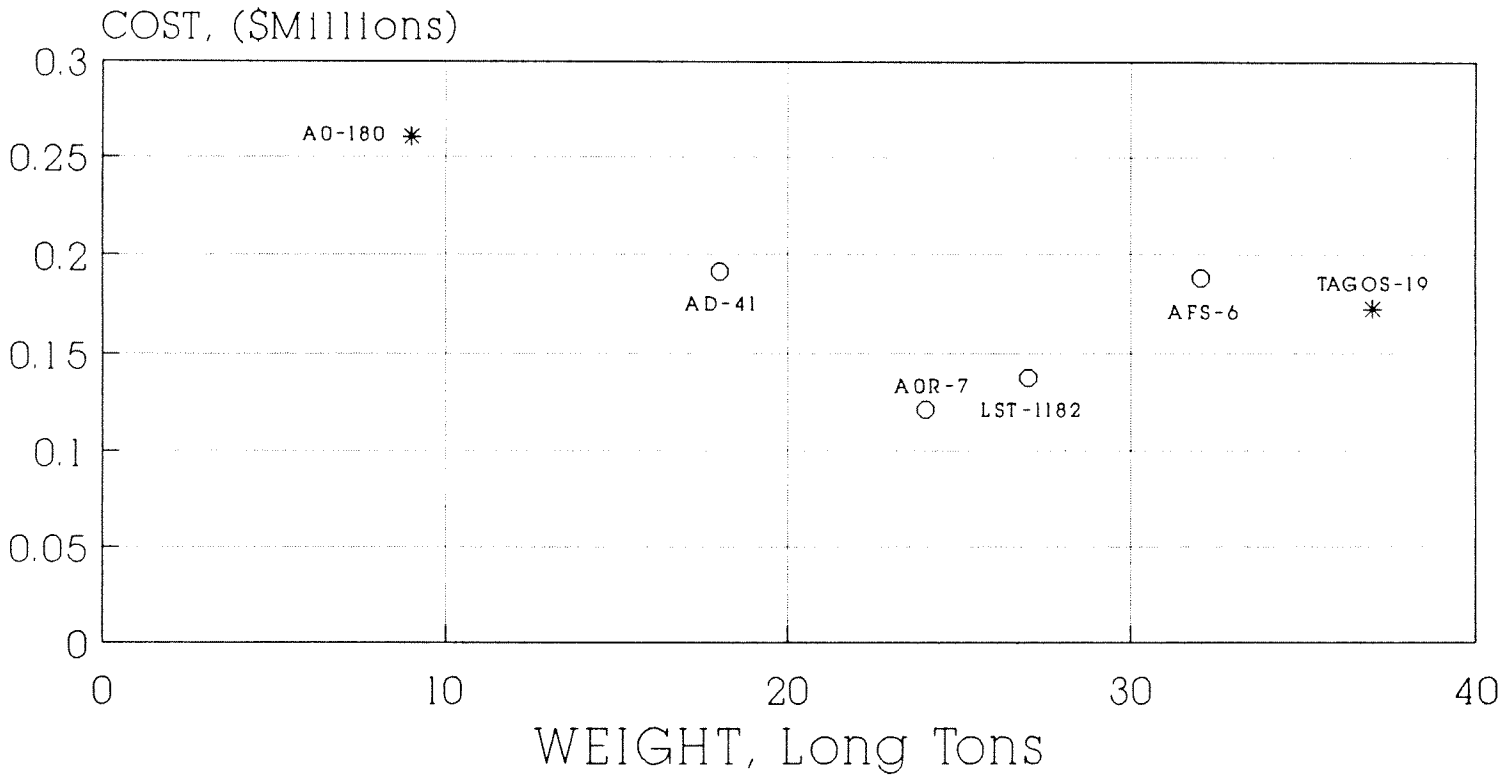


FIGURE 4-48

WEAPONS COMMAND
GROUP 4B
MATERIALS COST



○ Adjusted Return Cost * Estimated Cost

FIGURE 4-49

Labor Costs - Two CER's are provided for labor costs for Group 4B. Both are based on Group 4B weight and are for the following conditions: conventional auxiliary and amphibious ships, and commercial auxiliary and amphibious ships, as exemplified by the T-AGOS-19. The graph for Group 4B labor costs is shown in Figure 4-50 and the CER's for Group 4B labor costs are:

CER	=	MH = 12,700
Variable	=	N/A
Adjusted r^2	=	N/A
Application	=	Navy standards

CER	=	MH = 1000
Variable	=	N/A
Adjusted r^2	=	N/A
Application	=	Commercial standards

WEAPONS COMMAND
GROUP 4B
LABOR

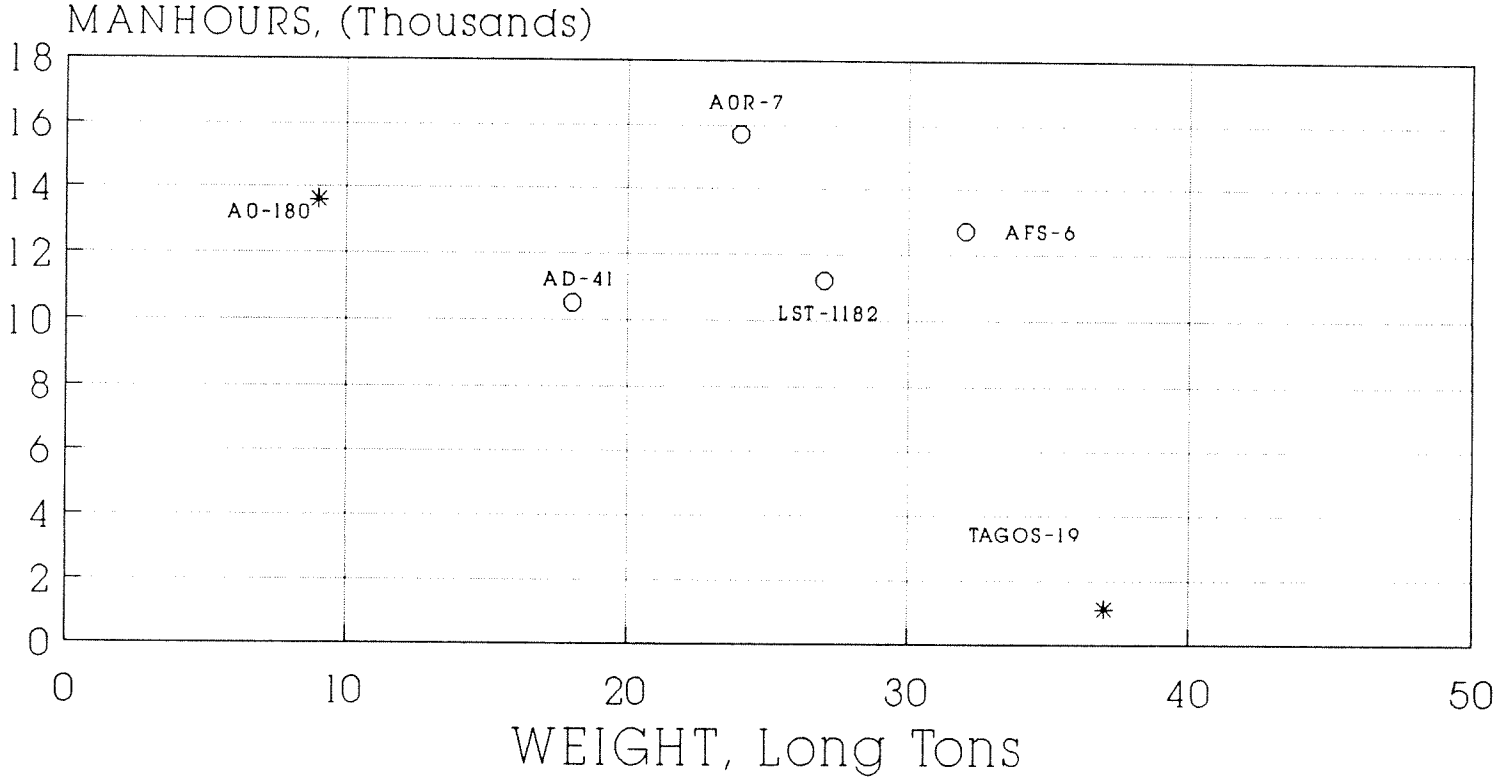


FIGURE 4-50

4.6 Group 5 - Auxiliary Systems

This one digit SWBS Group includes the following four two digit SWBS Groups:

Group 5A - Environmental Systems
Group 5B - Fluid Systems
Group 5C - Maneuvering Systems
Group 5D - Handling Systems

Material Costs: Two CER's are provided for Group 5 material costs. One is based on Group 5 weight and one is based on the ship's length times beam. The graphs for Group 5 material costs are shown in Figures 4-51 and 4-52 and the CER's for Group 5 material costs are:

CER:	$ = 9,054 (WT) + 3,340,900
Variable:	Group 5 WT in long tons
Adjusted r^2:	.52 - 6 points
Application:	All ships

CER:	$ = 470 (LxB) - 6,046,600
Variable:	(LXB) in square feet
Adjusted r^2:	.81 - 6 points
Application:	All ships

Labor Costs - Five CER's are provided for labor costs for Group 5. Two are based on Group 5 weight, two are based on ship's length times beam, and one is based on total ship's volume. The two based on Group 5 weight and on ship's length times beam, are for conventional auxiliary and amphibious ships, and for complex auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for the Group 5 labor costs are shown in Figures 4-53, 4-54, and 4-55 and the CER's for Group 5 labor costs are:

CER:	MH = 266 (WT) + 83,900
Variable:	Group 5 WT in long tons
Adjusted r^2:	.23 - 5 points
Application:	Conventional ships

AUXILIARY SYSTEMS
GROUP 5
MATERIALS COST

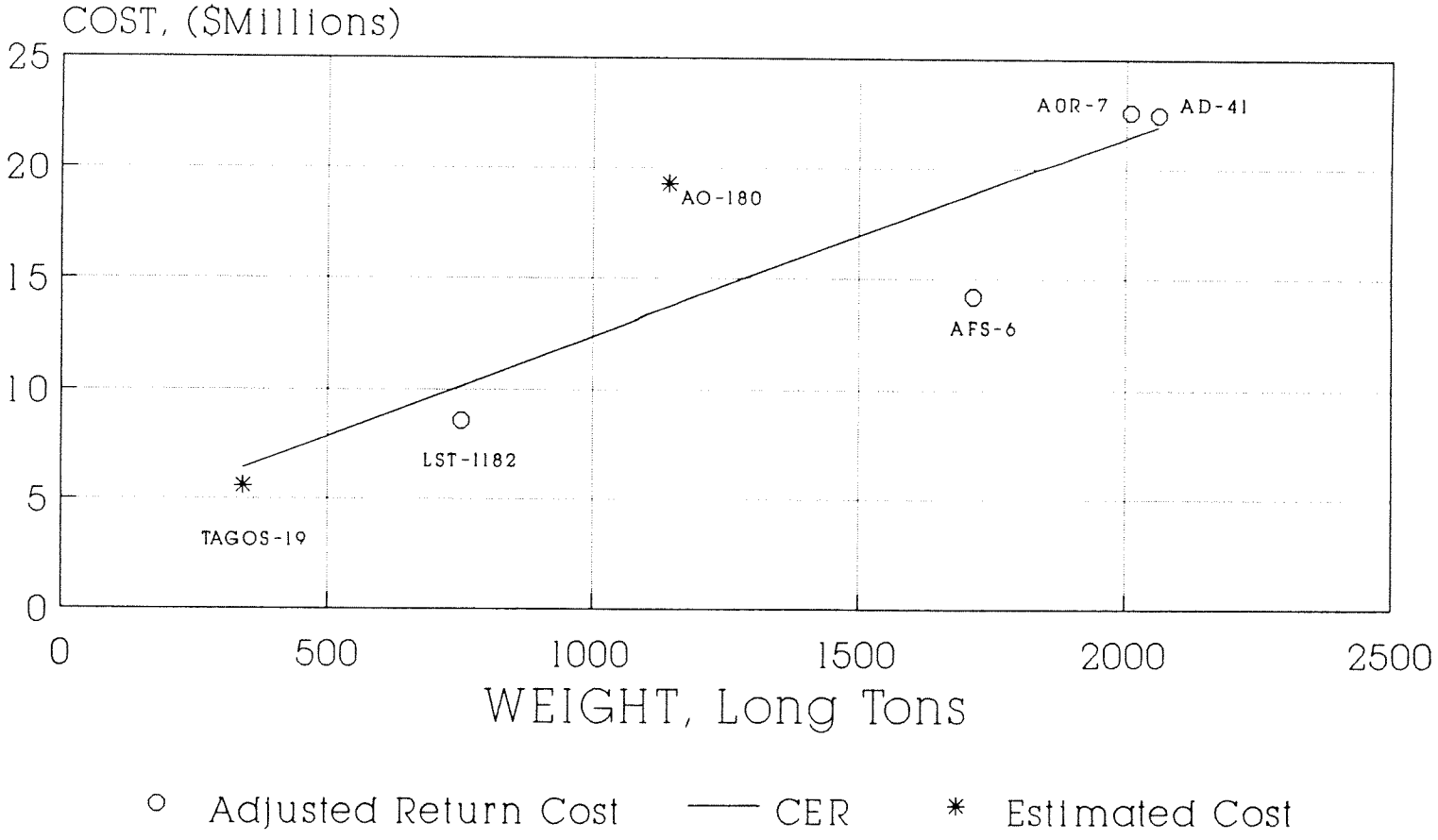


FIGURE 4-51

AUXILIARY SYSTEMS
GROUP 5
MATERIALS COST

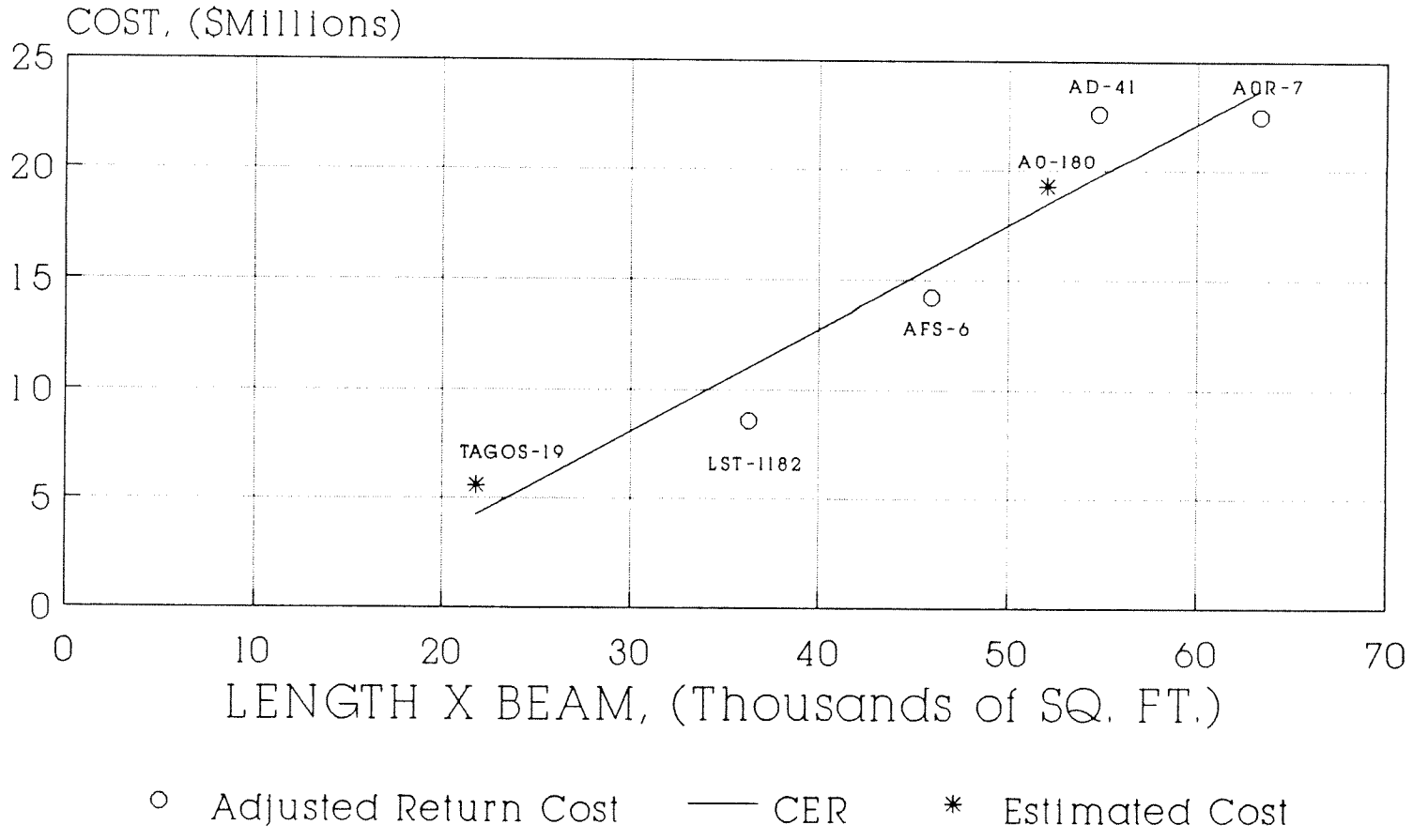


FIGURE 4-52

AUXILIARY SYSTEMS
GROUP 5
LABOR

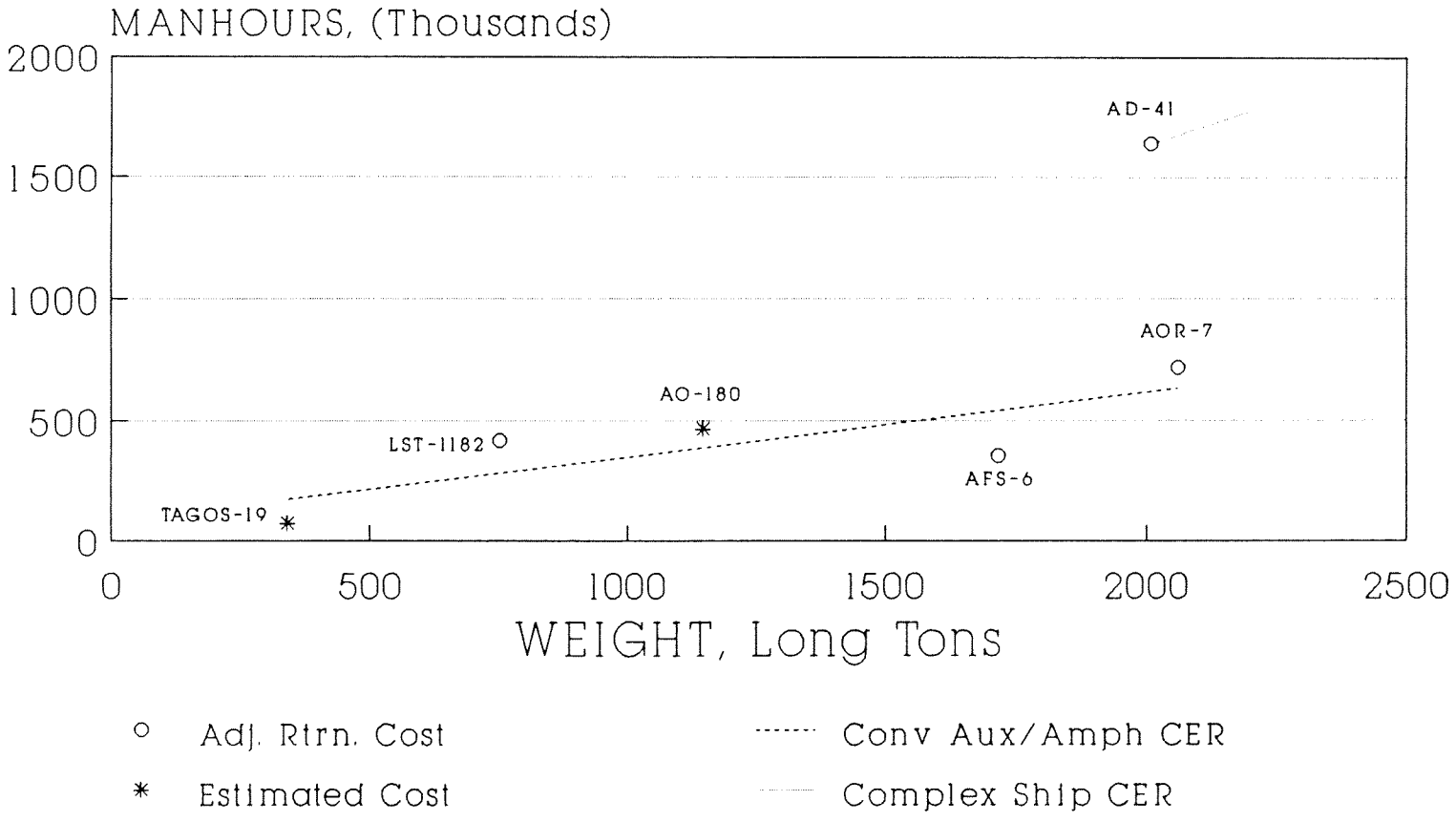


FIGURE 4-53

AUXILIARY SYSTEMS
GROUP 5
LABOR

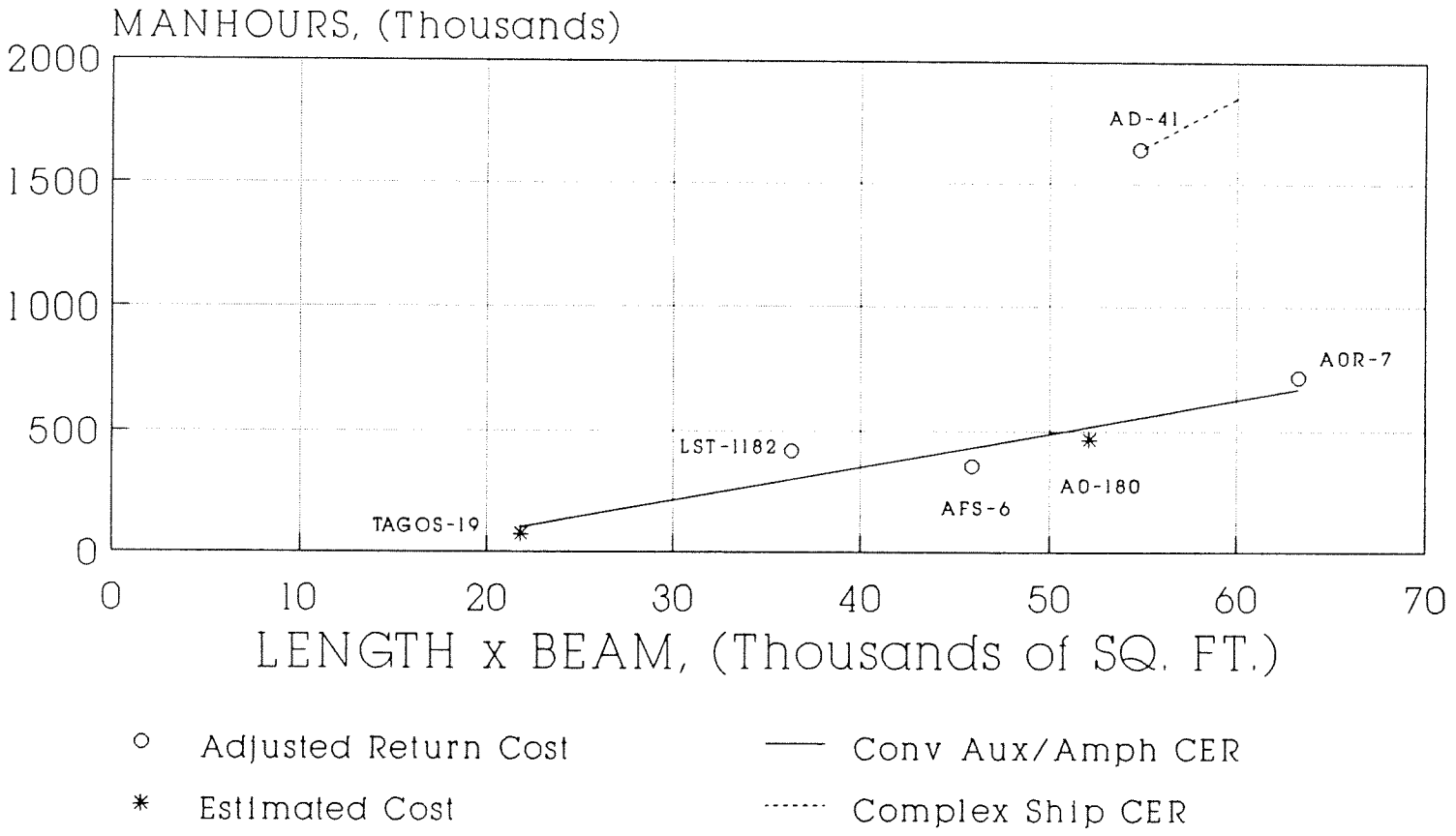


FIGURE 4-54

AUXILIARY SYSTEMS
GROUP 5
LABOR

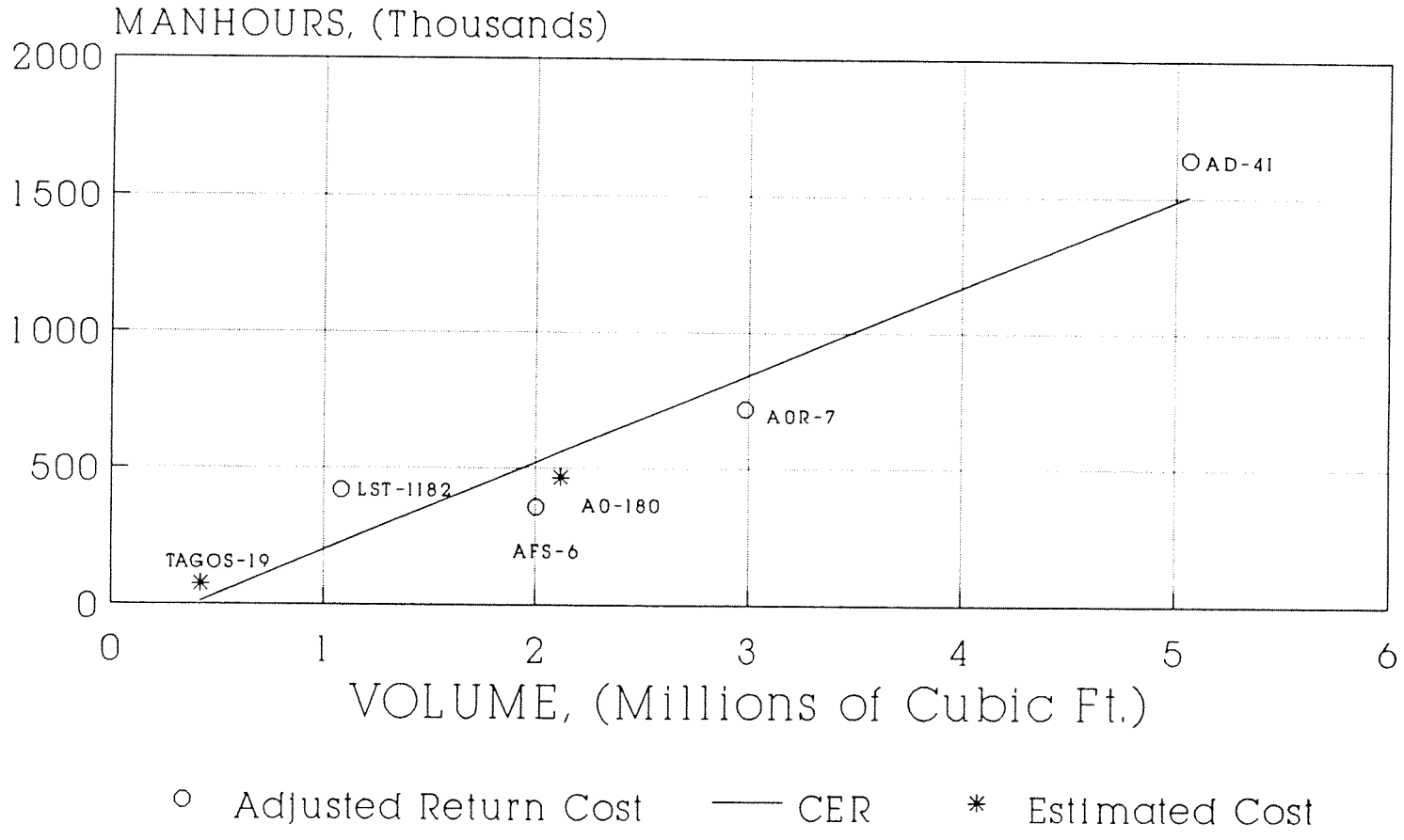


FIGURE 4-55

CER:	MH = 706 (WT) + 222,400
Variable:	Group 5 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	MH = 14 (LxB) - 200,600
Variable:	(LxB) in square feet
Adjusted r^2:	.70 - 5 points
Application:	Conventional ships

