PNL-3967
UC-62

Manufacturing and Cost Evaluation of Second Generation Heliostats Volume II - Appendices

K. Drumheller
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September 1981

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

Battelle

PNL-3967

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
Under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy $_____*; Microfiche $3.00

*Pages	NTIS Selling Price
001-025	$4.00
026-050	$4.50
051-075	$5.25
076-100	$6.00
101-125	$6.50
126-150	$7.25
151-175	$8.00
176-200	$9.00
201-225	$9.25
226-250	$9.50
251-275	$10.75
276-300	$11.00

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MANUFACTURING AND COST EVALUATION OF SECOND GENERATION HELIOSTATS

VOLUME II - APPENDICES

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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

The Second Generation Heliostat Program involved five contractors who provided designs, manufacturing plans, and cost estimates for heliostats. The program was sponsored by the Department of Energy and managed by Sandia National Laboratories, Livermore. As part of the program, Pacific Northwest Laboratory (PNL) evaluated and compared the contractors' costs and production plans, and compared the actual costs of the Solar One (Barstow, California) pilot-plant heliostats to estimated mass production costs. One purpose of this review was to adjust contractor estimates to provide a common basis for cost comparisons.

The five contractors were: Boeing Engineering and Construction, Martin Marietta Corporation, McDonnell Douglas Astronautics Company, Northrup Incorporated, and Westinghouse Electric Corporation. PNL evaluated the components and assembly of the five heliostats in terms of material, direct labor, production equipment, production building requirements, and overheads.

Two adjustments were made to the costs estimated by the manufacturers. The first, producing "Adjusted Costs," was primarily to add items that appeared to have been omitted from the contractors' estimates or delete items that were not required. The second, called "Uniform Assumptions Costs," used common ground rules for major materials, building, labor, and overhead costs.

The review of the contractors' production plans and cost estimates did not reveal any errors or omissions that would change the costs by more than 30%, when compared using uniform assumptions. This range is adequate for policy planning, and costs of $\$100/m^2$ appear achievable.

CONTENTS

INTRODUCTION

Developing reliable, low-cost heliostats is a basic goal of the U.S. Solar Thermal Energy Central Receiver Program. As a consequence, several heliostat-development projects, pursued during the last decade, have resulted in central receiver systems that are expected to produce energy at competitive costs when compared to the costs of fossil energy.

Included in the U.S. program is the Second Generation Heliostat Program, in which five contractors designed heliostats. Four of the five contractors also fabricated heliostats. The contractors provided manufacturing plans and cost estimates for these second generation designs, assuming mass production at a rate of 50,000 units per year and deployment in 50 MWe plants throughout the Southwest. This program was sponsored by the U.S. Department of Energy and managed by Sandia National Laboratories, Livermore.

As part of the Second Generation Heliostat program, Pacific Northwest Laboratory (PNL) evaluated the costs and manufacturing plans for the five heliostats; compared the plans to each other; and compared actual costs of pilot-plant heliostats (Solar One in Barstow, California[(a)]) to estimated mass production costs. Specifically, the objectives included:

- adjusting contractor estimated costs to compensate for specific omissions or additions
- adjusting contractor estimated costs to provide for comparison on a uniform basis
- providing recommendations for potential improvements in heliostat design or manufacturing methods
- developing potential volume production costs for Solar One (Barstow) heliostats.

Volume I of this report contains the results of the PNL evaluation. Also included is a brief description of the five heliostats. This volume (II) contains the appendices. Appendix A provides a summary evaluation of contractor

(a) 10 MWe plant scheduled for startup in December 1981.

estimated costs. Appendix B contains the cost comparison sheets. Appendix C lists the breakdown of contractor costs. Volume II was printed on a limited distribution, but copies are available on request.

The five contractors were:

- Boeing Engineering and Construction (Boeing), Seattle, Washington
- Martin Marietta Corporation (Martin Marietta), Denver, Colorado
- McDonnell Douglas Astronautics Company (McDonnell Douglas), Huntington Beach, California
- Northrup Incorporated (Northrup), Hutchins, Texas (a subsidiary of Atlantic Richfield Company)
- Westinghouse Electric Corporation (Westinghouse), Pittsburgh, Pennsylvania.

In the analysis of each contractor's manufacturing plan, PNL evaluated the components of the heliostats in terms of: material; direct labor; production equipment and production building requirements; and overheads. The contractors' original costs, "adjusted costs," and "uniform assumptions costs" are summarized in Table A.1. The purpose of the adjusted costs was to add items that appeared to be omitted from the original estimates or delete items not required. The uniform assumptions cost adjustment used common ground rules for major materials, building, labor, and overhead costs.

TABLE A.1. Original, Adjusted, and Uniform Assumptions Estimates for Mass-Produced Heliostats

	Installed Heliostat Cost, $ per Heliostat					
	Boeing	Martin Marietta	McDonnell Douglas	Northrup	Westing-house	Solar One
Heliostat Cost						
Original	6,513.27	5,837.56	4,830.00	6,716.00	12,356.00	15,930.00
Adjusted	6,446.33	5,839.56	5,366.58	6,298.59	13,304.00	
Uniform Assumptions	7,056.24	6,586.40	6,200.27	7,093.34	15,009.39	6,893.66
Cost per Square Meter						
Original	149.05	101.70	84.89	127.20	151.05	398.25
Adjusted	147.51	101.73	94.30	119.29	162.64	
Uniform Assumptions	161.47	114.75	108.97	134.34	183.49	172.34

APPENDIX A

CONTRACTOR ESTIMATED COSTS, SUMMARY EVALUATION

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Mirror Module

Contractor BEC

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Glass	? 1						
Mirroring	?						
Sandwich Core	?						
Assembly	?						
Brackets	X	X	X	X	X	X	X

1. There is not enough detail provided to make any judgements whatsoever.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Mirror Module

Contractor MMC

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Glass	X	X	X	X	X	X	X
Mirroring	X	X	X	X	X	X	X
Sandwich Core	1	X	X	X	1	1	X
Sandwich Materials	X	X	X	X	X	2	X
Assembly	X	X	3	X	X	X	X
Attachment	X	X	X	X	X	X	X
General	3	X	X	X	3	3	X

1. Vol. II, E-20 on Needs miscellaneous handling equipment and at least one operator.
2. Edge strip roll forming is pretty fast for a standard roll former, but can be done for 100K.
3. Degreasing will require more operators or more mechanization - Overall, this is lite on equipment and people.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Mirror Module

Contractor McDonnell Douglas

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Mirror	X	X	X	X	X	X	X
Backing	X	X	X	X	X	X	X
Assembly	X	X	X	X	X	X	X
Hot Sections	X	X	X	X	X	X	X

Seems complete and reasonable - in GM doc.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Mirror Module

Contractor Northrup

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Mirror	X	X	1	X	X	X	X
Backing	X	X	X	X	X	X	X
Assembly	X	X	X	X	X	X	X
General	X	X	X	X	X	X	X

1. P. 4-6, Vol IV, Silver at $15/oz. or .0375/ft^2 does not provide for any loss. Even with recovery, this seems a little optimistic.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Drive Unit

Contractor Boeing

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Azimuth Drive	X	X	1	2	2	X	X
Elevation	X	X	X	X	X	X	X

1. Material costs in BEC, Vol II are not consistent with material costs in Ford.

2. Direct labor hours are different in different places. I can not reconcile, e.g., on P. 132, Vol II, drive unit assembly says 2.19 MH or $16.11. This is not consistent with $7.50/H ($4.50 x 2.19 = $16.42)

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Drive Unit

Contractor Martin Marietta

Date _____ Reviewer KD

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Azimuth Drive	X	1	1	X	2	2	X
Elevation Drive	X	2	X	X	2	2	X

1. $.30 per pound for castings is optimistic, even with a captive foundry.

2. The equipment and personnel estimated for gear production are overly optimistic.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Drive Unit

Contractor McDonnell Douglas

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Azimuth Drive	X	X	1	X	X	X	X
Elevation Drive	X	X	X	X	X	X	X

1. Weights of castings are necessary to make a rational judgement.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Drive Unit

Contractor Northrup

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Azimuth Drive	X	X	X	X	X	X	X
Elevation Drive	X	X	X	X	X	X	X

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Support Structure

Contractor Boeing

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Torque Tube Assembly							
Tube	X	1	X	X	X	X	X
Flanges	2	X	X	X	X	X	X
Assembly	X	X	X	X	X	X	X
Beams	X	X	X	X	X	X	X
Struts & Reinforcing Angle	3	X	X	4	X	X	X
Assembly	X	X	X	5	X	X	X
General	X	X	X	6	X	7	X

1. Ford P. H-249. Why expand the whole torque tube? I would think selective sizing of parts might be less expensive, but this is not a problem - just a comment.

2. Flanges look very different in the drqwing, Fig. 2.2-2, Vol. I, yet have the same cost, p.127, and same operation (Ford A-253-A-257).

3. The quantities and numbers on P.127, Vol II, do not agree with Dwg.. 277-10120, Fig. 2.2-2, Vol.I. 12 angles,-24, and 4 struts, -5.

4. Ford P. A-231. Very speedy. 4.2 seconds for band saw with no apparent blade change time - no time for transfer. No transfer equipment noted. Three pieces per pass makes it 12.6 seconds - maybe O.K.

5. P.129 The man hours for reflector assembly seem very high. 3.2 man hours to load the facets on frames?

6. Ford P.A-244 A 125 ton press with an hourly capacity of only 8?

7. There seem to be more presses than necessary here, but it has not been checked in detail. Are they using the same piece of equipment for different parts in an optimum way

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Support Structure

Contractor Martin Marietta Company

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Main Beam	1	X	X	1	1	1	X
Racks	X	X	X	X	X	X	X
Assembly	1	X	X	1	1	1	X
General	1	X	X	1	1	1	X

1. P. E-54, Vol II. on - Our impression is that the equipment costs are skimpy, there is insufficient allowance for handling equipment - carts, conveyor, etc. and that the labor costs are optimistic based on the degree of mechanization possible with the equipment indicated. This is just an overall impression. Detailed analysis is required to properly evaluate this.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Support Structure

Contractor McDonnell Douglas

Date _____ Reviewer K.D.

