5105-99 #48

Solar Thermal Power Systems Project
Parabolic Dish Systems Development

JPL Parabolic Dish Development Bimonthly Technical Status Report

No. 48

June - July 1984

Prepared for
U.S. Department of Energy
Through an Agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL D-521, Issue 12

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JET PROPULSION LABORATORY
SOLAR THERMAL POWER SYSTEMS

PARABOLIC DISH PROJECT

BI-MONTHLY TECHNICAL STATUS REPORT

JUNE - JULY 1984

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

PARABOLIC DISH PROJECT
BI-MONTHLY STATUS REPORT

EXECUTIVE SUMMARY

CONCENTRATOR DEVELOPMENT

- All concentrator development tasks are now complete. This includes the examination of all data from the final PDC-1 tests with both optical scans and Flux Mapper results. The final PDC-1 report will review this data.

- Most of the property destined for Sandia National Laboratories Albuquerque (SNLA) has been picked up by them. Some items still remain at JPL, but all are ready for shipment except for a few minor items which may be used by JPL in future tasks for SNLA.

ORGANIC RANKINE DEVELOPMENT

- Funds to complete funding of FACC and their subcontractors for the interim period in 1983 were obligated to FACC in June.

- Transfer of all property has essentially been completed and arrangements have been made for the shipment from FACC of all contract generated documents and drawings to JPL.

BRAYTON CYCLE MODULE

- During the week of June 13, 1984, Sanders Associates obtained preliminary test data on the completed Development Test Module (DTM) at Merrimack, N. H.

- Sanders Associates conducted a Critical Design Review (CDR) for the Brayton Module at Merrimack, N. H. on June 12, 13 followed by a program review on June 13, 1984. JPL supported these reviews which were chaired by SNLA and conducted by Sanders.

STIRLING ENGINE MODULE

- The principal activity during June for the Vanguard project was the experiment requested by the Southern California Edison Company. SCE desired to compare the performance of three different solar electricity generating systems installed into their grid network. One of these is the Dish/Stirling Electric Power System. The other two are the Solar Once Central Receiver Electric Powder System and the Arco photovoltaic generator near Hesperia CA. SCE plans that next year the Luz International Solar Electric Generating Station I (an array of trough-shaped solar collectors located adjacent to Solar) will be included.

- After the Summer Solstice tests were completed in June, the Advanco Corporation continued testing, but during normal working hours as opposed to the intense sunrise-to-sunset tests of June. The weather in July was characterized as cloudy -- with high clouds carried into the Rancho Mirage, CA area from southeasterly tropical depressions. The cloudy weather condition made possible a series of transient tests to determine the response of the PCU to rapid insolation variations. Also included in July tests were the effect of the Stirling engine heater head temperature set point on engine performance. The test personnel also conducted an analysis of deflection, convection and gravity effects on the PCU, and an analysis of the engine cooling subassembly performance. A summary of the results from these tests will be published in the Advanco Corporation July monthly report.

TEST OPERATIONS

- The shutdown of the Parabolic Dish Test Site has been completed. Minor equipment remains to be moved to Sandia.

REPORTS

- Four reports were published.

CONCENTRATOR DEVELOPMENT

Accomplishments

- All concentrator development tasks are now complete. This includes the examination of all data from the final PDC-1 tests with both optical scans and Flux Mapper results. The final PDC-1 report will review this data.
- Most of the property destined for Sandia National Laboratories Albuquerque (SNLA) has been picked up by them. Some items still remain at JPL, but all are ready for shipment except for a few minor items which may be used by JPL in future tasks for SNLA.
- A report entitled "Innovative Concentrator Requirements Definition" was published.

Plans for the Next Two Months

- Final shipment of all remaining property items to SNLA will be made.
- Documentation tasks will be continued. The reports entitled "The Analysis of Concentrator Optical" and "Development and Testing of Parabolic Characteristics Dish Concentrator No. 1" will be published.

ORGANIC RANKINE DEVELOPMENT

Accomplishments

- Funds to complete funding of FACC and their subcontractors for the interim period in 1983 were obligated to FACC in June.
- Transfer of all property has essentially been completed and arrangements have been made for the shipment from FACC of all contract generated documents and drawings to JPL.
- The JPL documents describing the ORC development and the resolution of the ORC TAP bearing problem are in the final stages of writing.