CER:	MH = 41 (LxB) - 593,700
Variable:	(LxB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	MH = .32 (VOL) - 124,500
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.74 - 6 points
Application:	All ships

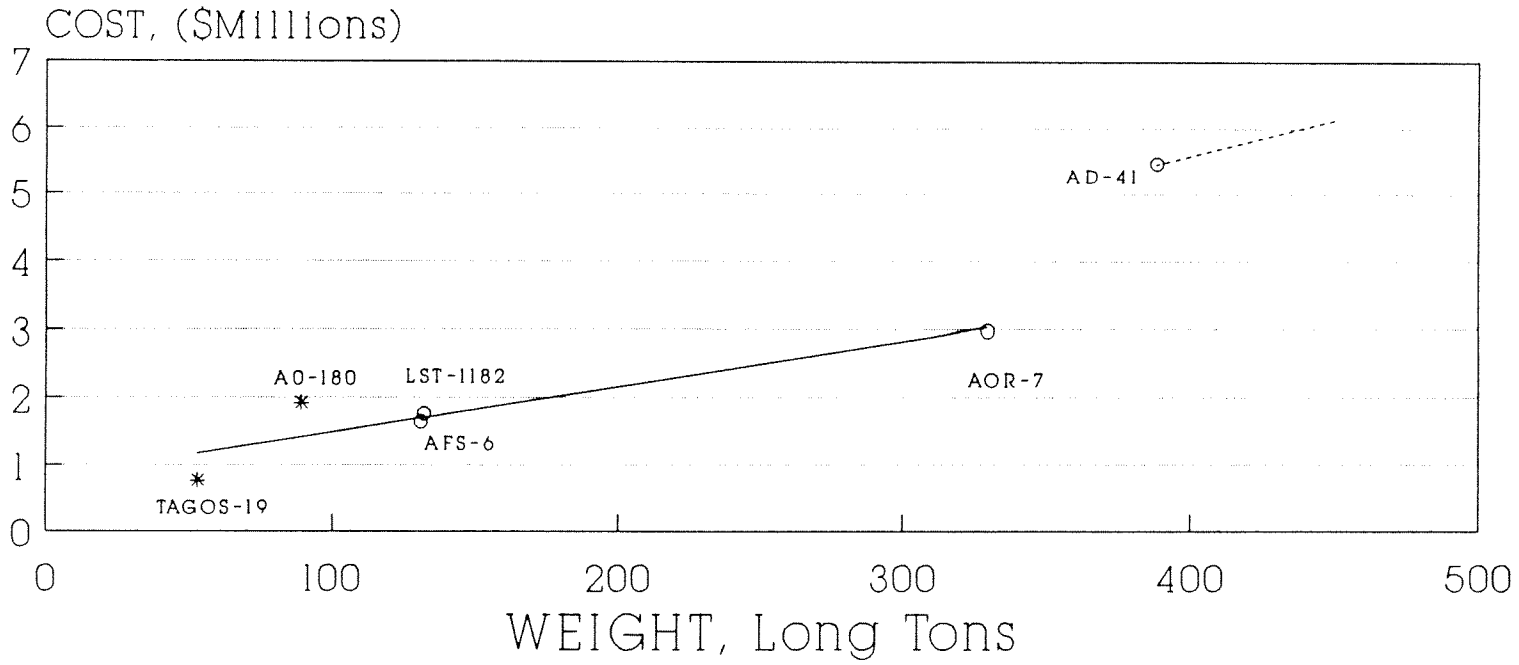
4.6.1 - Group 5A - Environmental Systems

This group includes the heating, ventilation and air conditioning systems, plus the refrigerated spaces.

Material costs - Three CER's are provided for material costs for Group 5A. Two are based on Group 5A weight and one is based on total ship's volume. The two CER's based on Group 5A weight are for conventional auxiliary and amphibious ships, and for complex auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for Group 5A material costs are shown in Figures 4-56 and 4-57 and the CER's for Group 5A material costs are:

CER:	$ = 6,717 (WT) + 820,500
Variable:	Group 5A WT in long tons
Adjusted r^2:	.59 - 5 points
Application:	Conventional ships

ENVIRONMENTAL SYSTEMS
GROUP 5A
MATERIALS COST



Cost and Weight of Refrigeration System Subtracted from AFS-6.

FIGURE 4-56

ENVIRONMENTAL SYSTEMS
GROUP 5A
MATERIALS COST

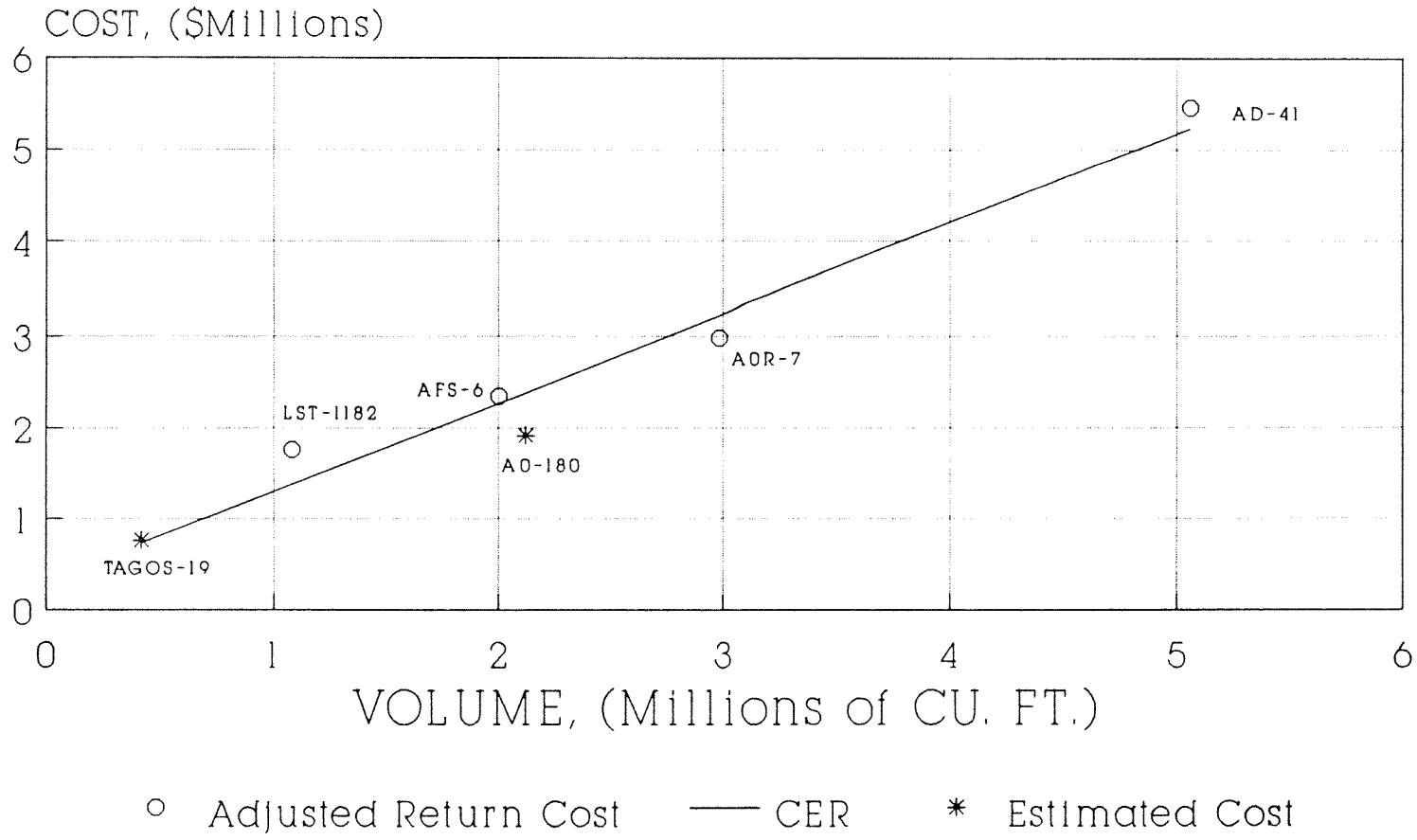


FIGURE 4-57

CER:	$ = 10,707 (WT) + 1,307,900
Variable:	Group 5A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	$ = 9.7 (VOL) + 322,900
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.90 - 6 points
Application:	All ships

Labor Costs - Four CER's are provided for labor costs for Group 5A. Three are based on Group 5A weight and one is based on total ship volume. The three CER's based on Group 5A weight are for the following conditions: conventional auxiliary and amphibious ships, complex auxiliary and amphibious ships, as exemplified by the AD-41, and auxiliary and amphibious ships, built with an emphasis on commercial standards as exemplified by the T-AGOS-19. The graphs for the Group 5A labor costs are shown in Figures 4-58 and 4-59 and the CER's for Group 5A material costs are:

CER:	MH = 316 (WT) + 99,500
Variable:	Group 5A WT in long tons
Adjusted r^2:	.71 - 4 points
Application:	Conventional ships

CER:	MH = 893 (WT) + 281,000
Variable:	Group 5A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	MH = 76 (WT) + 24,000
Variable:	Group 5A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Commercial standards

CER:	MH = 0.12 (VOL) - 61,140
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.67 - 6 points
Application:	All ships

ENVIRONMENTAL SYSTEMS
GROUP 5A
LABOR

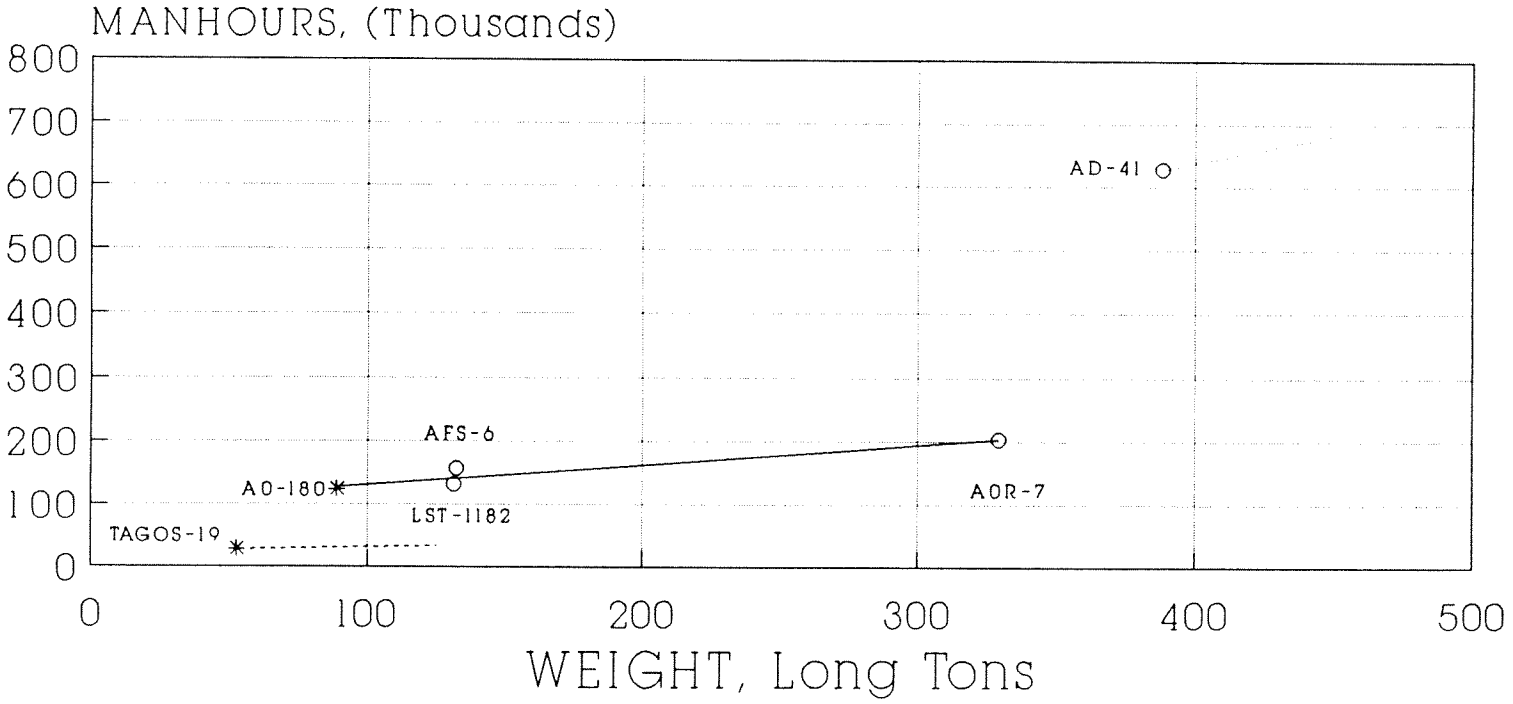


FIGURE 4-58

ENVIRONMENTAL SYSTEMS
GROUP 5A
LABOR

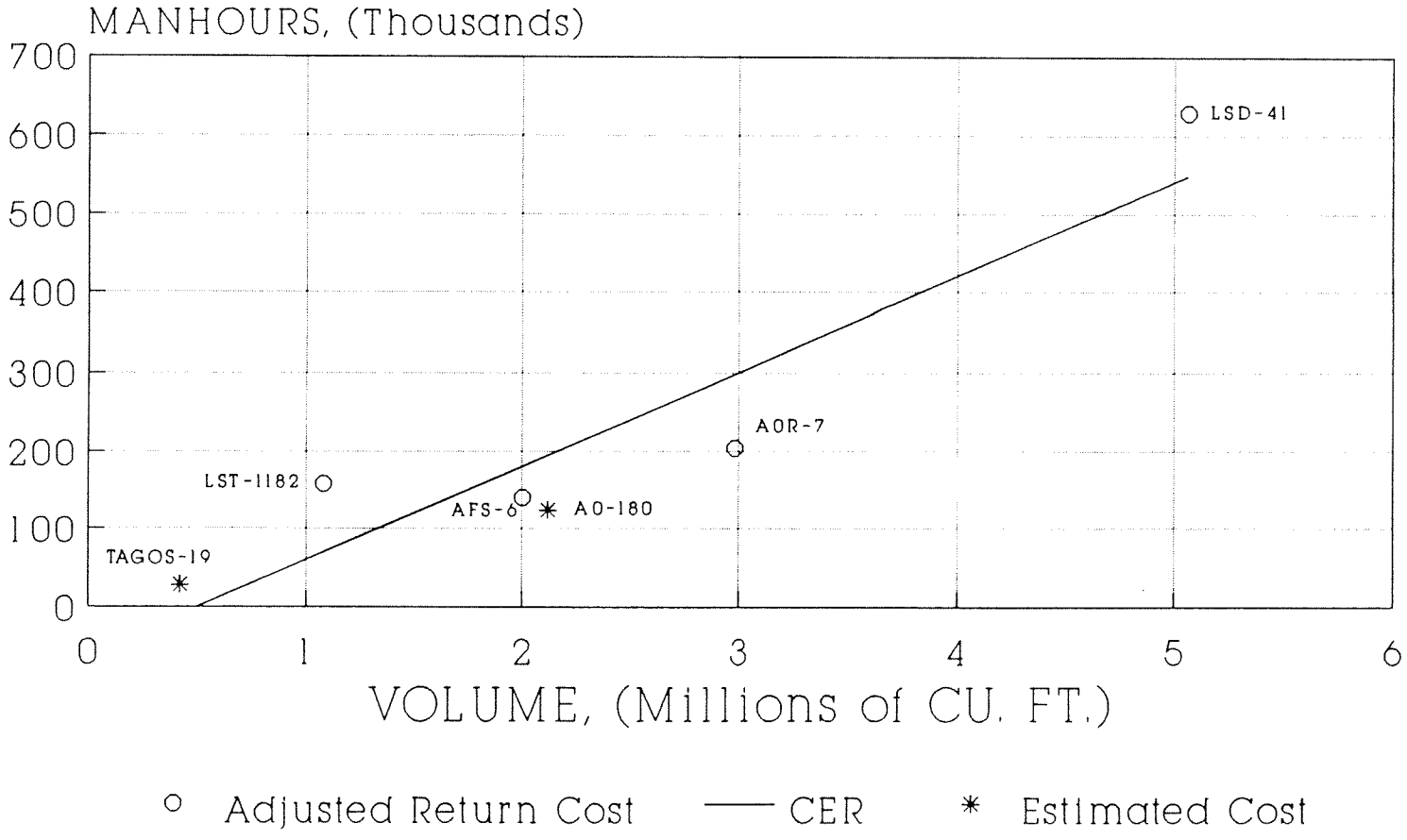


FIGURE 4-59

4.6.2 Group 5B - Fluid Systems

This group includes plumbing, firemain, drainage, ballast, freshwater, steam, compressed air and fuel systems.

Material Costs - Two CER's are provided for material costs for Group 5B. Both are based on weight and are for the following conditions: conventional auxiliary and amphibious ships, and complex amphibious and auxiliary ships. The graphs for Group 5B material costs are shown in Figure 4-60 and the CER's for Group 5B material costs are:

CER:	$ = 12,037 (WT) + 187,800
Variable:	Group 5B WT in long tons
Adjusted r^2:	.83 - 4 points
Application:	Conventional ships

CER:	$ = 16,159 (WT) + 252,200
Variable:	Group 5B WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

Labor Costs - Two CERs are provided for material costs for Group 5B labor. Both are based on weight and are for the following conditions: conventional auxiliary and amphibious ships, and complex auxiliary and amphibious ships. The graph for Group 5B labor costs is shown in Figure 4-61 and the CER's for Group 5B labor costs are:

CER:	MH = 619 (WT) - 2,100
Variable:	Group 5B WT in long tons
Adjusted r^2:	.85 - 5 points
Application:	Conventional ships

CER:	MH = 1,694 (WT) - 5,700
Variable:	Group 5B WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

FLUID SYSTEMS
GROUP 5B
MATERIALS COST

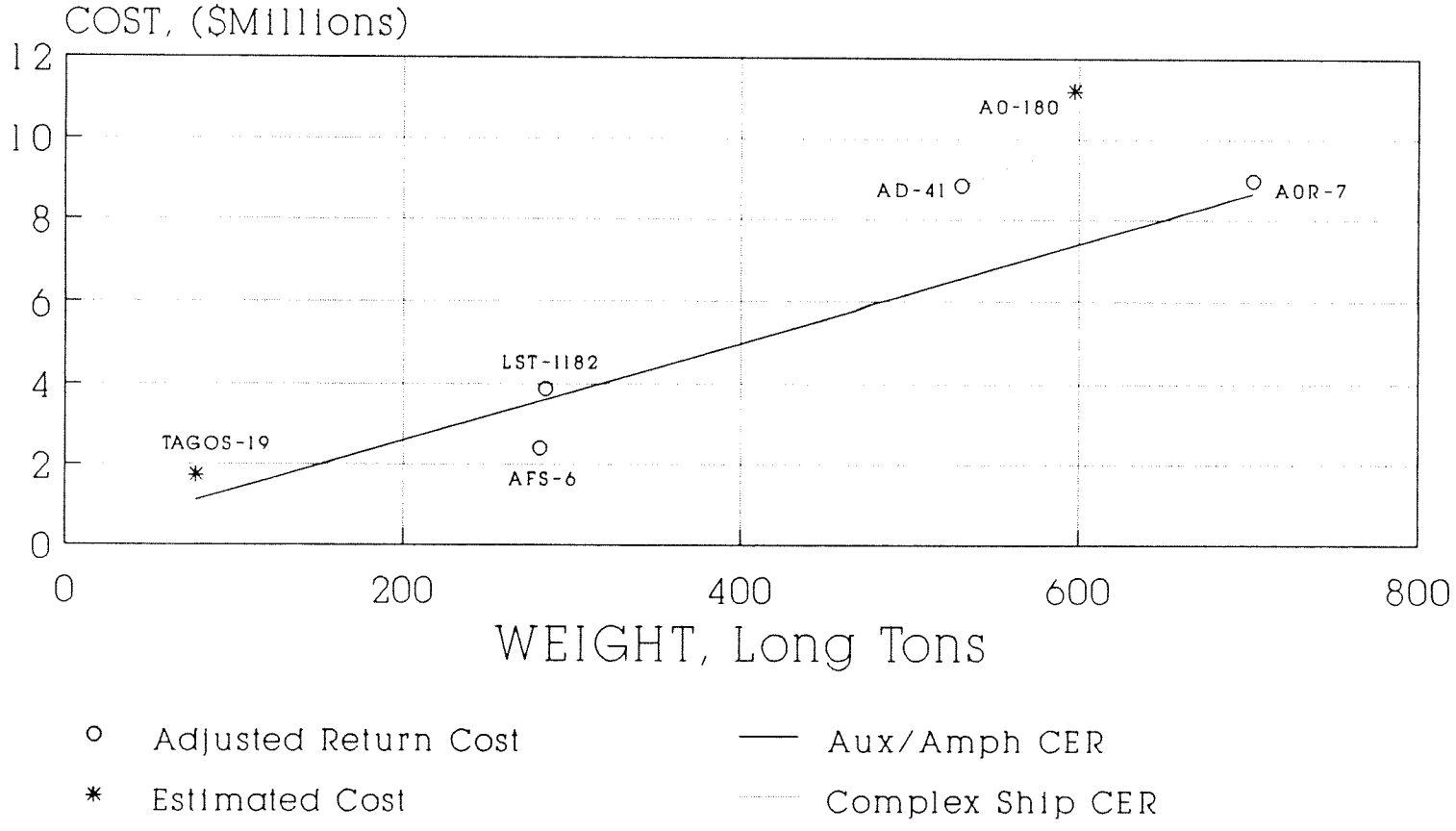


FIGURE 4-60

FLUID SYSTEMS
GROUP 5B
LABOR

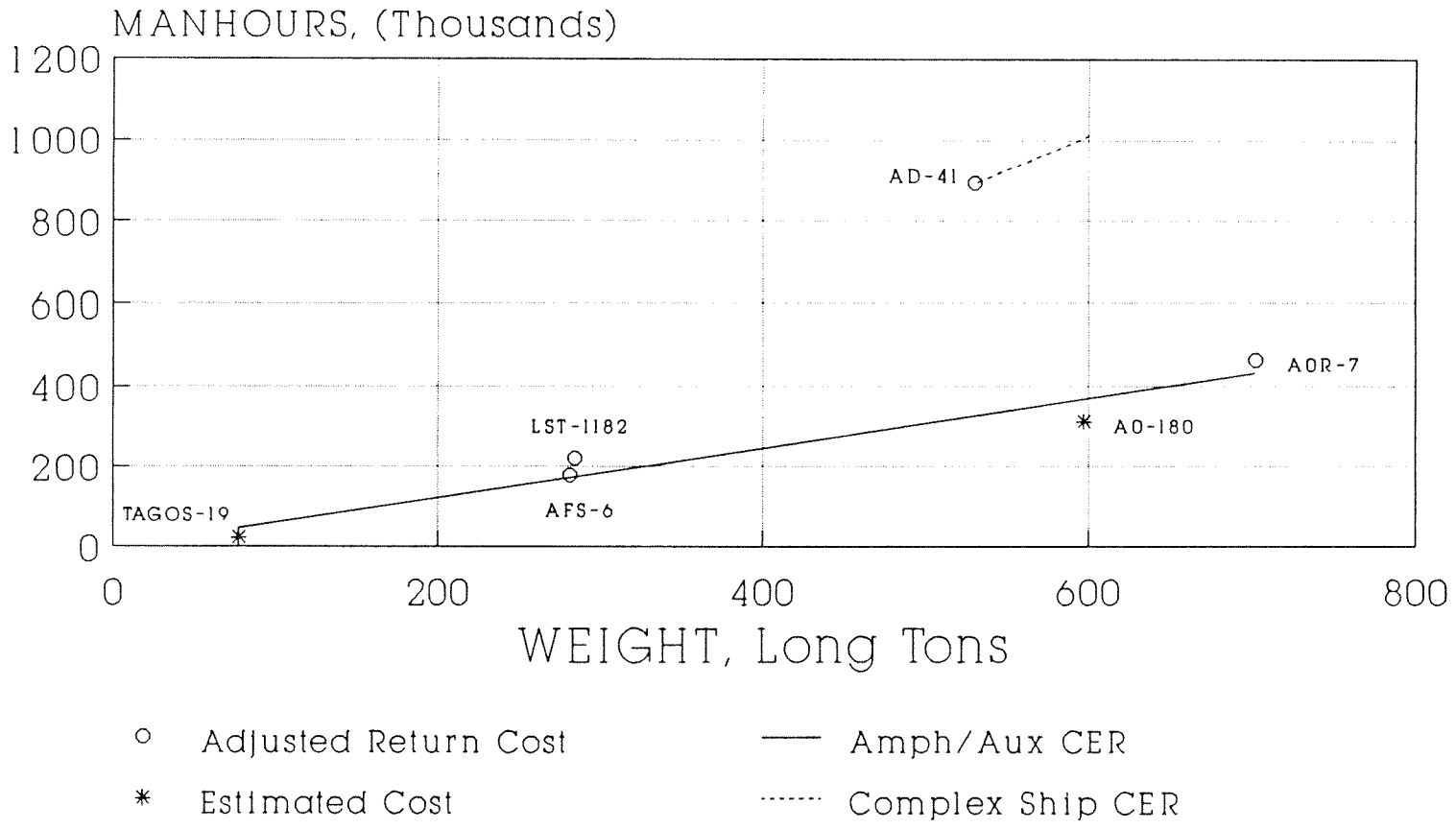


FIGURE 4-61

4.6.3 - Group 5C - Maneuvering Systems

This group includes the steering systems and rudder.