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Beams	X	X	1	X	X	X	X
Braces	X	X	X	X	X	X	X
Assembly	X	X	X	2,3	X	X	X

1. Note that most of the parts for this assembly are simply purchased. This is O.K. and probably realistic, but different from other contractors.

2. The assembly man hours, p. D3-5, for the mirror backing structure -.25 hrs., seems pretty lite. Achievable with high degree of mechanization, but still optimistic.

3. A one man inspection crew, P.D3-5, is more than 0.02 man hours per min.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Heliostat Controls

Contractor Martin Marietta Corp.

Date 3/30/81 Reviewer PDB

		COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
1.	Drive Motors	1	X	X	1	1	X	X
2.	Encoders or Positional Feedback Devices	2	X	2	3	3	3	3
3.	Power Distribution Equipment	X	X	X	3	3	3	3
4.	Calibration Equipment	-	4	-	-	-	-	-
5.	Field Control Equipment	5	5	6	5	5	5	5
6.	Control Signal Distribution	7	7	7	7	7	7	7

Notes:

1. Labor for installation of the drive motors is costed in drive assembly (4421)
2. Missing two encoder wiring harnesses
3. All wiring harnesses are purchased assembled
4. Costs of the Beam Characterization System (BCS) were included, but no details were provided.
5. No analysis was made on manufacturing costs of the heliostat controllers. Component costs were based on vendor quotes and labor costs were scaled from the Barstow design.
6. No schematic was provided giving the exact component requirements, but it seems that there are a few necessary (but not expensive) components missing from the materials list. It doesn't appear that they got large volume buy quotes from the quoted manfacturers.
7. Money was included for this but no detailed data was provided. Cost estimates were based on vendor quotes for purchased material and labor costs were scaled from the Barstow design.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Heliostat Controls

Contractor McDonnell Douglas

Date 4/2/81 Reviewer PDB

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
1. Drive Motors	X	X	X	X	X	X	X
2. Encoders or Positional Feedback Devices	2	X	X	X	X	X	X
3. Power Distribution Equipment	2	X	X	X	X	X	X
4. Calibration Equipment	3	-	-	-	-	-	-
5. Field Control Equipment	2	X	1	X	X	X	X
6. Control Signal Distribution Equipment	3	-	-	-	-	-	-

Notes:

1. Couldn't find the components for the heliostat controller in the indentured parts list, although the document states that the cost of the controller is included in the final price of the heliostat.

2. Manufacturing space, time, material and labor is included for this item, but determination as to its completeness is impossible without further details.

3. Money was included in the heliostat price for this category, but no details were provided so no analysis can be made.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Heliostat Controls

Contractor Northrup

Date 4/1/81 Reviewer PDB

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
1. Drive Motors	X	X	X	X	X	X	X
2. Encoders or Positional Feedback Devices.	1	X	X	2	X	X	X
3. Power Distribution Equipment	4	-	-	-	-	-	-
4. Calibration Equipment	4	-	-	-	-	-	-
5. Field Control Equipment	3	X	3	5	X	X	X
6. Control Signal Distribution Equipment	4	-	-	-	-	-	-

Notes:

1. No encoder is required in Northrups application because they use stepper motors. Limit switches are required.

2. They haven't included time for wiring the cable harnesses required for the various limit switches.

3. All of the materials listed in the "Bill of Materials" are not costed, suggesting that the materials estimate for 4430 maybe underestimated. Also the price quoted for the translator is significantly small ($630 vs. $75) than what was quoted for me. Presently the translators are not volume produced, don't know if that amount of cost reduction could realized with mass-production.

4. Could not find any cost information explicitly relating to this category.

5. No detailed analysis was made on the time required to manufacture and test a control unit. Electronics assembly and test time was assumed to be 1 2/3 hrs. @ $4.49 per hour.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Heliostat Controls

Contractor Westinghouse

Date 4/3/81 Reviewer PDB

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
1. Drive Motors	X	X	X	X	X	X	X
2. Encoders or Positional Feedback Devices	1	-	1	2	2	2	2
3. Power Distribution Equipment	3	-	-	-	-	-	-
4. Calibration Equipment	4	-	-	-	-	-	-
5. Field Control Equipment	X	-	5	X	6	6	6
6. Control Signal Distribution Equipment	7	-	-	-	-	-	-

Notes:

1. These are Westinghouse designed encoders. There are no cable and connectors included for making wiring harnesses for the encoders and limit switches. They could be included under the heliostat control category (4430)

2. No labor is included under this category for wiring of the cable harnesses, may be included under the heliostat control category (4430). Also, no equipment or space was provided for assembly of encoders or harnesses.

3. Couldn't find any costing explicitly relating to this category, but,both labor and materials could be included under the heliostat control category (4430).

4. No costs included under this category.

5. No schematics or part numbers were provided, making it difficult to evaluate the completeness of the materials, but, from the descriptions and listed prices, I would say most of the needed material is listed.

6. No equipment or space was provided for assembly of the control equipmer

7. Couldn't find anything explicitly relating to this category. Could be implicitly included under Heliostat Field Control (4810)

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Systems Checkout

Contractor Boeing

Date 4/3/81 Reviewer TA Williams

Account		COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
4469.1	Heliostat Reference Mark Setting	X	X	X	X	X	X	X
4469.2	Final Pedestal Survey	X	X	X	X	X	X	X
4468.2	Operate Gimbal & Verfiy Operability	X	X	X	X	X	X	X
4850	Plant Startup and Check Out	X	X	X	1			

1. Only overall cost given for this; breakdown is not available.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Handling & Transport

Contractor Boeing

Date 4/3/81 Reviewer TA Williams

Account	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
4410.6 Transport Reflectors to Pedestal	X	X	X	1	X	X	
4420.2.2 Transport Drive To Pedestal	2	X	X	3	X	4	
Pedestal Transportation	5						

1. 0.33 man hours/heliostat.
2. No explicit allowance made for loading drives on trailer.
3. Equal to 1/2 the reflector panel transport time.
4. Uncertain from text whether trailer supply is adequate to handle Drive Transportation.
5. An allowance for field handling & transportation of pedestals has not been included.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Electonics/Controls Installation

Contractor Boeing

Date 4/3/81 Reviewer TA Williams

Account		COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
4466	In plant Master Control Installation	1						
4468.1	Connect Electrical & Lighting Protection Connections	X	X	X	X	X	X	
	Install Field Transformers	1						
	Install Heliostat Controllers	1						

1. Not estimated.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Installations

Contractor Boeing

Date 4/3/81 Reviewer TA Williams

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Lay Power Cabling	1	-	-	-	-	-	-
Lay Control Cabling	1	-	-	-	-	-	-
Install Foundation/Pedestal	X	2	X	3	3	3	
Field Handling & Transportation	4	X	X	X	X	X	
Install Drive Unit	X	X	X	5	X	6	
Install Reflector Panel	X	X	X	7	X	X	
Install Electronics/Controls	8						
System Checkout	X	X	X	9	9	9	
Misc./ Other							
-							

1. Costs for this task not included.
2. Pile driven pedestal may not be applicable in all locations.
3. This task performed on a subcontracted basis, without estimates of time, personnel or equipment requirements.
4. Handling cost for pedestal is not included.
5. Time allocated to this task appears low. Total time to install is 0.26 MH/heliostat with two man crew.
6. Number of trailers required would increase if installation time is too low.
7. 1.55 MH/heliostat may be more than necessary.
8. Lacks installation of field transformers, heliostat installation, and central control system installation.
9. A large portion of cost is included as a lump sum cost, with no breakdown.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Installation

Contractor Martin Marietta

Date 4/3/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Lay Power Cabling	1						
Lay Control Cabling	1						
Install Foundation/Pedestal	1				4		
Field Handling & Transportation	2			3			
Install Drive Unit	2			3			
Install Reflector Panel	2			3			
Install Electronics/Controls	2						
System Checkout	2						

1. Materials and installation costs for power cabling, control cabling, and foundation/pedestal are not broken into separate elements. A more detailed breakdown of material unit costs, materials requirements, labor rates, and labor requirements is necessary to complete any normalization.

2. The other field installation tasks are not broken out at an adequate level of detail either. Further breakdown of man-hour requirements for these tasks would facilitate the normalization.

3. According to pages 3-71 and 3-75, heliostat assembly and erection will take place during two 8 hour shifts, producing 10 heliostats per shift. The heliostat transport vehicle requires one operator. The two work platform vehicles require two driver/assemblers each. This totals 5 laborers working 8 hours (40 man-hours) to install 10 heliostats. This rate of 4 man-hours per heliostat does not agree with the 2.32 man-hours reported in the cost section.

4. Are the labor and burden charges given in Table 5.5-1 for the foundation/pedestal general contractor's overhead expenses?