Plans for the Next Two Months

- Meetings will be conducted to resolve outstanding issues prior to formal termination of contract 955637 and to stop all work on that contract.
- The writing of documentation reporting the ORC development effort will be completed. The report entitled "Organic Rankine-Cycle Module Development" will be published.

BRAYTON CYCLE MODULE

Accomplishments

- During the week of June 13, 1984, Sanders Associates obtained preliminary test data on the completed Development Test Module (DTM) at Merrimack, N. H. The DTM consists of:

  1) AiResearch unimproved Mark III SABC engine with limited-capacity load-cell PMA.

  2) Sanders subatmospheric ceramic receiver.

  3) Abacus inverter.

  4) LaJet modified LEC 460 Concentrator with membrane facets.

  5) Sanders Module Control System

- The tests satisfactorily met the primary objective of providing design information particularly in exercising control options; however, the performance of the concentrator, receiver and especially the SABC engine were quite disappointing.

- Sanders Associates conducted a Critical Design Review (CDR) for the Brayton Module at Merrimack, N. H. on June 12, 13 followed by a program review on June 13, 1984. JPL supported these reviews which were chaired by SNLA and conducted by Sanders.

- In support of closing out action items from the Sanders CDR, JPL wrote a summary letter report for SNLA's use.

- The overall Brayton module development report was initiated.

- The transfer of the hardware inventory from the JPL Sanders Contract to the SNLA contract was initiated by the JPL Subcontract Review Property Offices.

Plans for the Next Two Months

- The Brayton module development report will be completed.

STIRLING ENGINE MODULE

Accomplishments

June

- After the four cables and fasteners damaged during zenith-pointing-stow over Memorial Day weekend were replaced, the Advanco Corporation reported the Vanguard module was back in normal operation on June 12.

- The principal activity during June for the Vanguard project was the experiment requested by the Southern California Edison Company. SCE desired to compare the performance of three different solar electricity generating systems installed into their grid network. One of these is the Dish/Stirling Electric Power System. The other two are the Solar Once Central Receiver Electric Power System and the Arco photovoltaic generator near Hesperia CA. SCE plans that next year the Luz International Solar Electric Generating Station I (an array of trough-shaped solar collectors located adjacent to Solar) will be included.

- Advanco Corporation operated the Vanguard module from sunrise-to-sunset over the period of from June 14 to June 28 while collecting performance data. Advanco Corporation published a table illustrating the performance for the complete month of June; this is shown below.

Table 1: Monthly Total Table for June 1984

Date	Gross kWH	Net kWH	Cumulative Insolation (kWH/Sq.m)	Gross Daily Eff	Net Daily Eff	Running Hours	Dish Reflectivity
6/1-6/13	--	--	--	--	--	4.9	--
6/14	220	200	9.97	25.5%	23.1%	11.2	.900
6/15	227	207	9.89	26.5%	24.1%	10.5	.880
6/16	213	193	9.57	25.7%	23.3%	12.9	.875
6/17	210	189	9.57	25.3%	22.8%	13.0	.876
6/18	204	184	9.33	25.2%	22.7%	13.1	.860
6/19	221	199	10.10	25.2%	22.7%	13.25	.860
6/20	236	216	10.55	25.8%	23.6%	13.25	.856
6/21	258	238	10.88	27.4%	25.2%	13.25	.920
6/22	249	227	10.69	26.9%	24.5%	13.05	.898
6/23	228	208	9.89	26.6%	24.3%	11.8	.894
6/24	0	-8	1.38	0.0%	-6.7%	0.2	.861
6/25	39	24	3.96	11.4%	7.0%	4.3	.858
6/26	202	181	8.93	26.1%	23.4%	12.85	.923
6/27	205	184	8.99	26.3%	23.6%	12.55	.898
6/28	96	77	5.26	21.0%	16.9%	9.1	.894
6/29	--	--	--	--	--	3.25	--
TOTAL	2808	2519	128.96	*25.1%	*22.5%	172.45	.884

* These averages calculated by dividing total power production by total input insolation for the month.

-- Data shown as dashed lines was not included but is available.

The best day was June 21, where the gross electricity generated was 258 kWh and the net electricity was 238 kWh resulting in a net daily conversion efficiency of 25.2%.