Material Costs - Two CER's are provided for material costs for Group 5C. Both CER's are based on Group 5C weight and are for the following conditions: conventional auxiliary and amphibious ships, and SWATH configured auxiliary and amphibious ships, as exemplified by the T-AGOS 19, since the T-AGOS-19 includes a forward canard system and bow thruster in addition to the aft rudder-stabilizers. The graph for the Group 5C material costs is shown in Figure 4-62 and the CER's for the Group 5C material costs are:

CER:	$ = 9,918 (WT) - 176,300
Variable:	Group 5C WT in long tons
Adjusted r^2:	.95 - 5 points
Application:	Conventional ships

CER:	$ = 39,472 (WT) - 701,700
Variable:	Group 5C WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	SWATH ships

Labor Costs - Four CER's are provided for labor costs for Group 5C. One is based on Group 5C weight and three on ship's length times beam. The CER's based on ship's length times beam are for the following conditions: single rudder, twin rudder and SWATH ship. The graphs for Group 5C labor costs are shown in Figures 4-63 and 4-64 and the CER's for the Group 5C labor costs are:

CER:	MH = 217 (WT) - 1,200
Variable:	Group 5C WT in long tons
Adjusted r^2:	.67, - 6 points
Application:	All ships

CER:	MH = 0.47 (LxB) - 14,100
Variable:	(L x B) in square feet
Adjusted r^2:	.13 - 3 points
Application:	Single rudder

MANEUVERING SYSTEMS
GROUP 5C
MATERIALS COST

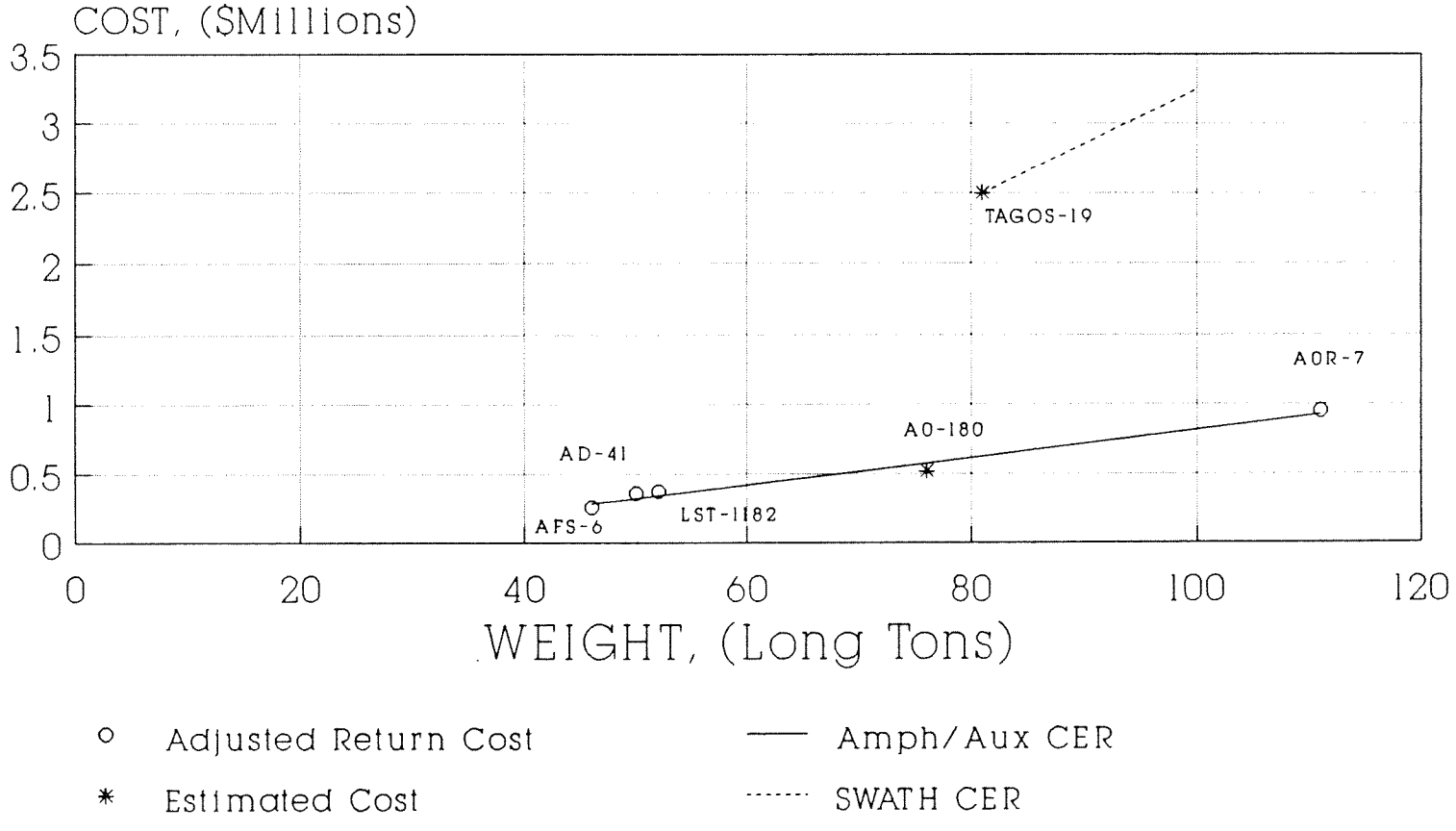


FIGURE 4-62

MANEUVERING SYSTEMS
GROUP 5C
LABOR

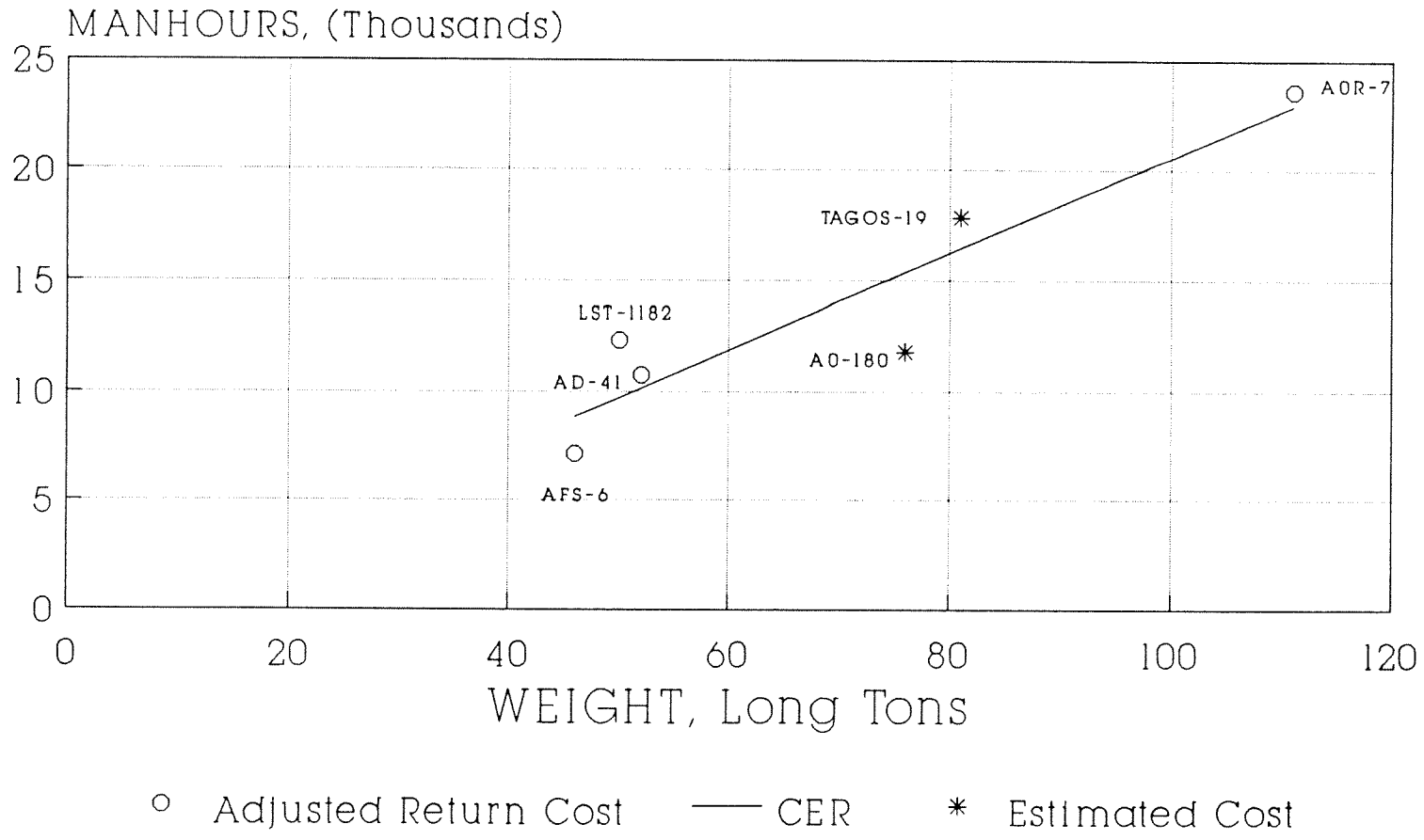


FIGURE 4-63

MANEUVERING SYSTEMS
GROUP 5C
LABOR

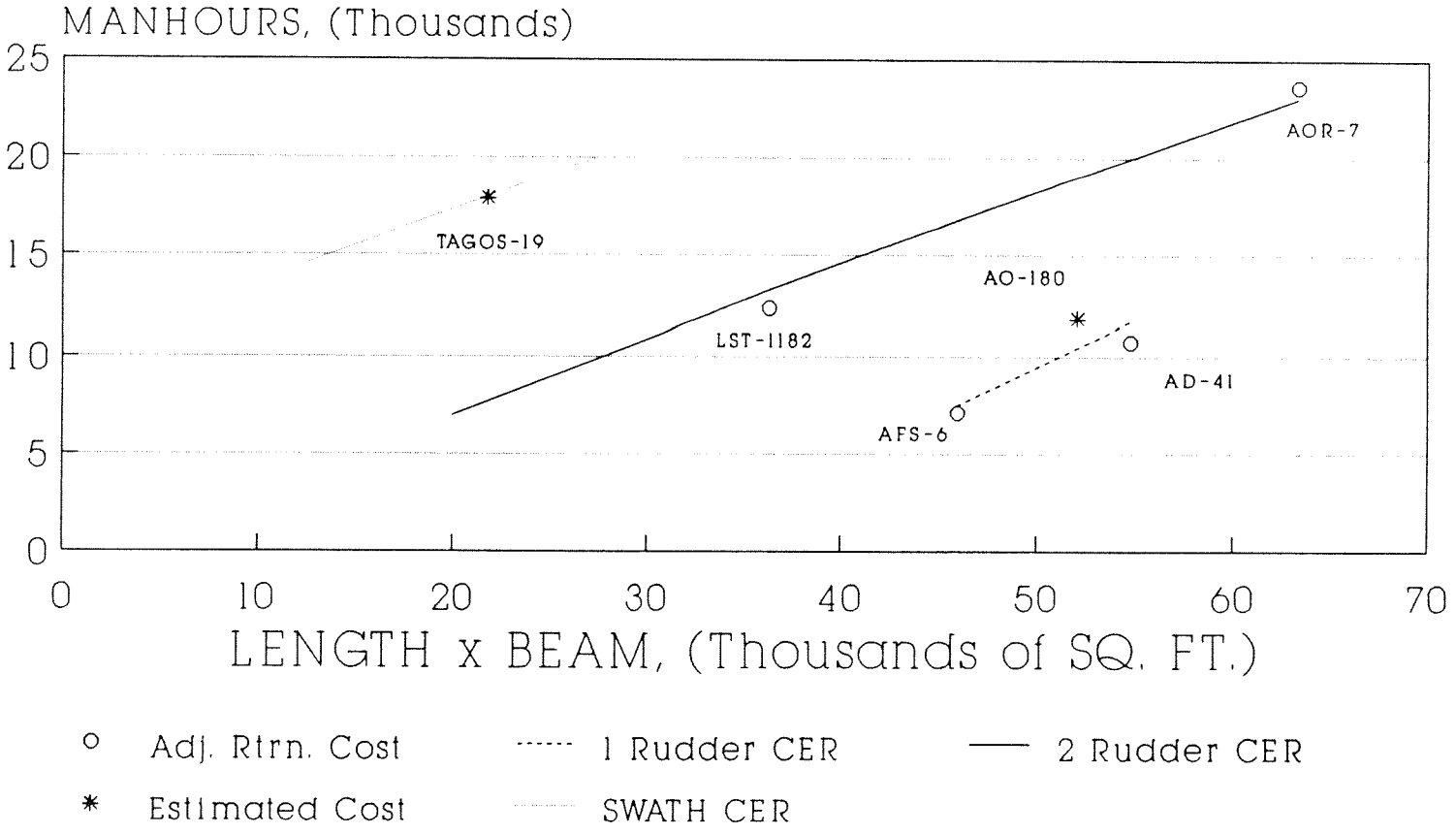


FIGURE 4-64

CER:	MH = 0.37 (LXB) + 0
Variable:	(LXB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Twin rudder

CER:	MH = 0.37 (LXB) + 10,000
Variable:	(LXB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	SWATH ships

4.6.4 Group 5D - Equipment Handling Systems

This group includes anchoring and mooring systems, replenishment at sea equipment, cargo handling systems, boats, boat handling systems and other miscellaneous auxiliary equipment.

Material Costs - Two CER's are provided for material costs for Group 5D. Both are based on Group 5D weight and are for the following conditions: non-replenishment ships and replenishment ships, as exemplified by the AO-180, AFS-6 and AOR-7. The graph for Group 5D material costs is shown in Figure 4-65, and the CER's for the Group 5D material costs are:

CER:	$ = 7,781 (WT) - 56,200
Variable:	Group 5D WT in long tons
Adjusted r^2:	.96 - 3 points
Application:	Non-replenishment ships

CER:	$ = 7,822 (WT) + 2,833,000
Variable:	Group 5D WT in long tons
Adjusted r^2:	.81 - 3 points
Application:	Replenishment ships

Labor Costs - Two CER's are provided for labor costs for Group 5D. Both are based on Group 5D weights and are for the following conditions: non-replenishment ships and replenishment ships as exemplified by the AO-180, AFS-6, and AOR-7. The graph for Group 5D labor costs is shown in Figure 4-66 and the CER's for Group 5D labor costs are:

EQUIPMENT HANDLING SYSTEMS
GROUP 5D
MATERIALS COST

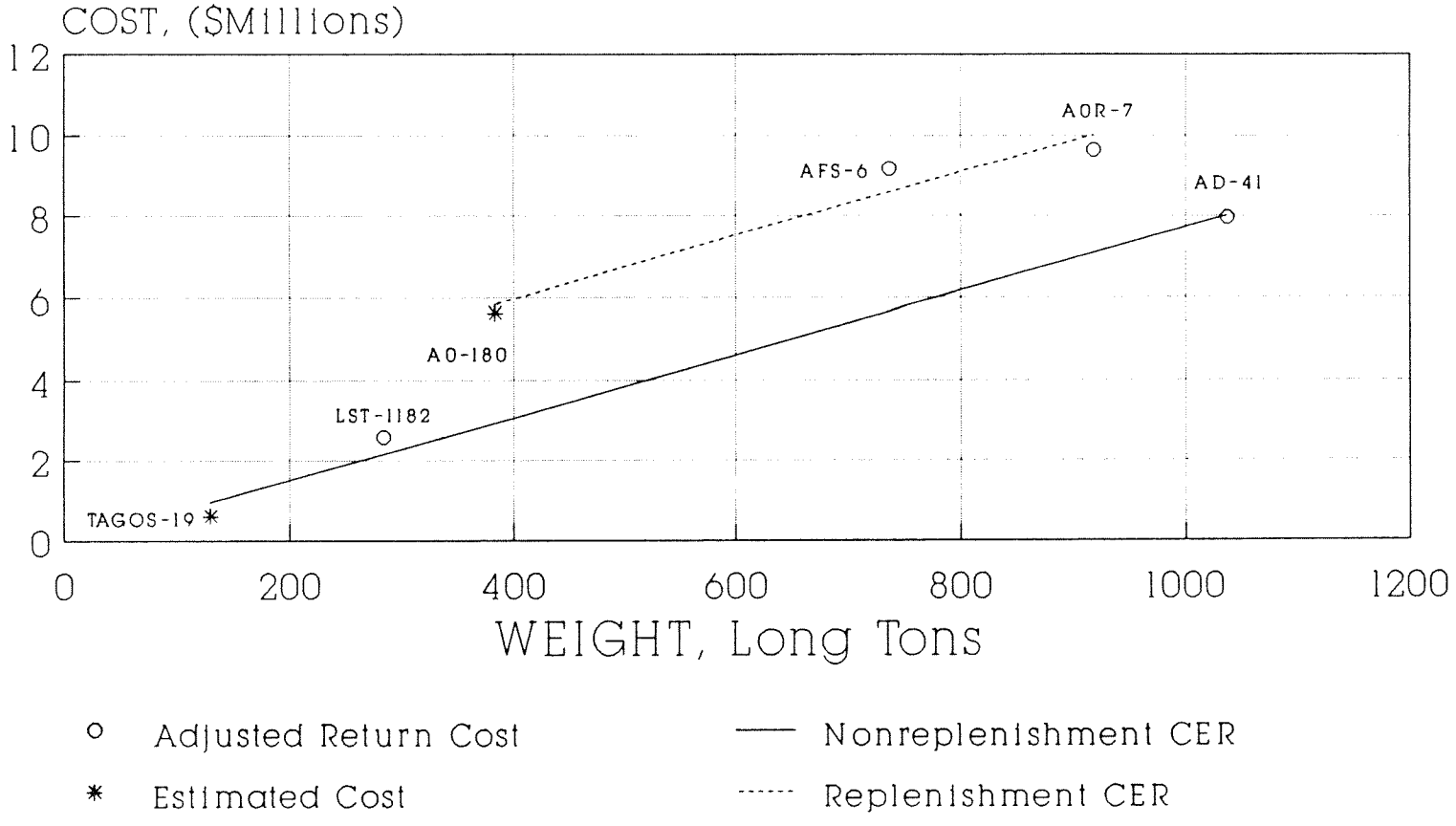


FIGURE 4-65

EQUIPMENT HANDLING SYSTEMS
GROUP 5D
LABOR

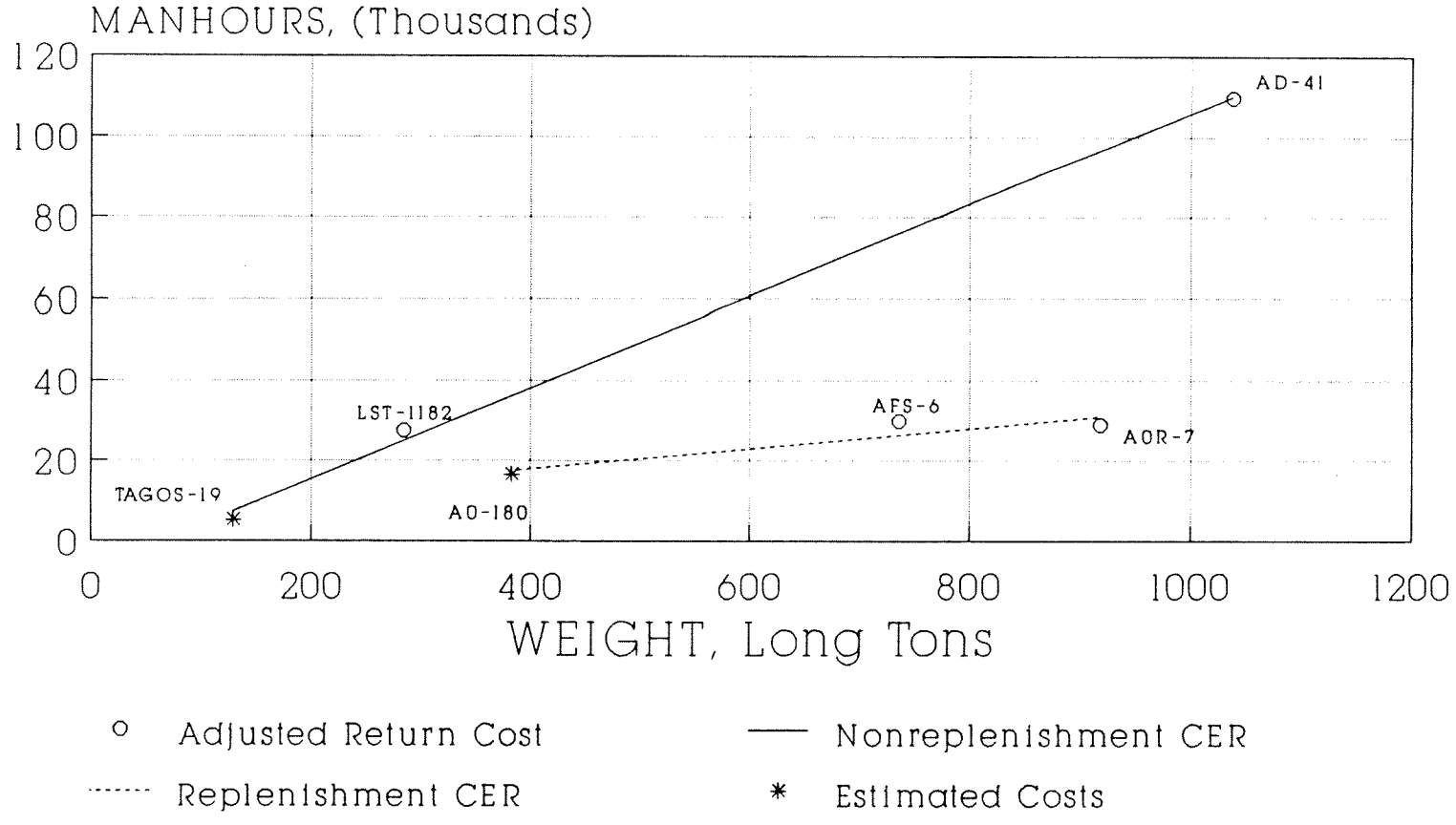


FIGURE 4-66

CER:	MH = 113 (WT) - 7,200
Variable:	Group 5D WT in long tons
Adjusted r^2:	.99 - 3 points
Application:	Non-replenishment ships

CER:	MH = 25 (WT) + 8,100
Variable:	Group 5D WT in long tons
Adjusted r^2:	.45 - 3 points
Application:	Replenishment ships

4.7 Group 6 - Outfit and Furnishings

This one digit SWBS Group includes the following five two digit SWBS Groups:

Group 6A - Hull Fittings
Group 6B - Non-Structural Subdivisions
Group 6C - Preservation
Group 6D - Ship Support
Group 6E - Habitability

Material Costs - Six CER's are provided for material costs for Group 6. Two are based on Group 6 weight, two on total ship's volume and two on total ship's complement. The two CER's for each case are for the following conditions: conventional auxiliary and amphibious ships and complex auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for Group 6 material costs are shown in Figures 4-67, 4-68, and 4-69 and the CER's for Group 6 material costs are:

CER:	$ = 5,630 (WT) - 2,490,000
Variable:	Group 6 WT in long tons
Adjusted r^2:	.54 - 5 points
Application:	Conventional ships

CER:	$ = 3,220 (WT) +3,000,000
Variable:	Group 6 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	$ = 1.9 (VOL) + 2,511,500
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.92 - 5 points
Application:	Conventional ships

CER:	$ = 5 (VOL) + 6,470,000
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