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Installation

Contractor Northrup

Date 4/3/81 Reviewer TA Williams

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATIONS
Lay Power Cabling	1							
Lay Control Cabling	1							
Install Foundation/Pedestal	1							3
Field Handling & Transportation	4	X	X	X	X	X		
Install Drive Unit	X	X	X	X	X	X		
Install Reflector Panel	5	X	X	X	X	X		
Install Electronics/Controls	X	X	X	X	X	X		
System Checkout	6							
Misc./Other								

1. An allowance of $200/heliostat is used to cover materials and installation of control and power cabling.
2. Costs for subcontracting this task are given, but a detailed breakdown is not provided. Costs for shim installation appear to be neglected.
3. Primary text description is given to installation with vibratory hammers, Cost estimate is based on an augered and grouted installation.
4. Does not include foundation/pedestal handling and transportation.
5. The reflector panel and drive unit form an integral assembly, and are installed together.
6. Not included in estimate.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Handling & Transportation

Contractor Northrup

Date 4/3/81 Reviewer TA Williams

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Foundation/Pedestal Transportation	1						
Heliostat Transportation	X	X	X	2	X	X	
Drive Unit Transportation	3						

1. Not included.
2. 2.4 MH/Heliostat
3. Included with Heliostat Transportation.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Drive Unit - Reflector Panel Installation (1)

Contractor Northrup

Date 4/3/81 Reviewer TA Williams

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Position crane & unlatch heliostat	X	X	X	X	X	X	X
Rig C frame to heliostat	X	X	X	X	X	X	X
Lift & Locate over pedestal	X	X	X	X	X	X	X
Lower onto pedestal flange	X	X	X	X	X	X	X
Tighten flange nuts-move to next pile	X	X	X	X	X	X	X

(1) Drive unit and reflector panel form one unit for installation.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Installation

Contractor Martin Marietta

Date 4/3/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Lay Power Cabling	1						
Lay Control Cabling	1						
Install Foundation/Pedestal	1				4		
Field Handling & Transportation	2			3			
Install Drive Unit	2			3			
Install Reflector Panel	2						
Install Electonics/Controls	2						
System Checkout	2						

1. Materials and installatin costs for power cabling, control cabling, and foundation/pedestal are not broken into separate elements. A more detailed breakdown of material unit costs, materials requirements, labor rates, and labor requirements is necessary to complete any normalization.

2. The other field installation tasks are not broken out at an adequate level of detail either. Further breakdown of man-hour requirements for these tasks would facilitate the normalization.

3. According to pages 3-71 and 3-74, heliostat assembly and erection will take place during two 8 hour shifts, producing 10 heliostats per shift. The heliostat transport vehicle requires one operator. The two work platform vehicles require two driver/assemblers each. This totals 5 laborers working 8 hours (40 man-hours) to install 10 heliostats. This rate of 5 man-hours per heliostat does not agree with the 2.32 man-hours reported in the cost section.

4. Are the labor and burden charges given in Table 5.5-1 for the foundation/pedestal general contractor's overhead expenses?

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Transportation

Contractor Martin Marietta

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATION
Shipping Crates								
Transportation from Central Manufacturing Facility to Site	2					1		
Return Transportation of Empty Crates to Central Manufacturing Facility	2					1		3

1. Martin Marietta transportation costs are based on all rail transportation. Costs will have to be normalized to truck transportation.

2. Neither packing or unloading of the shipping crates is included in the transportation costs.

3. Martin Marietta also describes truck and trailer use as alternative transportation. The bar joist laod for truck transportation, calculated to be 10 feet tall, exceeds the maximum load height of 9 ft, 6 inches. (See page 3-67)

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Materials

Contractor Martin Marietta

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Power Cabling and Equipment	1						
Control Cabling	1						
Foundation/Pedestal	1						
Misc. Mateials	1						

1. Materials and installation costs for power cabling, control cabling, and foundation/pedestal are not broken out into separate cost elements. A more detailed cost breakdown into material requirements and material unit costs is required for cost normalization.

2. The foundation/pedestal material cost in Table 5.4.3-2 does not agree with the material cost in Table 5.5-1.

3. According to page D-11, the $596 charge for the pedestal/foundation includes installation of the interface pipe, but not the material cost of the interface pipe. Does Table 5.5-1 imply that the interface tube material cost is $39.30? ($635.30 - $596.00)

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Equipment

Contractor Martin Marietta

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Cable Layer	1						
Trucks and Trailers	5						
Foundation Hole Augerer	1						
Rebar Cage Inserter	1						
Heliostat Transport Vehicle	2						
Work Platform Vehicles	2						
BCS	2						
Shipping Crates	2						
Misc. Field Tools	2						

1. Martin Marietta does not specifically include the cost of these equipment types (those marked with a "1" on the previous page). Are the equipment charges for cable laying and foundation/pedestal construction included in the one lump sum cost given for these tasks?

2. Field equipment marked with a "2" on the previous page were specifically included by Martin Marietta.

3. The BCS costs $38.86/heliostat on page 5-19 and $36.86/heliostat on page 5-21.

4. Special tools costs $3.89/heliostat on page 5-17 and $3.98/heliostat on page 5-21.

5. Trucks and trailers were described by Martin Marietta as an alternative to railroad transportation. Costs for trucks and trailers were not included.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Installation

Contractor McDonnell Douglas

Date 4/7/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATIONS
Lay Power Cabling		1						
Lay Control Cabling		1						
Install Foundation/Pedestal	2							
Field Handling and Transportation	3							
Install Drive Unit				5				
Install Reflector Panel								
Install Electronics/Controls	4							
System Checkout				6				7

1. The power and control cabling is laid as one single cable. Are they in a single conduit or other wrapping?

2. The augering of the foundation hole is apparently included under site preparation and is called drilling operations.

3. Trucks are driven straight from the factory to the heliostat foundation location. There is not separate field handling charge.

4. Electronics and controls are factory installed into the drive/pedestal/main beam assemlby.

5. Table 5-1 states a requirement of 54 man-minutes (0.9 man-hours) to install the drive unit. However, the cost basis in appendix D-3 is .54 man-hours.

6. In Table 5-1, 2 electricians and 2 laborers are allowed 15 minutes per heliostat for final connections and checkout. However, both the cost summary and cost details of appendix D-3 (see account 44622) show a $0 charge for this task.

7. The details of appendix D-3 (account 4464) show a $0 charge for heliostat alignment. The cost for this task is $19 per heliostat in the cost summary.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Transporation

Contractor McDonnell Douglas

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATIONS
Shipping pallets								
Drive assembly transportation	2			1				3
Mirror panel Transportation	2			1				3
Cabling/power equipment transportation	2			1				3
Rebar cage and Cone transportation	2							3
	4							

1. MDAC transportation costs are based on a round trip of 288 miles. This is about 1/2 the distance assumed by the other contractors.

2. MDAC does not specifically include costs for the use of trucks and trailers. Are these costs included in the overheads?

3. MDAC needs to explain the application of labor overheads to the transportation direct labor charges (e.g. account 44662 in Appenidix D-3).

4. MDAC includes a permit charge for oversized loads.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Materials

Contractor McDonnell Douglas

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATIONS
Power Equipment		1						
Power Cable								
Control Cabling								
Foundation/Pedestal		5						2,3
		6						

---

1. How do the types of pin connectors listed on page 39 of Appendix D-3 differ so as to cause such a unit cost difference ($7.58 versus $.48).

2. 2.32 yd^3 x (1 + .05) for overpour x $44.4/$yd^3$ = $108.16. MDAC calculates a cost of $111.08 from these inputs.

3. 396 lbs. of rebar x $.24/lb = $71.04. MDAC calculates a cost of $78.90. Does the difference include rebar wire ties and/or other materials?

4. 50 sets of bracings (forms?) are required at a cost of $216 each. How does MDAC arrive at a cost of $4.71/heliostat?

5. Other contractors have opted for a continuous foundation-pedestal construction. MDAC uses basically a 3 unit foundation-pedestal - why?

6. MDAC does not specifically include any charges for miscellaneous materials.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Equipment

Contractor McDonnell Douglas

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Cable Layer	1						
Trucks and Trailers	1						
Foundation Hole Augerer	1						
Rebar Cage Inserter	1						
Pedestal/Drive assembly-Installation Machine	1						
Reflector Panel Assembly-Installation Machine	1						
Forklifts	1						
BCS	2						
Packing Crates	2						
Misc. Field Tools	1						

1. MDAC does not explicitly include the cost of all these equipment types (those marked with a "1" on the previous page). Are the costs hidden somewhere in overhead charges?

2. The BCS and transportation packing crates are the only equipment MDAC specifically includes.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Installation

Contractor Westinghouse

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATIONS
Lay Power Cabling	1							
Lay Control Cabling	1							
Install Foundation/Pedestal	2							
Field Handling & Transportation	3							
Install Drive Unit	3							
Install Reflector Panel	3							
Install Electronics/Controls								
System Checkout	4							
Misc./Other	5							6

1. Does "Cable Plowing", page 2-12, Table 2.3-1, Vol. II, include control and power cabling? Does the cost for "Cable Plowing" include installation labor and/or equipment? Cable plowing should be broken into power and control cable components unless the two are laid as a single unit. Is "Drive Cable" installation included in account 4460, page 2-10, Table 2.2-1, Vol. II? Is "Drive Cable" the power cabling, the control cabling or something else?

2. Materials and installation costs for the foundation/pedestal are not broken into separate elements. A more detailed breakdown of materials unit costs, materials requirements, labor rates, and labor requirements is necessary to complete any normalization.

3. Separation of field handling and transportation, drive unit installatin, and reflector panel installation charges from the lump sum estimate into their respective categories would facilitate cost normalization.

4. Is system checkout included with the electronics/controls installation costs? If so, these costs should be segregated.

5. All costs need to be segregated into site assembly building or field installation tasks, especially those in Table 2.2-1.

6. In general, the numbers in Table 2.2-1, Vol.II do not seem to add up. For example, see Group 4460 on page 2-10 of Table 2.2-1.

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Transporatation

Contractor Westinghouse

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
The Westinghouse heliostat is primarily site manufactured. The central manufacturing plant is more of a central distribution facility. The transportation costs of materials from the central distribution facility to the site and transportation costs from parts manufacturers to the site are not included.							

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Materials

Contractor Westinghouse

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE	DEVIATIONS
Power Cabling and Equipment	1							
Control Cabling	1							
Foundation/Pedestal	2							
Turnbuckles			3					
Misc. Materials								4

1. The description of both power and control cabling materials is lacking in enough detail to allow more than a general comparison of costs from other contractors.

2. Materials and installation costs for the foundation/pedestal are not broken into separate elements. A more detailed breakdown of material unit costs, materials requirements, labor rates, and labor requirements is necessary to complete any normalization.

3. The $180 per heliostat cost for three turnbuckles seems rather expensive. Exactly what is the function of these turnbuckles, how big are they, and where are they included in the design?