July

- After the Summer Solstice tests were completed in June, the Advanco Corporation continued testing, but during normal working hours as opposed to the intense sunrise-to-sunset tests of June. The weather in July was characterized as cloudy -- with high clouds carried into the Rancho Mirage, CA area from southeasterly tropical depressions. The cloudy weather condition made possible a series of transient tests to determine the response of the PCU to rapid insolation variations. Also included in July tests were the effect of the Stirling engine heater head temperature set point on engine performance. The test personnel also conducted an analysis of deflection, convection and gravity effects on the PCU, and an analysis of the engine cooling subassembly performance. A summary of the results from these tests will be published in the Advanco Corporation July monthly report.

- Advanco Corporation reported 19 out of 328 reflectors on the Vanguard module have had mirrors delaminate from the foamglass substrate. After a study of the failures, Advanco concluded the most likely reason for the failures was poor adhesion due to faulty manufacture of the first batch of reflectors. Vibration stress due to the mounting of the PCU and to an air compressor on the solar concentrator unit structure was not entirely ruled out.

- On July 1, SNLA took over from JPL technical monitoring of the DOE/AL Advanco Corporation Cooperative Agreement

- The remaining equipment belonging the USSw has left JPL on its return journey to Sweden. It is currently in process by the U. S. Customs Service at Los Angeles International Airport.

Plans for the Next Two Months

- Advanco Corporation will complete performance tests needed to fulfill the requirement of the cooperative agreement. The terms of the cooperative agreement require a final report on the evaluation of design, fabrication, assembly, test and operations over the period of the activity. The final report is due on September 30, 1984.

- Advanco will receive an I-R 100 Award Plaque for the Vanguard Project achievements in 1984 at Chicago on September 20, 1984. The document describing overall Stirling module development will be published.

- The document describing overall Stirling module development will be published.

- The report entitled "Stirling Cycle-Module Technology Development", will be published.

ENGINEERING ANALYSIS AND INTEGRATION

(ENGINEERING STUDIES/PLANNING, ANALYSIS, AND INTEGRATION)

Accomplishments

- A report entitled "A Nomographic Methodology for Use in Performance Trade-Off Studies of Parabolic Dish Solar Power Modules" was published in June, 1984. The nomographic approach provides a basis for quickly estimating trade-offs.
- A first draft was prepared of a report that examines test data on dish-Stirling modules. These data were obtained during the series of tests conducted at the Parabolic Dish Test Site (PDTS).

Plans for the Next Two Months

- The final draft of the dish-Stirling test report will be prepared.

TEST OPERATIONS

Accomplishments

- The shutdown of the Parabolic Dish Test Site has been completed. Minor equipment remains to be moved to Sandia.
- Data reduction in support of the Advanco Test Site at Rancho Mirage continued until the end of June. At that time, responsibility for support was transferred to SNLA.

Plans for the Next Two Months

- The reports entitled "History and Operating Experience at the Parabolic Dish Test Site" and "Flux Mapper Software Development" will be published.

REPORTS

Published

June

- Survey of Manufacturers of High-Performance Heat Engines Adaptable to Solar Applications, W. B. Stine, DOE/JPL-1060-75, June 15, 1984.
- A Nomographic Methodology for Use in Performance Trade-Off Studies of Parabolic Dish Solar Power Modules, M. K. Selcuk and T. Fujita, DOE/JPL-1060-74, June 15, 1984.

July

- Experimental and Theoretical Study of a Solar Thermochemical Receiver Module, Y. S. Won, G. E. Voecks, and J. H. McCrary, DOE/JPL-1060-76, July 15, 1984.
- Innovative Concentrator Requirements Definition, T. O. Thosteson, JPL D-1664, July 15, 1984.