OUTFIT AND FURNISHINGS
GROUP 6
MATERIALS COST

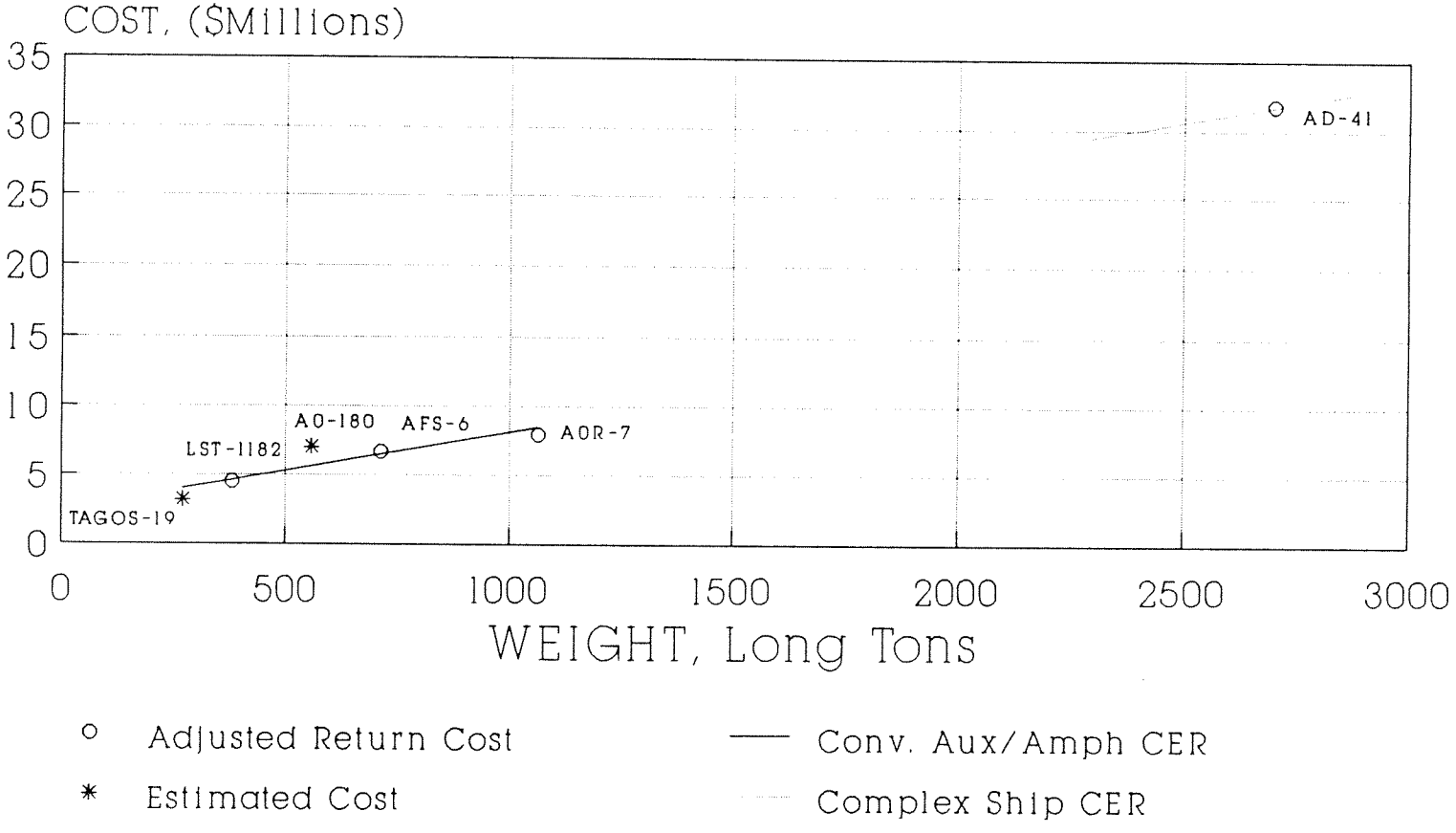


FIGURE 4-67

OUTFIT AND FURNISHINGS
GROUP 6
MATERIALS COST

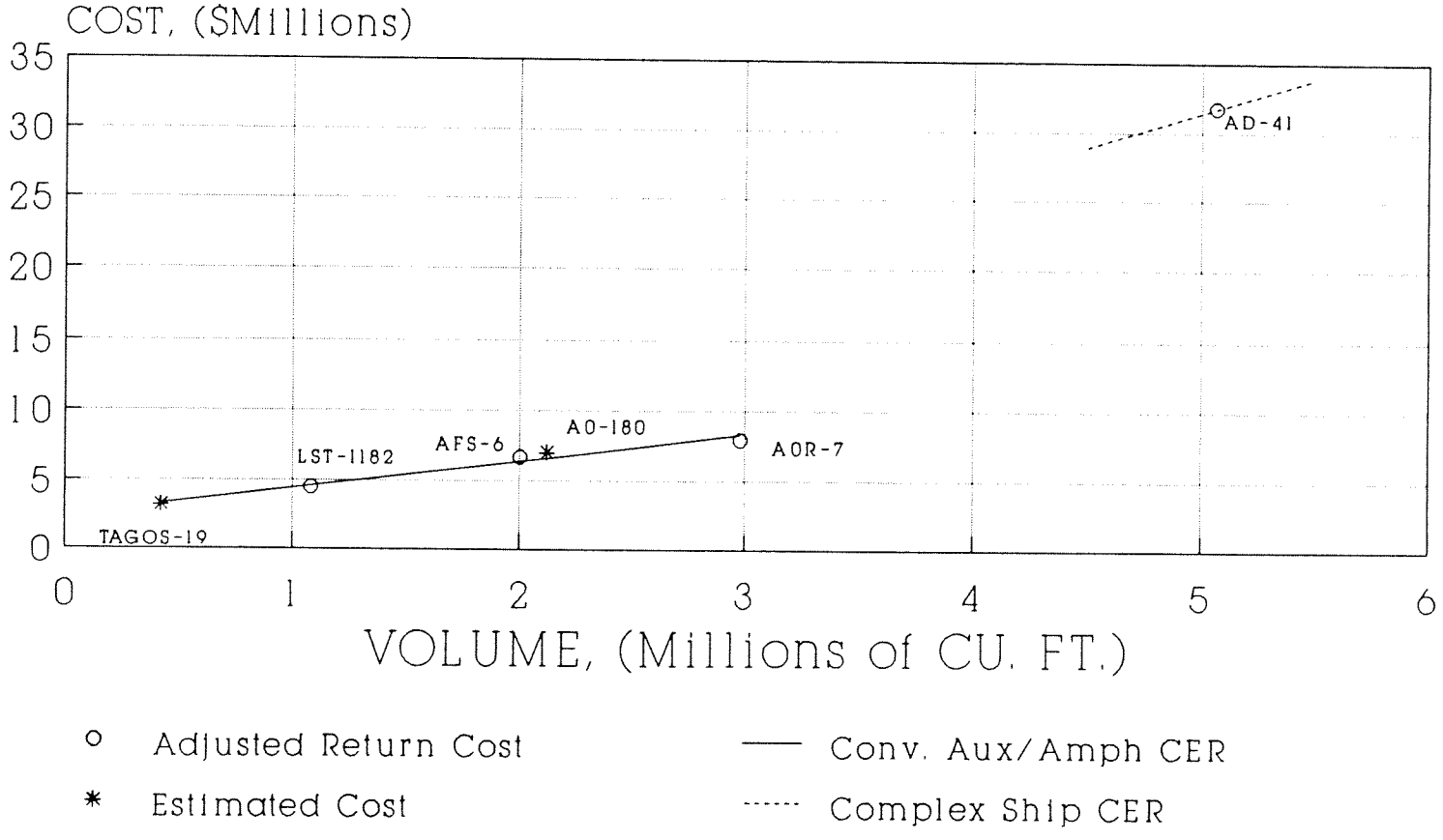


FIGURE 4-68

OUTFIT AND FURNISHINGS
GROUP 6
MATERIALS COST

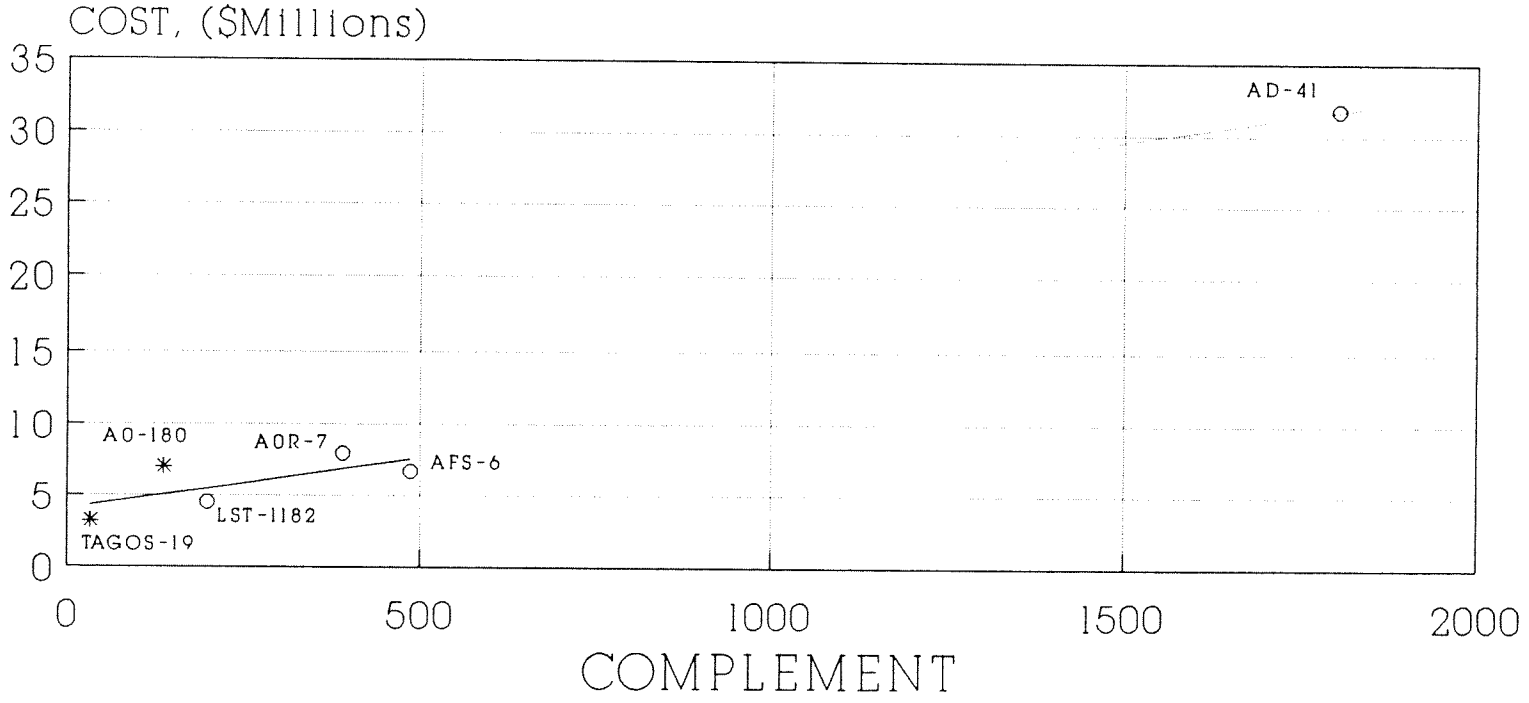


FIGURE 4-69

CER:	$ = 7,200 (CMP) + 4,062,500
Variable:	Total ship's complement
Adjusted r^2:	N/A - insufficient points
Application:	All ships

Labor Costs - Two CER's are provided for labor costs for Group 6. One is based on Group 6 weight and one on total ship's complement. The graphs for Group 6 labor costs are shown in Figures 4-70 and 4-71 and the CER's for Group 6 labor costs are:

CER:	MH = 331 (WT) + 500
Variable:	Group 6D WT in long tons
Adjusted r^2:	.90 - 6 points
Application:	All ships

CER:	MH = 441 (CMP) + 90,000
Variable:	Total ship's complement
Adjusted r^2:	.77 - 6 points
Application:	All ships

4.7.1 - Group 6A - Hull Fittings

This group includes hull fittings, rails, stanchions, rigging, airports and fixed portlights.

Material Costs - Two CER's are provided for material costs for Group 6A. One is based on ship's length times beam, and one is based on total ship's volume. The graphs for Group 6A labor costs are shown in Figures 4-72 and 4-73 and the CER's for Group 6A labor costs are:

CER:	$ = 11 (LxB) - 131,900
Variable:	(LXB) in square feet
Adjusted r^2:	.95 - 5 points
Application:	All ships

OUTFIT AND FURNISHINGS
GROUP 6
LABOR

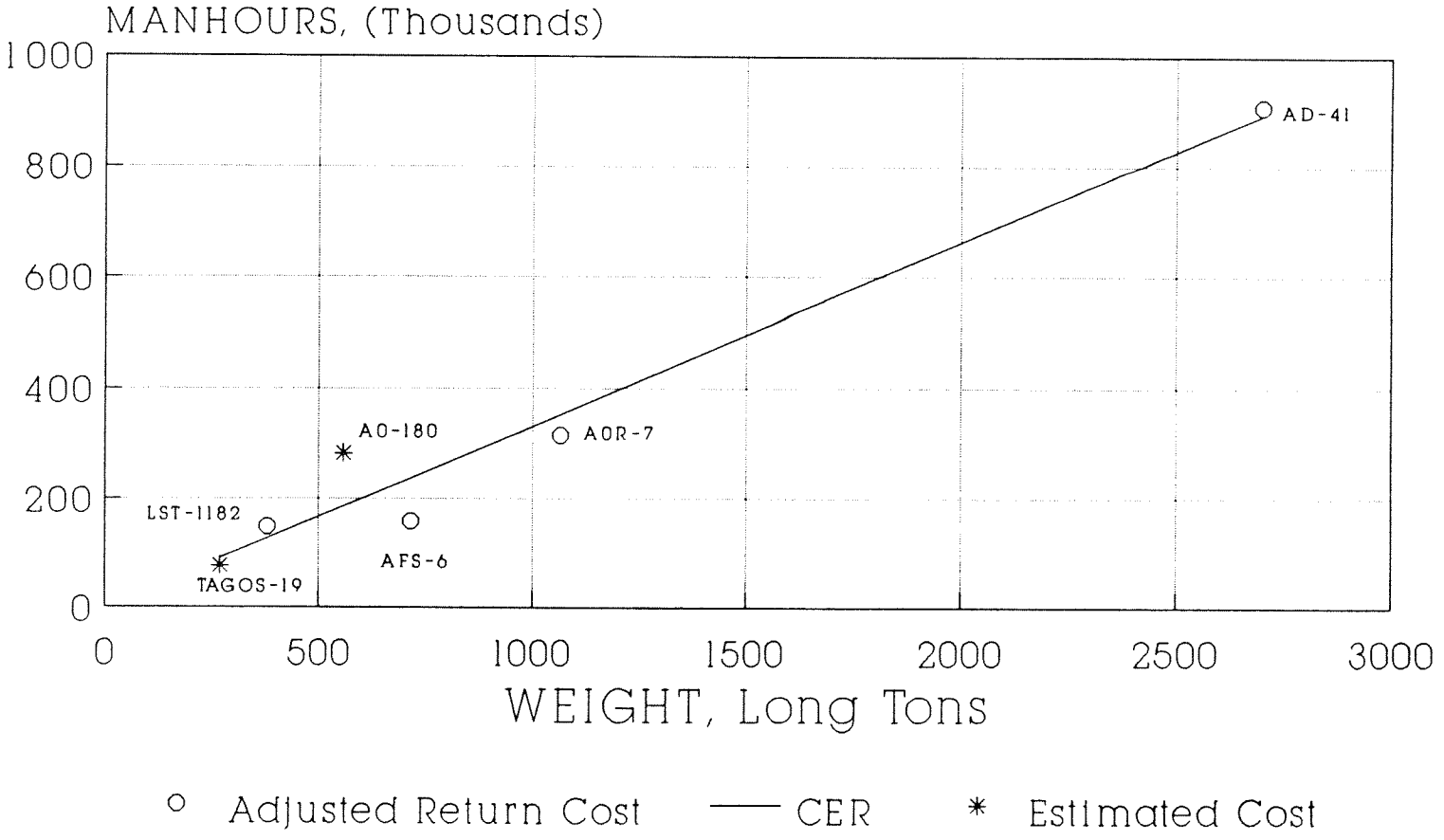


FIGURE 4-70

OUTFIT AND FURNISHINGS
GROUP 6
LABOR

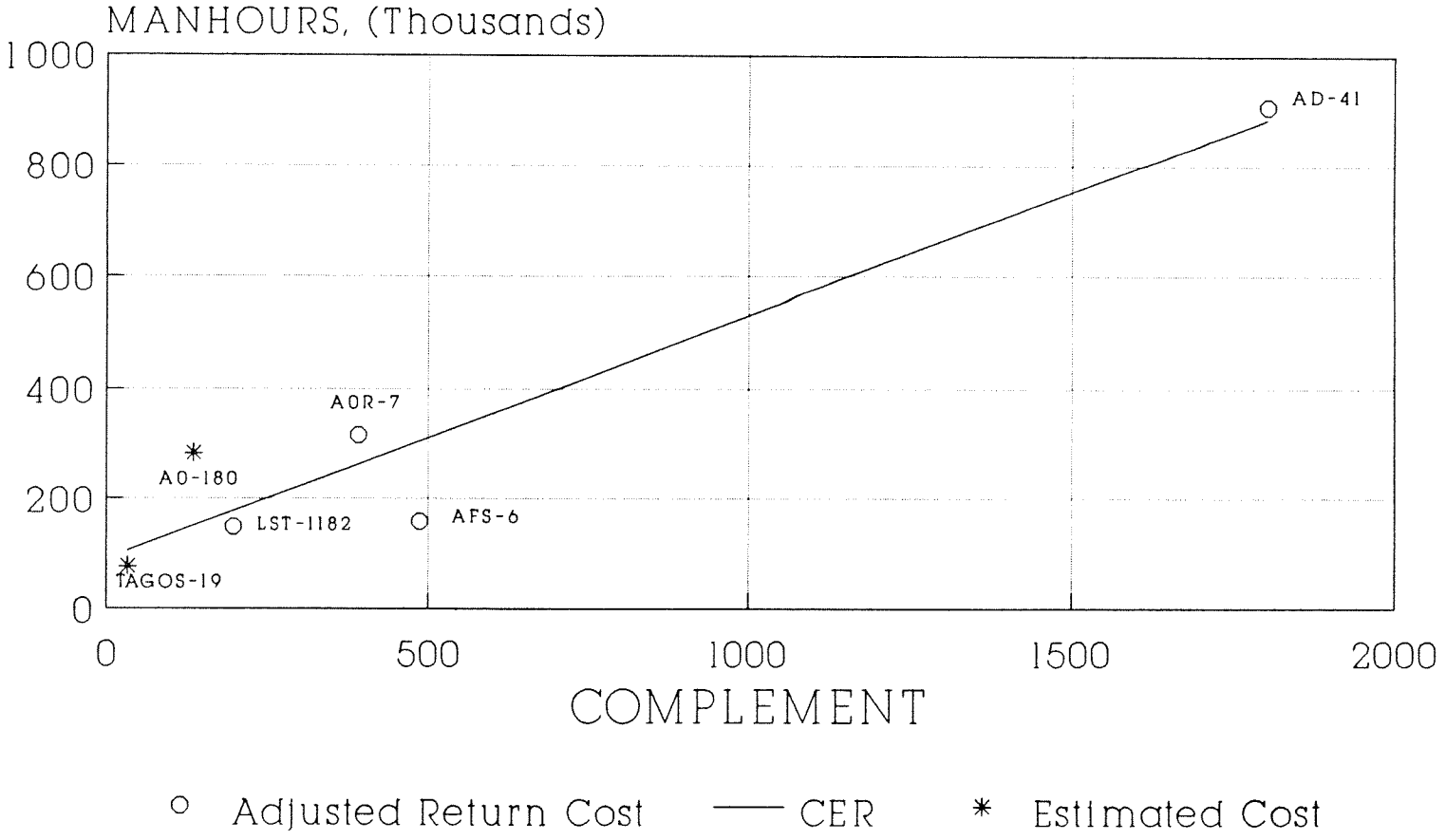


FIGURE 4-71

HULL FITTINGS
GROUP 6A
MATERIALS COST

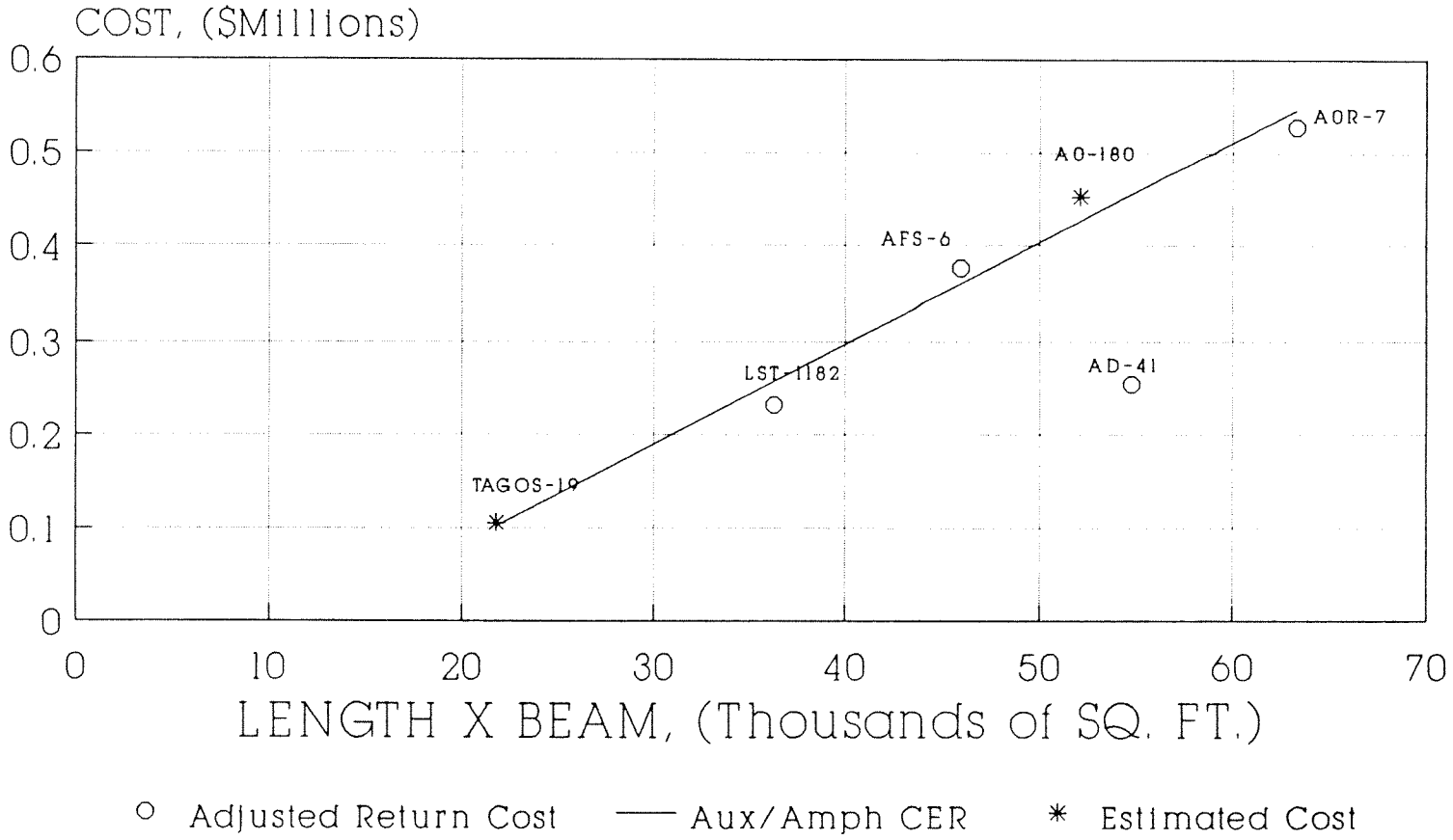


FIGURE 4-72

HULL FITTINGS
GROUP 6A
MATERIALS COST

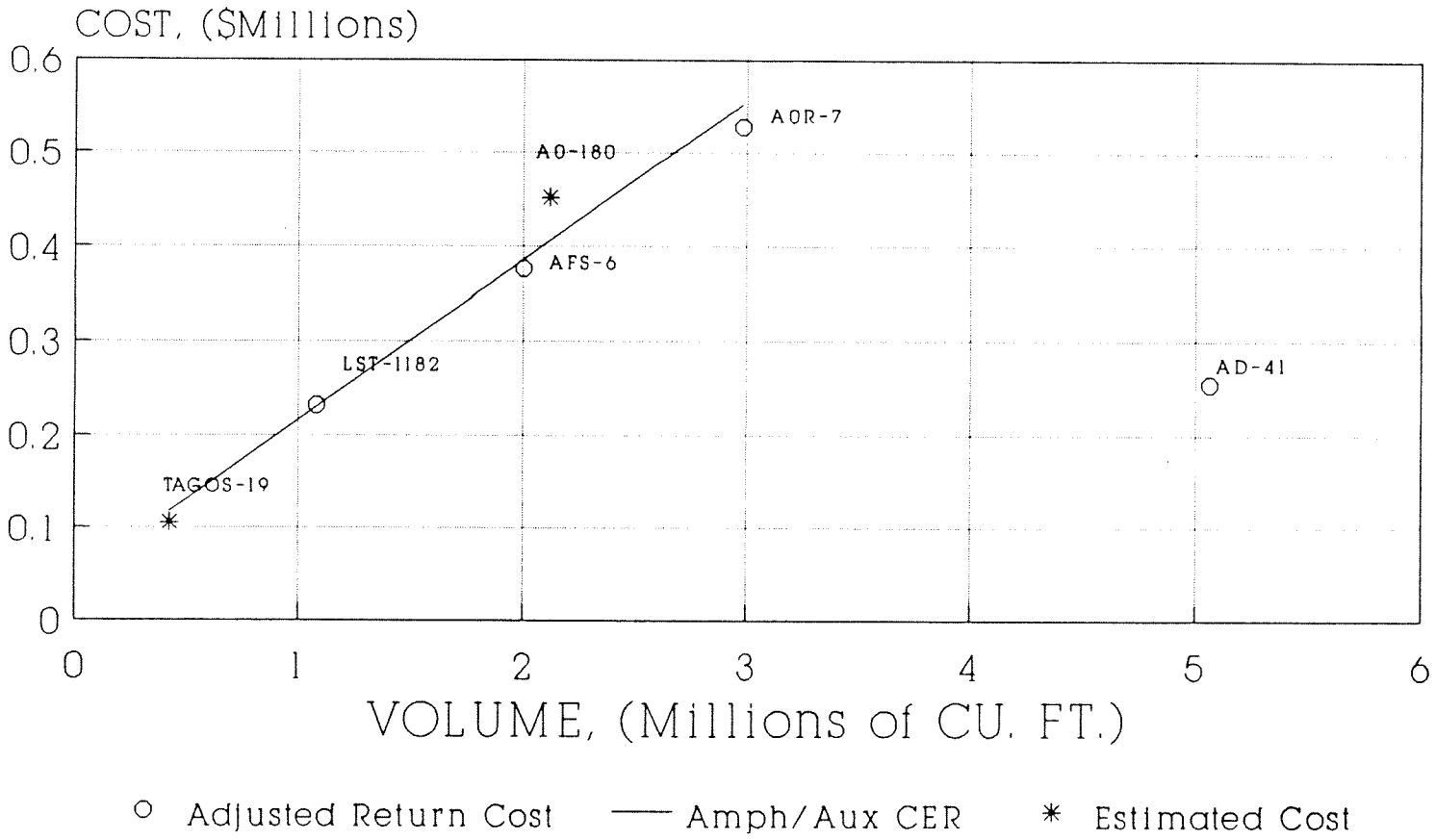


FIGURE 4-73

CER:	$ = 0.17 (VOL) + 46,400
Variable:	Total ship volume in cubic feet
Adjusted r^2:	.92 - 5 points
Application:	All ships

Labor Costs - Four CER's are provided for labor costs for Group 6A. Three are based on Group 6A weight and one on total ship's volume. The three CER's based on Group 6A weight are for the following conditions: conventional auxiliary and amphibious ships, ships capable of vehicular storage, as exemplified by the LST-1182, and ships with shops and monorail systems, as exemplified by the AD-41. The graphs for Group 6A labor costs are shown in Figures 4-74 and 4-75 and the CER's for Group 6A labor costs are:

CER:	MH = 426 (WT) - 400
Variable:	Group 6A WT in long tons
Adjusted r^2:	.88 - 4 points
Application:	Conventional ships

CER:	MH = 1,215 (WT) - 1,100
Variable:	Group 6A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Ships with vehicular storage

CER:	MH = 202 (WT) - 200
Variable:	Group 6A WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Ship with shops and monorails
CER:	MH = .005 (VOL) + 7,000
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.74 - 6 points
Application:	All ships

4.7.2 Group 6B - Non-Structural Subdivisions

This group includes non-structural bulkheads and doors, ladders, sheathing, etc.