4. Within Table 2.2-1 rivets are listed at $8 each. Is this a typo?

CONTRACTOR ESTIMATED COSTS
SUMMARY EVALUATION

Component Field Equipment

Contractor Westinghouse

Date 4/8/81 Reviewer DR Brown

	COMPLETENESS	FEASIBILITY	MATERIALS	TIME	PERSONNEL	EQUIPMENT	SPACE
Cable Layer	1						
Field Trucks and Trailers	2						
Pile Driver	1						
Field Leveling Fixtures							
Final Assembly and Checkout Fixture	3						
Portable Welders and Carts							
Misc. Field Tools							

1. Costs for the cable layer and pile driver are not included by Westinghouse.
2. Field transportation is included. As noted under Transportation, trucks and trailers required to deliver materials to the site are not included, nor are any other off-site transportation costs included.
3. Does "Final Assembly and Checkout Fixiture" include a crane for placing the heliostat frame on its foundation? Does it include a BCS?

APPENDIX B

COST COMPARISON SHEETS

CONTRACTOR COMPARISON

DATE 4/16/81

BY KD

COMPARISON AZ + Elevation Drive Materials

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Castings	El. Dr.					
Cast iron	.29-.92	.31-.32		.37-.58		
Meehanite	.91			about .50		
Nodular casting	.62-1.00			average		
Steel tubing	.25					
CR Steel	.25					
Steel plate			.26(1)			
Steel bar stock	.28	.40-.49		.42-.46		
SS	1.07					
Bronze		.80				
Gear forgings	.83	.80				
Gear Castings				.48-.53		
Cast iron	1.47					
Nodular	.62					
Gear steel				.42		
Expansion chamber		4.00 each	2.34 each	20.00 each		

(1) Not possible to say without very detailed calculation

CONTRACTOR COMPARISON

DATE 4/16/81

COMPARISON Mirror Materials

BY KD

	ITEM	COST					
		BEC	MMC	MDAC	N	W	Standard
	Facet Assy, total	1303.32					
E-3	Fusion Glass, .060 622.58 ft^2		280.16				
			.45/ft^2	+ 152/ tooling			
E-3	Silver, copper, paint & solvent for silvering						
	line 622.58 ft^2		124.52				
			.20/ft^2				
D3-3	Reflective surface - mirror complete			$29.62/unit			
B.2	.059 fusion glass, 132 x 48, 14 units/H			$.67/$ft^2$			
	44 ft^2/unit						
D3-3	Backlite .190 float 132 x 48			13.82/unit			
				$.314/$ft^2$			
H-6	Glass, low iron float 48 x 72, mirror facet				$\frac{10.32}{24}$ .43/ft^2		
	Silver $15/oz				$\frac{.90}{24}$ .375/ft^2		
	Paint 10/gal				$\frac{.50}{24}$ .042/ft^2		

CONTRACT COMPARISON

COMPARISON Reflector Glass

DATE 23/81

BY KD

ITEM	COST					
MMC	BEC	MMC	MDAC	N	W	Standard
Fusion Glass, .060 622.58 ft^2						
Corning, P. E-3		280.16	$\frac{280.16}{622.58}$ =	$45/$ft^2$		
Boeing						
Facet assy, complete						
P. 127, App II	1,303.32					
Northrup						
Mirror Facet Assembly,						
12 assy/H, 24 x 6' mirrors				11.72 ea		
Face area = 55.3 M^2 = 595.1 ft^2				23.44/assay		
low iron soda lime float glass				281.28/H		
R = .87, .094" thick						
($385.92 on p. 8-14)						
Westinghouse						
880 ft^2 - .935 R 1/4" thick front						
surface, 13-12x5 mirrors @ 66 and 2 10 x 15						
mirror @ 31 13x66 + 2x55 = 968					968.00	

CONTRACT COMPARISON

DATE /23/81

COMPARISON REFLECTOR GLASS

BY KD

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MDAC						
Glass, P A-3, .060 fusion, P. 2-1						
glass, Corning, 4x11			33.00/unit			
			= .75/ft^2			

COMPARISON Support Structure Materials

D. _____

BY _____

ITEM	COST					
	BEC	MMC	MDAC	N	W	Barstow
Support beam, 14 G, formed	$.34					
Torque Tube, 16 OD x .105 wall	.30					
MS < 1x1x1/8	.275					
Flanges, x	2.17					

COMPARISON Support Structure Materials

DATE

BY

ITEM		COST					
		BEC	MMC	MDAC	N	W	Barstow
36" Coil Carb S - .1875	$\frac{129.8}{649}$ OK		.20				
4 x 1.25 1010 Steel Bar	$\frac{11.55}{33.4}$		.35				
65-45-12 Ductile Castings	$\frac{35.34}{114}$		.31				
1-1/2 x 3 1018 CE Steel Bar	$\frac{9.54}{18}$		.53				
2" dia 1018 Steel Rod	$\frac{4.80}{12}$		.40				
3-1/2 dia 1018 Steel Rod	$\frac{1.29}{3.2}$		.40	They			
4.875 x .1875 Coil Stock	$\frac{123.34}{632.5}$		.195	used			
11/16 Rod Bar ASTM A36	$\frac{35.68}{178.4}$		.20	.34 to.36			
MC3 x 7.1 ASTM A36	$\frac{14.71}{58.84}$		.25	↓			
Galv. Roll Forwed 14 G, sec.				.39			
Galv. Roll Forwed 12 G, sec				.39			
2x2x1/8 ∠, say .39				.39			
.078 x 4' wide coil stock					.30		
Flange Plate, 3/4					.40		
Paint					10.00		
12" Schedule 20 pipe					.30		
Support Bracket, 0.90					.30		
1x1x1/4 ∠					.30		

COMPARISON Support Structure Materials

DATE _____

BY _____

ITEM		COST					
		BEC	MMC	MDAC	N	W	Barstow
36" Coil Carb S - .1875	$\frac{129.8}{649}$ OK		.20				
4 x 1.25 1010 Steel Bar	$\frac{11.55}{33.4}$		.35				
65-45-12 Ductile Castings	$\frac{35.34}{114}$		.31				
1-1/2 x 3 1018 CE Steel Bar	$\frac{9.54}{18}$		.53				
2" dia 1018 Steel Rod	$\frac{4.80}{12}$		.40				
3-1/2 dia 1018 Steel Rod	$\frac{1.29}{3.2}$		.40	They			
4.875 x .1875 Coil Stock	$\frac{123.34}{632.5}$		.195	used			
11/16 Rod Bar ASTM A36	$\frac{35.68}{178.4}$		.20	.34 to .36			
MC3 x 7.1 ASTM A36	$\frac{14.71}{58.84}$		.25	↓			
Galv. Roll Forwed 14 G, sec.				.39			
Galv. Roll Forwed 12 G, sec				.39			
2x2x1/8 ∠, say .39				.39			
.078 x 4' wide coil stock					.30		
Flange Plate, 3/4					.40		
Paint					10.00		
12" Schedule 20 pipe					.30		
Support Bracket, 0.90					.30		
1x1x1/4 ∠					.30		

CONTRACTOR COMPARISON

COMPARISON HELIOSTAT CONTROLS & POWER

DATE 5/7/81

BY K.D.

PAGE 1

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Drive Motors						
Material		252	109	300	103	
Labor		0(1)	0(1)	0(1)	0(1)	
Rate (Per hour)		-	-	-	-	
Burden		0(2)	0(1)	0(1)	0(1)	
Encoders and Positional Feedback Devices						
Material		385.15	55.00	25.93	375.00(7)	
Labor		5.42(3)	30.00	3.74	0(1)	
Rate (Per Hour)		12.32	75.00	4.49	-	
Burden		11.67	(6)	(1)	(1)	

CONTRACTOR COMPARISON

COMPARISON Heliostat Controls and Power

DATE /81

BY PDB

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Power Distribution Equipment						
Material		44.34 (4)	288.00	0	0	
Labor		0	55.00	0	0	
Rate (per hour)		-	68.75	-	-	
Burden		-	(6)	(1)	(1)	
Calibration Equipment						
Material		38.86	6	0	0	
Labor		-	1	0	0	
Rate (Per Hour)		-	-	-	-	
Burden		-	(6)	(1)	(1)	

CONTRACTOR COMPARISON

COMPARISON Heliostat Controls and Power

DATE 7/7/81

BY PDB

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Field Control Equipment						
Material (HC, HFC, and HAC)		534.93	182.00	233.48	1410.80(8)	
Labor		0	22.00	10.47	122.10	
Rate (Per Hour)		-	73.33	4.49	20.00	
Burden		0	(6)	(1)	(1)	
Control Signal Distribution Equipment						
Material		63.26	0(5)	0	0	
Labor		0	0	0	0	
Rate (per hour)		-	-	-	-	
Burden		0	(6)	(1)	(1)	

Notes

1. Not identifible.

2. Labor and Burden costs are included in the rest of the drive unit costs.

3. Missing 2 encoder wiring harnesses. All wiring harnesses are assumed to be purchased assembled.

4. The wiring harnesses are assumed to be purchased assembled.

5. It appears that McDonnel Douglas costed the HC in the control signal distribution category (4433) instead of the field control equipment category (4432). I moved it from 4433 to 4432. There doesn't appear to be any actual distribution equipment in 4433.

6. Labor includes the burden.

7. Includes only the encoder costs. No cabling cost - could be included under the controls category.

8. Includes Array controller, field controllers and heliostat controllers.

CONTRACTOR COMPARISON

COMPARISON Drive Motors

DATE 4/10/81

BY PDB

ITEM Page 1-2	COST					
	BEC	MMC	MDAC	N	W	Standard
1.) Bodine electric Co. 1/6 horsepower						
D.C. gear motors (2)		252				
Material Total - MMC		252				
1.) Azimuth motor, 1/4 hp., 20BV, 60 HZ						
3 phase.			54.70			
2.) Elevation motor, 1/3 hp, 20BV, 60 HZ						
3 phase			54.70			
MATERIAL TOTAL MDAC			109.40			
1.) Superior electric Co. stepper motor (2)				300.00		
MATERIAL TOTAL - NORTHRUP				300.00		

CONTRACTOR COMPARISON

DATE 4/10/81

BY PDB

COMPARISON Drive Motors - Material Breakdown

ITEM Page 2-2	COST					
	BEC	MMC	MDAC	N	W	Standard
1.) Azimuth motor, 1/2 hp, AC						
Westinghouse					50	
2.) Elevation motor, 1/3 hp, AC						
Westinghouse					53	
MATERIAL TOTAL- WESTINGHOUSE					103.00	

CONTRACTOR COMPARISON

DATE 1/10/81

BY PDB

COMPARISON ENCODERS AND POSITIONAL FEEDBACK DEVICES

MATERIALS BREAKDOWN

ITEM Page 1-2	COST					
	BEC	MMC	MDAC	N	W	Standard
1) El/AZ encoders, BEI electronics						
Incremental pptical encoders (2)		296.16				
2) EL/AZ Lock Limit Switch Harness						
Assembly (2) (inc. Labor)		32.66				
3. EL/AZ Limit Switch Harness Assembly						
(2) (Inc. Labor)		34.89				
4) Encoder mounting hardware		21.38				
Material Total - MMC		385.08				
1) Encoder Consists of counting motor						
revolutions by microprocessor. This						
also includes material costs for limit						
switches.			55.			
Material Total - MMC			55.00			

CONTRACTOR COMPARISON

DATE 4/10/81

BY

COMPARISON ENCODERS AND POSITIONAL FEEDBACK DEVICES

MATERIALS BREAKDOWN

ITEM PAGE 2-2	COST					
	BEC	MMC	MDAC	N	W	Standard
1) No encoder necessary due to use of stepper						
motor.						
2) Limit switches				12.25		
3) Limit switches (4)				13.68		
4) Couldn't identify costs of associated limit						
switch cabling						
MATERIAL TOTAL - NORTHRUP				25.93		
1) Elevation encoder - absolute type,						
magnetosonic (westinghouse design?)					275.00	
2) Azimuth encoder 0 absolute type						
magnetosonic (Westinghouse design?)					100.00	
MATERIAL TOTAL - WESTINGHOUSE					375.00	

CONTRACTOR COMPARISON

DATE 4/10/81

BY PDB

COMPARISON FIELD CONTROL EQUIPMENT

MATERIAL BREAKDOWN

ITEM PAGE 1-2	COST					
	BEC	MMC	MDAC	N	W	Standard
1) Modcomp Classic computer (7870)						
duol redundant system (HAC)		77.71				
2) HC/HFC - note that labor B included						
in this cost (scaled from Barstow design)		457.22				
MATERIAL TOTAL- MMC		534.93				
1) HAC-POP 11/34 (DEC)			22.00			
2) HC/HFC - labor is not included here			160.00			
MATERIAL TOTAL - MDAC			182.00			

CONTRACTOR COMPARISON

COMPARISON FIELD CONTROL EQUIPMENT

MATERIALS DESCRIPTION

DATE 4/10/81

BY PDB

ITEM Page 2-2	COST					
	BEC	MMC	MDAC	N	W	Standard
1) Could not find any money included for						
central computer.						
2) Do not have an HFC. HC's communicate with						
AAC directly. Or they didn't approach						
that problem				233.48		
MATERIAL TOTAL - NORTHRUP				233.48		
1) HAC - type not specified				10.52		
2) HFC - no details				93.28		
3) HC - this possibly includes wiring harnesses						
for encoders and power.				1307.00		
MATERIAL TOTAL - WESTINGHOUSE				1410.80		

CONTRACTOR COMPARISON

COMPARISON HELIOSTAT CONTROLS

DATE 1/7/81

BY PDB

ITEM PAGE 1	COST					
	BEC	MMC	MDAC	N	W	Standard
Drive Motors						
Material		252.00	109.00	300.00	103.00	
Labor		0(1)	0(1)	0(1)	0(1)	
Rate (Per Hour)		-	-	-	-	
Burden		0(2)	0(1)	0(1)	0(1)	
Encoders and Positional Feedback Devices						
Material		385.15	55.00	25.93	375.00(7)	
Labor		5.42(3)	30.00	3.74	0(1)	
Rate (Per Hour)		12.32	75.00	4.49	-	
Burden		11.67	(6)	(1)	(1)	

CONTRACTOR COMPARISON

COMPARISON HELIOSTAT CONTROLS

DATE 7/7/81

BY PDB

ITEM PAGE 1	COST					
	BEC	MMC	MDAC	N	W	Standard
Drive Motors						
Material		252.00	109.00	300.00	103.00	
Labor		0(1)	0(1)	0(1)	0(1)	
Rate (Per Hour)		-	-	-	-	
Burden		0(2)	0(1)	0(1)	0(1)	
Encoders and Positional Feedback Devices						
Material		385.15	55.00	25.93	375.00(7)	
Labor		5.42(3)	30.00	3.74	0(1)	
Rate (Per Hour)		12.32	75.00	4.49	-	
Burden		11.67	(6)	(1)	(1)	

CONTRACTOR COMPARISON

COMPARISON HELIOSTAT CONTROLS

DATE 4/7/81

BY PDB

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Power Distribution Equipment						
Material		44.34(4)	288.00	0	0	
Labor		0	55.00	0	0	
Rate (Per Hour)		-	68.75	-	-	
Burden		-	(6)	(1)	(1)	
Calibration Equipment						
Material		38.86	6	0	0	
Labor		-	1	0	0	
Rate (Per Hour)		-	-	-	-	
Burden		-	(6)	(1)	(1)	

CONTRACTOR COMPARISON

COMPARISON HELIOSTAT CONTROLS

DATE 4/7/81

BY PDB

ITEM PAGE 3	COST					
	BEC	MMC	MDAC	N	W	Standard
Field Control Equipment						
Material (HC, HFC, AND HAC)		534.93	24.00 (5)	233.48	1410.80 (8)	
Labor		0	0	10.47	122.10	
Rate (Per Hour)		-	-	4.49	20.00	
Burden		0	(6)	(1)	(1)	
Control Signal Distribution Equipment						
Material		63.26	158.00	0	0	
Labor		0	22.00	0	0	
Rate (Per Hour)		-	73.33	-	-	
Burden		0	(6)	(1)	(1)	

CONTRACTOR COMPARISON

COMPARISON HELIOSTAT CONTROLS

DATE /9/81

BY PDB

ITEM	COST					
PAGE 4	BEC	MMC	MDAC	N	W	Standard
Heliostat Controls (totals)		1212.54	640.00	559.41	1888.80	
Material		5.42	108.00	14.21	122.10	
Labor		12.32	0(1)	0(1)	0(1)	
TOTAL CONTROL COST (PER HELIOSTAT)		1236.28	748.00	573.62	2010.90	
# Heliostat for 50MWe field		5142.00	5412.00	5974.00	3956.00	
total assay. control costs		$6.36 x 10^6	$4.05 x 10^6	$3.43 x 10^6	$7.96 x 10^6	
Production Equipment Costs		0	$290,000.00	$680,000.00	0	

Notes

1) Not identifiable

2) Labor and Burden costs are included in the rest of the drive unit costs.

3) Missing 2 encoder wiring harnesses. All wiring harnesses are assumed to be purchased assembled.

4) The wiring harnesses are assumed to be purchased assembled.

5) Seems small, possibly absorbed in other costs?

6) Labor includes burden.

7) Includes only the encoder costs. No cabling cost - could be included under the controls category.

8) Includes Array controller, field controllers and heliostat controllers.

HELIOSTAT CONTROL SYSTEM COST BREAKDOWN STRUCTURE

1. Drive Motors - The motors used to drive the individual heliostats. There are typically two of them, one for elevation and one of azimuth.

2. Encoders or Positional Feedback Devices - This includes encoders or any other type of position determining device, any associated cable harnesses and brackets. This includes limit switches.

3. Power Distribution Equipment - This includes all cables and connectors used for distribution of power within the individual heliostat.

4. Calibration Equipment - Assembly device used for calibration of the array, including the Beam Characterization System. (BCS)

5. Field Control Equipment - The actual electronic circuiting used to control the heliostat positions. This includes any central computer, plus the electronics on the individual heliostats.

6. Control Signal Distribution Equipment - Assembly equipment used for sending control signals between heliostats or for communication between the central computer and individual heliostats.

CONTRACTOR COMPARISON

COMPARISON Direct Labor Man Hours

DATE 4/21/81

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Reflective Assembly-Mirror Module						
Silvering		0.4	0.9			
parts Fab.	Facet Assy. 0.30		0.3			
Assembly			0.7	0.29		
Other -	Attn. Bracket .73					
Total-Mirror Module		2.86	1.9	3.45		
Drive unit						
AZ. Drive Parts Mach	3.85	3.25		13.1		
AZ. Drive Parts, Other						
AZ. Drive Assy.	1.02	1.92	3.6 total	3.33		
EL Drive Parts, Mach	2.00					
EL Drive Other						
EL Drive Assy	.55		1.7 total			
Other						
AZ Drive Assy Parts	1.83					
Center Torque Arm Assy	1.59					
EL Beam Assy		0.786				
TOTAL, DRIVE UNIT	10.84		7.3	17.11		

CONTRACTOR COMPARISON

DATE 4/21/81

COMPARISON Direct Labor Man Hours

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC D3-1	N	W	Standard
Controls			0.3 Total	2.33		
				1.67 is	included in	2.33 above
Power Supply			0.8 total	1.67		
Assy Dr/Ped/Elect. P.			0.7 total			
AZ Encoder		0.22	0.4 total			
El Encoder		0.22	D3-1			

CONTRACT COMPARISON

COMPARISON Direct Labor Man Hours

DATE 4/21/81

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Foundation/ Pedestal						
Ped. Delivered to Site., Purch.						
Ped. Interface Tube		0.17				
Pile Assy.				1.00		

CONTRACT COMPARISON

DATE 4/21/81

COMPARISON Direct Labor Man Hours

BY KD.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Support Structure						
Parts Fab	1.02	0.94	0.4			
Assembly	4.25					
Total Support Structure				10.96		
Assembly						
Reflector Assy	6.03					
Drive Unit Assy. At CMF	.36					
Ass. El Drive to AZ.	0.08					
Ass. Ctr Torque Tube to AZ-EL	0.18					
Oper. Checkout	0.10					
Heliostat Field Assy	7.0					

4410

CONTRACTOR COMPARISON

DATE 7-1-81

BY KD

COMPARISON Reflector Unit Direct Labor - Man Hours.