HULL FITTINGS
GROUP 6A
LABOR

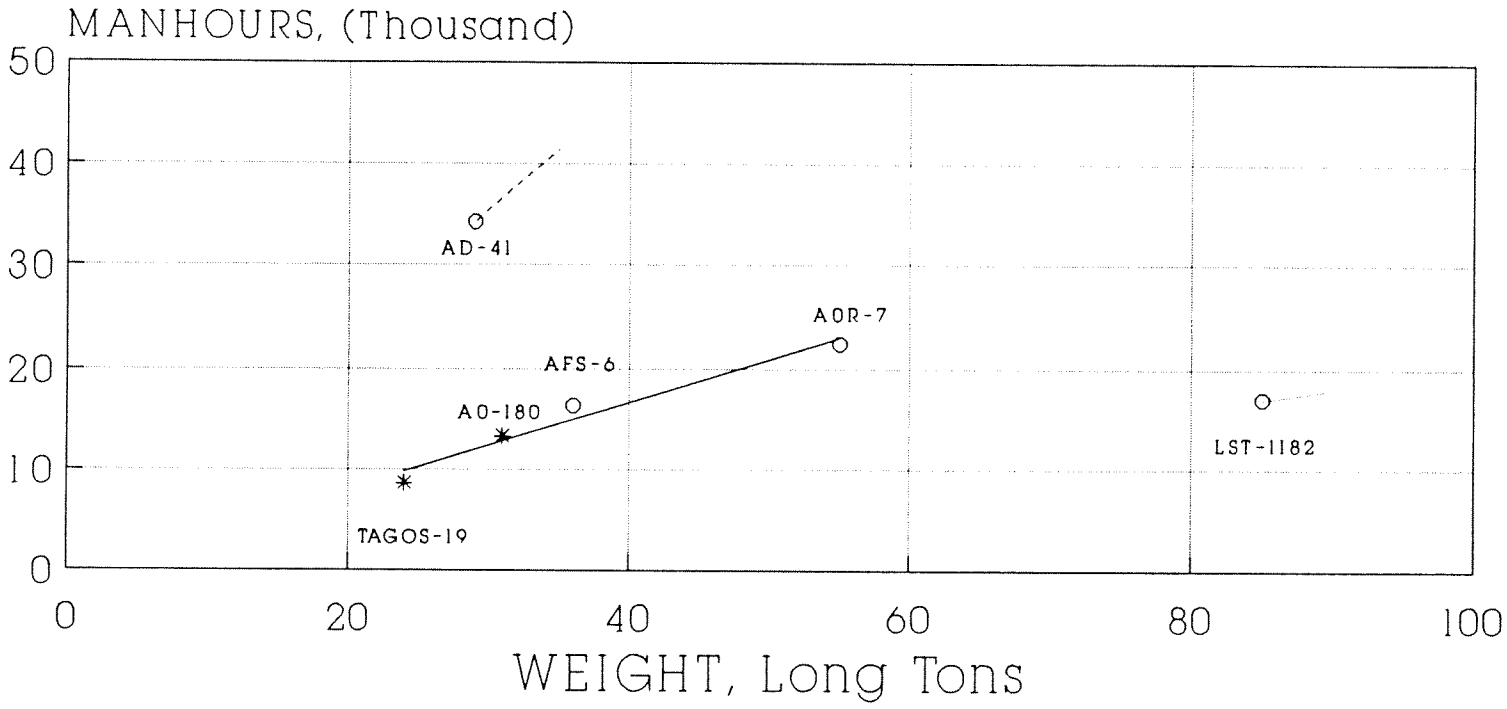


FIGURE 4-74

HULL FITTINGS
GROUP 6A
LABOR

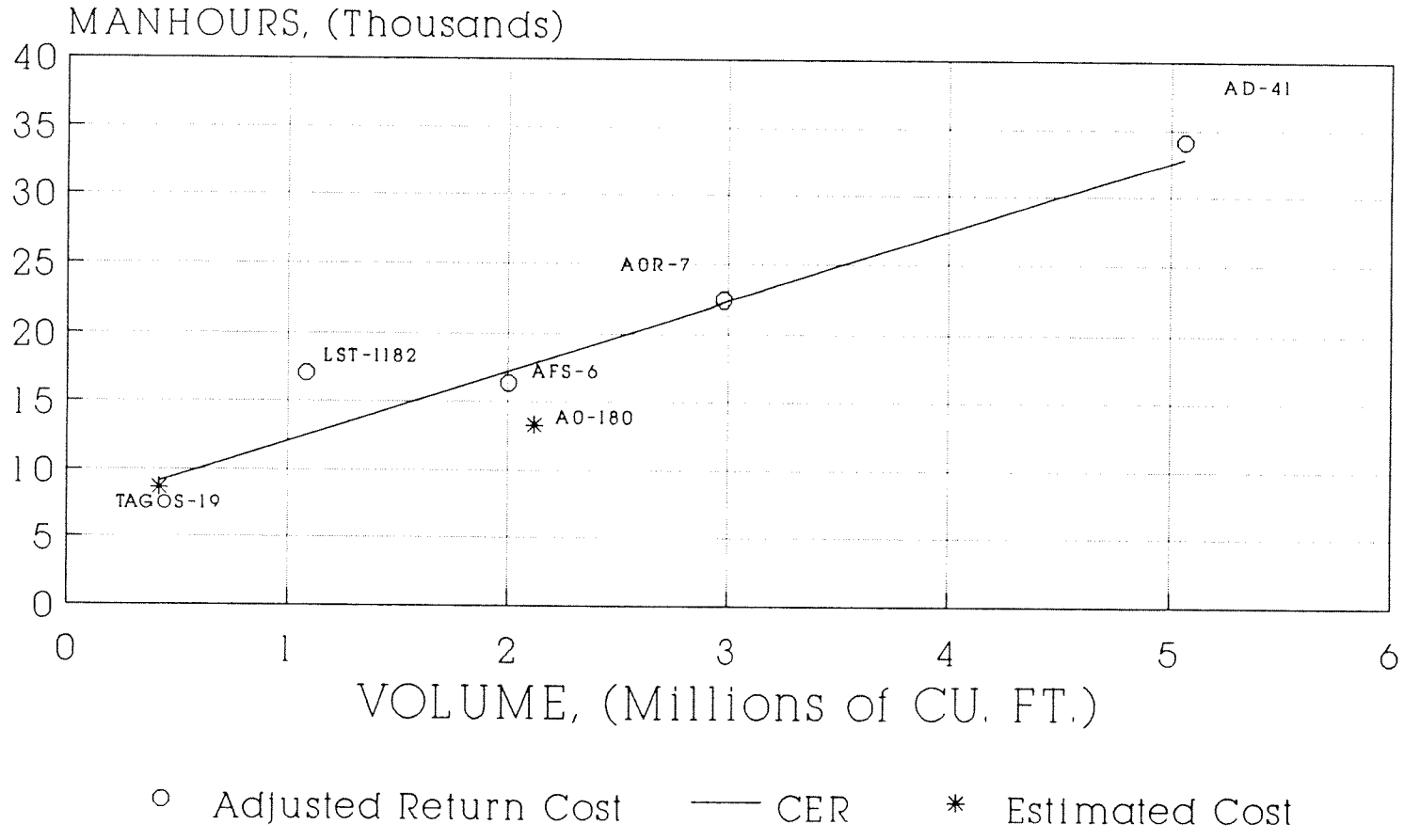


FIGURE 4-75

Material Costs - Three CER's are provided for material costs for Group 6B. Two are based on ship's length times beam and one is based on total ship's complement. The two based on ship's length times beam are for the following conditions: conventional auxiliary and amphibious ships, and complex, or highly subdivided, auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for the Group 6B material costs are shown in Figures 4-76 and 4-77 and the CER's for the Group 6B material costs are:

CER:	$ = 3.4 (LXB) - 414,200
Variable:	(L x B) in square feet
Adjusted r^2:	.61 - 5 points
Application:	Conventional ships

CER:	$ = 142 (LxB) - 1,726,700
Variable:	(LxB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	$ = 3,079 (CMP) + 346,100
Variable:	Total ship's complement
Adjusted r^2:	.83 - 6 points
Application:	All ships

Labor Costs - Three CER's are provided for labor costs for Group 6B. Two are based on the ship's length times beam and one is based on total ship's volume. The two based on the ship's length times beam are for the following conditions: conventional auxiliary and amphibious ships, and complex, or highly subdivided, auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for Group 6B labor costs are shown in Figures 4-78 and 4-79 and the CER's for Group 6B labor costs are:

CER:	MH = 1.5 (LxB) - 27,200
Variable:	(LxB) in square feet
Adjusted r^2:	.59 - 5 points
Application:	Conventional ships

NON-STRUCTURAL SUBDIVISIONS
GROUP 6B
MATERIALS COST

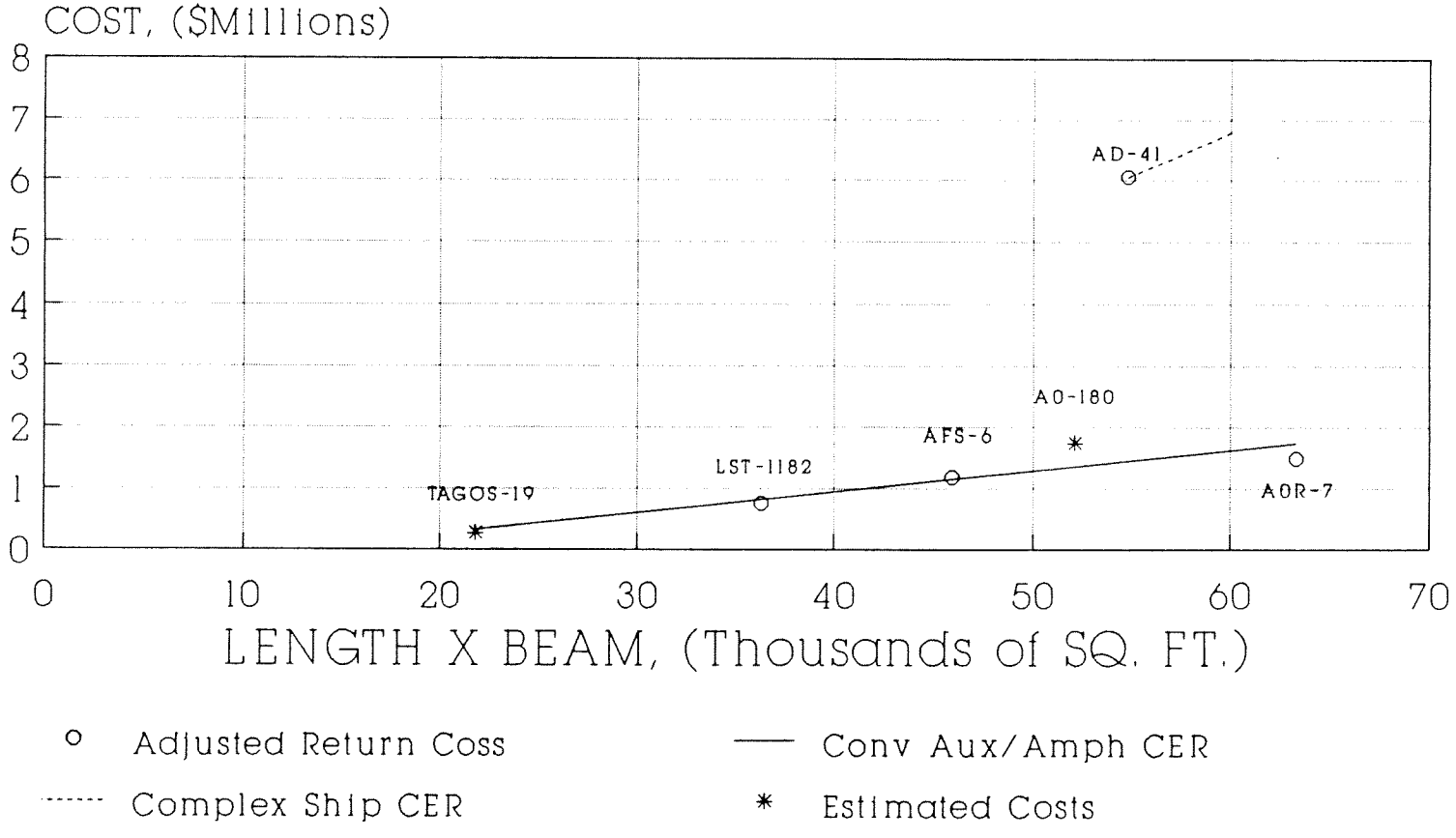


FIGURE 4-76

NON-STRUCTURAL SUBDIVISIONS
GROUP 6B
MATERIALS COST

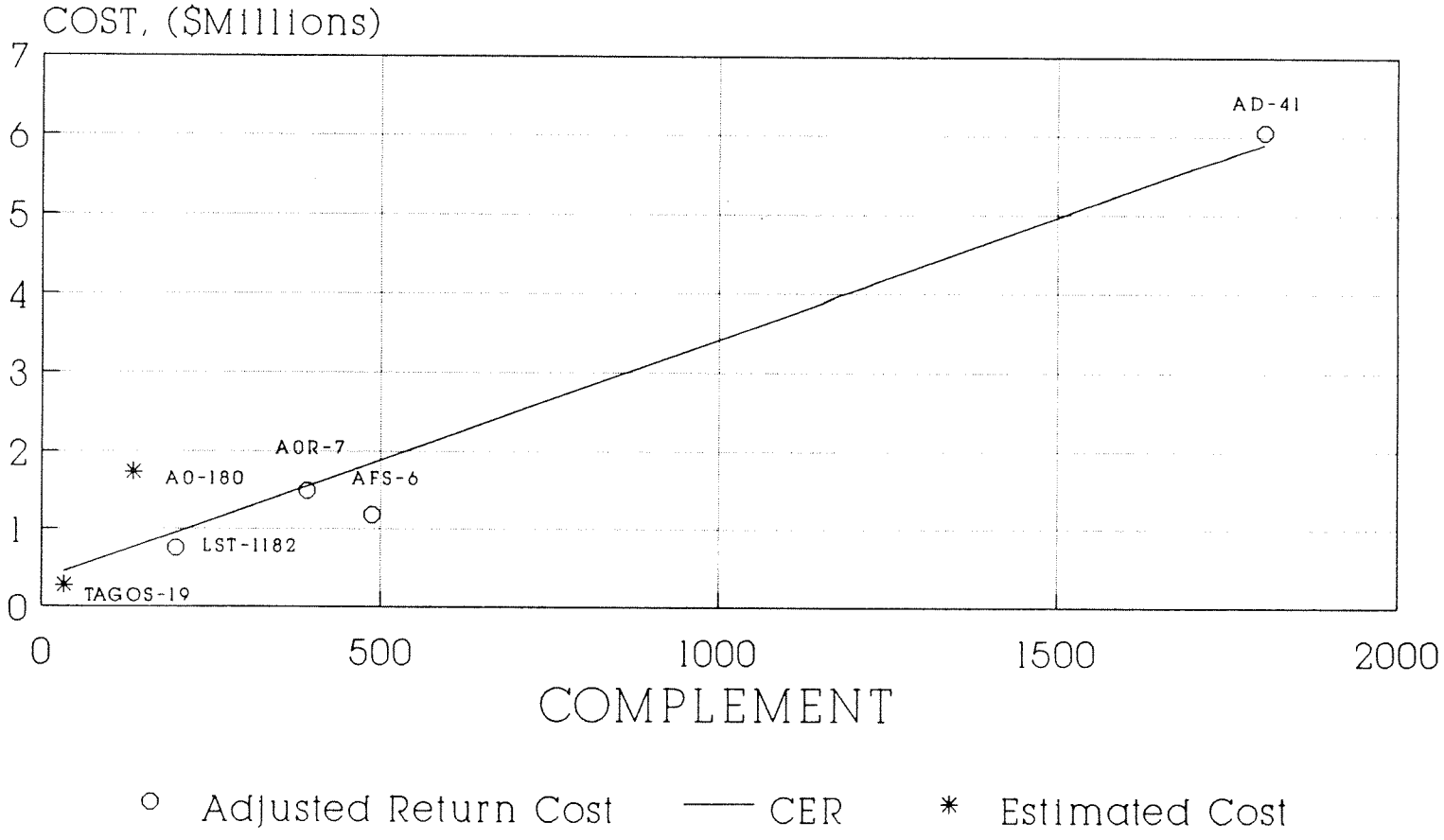


FIGURE 4-77

NON-STRUCTURAL SUBDIVISIONS
GROUP 6B
LABOR

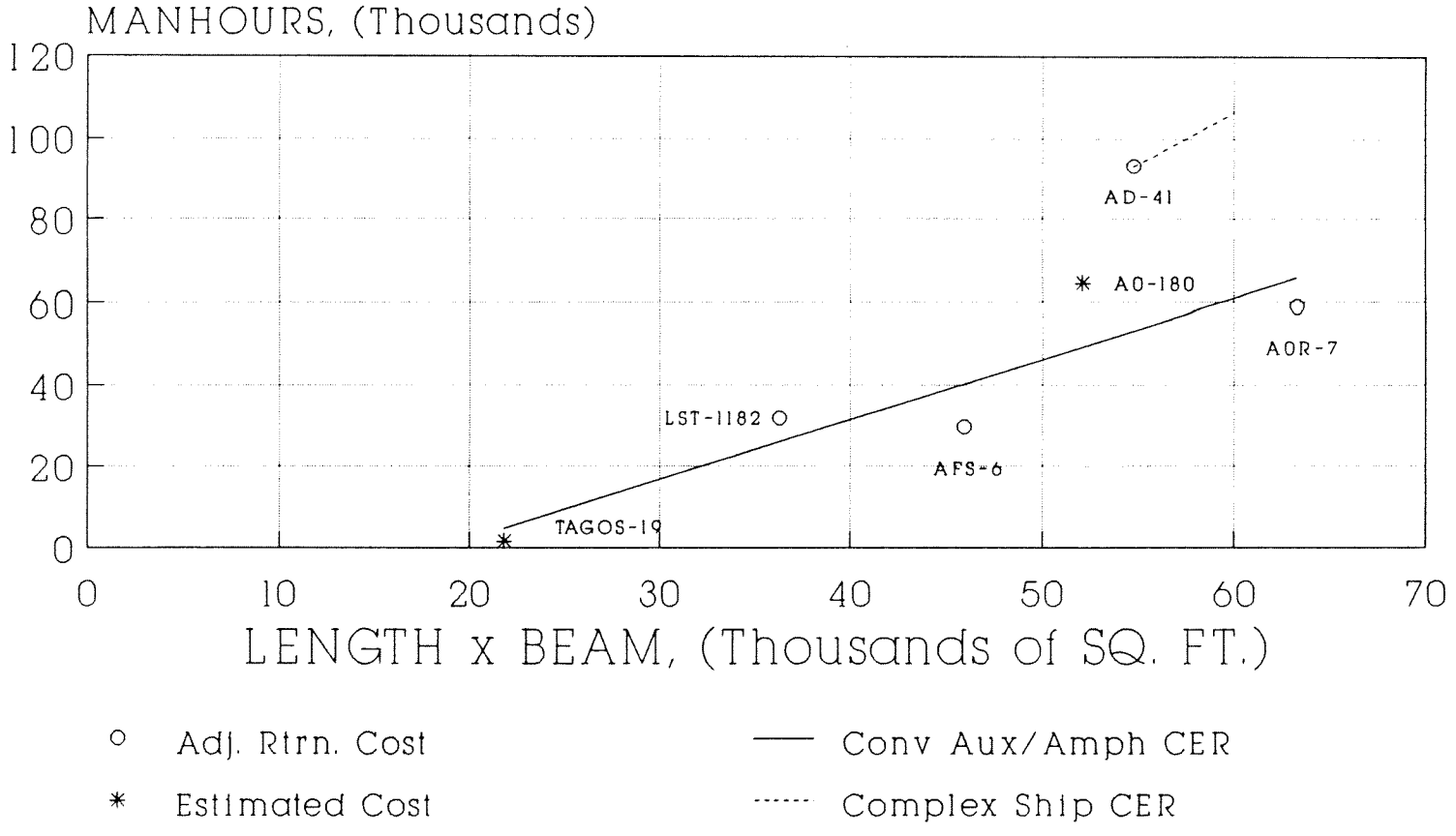


FIGURE 4-78

NON-STRUCTURAL SUBDIVISIONS
GROUP 6B
LABOR

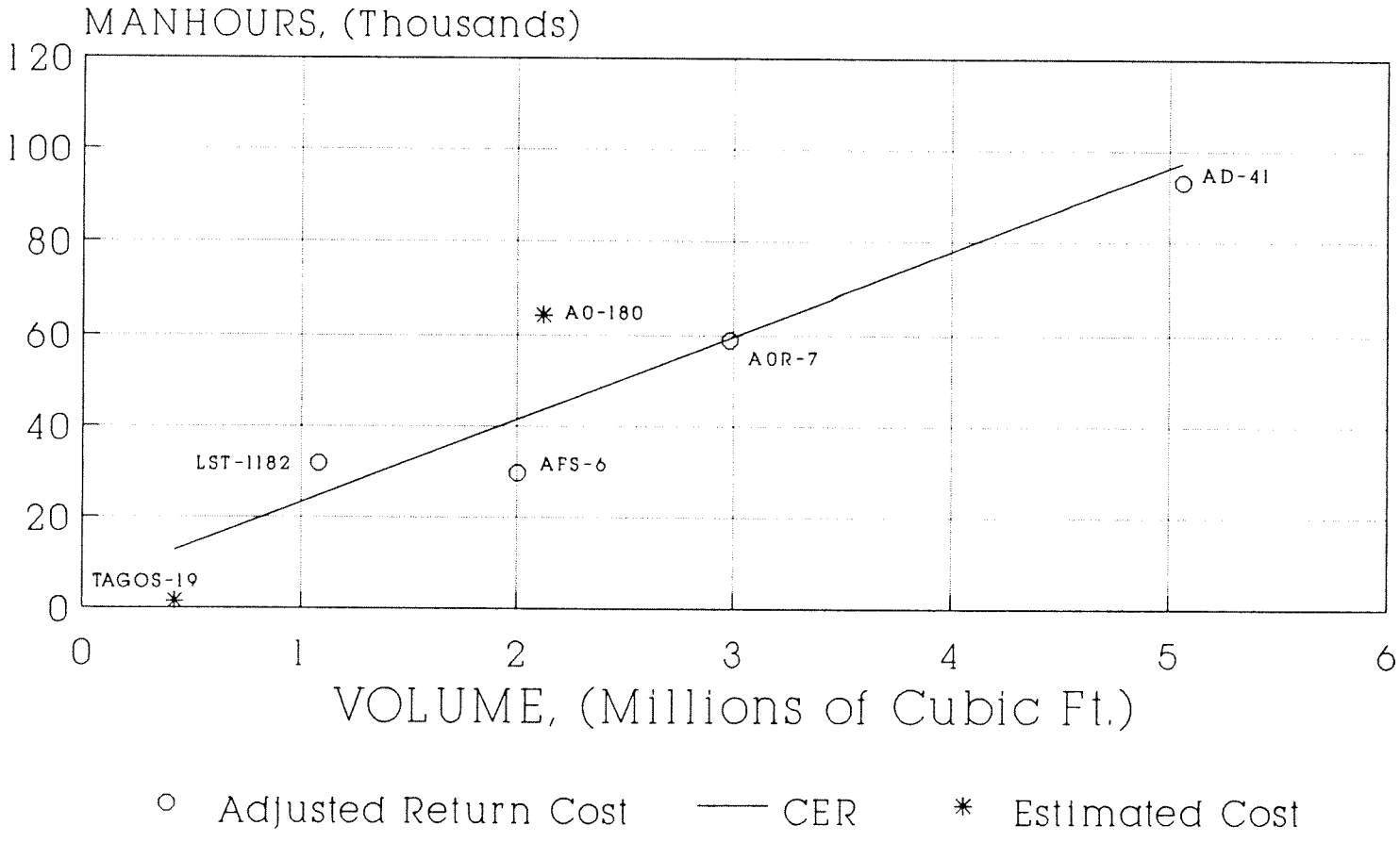


FIGURE 4-79

CER:	MH = 2.5 (LxB) - 47,500
Variable:	(LxB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

CER:	MH = 0.2 (VOL) + 5,000
Variable:	Total ship's volume in cubic feet
Adjusted r^2:	.65 - 6 points
Application:	All ships

4.7.3 - Group 6C Preservation

This group includes painting, deck covering and hull insulation.

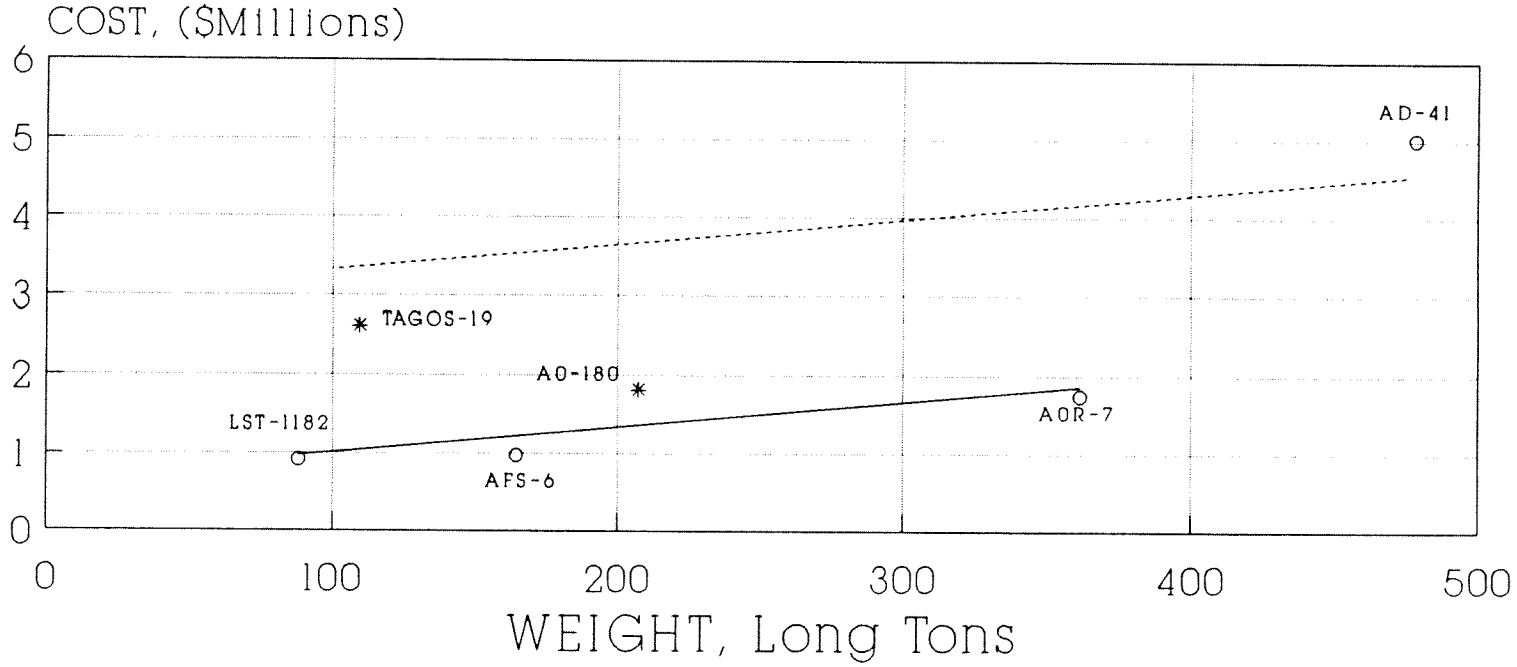
Material Costs - Four CER's are provided for material costs for Group 6C. Two are based on Group 6C weight and two are based on the ship's length times beam. The two CER's in each case are for the following conditions: conventional auxiliary and amphibious ships and complex configured auxiliary and amphibious ships, as exemplified by the T-AGOS-19 and AD-41. The graphs for the Group 6C material costs are shown in Figures 4-80 and 4-81 and the CER's for Group 6C material costs are:

CER:	$ = 3,220 (WT) + 691,200
Variable:	Group 6C WT in long tons
Adjusted r^2:	.13 - 5 points
Application:	Conventional ships

CER:	$ = 3,220 (WT) + 3, 000,000
Variable:	Group 6C WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Complex configured ships

CER:	$ = 36 (LxB) - 406,100
Variable:	(LxB) in square feet
Adjusted r^2:	.24 - 4 points
Application:	Conventional ships

PRESERVATION
GROUP 6C
MATERIALS COST



Cost and Weight of Radiation Shielding
Removed from AD-41

FIGURE 4-80

PRESERVATION
GROUP 6C
MATERIALS COST

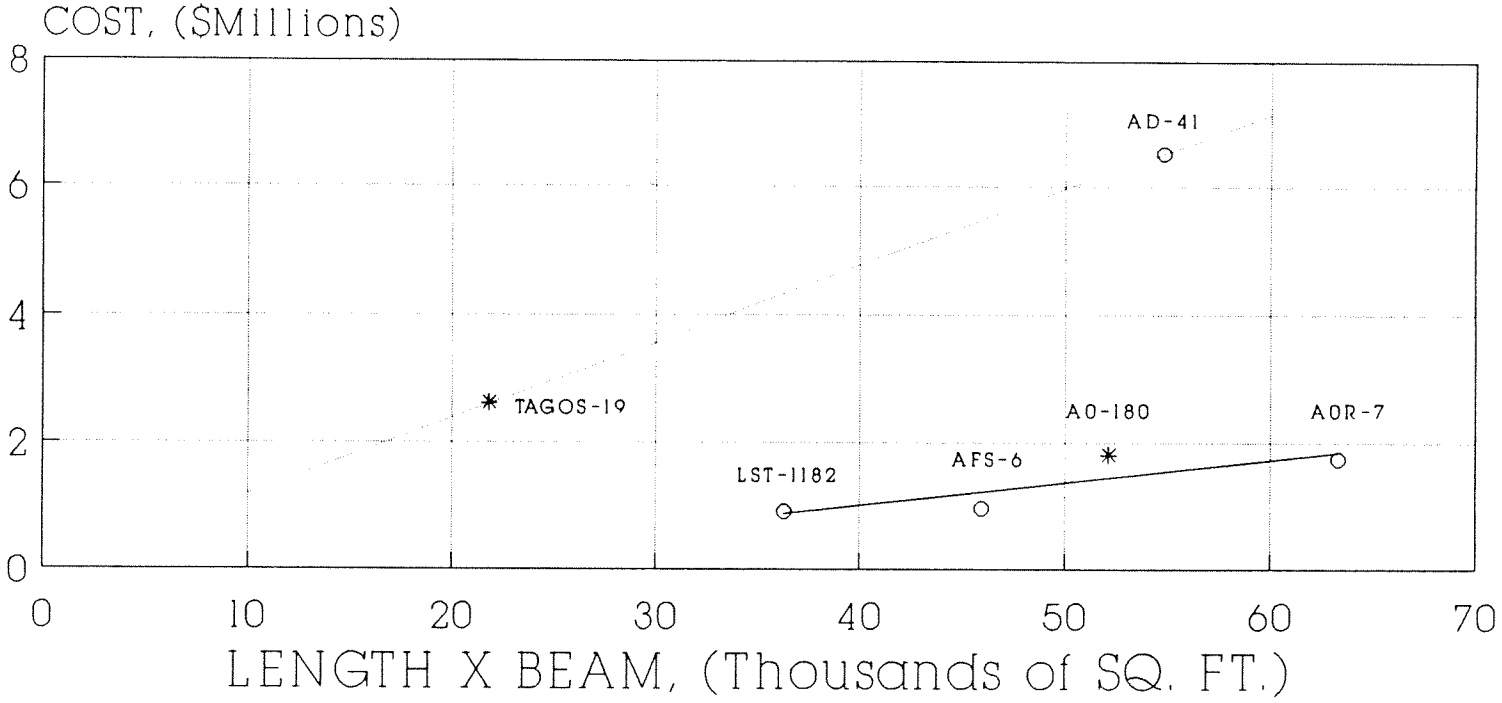


FIGURE 4-81

CER:	$ = 119 (LxB) + 0
Variable:	(LxB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex configured ships

Labor Costs - Three CER's are provided for labor costs for Group 6C. One CER is based on Group 6C weight and two CER's are based on the ship's length times beam. The two CER's based on the ship's length times beam are for the following conditions: conventional auxiliary and amphibious ships and complex auxiliary and amphibious ships, as exemplified by the AD-41. The graphs for Group 6C labor costs are shown in Figures 4-82 and 4-83 and the CER's for Group 6C labor costs are:

CER:	MH = 1,073 (WT) - 65,700
Variable:	Group 6C WT in long tons
Adjusted r^2:	.64 - 6 points
Application:	All ships

CER:	MH = 3.6 (LxB) - 41,100
Variable:	(LxB) in square feet
Adjusted r^2:	.50 - 5 points
Application:	Conventional ships

CER:	MH = 12 (LxB) - 141,000
Variable:	(LxB) in square feet
Adjusted r^2:	N/A - insufficient points
Application:	Complex ships

4.7.4 Group 6D - Ship Support

This group includes storerooms and equipment for utility spaces and workshops.