	ITEM	COST					
		BEC	MMC	MDAC	N	W	Standard
H-2	Northrup H-2, $15.48 DL						
	Assemble from substrate and facet .078 pcs/hr						
	x 13 = .9408 mh/H						
H-5	Total MH = .2462 x 12 =				2.95/H		This does not jibe with
	Assemble sandwich from components .0784 x 12 =				0.9408		
							$15.48/H
	7.84 mh/100 pc. = $.35/pc						at 4.49/hr.
	.0784 mh/pc = 12.76 pcs/hr.						
	$.35/pc x 12.76 pc/hr.						15.48 =3.45 4.49 mh/hr.
	= $4.46/hr.						
	They say $4.49 DL rate						The difference
	$\frac{\$15.48/PL}{4.46}$ = 3.47						is someplace
							on PH-4 -H-6

4410

CONTRACT COMPARISON

DATE 3-31-81

BY KD.

COMPARISON Reflector Unit Direct Labor-
Man Hours

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Facet Assy. -Assy. 3.50 X 12 = 42.00						
Total Direct 2.22 Assy Labor "" Variable 1.28 3.50	$26.64					
2.22 X 12 = 26.64	3.33 MH					
P. 128 Vol.II 4.25MH = $34.00 =8.00/hr.						
P. 129- several figures at 8.00/MH						
Mirror Assembly $34.99 / 12.23 $/Hr. = 2.81 MH		2.86 MH				
71 people (pE-24), also p.E62, 2.86 MH		↑				
Includes making edge strips, honeycomb,		TOTAL				
mirroring & assembly.						
Mirror Modulessy only - pE-62		1.04				
Mirroring only		.40				
Mirror Module Total Labor						
.07522 X 14 =			1.053			

CONTRACT COMPARISON

DATE

COMPARISON Direct Labor Elements

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Central Factory Rate	7.50/hr.					
Site Factory Rate	8.00/hr.					
Base Hourly Wage mmp 5-9		5.90				
Payroll Taxes and Insurance		1.21				
Pension and Benefits		1.12				
Premiums		2.02				
Total		10.25				
Vacation, Holidays, Absence		1.98				
Touch Labor Rate		12.23				
10.25/hr. x 2080 paid hrs/yr =21,320/yr						
21,330/yr ÷ 1744 touch hours/yr						
= $12.23/hr direct labor rate						
(MMC p. 5-10)						

CONTRACT COMPARISON

COMPARISON Direct Labor Elements

DATE

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MDAC - Table 6-11						
Base Rate			7.01			
Industry Factor			.15			
Applied Rate			8.06			
Labor efficiency			.92 ← see pg. D5-1			
Machine down time			.05 -.10			
Scrap			.02- .03			
Rework (5% at 4x labor)			.20			
Relief			.167			
Relief (including lunch)			.247			
NORTHRUP						
Direct Labor				4.49		
Shift Difference - 50% of cap.				.8%		
100%				2.9%		
135%				3.6%		

CONTRACTOR COMPARISON

DATE_____

COMPARISON OH and Cost Rules

BY_____

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
BEC, 93						
Units Produced						
Variable Costs						
Equip. Rental	8.47					
Collector Subs. Var. Cost	5892.87					
Warranty Service	13.26					
Power, Utilities & Facil. Maint.	5.69					
Economic Profit	198.12					
Total Variable Costs	6121.28					
Fixed Costs						
Central Mfg. Plant						
Plant Design & Const. Fees	7.52					
Plant Turnover/Accept	0.48					
Process Design	11.98					
Plant Startup	26.45					
Depreciation	169.33					
Taxes	48.92					

CONTRACTOR COMPARISON

DATE _____

COMPARISON OH & Cost Rules(cont'd)

BY _____

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Site Assembly Bldg.						
Process Design	0.36					
Equipment depreciation	1.47					
Site Activiation/Downstream	6.57					
Insurance	15.06					
Design Change Admin.	3.49					
Gen & Admin. Overhead	103.23					
TOTAL FIXED COSTS	394.86					
TOTAL COSTS	6,513.27					

CONTRACTOR COMPARISON

DATE 1/22/81

COMPARISON COSTING I

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MMC						
ROI		17.5				
80% Equity Financing, 20% Rate of Return						
20% Debt Financing, 15% Interest RAte						
50% Composite Income Tax Rate						
10% Investment Tax Credit on Mach. & Equip.						
17.5% Cost of Capital(discount factor)						
FCR - Bldg. and Site Facilities		0.2916				
Machinery and Equipment		0.2754				
Special Tooling		0.2625				
Central Manf. Facility						
Base Hourly Wages			$5.90			
Payroll Taxes and Insurances						
FICA (6.13%)		0.36				
FUI (0.70%)		0.04				
SUI (3.25%)		0.19				
Workmen's Compensation (7.5%)		0.44				

CONTINUED

CONTRACTOR COMPARISON

DATE_____

COMPARISON COSTING (cont'd) 2

BY_____

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Liability Insurance (3.0%)		0.18				
	Total =	$1.21	$7.11			
Pension and Benefits						
Pension Contribution (10%)		0.59				
Health & Walfare (9%)		0.53				
	Total =	$1.12	$8.23			
Premiums						
Overtime Allowance (5%)		0.41				
Shift Differential (7%)		0.58				
COLA (12.5%)		1.03				
Note: 1) $10.25/h x 2080 paid hours/year	Total =	$2.02	$10.25			
= $21,320/yr.						
2) $21,330/yr ÷ 1744 touch hours/year =						
$12.23/h direct labor rate.						
Indirect Labor		$81.62	$98.62			
Overhead Labor		17.00				

CONTRACTOR COMPARISON

DAT.

BY

COMPARISON COSTING (cont'd) 3

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Perishable Tooling		$ 72.40				
Supplies		5.00	$90.00			
Scrap		12.60				
Utilities		36.20				
Depreciation Expense (Facilities)		46.55				
Depreciation Expense (Equipment)		54.32	$115.27			
Property Taxes		14.40				
General and Administrative		22.00				
TOTAL BURDEN COST →		$362.09	per Heliostat			

CONTRACT COMPARISON

COMPARISON OH & Cost Rules MDAC

DATE

BY

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MDAC 6.1.3.1						
Depreciation -			Straight Line			
p. ROI			15% in 10th year			
p. 10th year plant						
Q. No IDC						
R. No state sales tax						
S. Cost reduction?						
Special profit center						
For ratios - Table 6-9			million Dollars/year			
DL			4.38			
Variable Fringe			3.16			
Fixed Fringe			1.85			
Overtime			.22			
Night Shift			.18			
COLA			.50			
Variable Burden			9.36			
Fixed Burden			4.64			
Product. Engineering			.61			
SUB-TOTAL			24.90			

DATE

BY KD

COMPARISON OH & Cost Rules
MDAC

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Sub Total from prev. page			24.90			
Direct Material			146.07			
Subtotal			170.97			
Depreciation			7.09			
Total			178.06			
G&A			8.25			
Total			190.92			

DATE

BY KD

COMPARISON OH & Cost Rules
MDAC

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Sub Total from prev. page			24.90			
Direct Material			146.07			
Subtotal			170.97			
Depreciation			7.09			
Total			178.06			
G&A			8.25			
Total			190.92			

CONTRACT COMPARISON
$

COMPARISON Reflector Unit

Equipment Costs

DATE 12/81

BY KD

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Mirror Facet	NSI					
Mirror Line		3,000				
Feed and Index Station		100	F - 165 + I			
Special Dolles		200	B - 110 + I			
Move Dolles		25				
Feed Lites to PIB Line		100				
Electrostatic Clean		15				
Apply PIB and arc		500				
Feed						
Feed and straighten steel shot		100				
Shear to 12'		100				
Shear to 2.5 + 5'		50				
Solvent Clean		75				
Conveyor		60				
Palletyped bond line		818				
Edge Strips and Center Strips						
Coil Auto Feed		100				
Roll foner and cut		100				

CONTRACTOR COMPARISON

DATE /2/81

BY KD

COMPARISON Reflector Unit

Equipment Costs

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Edge, strips (corner)						
Solvent Clean		50				
Extrude PIB		20				
Extrude Adhesive		20				
Support Doubles						
Flatten - 30T OBI press		30				
Drill and Tap - Kingsberry dial trans. 6 stat.		250				
Mirror Module Assy.						
Air Table & auto feed edge		300				
Auto screw insertion - 3 screws		50				
Stitch face						
Apply silicon sealant		40				
Sand blast doublers		50				
Apply adhesive		20				
Locate doublers and press		90				
check contour and inspect		80				

CONTRACTOR COMPARISON

COMPARISON Reflector Unit

Equipment Costs

DATE /2/81

BY KD

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Sub assemble stringers - clinch						
Nuts			205			
Bridge Crane			50			
Spray Primer			68			
Assemble Mirror Mod-Conveyor			158			
"			62			
Load stringers			137			
Jet spray wash			55			
Deionized Water Rinse			77			
Warm air dry			55			
Spray adhesive			38			
Nip roller			99			
Extrude adhesive			39			
Pallets and Special tools			approx. 600			
Pallet			110			
Stacking elevators			580			
Racks and conveyor			approx 1,800			
Autoclaves			approx 2,600			

CONTRACT COMPARISON

DATE /2/81

BY KD

COMPARISON Reflector Unit

Equipment Costs

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Apply edge sealent - auto extruder			59			
conveyor			approx 200			
Mirror line				TOTAL 2/45 101 + inst.		
Unloader and transfer				2 322		
Edge and end Sealent				2 322		
Washer Dryer				2 66		
Convey				2 110		
Loaders				2 110		
Silvering Line				2 2,300		
Waste Water Treatment				1 2,300		
Webs and Edge Molding						
Pay off reel				2 24		
Roll fomer				2 90		
Cutoff				2 42		
Stiffens and end piece and mtg. bracket and corner modling and etc.						
Pay off real				1 12		
40 T Press				1 20		
100 T Press				1 40		

CONTRACTOR COMPARISON

DATE ,-3-81

BY Kirk Drumheller

COMPARISON Reflector Unit Equipment Costs
Summary

	ITEM	COST					
		BEC	MMC	MDAC	N	W	Standard
II-4	Mirror Line		3,000(1)	-	4,149(2)	+ Water Treatment	
	Substrate Assembly				2,131		
	Backing plate				809		
	Molding, side				37		
II-36	Assemble mirror to substrate				1,098		
	Autoclaves			2,518			
II-4	Spray Washer			55			
	Deionized Water Rinser			77			
	Warm Air Dryer			55			
	Adhesive Sprayer			38			
	Pinch Roller			99			
	Adhesive Extrude			39			
	Conveyor & Pallets						
	Glass loader - back lite			110	101	2	
	Glass loader - lite		100	165			
				3,156			
	TOTAL			7,469			
	Conveyor			~4,313			

CONTRACTOR COMPARISON

DATE 3-81

BY K.D.