Material Costs - Two CER's are provided for material costs for Group 6D. One is based on Group 6D weight and one is based on the ship's total complement. The graphs for Group 1C material costs are shown in Figures 4-84 and 4-85 and the CER's for Group 6D material costs are:

PRESERVATION
GROUP 6C
LABOR

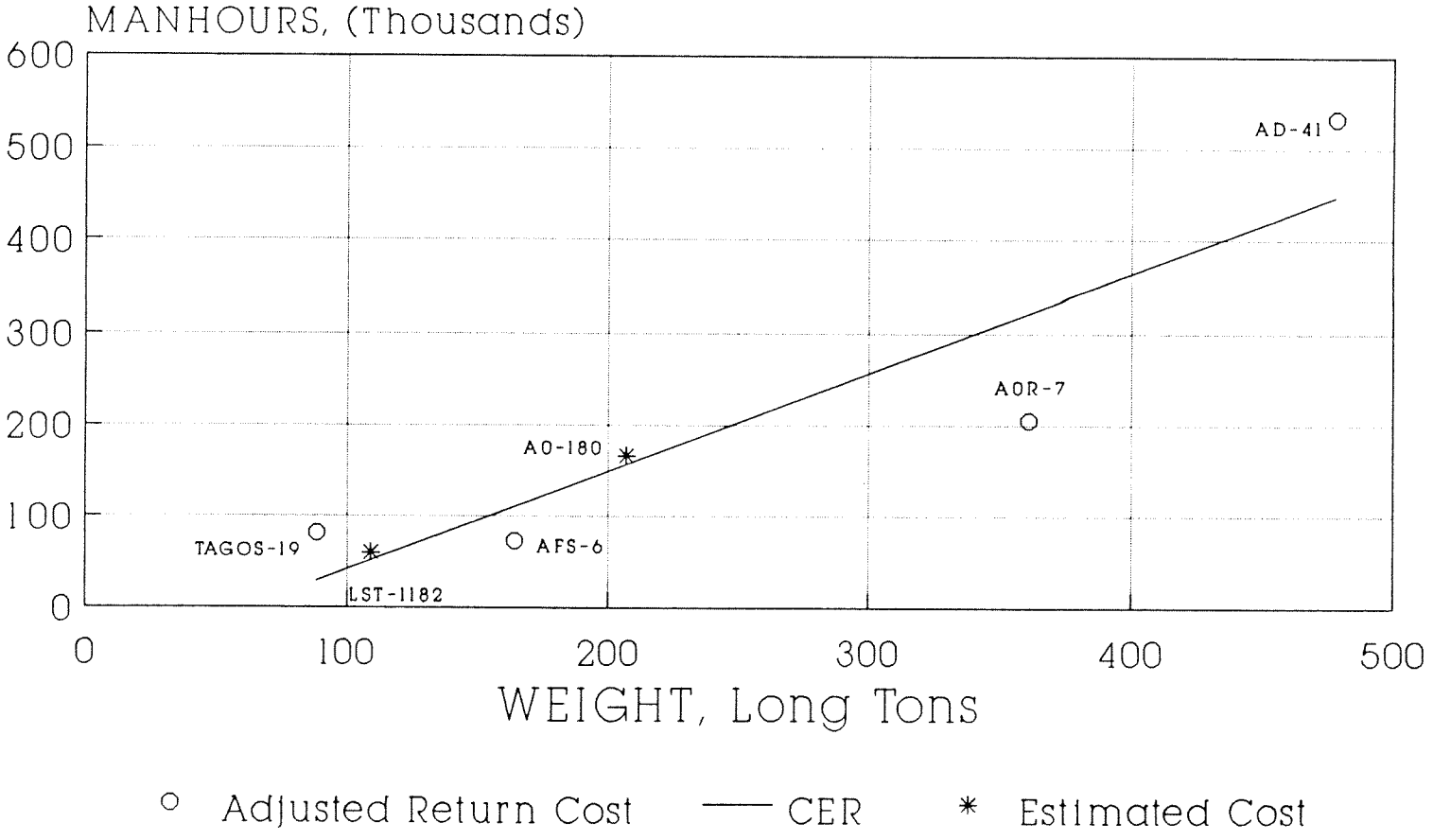


FIGURE 4-82

PRESERVATION
GROUP 6C
LABOR

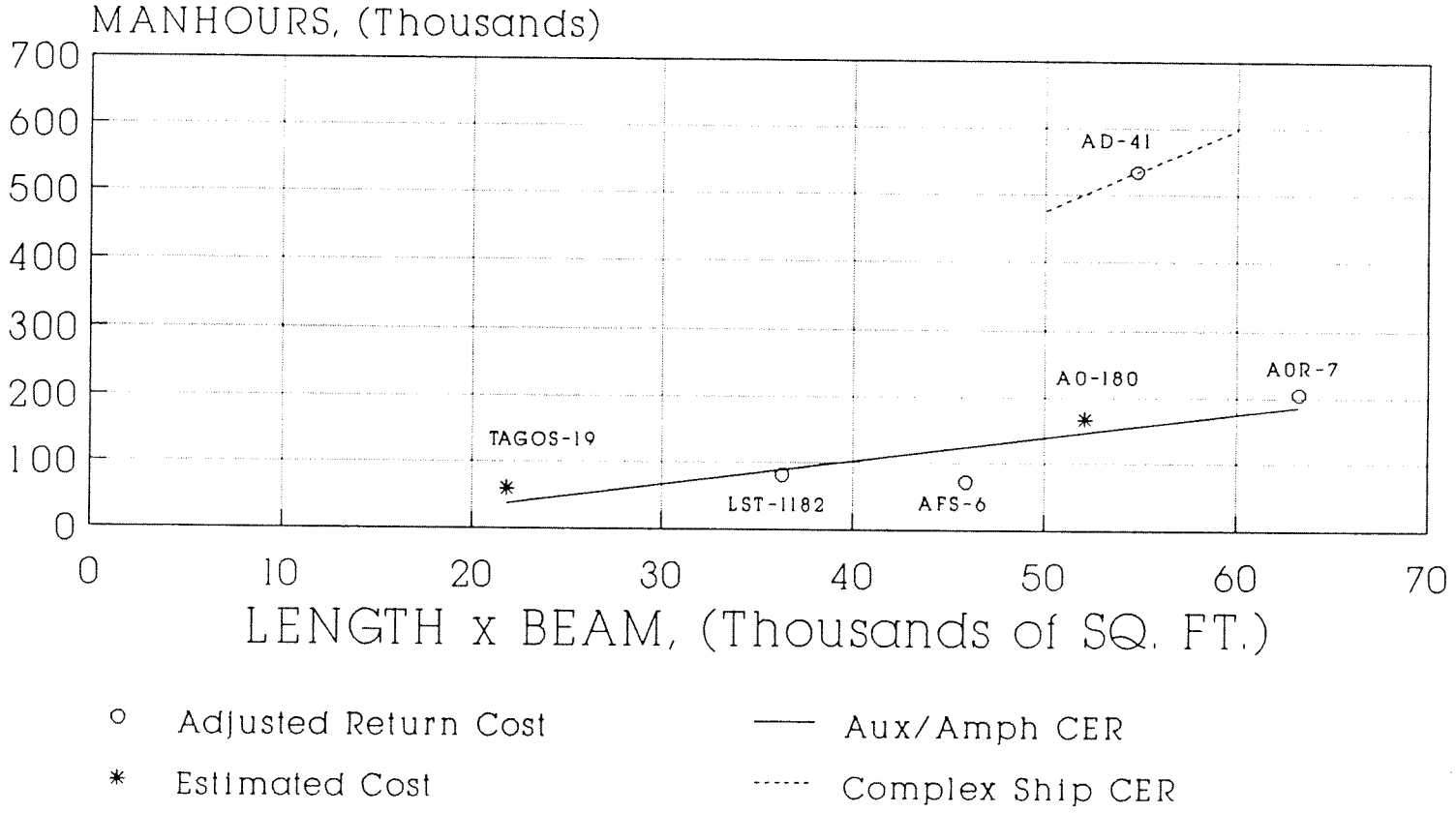


FIGURE 4-83

Labor for Installation of Radiation Shielding Subtracted from AD-41

SHIP SUPPORT
GROUP 6D
MATERIALS COST

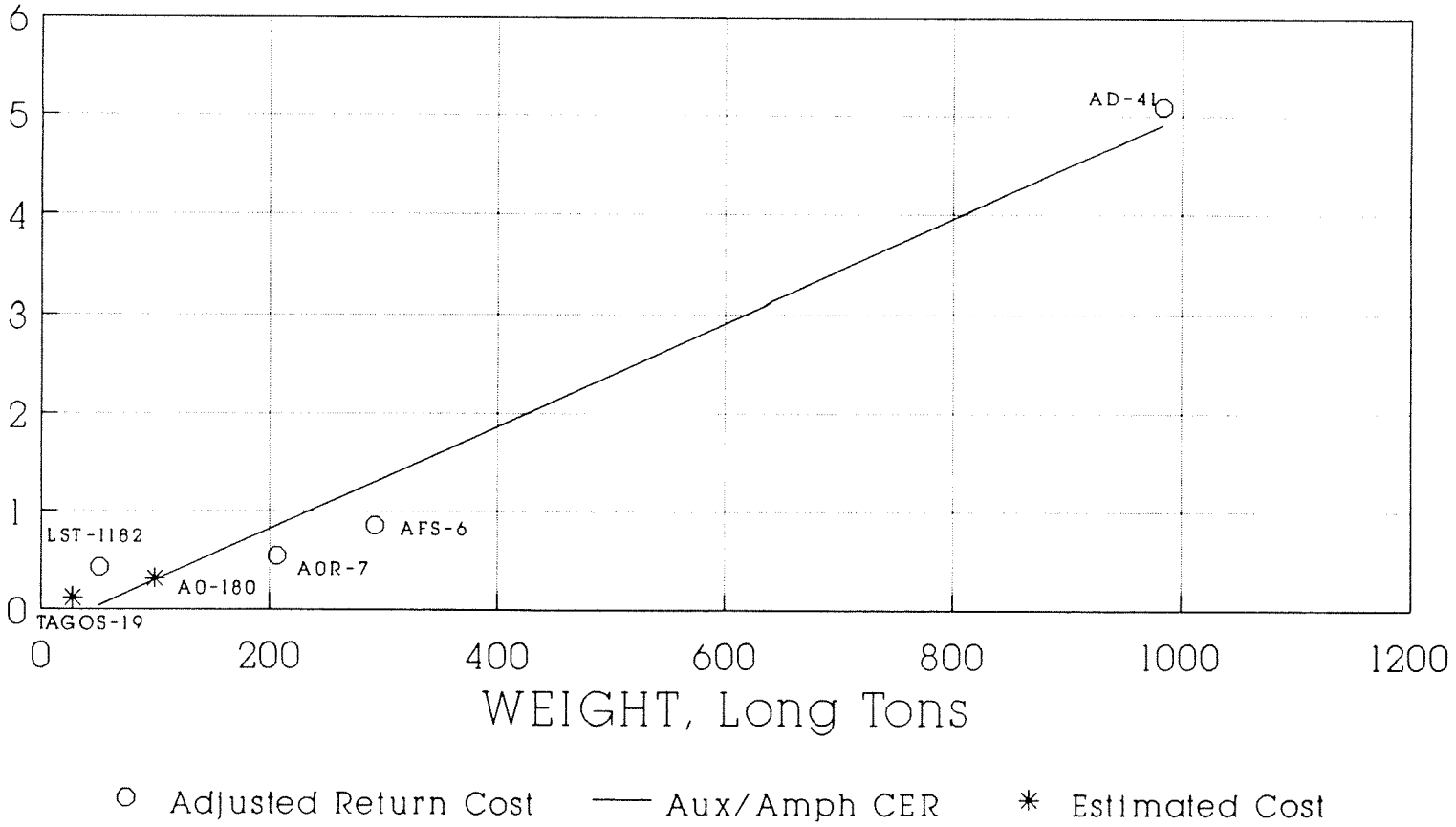


FIGURE 4-84

SHIP SUPPORT
GROUP 6D
MATERIALS COST

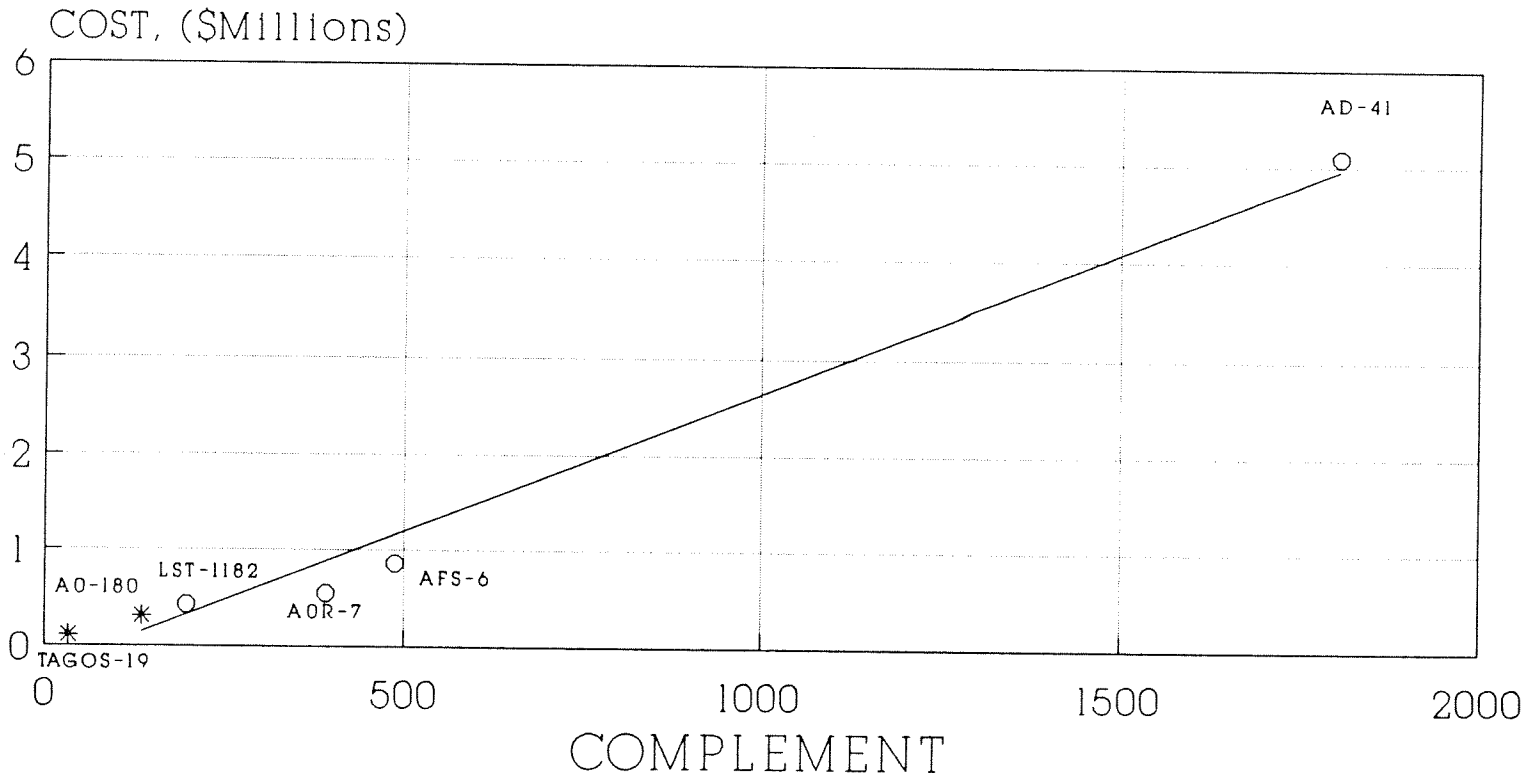


FIGURE 4-85

CER:	$ = 5,230 (WT) - 224,800
Variable:	Group 6D WT in long tons
Adjusted r^2:	.93 - 6 points
Application:	Conventional ships

CER:	$ = 2,885 (CMP) - 244,600
Variable:	Ship's complement
Adjusted r^2:	.95 - 6 points
Application:	All ships

Labor Costs - Two CER's are provided for labor costs for Group 6D. One is based on Group 6D weight and one is based on total ship's complement. The graphs for Group 6D labor costs are shown in Figures 4-86 and 4-87, and the CER's for group Group 6D labor costs are:

CER:	MH = 67 (WT) - 8,300
Variable:	Group 6D WT in long tons
Adjusted r^2:	.90 - 6 points
Application:	All ships

CER:	MH = 37 (CMP) + 8,800
Variable:	Total ship's complement
Adjusted r^2:	.85 - 6 points
Application:	All ships

4.7.5 Group 6E - Habitability

This group includes furnishing for living spaces, machinery spaces, medical spaces and galley equipment.

Material Cost - A single CER, based on Group 6E weight, is provided for material costs for Group 6E. The graph for Group 6E material costs is shown in Figure 4-88 and the CER for Group 6E material costs is:

CER:	$ = 33,966 (WT) - 167,100
Variable:	Group 6E WT in long tons
Adjusted r^2:	.98 - 6 points
Application:	All ships

SHIP SUPPORT
GROUP 6D
LABOR

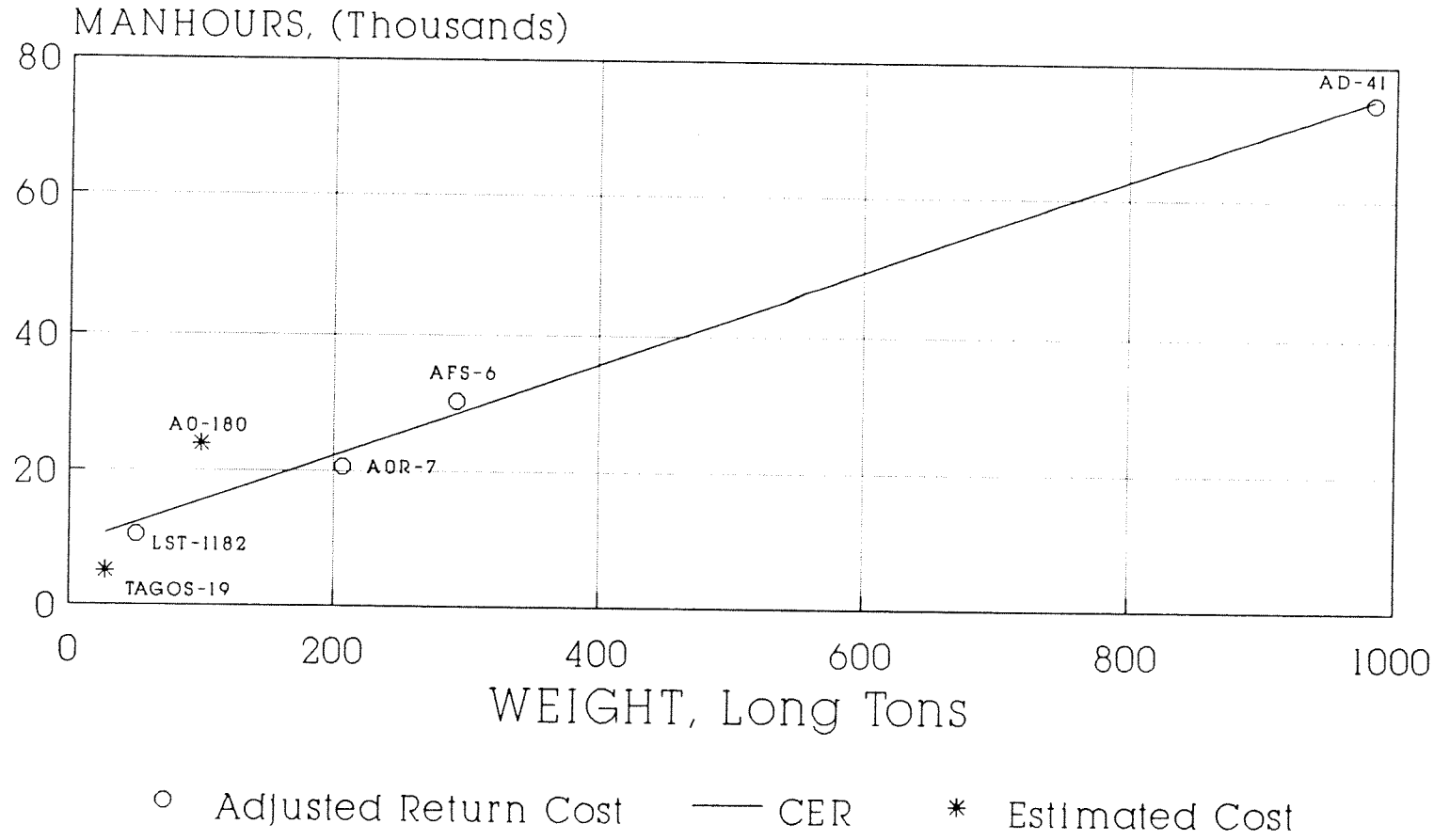


FIGURE 4-86

SHIP SUPPORT
GROUP 6D
LABOR

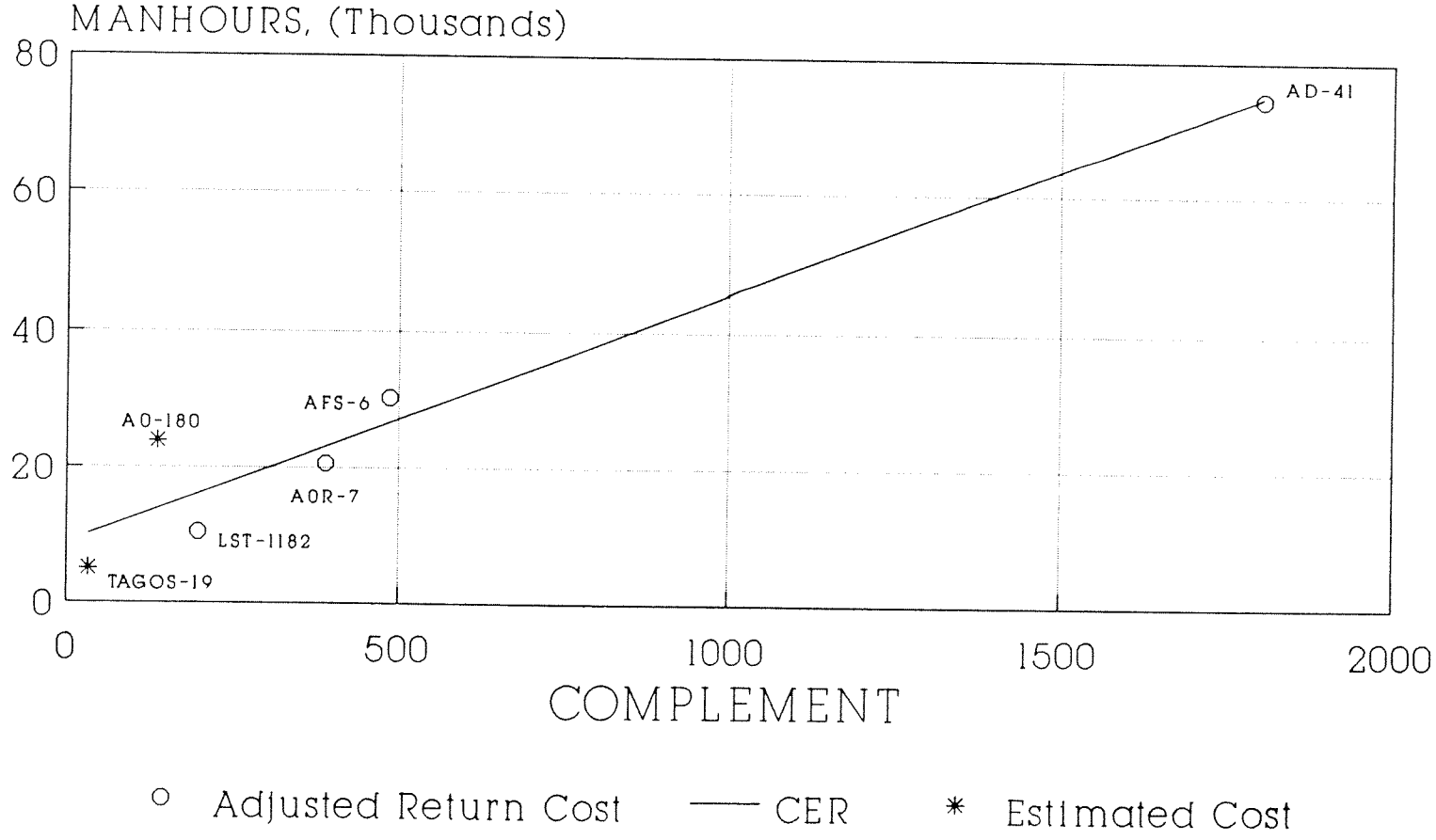


FIGURE 4-87

HABITABILITY
GROUP 6E
MATERIALS COST

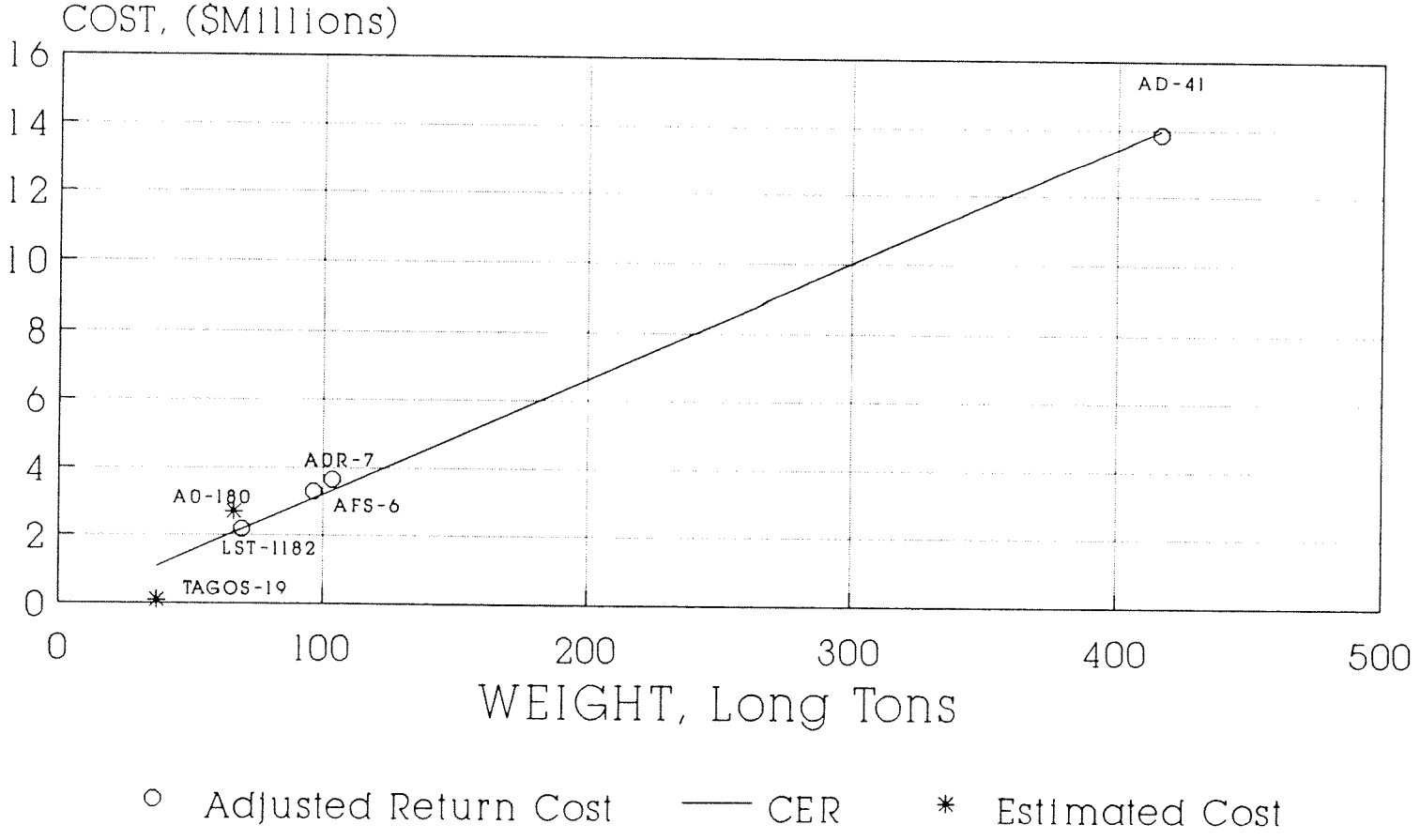


FIGURE 4-88

Labor Costs - A single CER, based on Group 6E weight, is provided for labor costs for Group 6E. The graph for Group 6E labor costs is shown in Figure 4-89 and the CER for Group 6E labor costs.