COMPARISON Reflector Unit Equipment Costs
Summary

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
STEEL SHEET						
Coil Holder				49		
Leveler				200		
Cut-Off				375		
Stacker				75		
Feed & Straighten		100				
Shear to 12'		100	250			
Shear to 2.5 + 5		50				
Northrup totals $809.00 for each of two pices, 1618 total for front and back sheets						
MMC totals $385 for both sides.		CHECK. 1618				
			385			
			1233 is the difference?			

CONTRACTOR COMPARISON

COMPARISON Reflector Unit Equipment Costs
Summary

DATE -3-81
BY KD

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
Edge Strips and Center Strip						
Coil Auto. feed		100		24		
Roll form & Cut		100		45 + 21		
30 T Press		30				
40 T Press				20		
100 T Press				40		

CONTRACTOR COMPARISON

DATE _____

BY _____

COMPARISON Reflector Unit

Equipment Costs

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
H-32 Backing Sheet and Mirror backing Sheet H35						
Coil holder				49		
Levels				200		
Cut-off				375		
Stacker				75		
Web Assy.						
Adhesive disc.						
Stapler						
Run-out Table						
Substrate Assy						
Conveyor				920		
Module Assy						
Grease dist.				50		
Module Assy Conv.				1240		
Final Assy Conv.				600		

CONTRACT COMPARISON

COMPARISON Mirror Line

DATE 3-2-81

BY K.D.

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
BEC - Integrated with fusion glass production						
by Corning at Blacksburg - in line						
conventional wet chemistry, P. 29	--					
MMC - Silver and Paint Mirrors, dry for 3 min.		3,000,000.	1op/shift			
@ 220°F						
Rack lites on dollies for cure						
feed and index station		100,000	1op/shift			
special dollies		200,000				

COMPARISON Equipment Speeds

DATE

BY

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
5" Turret Lathe - HS Cup Open B-800240						
Chuck on OD, face one						
end, Drill 1.12 hole, bore 1.34	1.72 min					
CB, rough 1.57 D hole,	per pc.					
rough cut OD step	PA-50F					
Mill 1/4" key way, horz. mill	1.60 m/p					
	p. A-64F					
A-835234A HS Housing brushing						
Abrasive, cut-off	0.4 m/p					
Grind OD	0.2 m/p					
	p a-77F					

CONTRACTOR COMPARISON

COMPARISON Equipment Speeds

DATE

BY KD

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
D-926610, Base housing						
Drill 9 bolt holes, NATCO-9						
spindle drill press	0-96 M/P					
	A-84F					
D-926220, cover housing						
1st chucking, rough and finish						
Bullerd 25'D twin spindle						
Vertical Chucking Machine	3.2 M/P					
$269,000	A-91 F					
936310 Planet Gear, Hobbing Machine						
(13 reg.) - Hob gear teeth	3.90/13					
$2,200,000 Total for 13	A-97 F					
Shave Gear Teeth 8.2 PD						
4 mach.	1.50/4					
$387,000 total for 4	A-97 F					

DATE _____

BY _____

COMPARISON Equipment Speeds

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
926,360 Fricteon						
shear 36" to 2" strips, 8 ton	.08 m/p					
shear press	A-126F					
200 T press	.08 m/p					
	A-126F					
1x 1x 1/2 ∠, saw -DO-ALL						
Auto feed band saw, 720 p/h	.07 m/p					
	A-231 F					
Pierce 5 holes -80T press, 400/hR	.12 m/p					
	A-231F					
Sheer 32.5 X 60X .194						
80T press 520/Hr.	.09 m/p					
	A-240 F					
Blank & Pierce, 125 T press						
500/H	.10 m/p					
	A-240F					

CONTRACTOR COMPARISON

DATE 4

BY

COMPARISON Equipment Speeds

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
SK 6140-002-2 Torque						
Tube Weld, Core						
Weld 3/8D 20 places	2.00 m/p					
	A-249F					

CONTRACT COMPARISON

DATE _____

BY _____

COMPARISON Equipment Speeds

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MMC						
Roll Form Edge Strip						
Auto Feed coil stock						
Roll form, cut to length, meter		5400 Ft/hr				
		E-24				
Flatten doublers,30T press		1800 p/h				
30K		E-26				
Drill & Tap, Kingsburg 6 stat.						
250K		500 p/h				
		E-26				
AZ shaft, rough gang turn						
New Britain Acme Lathe, 150K		21.3 p/h				
		E-29				
Ele. Shaft, Cut off & rough						
Trim, Multi spindle screw		16.7 p/h				
mach. 340K		E-30				

COMPARISON Equipment Speeds

DATE

BY

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MMC						
Intermediate Pinion						
Pot Broach 150K		38 P/H				
Hob Warm Gear						
Single spindle hobber						
2 reg- 330K total		40 P/H				
		E-33				
Elevation Cover						
Kingsburg Vist. Center Col.						
Dial Transfer 8 Station						
2,000,000		16.1 P/H				
		E-33				
Encoder Shaft Mount						
300 T Press 175K		50 P/H				
		E-40				

DATE_____

BY_____

COMPARISON Equipment Speeds & Cost

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
MMC						
Elevation Tube						
Special Tube Fabricating machine						
550 K						
elevation beam assy.						
Special Welding Jig.						
80K		15.87 p/h				
		E-59				
Paint		25 p/h				
150K		E-59				
Bar joist						
Feed roll stock roll form						
& cut to length , 44K						
Total for Bar joint						
301,500 E-60						

CONTRACTOR COMPARISON

DATE _____

COMPARISON Equipment Speeds & Cost

BY _____

ITEM	COST					
MDAC	BEC	MMC	MDAC	N	W	Standard
PVB roller 14 K, B-5 GM						
Resistance weld support						
Struc. - drill 8 holes						
& straighten 2,274K B-8, GM						
AZ Drive Housing Welding						
Weld bearing sleeve To						
lower housing	0.1334					
Dollar Weld March 34,960	H/P					
	B-16 GM					
Broach Flex Spline Teeth						
143,595 plus 28,000 tooling						
plus 84,620 non durable tooling						
plus 21,550 installation	0.25 H/P					
	b-38GM					

DATE _____

COMPARISON Equipment Speeds & cost

BY _____

ITEM MDAC	COST BEC	MMC	MDAC	N	W	Standard
Circular spline, turn,						
face, bore, cham. .						
Bullard Templa Turn						
Vesit Turret Lathe						
946K + 142 K winch	.05 H/P					
B-39 GM	B-39 GM					
AZ Drive bearing retainer,						
Drill 16. ,40 dia holes,						
Lamb 4, sta.dial Mach.						
308K, 181K special tolling						
68K durable tooling						
46K inch. 54 P/H	.01852 H/P					
	B-47 GM					

CONTRACTOR COMPARISON

DATE _____

BY _____

COMPARISON Equipment Speeds & costs

	ITEM	COST					
		BEC	MMC	MDAC	N	W	Standard
	Northrup						
H-28	Mirror silvering line, 2@ 1,150						
	Waste Water Treatment 1,150						
H-29	Roll former						
	Payoff reel 2@ 14.4						
	Former 2@ 51.2						
	Cut-off 2@ 24						
H-30	40 T Press 23						
	100 T Press 46						
H-32	Backing Sheet						
	Leveler 225						
	Special Cut-off 419						

CONTRACTOR COMPARISON

DATE _____

BY _____

COMPARISON Equipment Speeds & Costs

	ITEM	COST					
		BEC	MMC	MDAC	N	W	Standard
H-34	Substrate Assy.						
	Adhesive dispenser 22						
H-36	Module Assy.						
	Grease dispenser 58						
	Module Assy. Coro. 1240						
	Final Assy Corro. 600						
H-40	Drive Cover						
	Face, NC chucker 2@ 312				5 M/P		
	Grinder 212						
	Bearing Retainer ring 3 NC chuckers						
	Face @312				3 M/P		
	Bore 17.25 ID				5 "		
	Bore 18.0018 ID				7 "		
	Bore 18.380 ID				5 "		
	Chanf. .09 x 45				1 "		
	10 per - 2 mach.						