CER:	MH = 196 (WT) - 6,400
Variable:	Group 6E WT in long tons
Adjusted r^2:	.93 - 6 points
Application:	All ships

HABITABILITY
GROUP 6E
LABOR

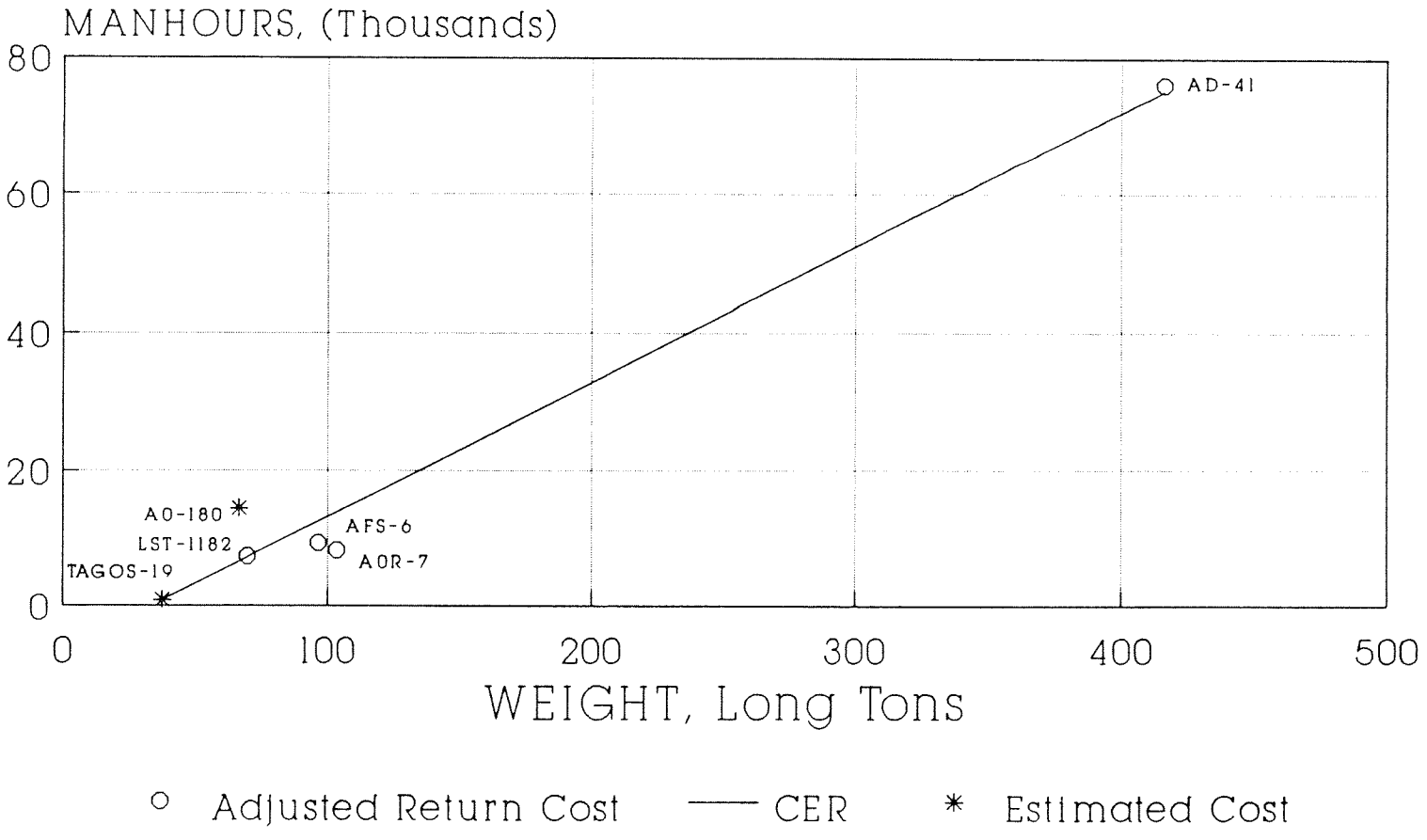


FIGURE 4-89

4.8 Group 7 - Armament

This one digit, and in this case two digit, SWBS Group includes the installation of gun and missile systems, ordnance handling equipment and small arms. Cargo munitions stowage and handling are included in Group 5D with other similar equipment.

Material Costs - Two CER's are provided for material costs for Group 7. Both are based on Group 7 weight and are for the following conditions: non-air capable auxiliary and amphibious ships, and air capable auxiliary and amphibious ships, as exemplified by the LHA. The graph for Group 7 material costs is shown in Figure 4-90 and the CER's for Group 7 material costs are:

CER:	$ = 1,044 (WT) + 5,500
Variable:	Group 7 WT in long tons
Adjusted r^2:	.92 - 5 points
Application:	Standard auxiliary/amphibious

CER:	$ = 3,207 (WT) + 16,900
Variable:	Group 7 WT in long tons
Adjusted r^2:	N/A - insufficient points
Application:	Extensive armaments

Labor Costs - A single CER, based on Group 7 weight, is provided for labor costs for Group 7. The graph for Group 7 labor costs is shown in Figure 4-91, and the CER for Group 7 labor costs is:

CER:	MH = 135 (WT) - 4,700
Variable:	Group 7 WT in long tons
Adjusted r^2:	.79 - 6 points
Application:	All ships

ARMAMENT
GROUP 7
MATERIALS COST

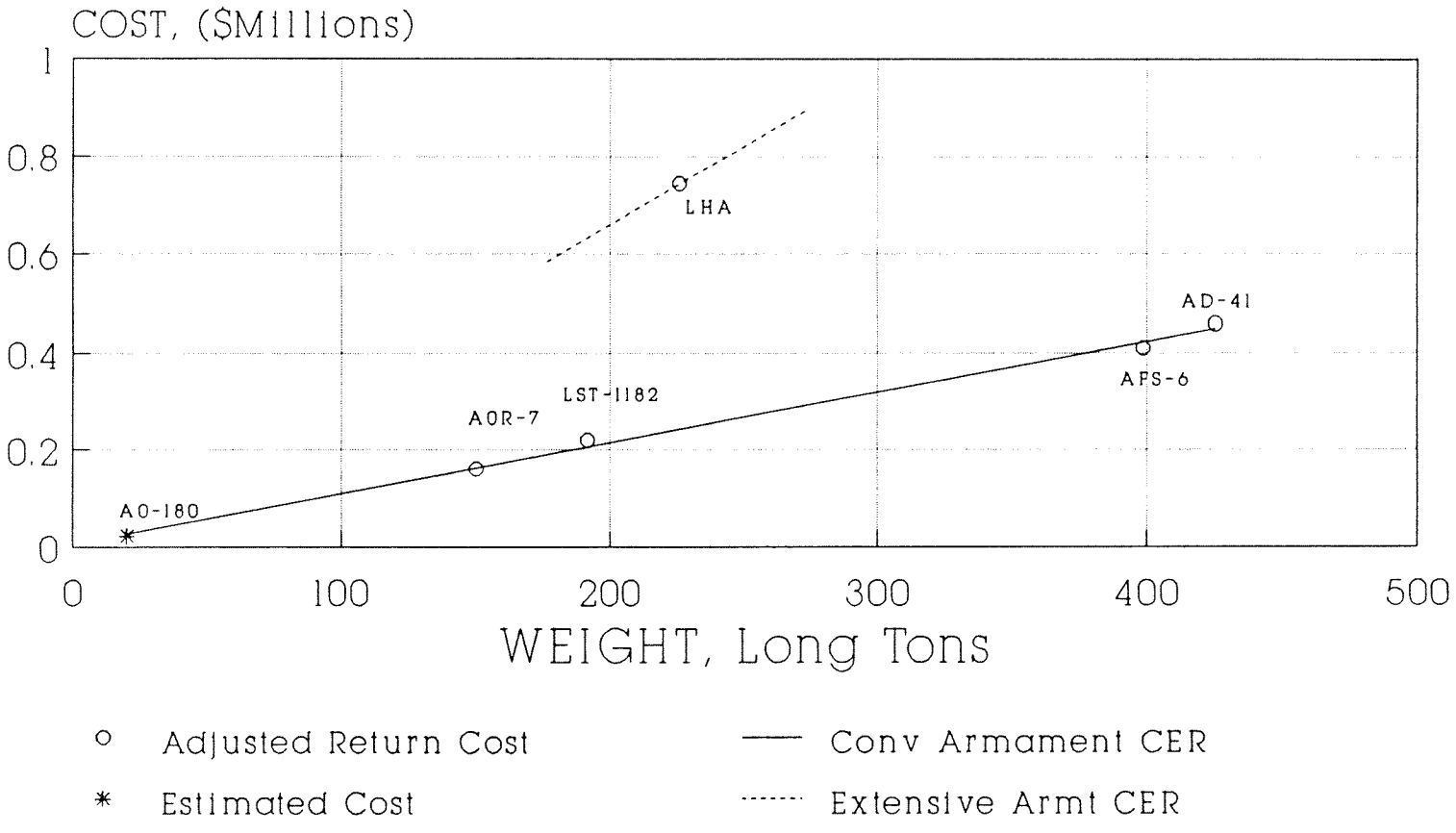


FIGURE 4-90

ARMAMENT
GROUP 7
LABOR

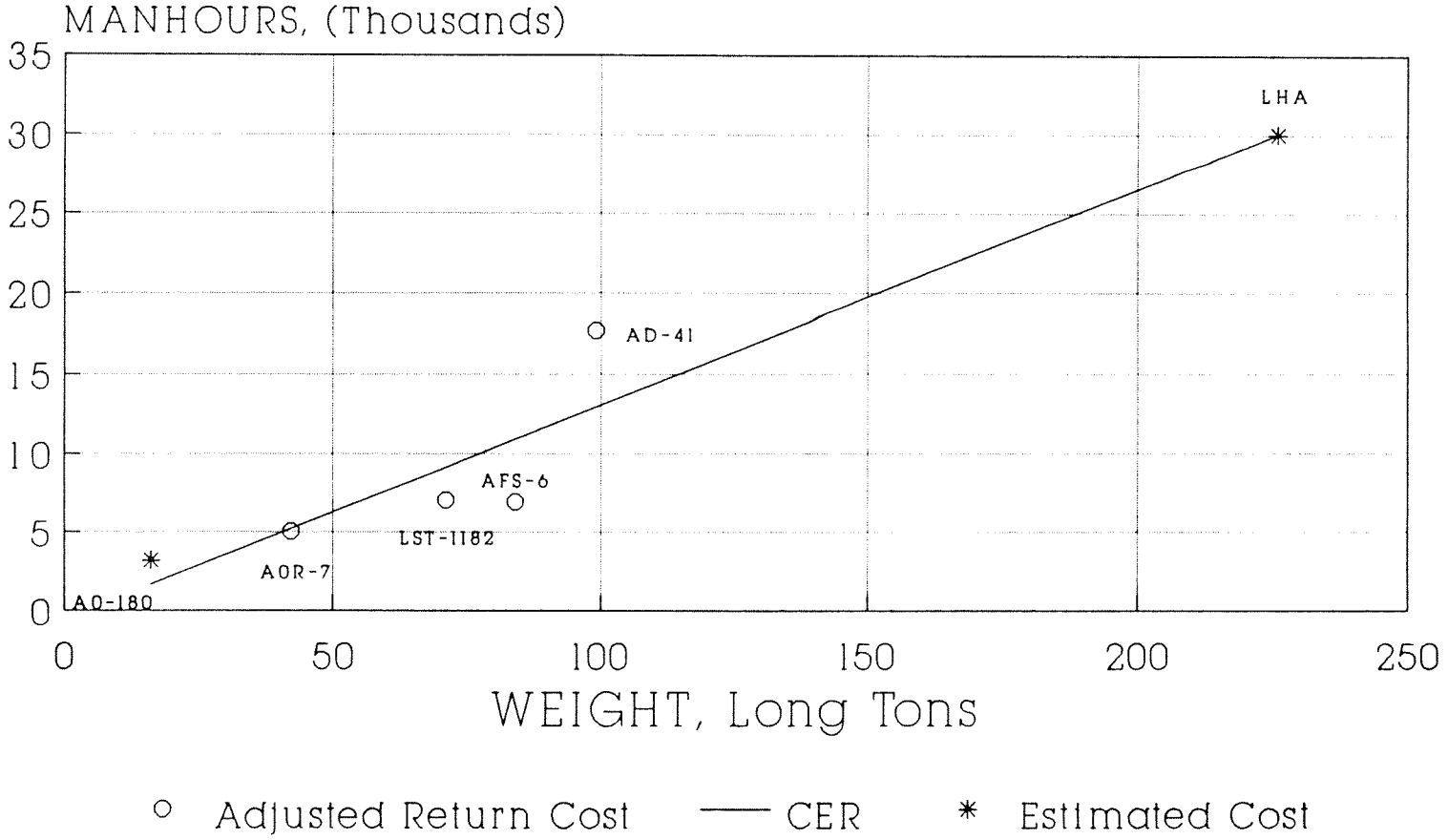


FIGURE 4-91

4.9 SWBS Group 8 - Integration/Engineering

SWBS Group 8 encompasses a wide variety of shipbuilder engineering support during construction. Included in this are the following elements:

- Design support - specifications, weight, computer programs, engineering calculations, models and mockups, photographs, design/engineering liaison, lofting.

- Quality assurance - tests and inspections, trials support, inclining experiment and trim dive, combat systems, checkout, certification standards.

- Integrated logistics support (ILS) engineering - maintenance, support and test equipment, supply support, transportation, engineering drawings and specifications, technical manuals and other data, facilities, personnel and training, training equipment.

- Special purpose items - human factors, standardization, value engineering, reliability and maintainability (RMA), data management, project management.

Whereas SWBS Groups 1-7 are related to the construction of the ship and tend to follow reasonable trends, SWBS Group 8 relates to support requirements placed on the shipyard by the Navy, which are subject to change as Navy policy changes. Over the past 10 years, the Group 8 support has grown dramatically in response to the increased demand for project management support and increased focus on ILS, RMA, human factors and the like. Although recent return cost data from Group 8 was not available for the update of this model, a similar update for the Destroyer/Cruiser Construction Cost Model (Reference 6) indicates that in the time frame between the lead ships for the FFG-7 program, and the CG-47 and DDG-51 programs, material costs grew by a factor of 27, and labor costs by a factor of 7. With tightening budgets and the maturity of some of the Group 8 programs, it is unlikely that the growth will continue and it is probable

Arvo Aamph CCM 9/88

that there will be a gradual decline in Group 8 support because of increased budgetary pressures.

The values for Group 8 for this current model update have been derived by updating the original model's Group 8 material costs to 1986 dollars and then multiplying both the material and labor costs by factors equivalent to those experienced in the destroyer model (i.e., 27 for material costs and 7 for labor costs). This results in a Group 8 material cost of $ = 5 Million and Group 8 labor cost of MH = 2.0 Million. It is believed that these values are conservative, since they are based on surface combatant experience, and surface combatants are more complex ships with higher visibility than auxiliary and amphibious ships. The model user may choose to scale these numbers down by as much as the multiplicative factors applied, especially for less complex or mission essential ships.

4.10 SWBS Group 9 - Ship Assembly and Support Services

SWBS Group 9 encompasses the general shipyard support services required for construction of the ship that do not fall within any of the previous SWBS Groups. Included in SWBS Group 9 are the following:

- Ship assembly identification
- Non-engineering contractual and production support services - assist ships force, insurance, trials support, delivery support, fire and flooding protection, tests and inspection support, weighing and recording, administrative contract data requirements, fitting-out support
- Construction support - staging, scaffolding and cribbing services, temporary utilities and services, material handling and removal, cleaning services, molds and templates, jigs, fixtures and specifications, tools, launching, drydocking.

As with SWBS Group 8, SWBS Group 9 costs have increased over the past 10 years. This growth is attributable, in part, to the general growth in support services to respond to Navy requirements, as well as the increased planning and coordination required for extensive pre-outfitted construction. The growth in SWBS Group 9 costs has not been as dramatic as SWBS Group 8 since the SWBS Group 9 activities are primarily in support of construction activities within the yard.

In the original version of the model, SWBS Group 9 costs were related to the length of time the vessel is in the shipyard. This convention is carried over for this update. As with Group 8, the Group 9 material costs have been updated to 1986 dollars and both material and labor costs have been multiplied by a factor based on the surface combatant experience, i.e. 4 for material costs and 2 for labor costs. The CER's for the Group 9 costs are:

Materials: $ = 200,000 x no. months in the shipyard

Manhours: MH = 50,000 x no. months in the shipyard

The number of months an auxiliary and amphibious ship is in the shipyard ranges typically from 10 to 25, depending upon size and complexity. If the anticipated length of stay in a shipyard is unknown, the model user should use 15 months.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The original 1980 model was considered by NCA to be a good model from the point of view of accuracy and model structure. This revision to the model has retained the positive elements of the original model, while attempting to improve upon the data base and the narrative portion of the report. The revision includes new data on the SWATH T-AGOS-19. The data base was computerized and the data was analyzed for each cost group and new CER's developed based on this analysis. Also, an analysis was made of non-linear relationships for the data (Reference 5). Finally, all costs were revised to 1986 values using the NAVSEA numbers. These revisions should make the model current. The computerization of the data base should also allow for easier future updates as well as allow NCA personnel to do additional data analysis, if required.

The primary recommendation is that the data base be updated as new ships or technologies evolve. Special attention should be given to future trends in shipbuilding practices, such as increased automation, changes in union/management relationships, or dramatic changes in the industrial base, as they will have significant effects on the cost estimating relationship provided in this model. Similarly, changes in Navy requirements and policy will also affect the cost estimating relationships presented in the model, with potential budgetary constraints having significant impacts on the SWBS Group 8 and 9 support costs.

6. REFERENCES

1. Gibbs & Cox, Inc. U.S. Naval Vessels (Auxiliary and Amphibious Ships) Cost Model, ONR Contract No. N00014-81-0643, 1983.

2. Jane's Fighting Ships - 1986-87, Jane's Publishing Inc., NY, NY 1987

3. BIW, Inc. (R.G. Ford) letter to Gibbs 7 Cox, Inc. (W.W. Rogalski), Subject: Cost Estimating Data for T-AGOS-19 and T-AGX, February 22, 1988.

4. BIW, Inc., (R.G. Ford) letter to Gibbs & Cox, Inc. (W.W. Rogalski) Subject: Cost Estimating Data for LSD-41, dated February 2, 1988.

5. MCR, Inc. Parametric Shipbuilding Construction Cost Models, Gibbs & Cox, Inc. Contract No. 11021-1 under ONR Contract No. N00014-86-C-0796, 1988.

6. Gibbs & Cox, Inc., Revised Destroyer/Cruiser Construction Cost Model (Draft Final Report), ONR Contract No. N00014-86-C-0796, 1988.

APPENDIX A--

DATA WORK SHEETS

Table A-1

Input Data Requirements
One Digit SWBS Level Cost Model

Vessel Description: _____

_____

_____

Analyst: _____

Reviewed/Approved: _____

Date: _____

Ship Characteristic	Factor	Value
Group 1 Weight	Long Tons	_____
Group 2 Weight	Long Tons	_____
Group 3 Weight	Long Tons	_____
Group 4 Weight	Long Tons	_____
Group 5 Weight	Long Tons	_____
Group 6 Weight	Long Tons	_____
Group 7 Weight	Long Tons	_____
Total Weight	Long Tons	_____
Total Shaft Horsepower	Shaft Horsepower	_____
Total Installed Generating Capacity	Kilowatt	_____
Ship's Length (L)	Feet	_____
Ship's Beam (B)	Feet	_____
Ship's Depth (D)	Feet	_____

Ship's (LxB)	Square Feet	_____
Total Ship's Volume	Cubic Feet	_____
Total Ship's Complement	Number of People	_____
Ship Type	Conventional, Complex, SWATH, Commercial, Air Capable, Replenishment Ship, With Shop, With Vehicle Storage	_____
Superstructure Type	Steel, Aluminum	_____
Propulsion Plant Type	Steam, Diesel, Electric Drive	_____
Propeller Type	Fixed Pitch, Controllable Pitch, Fixed Pitch Electric Drive	_____
Number of Shafts	Number	_____
Type of Blowers	Single Steam Forced Draft, Double Steam Forced Draft, Electric Motor Driven	_____
Time in Shipyard	Number of Months	_____
Current Year of Estimate	Year	_____
Labor Rate	Dollars/Manhour	_____

Table A-2

Cost Estimate Worksheet
One Digit SWBS Level Cost Model

Vessel Description:_____

_____

_____

Analyst:_____

Reviewed/Approved:_____

Date:_____

SWBS Group Number	Variable Application	Material Cost ($)	Labor Cost (MH)	Labor Cost ($)
1	Material			
1	Labor			
1	Subtotal	-----	-----	
2	Material			
2	Labor			
2	Subtotal	-----	-----	
3	Material			
3	Labor			
3	Subtotal	-----	-----	
4	Material			
4	Labor			
4	Subtotal	-----	-----	

SWBS Group Number	Variable	Application	Material Cost ($)	Labor Cost (MH)	Labor Cost ($)
5	Material				
5	Labor				
5	Subtotal	-----	-----		
6	Material				
6	Labor				
6	Subtotal	-----	-----		
7	Material				
7	Labor				
7	Subtotal	-----	-----		
8	Material				
8	Labor				
8	Subtotal	-----	-----		
9	Material				
9	Labor				
9	Subtotal	-----	-----		
Total Subtotal			_____	_____	_____
Total Cost ($)			_____		

Table A-3

Input Data Requirements
Two Digit SWBS Level Cost Model

Vessel Description: _____

_____

_____

Analyst: _____

Reviewed/Approved: _____

Date: _____

Ship Characteristics	Factor	Value
Group 1A Weight	Long Tons	_____
Group 1B Weight	Long Tons	_____
Group 1C Weight	Long Tons	_____
Group 1D Weight	Long Tons	_____
Group 1 Weight	Long Tons	_____
Group 2A Weight	Long Tons	_____
Group 2B Weight	Long Tons	_____
Group 2C Weight	Long Tons	_____
Group 2D Weight	Long Tons	_____
Group 2 Weight	Long Tons	_____
Group 3A Weight	Long Tons	_____
Group 3B Weight	Long Tons	_____
Group 3 Weight	Long Tons	_____

Group 4A Weight	Long Tons	_____
Group 4B Weight	Long Tons	_____
Group 4 Weight	Long Tons	_____
Group 5A Weight	Long Tons	_____
Group 5B Weight	Long Tons	_____
Group 5C Weight	Long Tons	_____
Group 5D Weight	Long Tons	_____
Group 5 Weight	Long Tons	_____
Group 6A Weight	Long Tons	_____
Group 6B Weight	Long Tons	_____
Group 6C Weight	Long Tons	_____
Group 6D Weight	Long Tons	_____
Group 6E Weight	Long Tons	_____
Group 6 Weight	Long Tons	_____
Group 7 Weight	Long Tons	_____
Total Weight	Long Tons	_____
Total Shaft Horsepower	Shaft Horsepower	_____
Total Installed Generating Capacity	Kilowatts	_____
Ship's Length (L)	Feet	_____
Ship's Beam (B)	Feet	_____
Ship's Depth (D)	Feet	_____

Ship's (LxB)	Square Feet	_____
Total Ship's Volume	Cubic Feet	_____
Total Ship Complement	Number of People	_____
Ship Type	Conventional, Complex, SWATH, Commercial, Air Capable, Replenishment Ship, With Shop, With Vehicle Storage	_____
Superstructure Type	Steel, Aluminum	_____
Propulsion Plant Type	Steam, Diesel, Electric Drive	_____
Propeller Type	Fixed Pitch, Controllable Pitch, Fixed Pitch Electric Drive	_____
Number of Shafts	Number	_____
Type of Blowers	Single Steam Forced Draft, Double Steam Forced Draft, Electric Motor Driven	_____
Time in Shipyard	Number of Months	_____
Current Year of Estimate	Year	_____
Labor Rate	Dollars/Manhour	_____

Table A-4

Cost Estimate Worksheet
Two Digit SWBS Level Cost Model

Vessel Description:_____

_____

_____

Analyst:_____

Reviewed/Approved:_____

Date:_____

SWBS Group Number	Variable Application	Material Cost ($)	Labor Cost (MH)	Labor Cost ($)
1A	Material			
1A	Labor			
1B	Material			
1B	Labor			
1C	Material			
1C	Labor			
1D	Material			
1D	Labor			
1	Subtotal	-----	-----	
2A	Material			
2A	Labor			
2B	Material			
2B	Labor			

SWBS Group Number	Variable Application	Material Cost ($)	Labor Cost (MH)	Labor Cost ($)
2C Material				
2C Labor				
2D Material				
2D Labor				
2 Subtotal	-----	-----		
3A Material				
3A Labor				
3B Material				
3B Labor				
3 Subtotal	-----	-----		
4A Material				
4A Labor				
4B Material				
4B Labor				
4 Subtotal	-----	-----		
5A Material				
5A Labor				
5B Material				
5B Labor				
5C Material				
5C Labor				

SWBS Group Number	Variable Application	Material Cost ($)	Labor Cost (MH)	Labor Cost ($)
5D Material				
5D Labor				
5 Subtotal	-----	-----		
6A Material				
6A Labor				
6B Material				
6B Labor				
6C Material				
6C Labor				
6D Material				
6D Labor				
6E Material				
6E Labor				
6 Subtotal	-----	-----		
7 Material				
7 Labor				
7 Subtotal	-----	-----		
8 Material				
8 Labor				
8 Subtotal				
9 Material				
9 Labor				

SWBS Group Number	Variable Application	Material Cost ($)	Labor Cost (MH)	Labor Cost ($)
9 Subtotal	-----	-----		
Total Subtotal Cost		_____	____	____
Total Cost ($)		_____		

APPENDIX B--

TWO-DIGIT SWBS DISTRIBUTION

Appendix B
Two-Digit SWBS Distribution

The basic two-digit structure has been somewhat modified to take into account special systems costs and areas where the cost estimators data would not fit into the two-digit structure. These are outlined below.