CONTRACTOR COMPARISON

DATE

BY

COMPARISON Equipment Speeds & Costs

Northrup

	ITEM	COST					
		BEC	MMC	MDAC	N	W	Standard
H-43	Elevation Gear, Cut						
	Worm teeth, 120 min/P						
	18 Hobbers, 4,356,000 total				120 M/P		
H-52	Azimuth Housing						
	Integrated Machining Center						
	or Transfer line 5,000,000						

CONTRACTOR COMPARISON

DAT. 4/15/81

COMPARISON DIRECT LABOR HOURS

BY Kirk Drumheller

page D-31

ITEM	COST					
	BEC	MMC	MDAC	N	W	Standard
GRAND TOTAL						
Reflective Unit			1.9			
Reflective Surface			.9			
Mirror Back Struc.			.3			
Assy. - Reflective UN			.7			
DRIVE UNIT			7.3			
Azimuth			3.6			
Elevation			1.7			
Motors- Total			0.0			
Pos/Lim. Indicator			.4			
Power Supply/ Distribution			.8			
Assy Dr/ Ped/ Elct. Power			.7			
CONTROL/INSTRUMENT EQ.			.3			
Sensor/ Calib. Equipment			.0			
Field Conrol			.0			
Control/Sig. Equipment			.3			
Helio Spt. Struc./ PR En			.4			
Helio Supp. Structure			.4			

APPENDIX C

BREAKDOWN TO FACTORY, TRANSPORTATION, SITE ASSEMBLY, AND INSTALLATION COSTS

BEC INSTALLATION SUMMARY

Materials			
Install Drive		1.35	
Contract			
4451 Pedestal		618.00	
4441 Land		67.97	
4453 Lightning Prot.		40.69	
4460 Mobilize & Site Prep		368.17	
Mobilize	7.23		
Site Prep	360.94		
4466 Integration equip-cleaning			
Fluid Processing		36.16	
4467 Pedestal Installation		315.00	
Field Design		21.70	
Software Adaptation		7.23	959.84
Computer Programs		1.23	
Maint. Support equip.		57.85	
Spare parts		4.68	
A&E		109.60	125.93
Const. Mgmt.		16.33	
Inst. Calib. and check		36.16	
Initial cleaning		3.00	
Contingency		244.55	

BEC Installation

				Subcontract	
142	4453	Lightning Prot.	Copper grid wire	210,600	$30.36/H
			weld ties	20,742	3.00
			pedestal to counterprice conn.	50,000	7.23
					40.69
143	4460,p.143	Mobilize, site survey Clear & Level, drainage fire prot, fence	50,000 + 12,560 +525,950 + 765,570 +500,000 + 500,000 + 191.475 = 2,545,555 ÷ 6914 = $368.17/H		
	4465,p.144	Integration equipment processing	cleaning fluid $250,000		36.16/H
	4469,p.144	Heliostat ref. & final survey	1.25 MH/H $8.00/hr 8643 MH total = 69144=		10.00/H
	4468.2p P. 144	Pedestal survey	0.25 MH/H, $8/hr 17285h, 13,828		$2.00/H
	4467	Pedestal Installation	2,177,910÷6914		315.00/H
	4468.1	Connect Electrical	.15 mh/Unit 16.05/hr. + burden .15 x 22.55 x 6914 = $23,387		6.50/H 3.38/H
	4468.2	Operate Gimbal & Verify	.083 mh/H, 16.05/hr + 6.50/hr burden 0.83 x 22.55 = 12,940 They say $12,993, 12,993 ÷ 6914		1.88/H
147	4471	Field Design	$150,000		
147	4472	Software Adaptation	$ 50,000		
148	4480	Computer Programs	8,500		
149-151	4490	Maintenance Support Equip.	400,500		
152	4820	Spare Parts	32,375		
		A&E	757,782		
		Comp. Mgmt	112,898		
		Inst. Calib & Check	250,000		
		Inst. Cleaning	20,742		
		Com.	1,690,848		

BEC INSTALLATION COST

Materials

1.35 apparently not in BEC no.

Contracts	949.84	(includes 67.97 per land)
	618.00	(pedestal procurement)
less land -	67.97	
""site prep-	268.16	
	1241.71	←
Labor	35.73	←
Indirects		
A&E	109.60	
Const. Mgm.	16.33	
Part of Contingency	143.39	
	269.32	
	1546.76	
Land	67.97	
Site Prep.	268.16	
	1882.89	

Using our arbitary distribution of $1891.43 for the total installation cost, less $1241.71 for materials and contracts, less $35.73 for labor, less $31.86 for equipment leaves $1891.43 - $1241.71 - $35.73 - $31.86 = $582.13 for indirects, site prep and land Subtracting $268.16 for site prep and $67.97 for land leaves $246.00 for indirects.

BEC SITE PREP

P. 143		Total	Per H	
4460.1.1	Movilize & Set up	50,000	7.23	7.23
4460.1.2	Initial Site Survey	12,560	1.82	1.82
4461	Clear & Grub	525,950	76.07	76.07
	Grade	765,570	110.73	110.73
4462	Storm Drainage	500,000	72.32	72.32
4463	Fire Protection	500,000	72.32	
4464.1	Fence	191,475	27.69	
				268.17

For the Boeing breakdown, we have treated the site assembly operations as factory. For the Boeing Table 3-3, p. 94, clear factory costs are 4410 & 4420, totaling $25,592,499 for 6914 heliostats or $3,846.18. Installation costs including the total contingency, are 4441-4850, totaling $12,459,942 or $1802.13 per heliostat. Assuming that the fixed costs of Table 3-3, p. 93 and 94 are distributed as follows:

	Mfg.	Installation
	7.52	
	.48	
	11.98	
	26.45	
	169.33	
	48.92	
	.36	
	1.47	
		6.57
		15.06
	3.49	
	80.00	23.23
	350.00	44.86
	44.86	
	394.86	

and the $225.54 cost of Table 3-3, p. 94 is split $150.00 to Mfg. and $75.54 to transportation and installation, we have the following split:

	Mfg.	Installation	Total
Table 3-3, p. 94	3846.18	1802.13	5648.31
Dist. - from Table 3-3	150.00	75.54	225.54
Dist. - from Table 3-3	350.00	44.86	394.86
Contingency (See next page)	101.06	143.49	244.55
	4447.24	2066.02	6513.26

The above are used, arbitrarily, as the manufacturing and transportation and installation costs.

Total	2066.02
Transportation	174.60
Balance for install.	1891.42 - use 1891.43

Boeing Contingency Table 3-3, p. 94

Total	1,690,848
Includes	147,246 on electric power (4425) which is not priced.

For split to Manufacturing and Installation

Mfg. includes - for our use: (from p. 153)

4410	440,678			
4420	110,832			
4425	147,246			
	698,756	÷ 6914	=	101.06/H

Balance for installation = 1,690,848 - 698,756 = 992,092 ÷ 6914 = 143.49/H

Total = 244.55

Note that the $31.86 for equipment, our number, is also somewhat arbitrary.

Factory, Transportation, Site, Installation
Cost Distribution - Martin Marietta

Martin Marietta Summary - See Volume 1.

5-14	Central Production Facility		4214.94	
	Transportation		231.37	
	Site Assembly			
5-18	DL, Heliostat assembly in site assy. bldg.		85.61	39.54
	Deprec. on site assy. bldg.		14.35	
	Profit for "" "" ""		25.19	
	Total, site assy bldg.		125.15	
	Installation			
	Direct Material		1017.87	
	Direct Labor - heliostat installation	31.83		
	"" "" - checkout & test	31.83	63.66	
	Burden - $57.09 less 14.35 dep. on site assy. bldg.		42.74	
	Disposable capital equipment		141.83	
			1266.10	
	TOTAL, SITE ASSY. AND INST.		1391.25	

Factory, Transportation, Site, Installation
Cost Distribution - McDonnell Douglas

In order to arrive at the Factory Cost numbers used by McDAC in Table 6-9, the following materials are pulled from the total of Table 6-12.

Control/Inst. Equipment	167
Found/Site Preparation	148 + 79
Field Assy. & C/O	21
TOTAL	415

From the first line of Table 6-12 this gives:

1518 + 1844 - 415 + 2947

Adding the bottom line give 2947 + 8 = 2955

This leaves a discrepancy of 2955 - 2921.40 = $33.60.

Using 3726.20 (p.6-9) as the factory cost, leaves a balance for transportation and installation of $4830.00 (Table 6-2) - $3726.20 = $1103.80. Using $237 for transportation, the total for installation is $1103.80 - $237.00 = $866.80.

From above, the installation materials are $415.00 plus $33.60 minus the $21.00 included in transportation, or $427.60.

This leaves a balance for direct labor and indirects of $866.80 - $427.60 = $439.20

Factory, Tranportation, Site, Installation Cost Distribution

Northrup

(Mostly self evident in document)

Factory

p. 8-8	DM	$3,272.47	
	DL	118.23	
p. 8-8	Indirect Material	65.00	(2% of direct)
p. 8-9	Shift Premium	3.43	
p. 8-10	Variable Indirect	82.76	
p. 8-10	Fixed Indirect	59.12	
p. 8-10	Utilities	75.00	
p. 8-11	Depreciation	168.94	
8-11	Property Taxes	24.19	
8-19	R&D	100.00	
8-20	G&A	300.00	
p. 8-20	Income Tax	200.00	
	Profit	400.00	
		∿ 4868.00	

Transportation

p. 8-16, $119

Installation

p. 8-18, Table 8-4

Pile Installation, Contract Installer		$220
Heliostat Transportation & erection		
5.2 hrs. @ 26	135	
Equipment	10	145
Control Installation		
2.2 hrs @ 26	57	
Equipment	1	
		58

p. 8-22, Table, Table 8-5

HC	167	
Field Wiring (HC to heliostat)	200	
		587

Direct Material

HC -	167
Field Wiring	200
Pile Instal	220
	587

Direct Labor

Trans. & Erect	- 135
Control	57
	192

Equipment

Trans. & Erect	10
Controls	1
	11

Site Assembly

p. 8-18, Table 8-4

17.5 hours @ 26 -	455
Facility & Equipment	65
Total	520

Factory, Transportation, Site, Installation
Cost Distribution
Westinghouse
(Mostly self evident)

For Installation Cost, from total Costs, Table 2.2-1, p. 2-10

4440, Foundation, Piles & Posts	$779
4460, Field Assembly - Material Labor	503
	120

From Table 2.3-1, p. 2-12

4810, Control/Instrumentation, 94 + 133 + 11 =	239
4820, Cable Plowing	150
Contingency	19
Total Installation Cost	$1810.00

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