SWBS 197 - Welding

This is apportioned between 1A, 1B, 1C, and 1D by the same percentage that the two-digit weight is of the total Group 1 weight.

SWBS 252 - Propulsion Control System

This is estimated separately from Group 2D because of the variety of automation systems that may be found on auxiliaries and amphibious vessels.

SWBS 475 - Degaussing

Degaussing is estimated separately from the rest of Group 4A because it is not found on all auxiliaries and its cost factor is different than that for the rest of Group 4A.

SWBS 639 - Radiation Shielding

This is not found in large quantitites on all auxilairies and has a higher cost factor. It is estimated as a function of weight.

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 1A

SWBS NO.	DESCRIPTION	WEIGHT
111	SHELL PLATING, SURF. SHIP AND SUBMARINE PRESS. HULL	
113	INNER BOTTOM	
114	SHELL APPENDAGES	
115	STANCHIONS	
116	LONGIT. FRAMING, SURF. SHIP AND SUBMARINE PRESS. HULL	
117	TRANSV. FRAMING, SURF. SHIP AND SUBMARINE PRESS. HULL	
121	LONGITUDINAL STRUCTURAL BULKHEADS	
122	TRANSVERSE STRUCTURAL BULKHEADS	
123	TRUNKS AND ENCLOSURES	
124	BULKHEADS IN TORPEDO PROTECTION SYSTEM	
131	MAIN DECK	
132	2ND DECK	
133	3RD DECK	
134	4TH DECK	
135	5TH DECK AND DECKS BELOW	
136	01 HULL DECK	
137	02 HULL DECK	
141	1ST PLATFORM	
142	2ND PLATFORM	
143	3RD PLATFORM	
144	4TH PLATFORM	
145	5TH PLATFORM	
149	FLATS	
166	SPONSONS	
197	WELDING (1A PERCENTAGE OF 197)	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 1B

SWBS NO.	DESCRIPTION	WEIGHT
151	DECKHOUSE STRUCTURE TO FIRST LEVEL	
152	1ST DECKHOUSE LEVEL	
153	2ND DECKHOUSE LEVEL	
154	3RD DECKHOUSE LEVEL	
155	4TH DECKHOUSE LEVEL	
156	5TH DECKHOUSE LEVEL	
157	6TH DECKHOUSE LEVEL	
158	7TH DECKHOUSE LEVEL	
159	8TH DECKHOUSE LEVEL AND ABOVE	
164	BALLISTIC PLATING	
197	WELDING (1B PERCENTAGE OF 197)	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 1C

SWBS NO.	DESCRIPTION	WEIGHT
182	PROPULSION PLANT FOUNDATIONS	
183	ELECTRIC PLANT FOUNDATIONS	
184	COMMAND AND SURVEILLANCE FOUNDATIONS	
185	AUXILIARY SYSTEMS FOUNDATIONS	
186	OUTFIT AND FURNISHINGS FOUNDATIONS	
187	ARMAMENT FOUNDATIONS	
189	COMBAT SYSTEM ALIGNMENT	
197	WELDING (IC PERCENTAGE OF 197)	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 1D

SWBS NO.	DESCRIPTION	WEIGHT
161	STRUCTURAL CASTINGS, FORGINGS, AND EQUIV. WELDMENTS	
162	STACKS AND MACKS (COMBINED STACK AND MAST)	
163	SEA CHESTS	
165	SONAR DOMES	
167	HULL STRUCTURAL CLOSURES	
168	DECKHOUSE STRUCTURAL CLOSURES	
169	SPECIAL PURPOSE CLOSURES AND STRUCTURES	
171	MASTS, TOWERS, TETRAPODS	
172	KINGPOSTS AND SUPPORT FRAMES	
179	SERVICE PLATFORMS	
197	WELDING (1D PERCENTAGE OF 197)	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 2A

SWBS NO.	DESCRIPTION	WEIGHT
221	PROPULSION BOILERS	
222	GAS GENERATORS	
223	MAIN PROPULSION BATTERIES	
224	MAIN PROPULSION FUEL CELLS	
231	PROPULSION STEAM TURBINES	
232	PROPULSION STEAM ENGINES	
233	PROPULSION INTERNAL COMBUSTION ENGINES	
234	PROPULSION GAS TURBINES	
235	ELECTRIC PROPULSION	
236	SELF-CONTAINED PROPULSION SYSTEMS	
237	AUXILIARY PROPULSION DEVICES	
241	PROPULSION REDUCTION GEARS	
242	PROPULSION CLUTCHES AND COUPLINGS	
253	MAIN STEAM PIPING SYSTEM	
254	CONDENSERS AND AIR EJECTORS	
255	FEED AND CONDENSATE SYSTEM	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 2B

SWBS NO.	DESCRIPTION	WEIGHT
243	PROPULSION SHAFTING	
244	PROPULSION SHAFT BEARINGS	
245	PROPULSORS	
246	PROPULSOR SHROUDS AND DUCTS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 2C

SWBS NO.	DESCRIPTION	WEIGHT
251	COMBUSTION AIR SYSTEM	
259	UPTAKES (INNER CASING)	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 2D

SWBS NO.	DESCRIPTION	WEIGHT
256	CIRCULATING AND COOLING SEA WATER SYSTEM	
258	H.P. STEAM DRAIN SYSTEM	
261	FUEL SERVICE SYSTEM	
262	MAIN PROPULSION LUBE OIL SYSTEM	
264	LUBE OIL FILL, TRANSFER, AND PURIFICATION	
252	PROPULSION CONTROL SYSTEM	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 3A

SWBS NO.	DESCRIPTION	WEIGHT
311	SHIP SERVICE POWER GENERATION	
312	EMERGENCY GENERATORS	
314	POWER CONVERSION EQUIPMENT	
342	DIESEL SUPPORT SYSTEMS	
343	TURBINE SUPPORT SYSTEMS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 3B

SWBS NO.	DESCRIPTION	WEIGHT
313	BATTERIES AND SERVICE FACILITIES	
321	SHIP SERVICE POWER CABLE	
322	EMERGENCY POWER CABLE SYSTEM	
323	CASUALTY POWER CABLE SYSTEM	
324	SWITCHGEAR AND PANELS	
331	LIGHTING DISTRIBUTION	
332	LIGHTING FIXTURES	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 4A

SWBS NO.	DESCRIPTION	WEIGHT
421	NON-ELECTRICAL/ELECTRONIC NAVIGATION AIDS	
422	ELECTRICAL NAVIGATION AIDS (INCL NAVIG. LIGHTS)	
423	ELECTRONIC NAVIGATION SYSTEMS, RADIO	
424	ELECTRONIC NAVIGATION SYSTEMS, ACOUSTICAL	
426	ELECTRICAL NAVIGATION SYSTEMS	
427	INERTIAL NAVIGATION SYSTEMS	
428	NAVIGATION CONTROL MONITORING	
431	SWITCHBOARDS FOR I.C. SYSTEMS	
432	TELEPHONE SYSTEMS	
433	ANNOUNCING SYSTEMS	
434	ENTERTAINMENT AND TRAINING SYSTEMS	
435	VOICE TUBES AND MESSAGE PASSING SYSTEMS	
436	ALARM, SAFETY, AND WARNING SYSTEMS	
437	INDICATING, ORDER, AND METERING SYSTEMS	
438	INTEGRATED CONTROL SYSTEMS	
443	VISUAL AND AUDIBLE SYSTEMS	
473	TORPEDO DECOYS	
474	DECOYS (OTHER)	
476	MINE COUNTERMEASURES	
491	ELECTRONIC TEST, CHECKOUT, AND MONITORING EQUIPMENT	
492	FLIGHT CONTROL AND INSTRUMENT LANDING SYSTEMS	
493	NON COMBAT DATA PROCESSING SYSTEMS	
494	METEOROLOGICAL SYSTEMS	
495	SPECIAL PURPOSE INTELLIGENCE SYSTEMS	
475	DEGAUSSING	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 4B

SWBS NO.	DESCRIPTION	WEIGHT
411	DATA DISPLAY GROUP	
412	DATA PROCESSING GROUP	
413	DIGITAL DATA SWITCHBOARDS	
414	INTERFACE EQUIPMENT	
415	DIGITAL DATA COMMUNICATIONS	
417	COMMAND AND CONTROL ANALOG SWITCHBOARDS	
441	RADIO SYSTEMS	
442	UNDERWATER SYSTEMS	
444	TELEMETRY SYSTEMS	
445	TTY AND FACSIMILE SYSTEMS	
446	SECURITY EQUIPMENT SYSTEMS	
451	SURFACE SEARCH RADAR	
452	AIR SEARCH RADAR (2D)	
453	AIR SEARCH RADAR (3D)	
454	AIRCRAFT CONTROL APPROACH RADAR	
455	IDENTIFICATION SYSTEMS (IFF)	
456	MULTIPLE MODE RADAR	
459	SPACE VEHICLE ELECTRONIC TRACKING	
461	ACTIVE SONAR	
462	PASSIVE SONAR	
463	MULTIPLE MODE SONAR	
464	CLASSIFICATION SONAR	
465	BATHYTHERMOGRAPH	
471	ACTIVE ECM (INCL COMBINATION ACTIVE/PASSIVE)	
472	PASSIVE ECM	
481	GUN FIRE CONTROL SYSTEMS	
482	MISSILE FIRE CONTROL SYSTEMS	
483	UNDERWATER FIRE CONTROL SYSTEMS	
484	INTEGRATED FIRE CONTROL SYSTEMS	
489	WEAPON SYSTEMS SWITCHBOARDS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 5A

SWBS NO.	DESCRIPTION	WEIGHT
511	COMPARTMENT HEATING SYSTEM	
512	VENTILATION SYSTEM	
513	MACHINERY SPACE VENTILATION SYSTEM	
514	AIR CONDITIONING SYSTEM	
517	AUXILIARY BOILERS AND OTHER HEAT SOURCES	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 5B

SWBS NO.	DESCRIPTION	WEIGHT
521	FIREMAIN AND FLUSHING (SEA WATER) SYSTEM	
522	SPRINKLER SYSTEM	
523	WASHDOWN SYSTEM	
524	AUXILIARY SEA WATER SYSTEM	
526	SCUPPERS AND DECK DRAINS	
557	FIREMAIN ACTUATED SERVICES - OTHER	
528	PLUMBING DRAINAGE	
529	DRAINAGE AND BALLASTING SYSTEM	
531	DISTILLING PLANT	
532	COOLING WATER	
533	POTABLE WATER	
534	AUX. STEAM AND DRAINS WITHIN MACHINERY BOX	
535	AUX. STEAM AND DRAINS OUTSIDE MACHINERY BOX	
536	AUXILIARY FRESH WATER COOLING	
541	SHIP FUEL AND FUEL COMPENSATING SYSTEM	
542	AVIATION AND GENERAL PURPOSE FUELS	
543	AVIATION AND GENERAL PURPOSE LUBRICATING OIL	

COST GROUP: 5B (Continued)

SWBS NO.	DESCRIPTION	WEIGHT
544	LIQUID CARGO	
545	TANK HEATING	
549	SPECIAL FUEL AND LUBRICANTS, HANDLING AND STOWAGE	
551	COMPRESSED AIR SYSTEMS	
552	COMPRESSED GASES	
553	O_2N_2 SYSTEM	
554	LP BLOW	
555	FIRE EXTINGUISHING SYSTEMS	
556	HYDRAULIC FLUID SYSTEM	
557	LIQUID GASES, CARGO	
558	SPECIAL PIPING SYSTEMS	
565	TRIM AND HEEL SYSTEMS (SURFACE SHIPS)	
593	ENVIRONMENTAL POLLUTION CONTROL SYSTEMS	
594	SUBMARINE RESCUE, SALVAGE, AND SURVIVAL SYSTEMS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 5D

SWBS NO.	DESCRIPTION	WEIGHT
571	REPLENISHMENT-AT-SEA SYSTEMS	
572	SHIP STORES AND EQUIPMENT HANDLING SYSTEMS	
573	CARGO HANDLING SYSTEMS	
770	CARGO MUNITIONS	
772	CARGO MUNITIONS HANDLING	
773	CARGO MUNITIONS STOWAGE	
574	VERTICAL REPLENISHMENT SYSTEMS	
581	ANCHOR HANDLING AND STOWAGE SYSTEMS	
582	MOORING AND TOWING SYSTEMS	
583	BOATS, BOAT HANDLING AND STOWAGE SYSTEMS	
584	MECHANICALLY OPERATED DOOR, GATE, RAMP, TURNTABLE SYSTEM	
585	ELEVATING AND RETRACTING GEAR	
588	AIRCRAFT HANDLING, SERVICING AND STOWAGE	
589	MISCELLANEOUS MECHANICAL HANDLING SYSTEMS	
592	SWIMMER AND DIVER SUPPORT AND PROTECTION SYSTEMS	
595	TOWING, LAUNCHING AND HANDLING FOR UNDERWATER SYSTEMS	
596	HANDLING SYSTEMS FOR DIVER AND SUBMERSIBLE VEHICLES	
597	SALVAGE SUPPORT SYSTEMS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 6A

SWBS NO.	DESCRIPTION	WEIGHT
605	RODENT AND VERMIN PROOFING	
611	HULL FITTINGS	
612	RAILS, STANCHIONS, AND LIFELINES	
613	RIGGING AND CANVAS	
625	AIRPORTS, FIXED PORTLIGHTS, AND WINDOWS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 6B

SWBS NO.	DESCRIPTION	WEIGHT
621	NON-STRUCTURAL BULKHEADS	
622	FLOOR PLATES AND GRATINGS	
623	LADDERS	
624	NON-STRUCTURAL CLOSURES	
637	SHEATHING	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 6C

SWBS NO.	DESCRIPTION	WEIGHT
602	HULL DESIGNATING AND MARKING	
603	DRAFT MARKS	
604	LOCKS, KEYS, AND TAGS	
631	PAINTING	
632	ZINC COATING	
633	CATHODIC PROTECTION	
634	DECK COVERING	
635	HULL INSULATION	
636	HULL DAMPING	
639	RADIATION SHIELDING	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 6D

SWBS NO.	DESCRIPTION	WEIGHT
654	UTILITY SPACES	
655	LAUNDRY SPACES	
656	TRASH DISPOSAL SPACES	
664	DAMAGE CONTROL STATIONS	
665	WORKSHOPS, LABS, TEST AREAS (INCLUDING PORTABLE TOOLS, EQUIPMENT)	
671	LOCKERS AND SPECIAL STOWAGE	
672	STOREROOMS AND ISSUE ROOMS	
673	CARGO STOWAGE	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 6E

SWBS NO.	DESCRIPTION	WEIGHT
638	REFRIGERATED SPACES	
641	OFFICER BERTHING AND MESSING SPACES	
642	NONCOMMISSIONED OFFICER BERTHING AND MESSING SPACES	
643	ENLISTED PERSONNEL BERTHING AND MESSING SPACES	
644	SANITARY SPACES AND FIXTURES	
645	LEISURE AND COMMUNITY SPACES	
651	COMMISSARY SPACES	
652	MEDICAL SPACES	
653	DENTAL SPACES	
661	OFFICES	
662	MACHINERY CONTROL CENTERS FURNISHINGS	
663	ELECTRONICS CONTROL CENTERS FURNISHINGS	

APPENDIX B
TWO-DIGIT SWBS DISTRIBUTION

COST GROUP: 7

SWBS NO.	DESCRIPTION	WEIGHT
701	GENERAL ARRANGEMENT - WEAPONRY SYSTEMS	
711	GUNS	
712	AMMUNITION HANDLING	
713	AMMUNITION STOWAGE	
721	LAUNCHING DEVICES (MISSILES AND ROCKETS)	
722	MISSILE, ROCKET, AND GUIDANCE CAPSULE HANDLING SYSTEM	
723	MISSILE AND ROCKET STOWAGE	
724	MISSILE HYDRAULICS	
725	MISSILE GAS	
726	MISSILE COMPENSATING	
727	MISSILE LAUNCHER CONTROL	
728	MISSILE HEATING, COOLING, TEMPERATURE CONTROL	
729	MISSILE MONITORING, TEST AND ALIGNMENT	
731	MINE LAUNCHING DEVICES	
732	MINE HANDLING	
733	MINE STOWAGE	
741	DEPTH CHARGE LAUNCHING DEVICES	
742	DEPTH CHARGE HANDLING	
743	DEPTH CHARGE STOWAGE	
751	TORPEDO TUBES	
752	TORPEDO HANDLING	
753	TORPEDO STOWAGE	
754	SUBMARINE TORPEDO EJECTION	
761	SMALL ARMS AND PYROTECHNIC LAUNCHING DEVICES	
762	SMALL ARMS AND PYROTECHNIC HANDLING	
763	SMALL ARMS AND PYROTECHNIC STOWAGE	
782	AIRCRAFT RELATED WEAPONS HANDLING	
783	AIRCRAFT RELATED WEAPONS STOWAGE	
792	SPECIAL WEAPONS HANDLING	
793	SPECIAL WEAPONS STOWAGE	
797	MISCELLANEOUS ORDNANCE SPACES	

APPENDIX C--

WEIGHT, LABOR AND MATERIAL COST DATA

TABLE C-1. SHIPS CHARACTERISTICS

	AD-41	AFS-6	LST-1182	AD-180	ADR-7	SWATH	LHA	LPH	ASR-21	LSD-41	LST-1179	TAG(X)
CUBE NO						10631.4						
LxB	54740	45899	36279	52096	63264	21808	86920	50568	21586	51072		
L+D						11310						
LxT	14490	13944	5135	20720	21944.7	5742	21320	15652	5346.3	11856		
SHP	30000	22000	16000	24000	32000	2800				36000	16000	2420
KW	11000	4800	2250	8250	8500	3340						
VOLUME	5060000	2000000	1080000	2120000	2930000	420100		3800000		2200000		
COMPLEMEN	1803	486	196	135	390	33			115	338		
L	644	581	522	592	659	232	820	602	251	608		
400HZKW	90	60	10	6	130	30						

TABLE C-2. WEIGHT SUMMARY

	AD-41	AFS-6	LST-1182	AD-180	ADR-7	SWATH	LHA	LPH	ASR-21	LSD-41	LST-1179	TAG(X)
1A	6075.0	4024.0	2122.0	4286.0	6696.0	1475.0	14612	5723	1068			
1E	745.0	695.0	98.0	864.0	967.0	109.0			321			
1C	128.0	175.0	126.0	144.0	180.0	80.0			113			
1D	282.0	391.0	361.0	278.0	380.0	57.0			104			
2A	329.0	427.0	165.0	430.0	606.0	44.0				519	**173**	66
2E	68.0	195.0	87.0	121.0	240.0	13.0				151	**93**	27
2C	30.0	32.0	38.0	32.0	39.0	3.0				73	**50**	11
2D	26.0	42.0	57.0	63.0	86.0	9.0				105	67	20
3A	147.0	45.0	70.0	127.0	125.0	68.0						
3E	282.0	95.0	66.0	140.0	198.0	51.0						
4A	35.0	43.0	50.0	39.0	78.0	9.0						
4E	18.0	32.0	27.0	9.0	24.0	37.0						
5A	398.0	651.0	132.0	89.0	329.0	53.0						
5E	530.0	281.0	284.0	597.0	702.0	77.0						
5C	52.0	46.0	50.0	76.0	111.0	81.0						
5D	1037.0	736.0	284.0	383.0	918.0	129.0						
6A	29.0	26.0	85.0	31.0	55.0	24.0						
6E	527.0	125.0	87.0	155.0	338.0	72.0						
6C	744.0	164.0	98.0	207.0	361.0	109.0						
6I	983.0	292.0	50.0	99.0	206.0	27.0						
6E	416.0	96.0	69.0	66.0	103.0	37.0						

	AD-41	AFS-6	LST-1182	AD-180	ADR-7	SWATH	LHA	LPH	ASR-21	LSD-41	LST-1179	TAG(X)
1 TOTW	7230.0	5285.0	2707.0	5572.0	8183.0	1721.0			1606.0			
3 TOTW	447.0	696.0	348.0	642.0	971.0	69.0				848.0	383	124
3 TOTW	429.0	140.0	136.0	267.0	323.0	119.0						
4 TOTW	53.0	75.0	77.0	48.0	102.0	46.0						
5 TOTW	2007.0	1714.0	750.0	1145.0	2060.0	340.0						
6 TOTW	2699.0	713.0	379.0	558.0	1063.0	269.0						
7 TOTW	99.0	84.0	71.0	16.0	42.0		226					

12969 8717 9465 8251 17744

TABLE C-3. MATERIAL COSTS IN MILLIONS OF DOLLARS

	AD-41	AFS-6	LST-1182	AD-180	AOR-7	SWATH	LHA	LPH	ASR-21	LSD-41	27K SHP	LST-1179	TAG(X)
1A	4.9	2.6	2.0	3.5	4.8	1.2	12.1	4.7	0.9				
1B	0.5	0.4	0.7	0.6	0.6	0.1			0.3				
1C	0.2	0.2	0.1	0.1	0.1	0.1			0.1				
1D	1.6	0.9	0.9	0.7	1.0	0.1			0.2				
2A	5.1	5.3	3.8	6.1	7.1	0.9				12.2	6.5	4.6	1.7
2B	0.6	0.8	1.8	0.9	1.3	0.5				3.5	1.5	2.2	0.8
2C	0.8	0.4	0.1	0.2	0.8	0.0				1.1	0.1	0.5	0.1
2D	0.9	1.5	0.9	2.1	1.3	0.6				5.1	2.4	3.2	0.8
3A	3.5	1.8	1.1	3.1	2.7	1.5							
3B	3.6	3.2	3.8	3.8	3.5	0.4							
4A	1.2	0.7	0.9	1.4	0.9	0.9							
4B	0.2	0.2	0.1	0.3	0.1	0.2							
5A	3.5	2.3	1.8	1.9	3.0	0.8							
5B	8.6	2.4	3.9	11.2	6.9	1.7							
5C	0.4	0.3	0.4	0.5	0.9	2.5							
5D	7.9	9.2	2.6	5.6	9.6	0.6							
6A	0.3	0.4	0.2	0.5	0.5	0.1							
6B	6.0	1.2	0.7	1.7	1.5	0.3							
6C	6.5	1.0	0.9	1.8	1.7	2.6							
6D	5.1	0.9	0.4	0.2	0.5	0.1							
6E	13.8	3.3	2.2	2.7	3.6	0.1							

	1 TOTC	2 TOTC	3 TOTC	4 TOTC	5TOTC	6 TOTC	7 TOTC	TOTAL COST
AD-41	7.2	7.4	7.1	1.4	22.6	31.8	0.5	77.9
AFS-6	4.1	7.9	5.0	0.9	14.2	6.7	0.4	39.1
LST-1182	3.7	6.6	4.9	1.0	8.5	4.5	0.2	29.4
AD-180	5.0	9.3	6.9	1.7	19.3	7.0	0.0	49.2
AOR-7	6.5	10.6	6.2	1.0	22.5	7.9	0.2	54.9
SWATH	1.4	2.0	1.9	1.1	5.6	3.2		15.1
LHA							0.7	0.7
LPH								
ASR-21	1.5							1.5
LSD-41		21.8						21.8
27K SHP		10.5						10.5
LST-1179		10.6						10.6
TAG(X)		3.5						3.5

TABLE C-4. LABOR COSTS IN THOUSANDS OF MANHOURS

	AD-41	AFS-6	LST-1182	AD-180	AOR-7	SWATH	LHA	LPH	ASR-21	LSD-41	27K SHP	LST-1179	TAG(X)
1A	950.1	307.6	279.2	423.8	676.0	179.2	1613.8	727.8	154				
1B	133.9	50.3	49.6	102.5	117.8	7.1			50				
1C	122.0	40.0	52.9	56.7	92.4	8.0			45.2				
1D	74.5	59.7	73.1	44.5	77.3	6.9			20.8				
2A	74.9	52.5	13.5	55.3	90.6	1.2				16.1	11.95	12.1	1.95
2B	9.7	9.9	15.3	11.3	15.2	2.0				12.7	15.55	10.1	2.6
2C	19.8	10.1	15.4	11.8	14.6	3.2				14.2	15.66	9.7	2.8
2D	74.4	39.8	54.8	42.9	60.3	10.9				32.2	43.75	20.2	11.8
3A	2.3	4.6	1.6	1.4	1.7	2.7							
3B	348.7	56.6	55.6	168.2	141.9	23.7							
4A	64.8	28.2	33.9	60.6	57.0	9.4							
4B	10.5	13.7	11.6	13.6	15.7	1.1							
5A	627.7	139.4	156.7	123.6	202.6	28.0							
5B	891.9	176.4	219.0	311.5	462.2	21.5							
5C	10.7	7.1	12.3	11.6	23.6	17.8							
5D	109.6	29.7	27.5	16.5	28.8	5.3							
6A	34.1	16.3	17.0	13.3	22.4	6.6							
6B	92.9	29.6	31.7	64.3	58.8	1.5							
6C	631.0	71.7	80.5	166.0	204.6	59.2							
6D	74.4	30.2	10.3	23.9	20.5	5.0							
6E	76.1	9.2	7.2	14.4	8.1	0.9							

	1 TOTL	2 TOTL	3 TOTL	4 TOTL	5 TOTL	6 TOTL	7 TOTL	TOTAL COST
AD-41	1280.5	178.8	351.0	75.3	1639.9	908.5	17.7	4451.7
AFS-6	457.6	111.7	61.2	40.9	352.6	157.0	6.9	1187.9
LST-1182	454.5	103.0	57.2	45.1	415.5	146.7	7.0	1229.3
AD-180	627.5	121.3	169.6	74.2	463.4	281.9	3.2	1741.1
AOR-7	963.5	180.7	143.6	72.7	717.2	314.4	5.0	2397.1
SWATH	201.2	17.2	26.4	10.5	72.6	75.2		403.139
LHA							30	30
LPH								
ASR-21	270							270
LSD-41		75.2						75.2
27K SHP		86.9						86.91
LST-1179		52.1						52.1
TAG(X)		19.2						19.2

NT TOTAL