Planned Publications

August

- Analysis of Concentrator Optical Characteristics

September

- Organic Rankine-Cycle Module Development
- Stirling-Cycle Module Technology Development
- Development and Testing of Parabolic Dish Concentrator No. 1
- History and Operating Experience at the Parabolic Dish Test Site
- Flux Mapper Software Development

REMAINING REPORTS

- Summary Assessment of Solar-Thermal Parabolic Dish Technology for Electrical Power Generation
- Techno-Economic Projections and Markets
- Brayton-Cycle Module Development
- Concentrator Control System Development
- Concentrator Design Using Analytical Models
- Design and Testing of Receivers for Parabolic Dish Modules
- Bearing Development for the Organic Rankine-Cycle Engine
- Radiometer Field-of-View Management
- Flux Mapping of a Parabolic Dish Concentrator
- Calorimetry Testing of a Parabolic Dish Concentrator
- Stirling Engine Test Data Analysis
- Dish Analysis Procedure Using a Programmable Calculator

- Overview of Software Development at the PDTS
- Comparison of Engines for Parabolic Dish Systems
- Reversible Chemical Reactions for Transport and Storage

PARABOLIC DISH PROJECT
TOTAL $K
(COSTS)

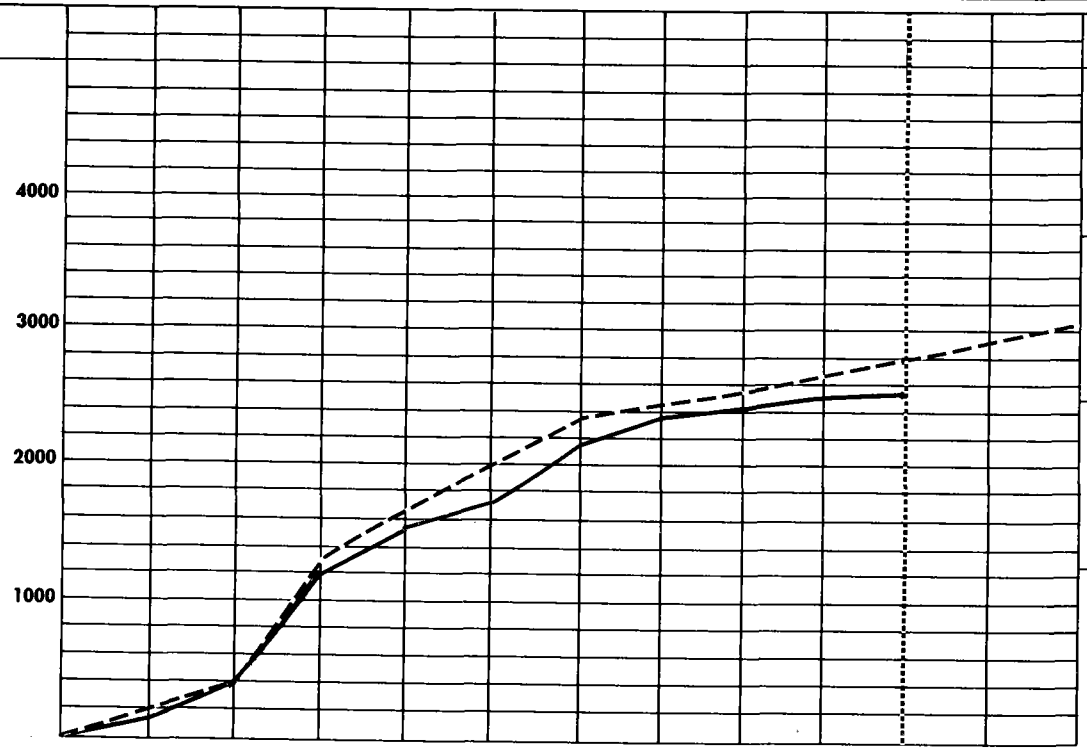
7. Months	O	N	D	J	F	M	A	M	J	J	A	S	8. FY 84

10. Cost Status

a. Dollars K

Legend:

- Planned & Approved
- Actual
- Reporting Date



e. Actual Costs Prior FYs

$58,157,267

f. Planned Costs Prior FYs

$58,519,618

g. Total Estimated Accrued Costs for Contract

NA for ongoing Contract

h. Total Contract Value

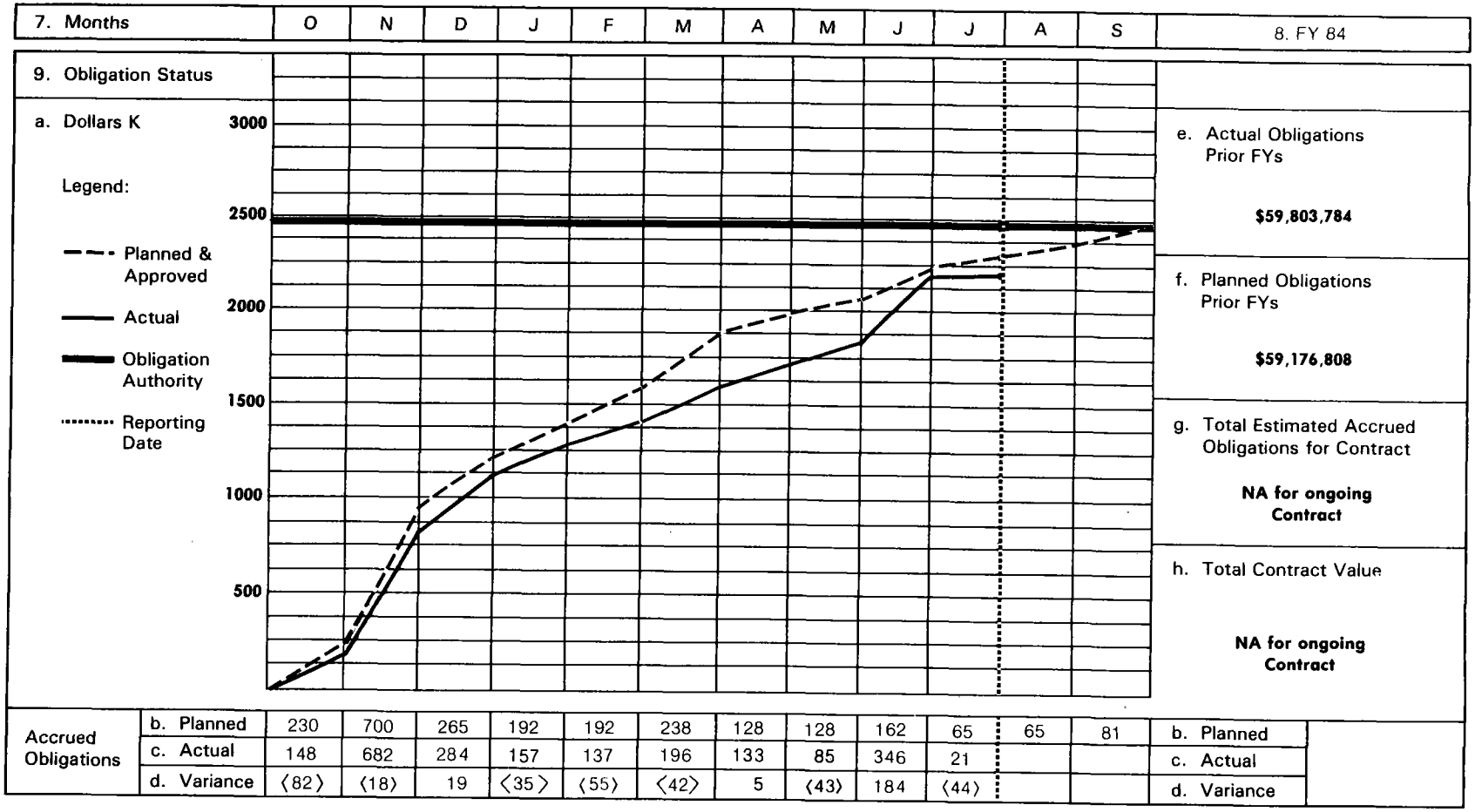
NA for ongoing Contract

Accrued Costs														
	b. Planned	200	200	900	322	322	402	105	105	132	111	112	140	b. Planned
	c. Actual	165	205	863	283	176	442	214	88	86	5			c. Actual
	d. Variance	⟨35⟩	5	⟨37⟩	⟨39⟩	⟨146⟩	40	109	⟨17⟩	⟨46⟩	⟨106⟩			d. Variance

Accrued Costs

12. Remarks

PARABOLIC DISH PROJECT
TOTAL $K
(OBLIGATIONS)



Accrued Obligations		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	230	700	265	192	192	238	128	128	162	65	65	81	b. Planned
	c. Actual	148	682	284	157	137	196	133	85	346	21			c. Actual
	d. Variance	⟨82⟩	⟨18⟩	19	⟨35⟩	⟨55⟩	⟨42⟩	5	⟨43⟩	184	⟨44⟩			d. Variance

12. Remarks

PARABOLIC DISH PROJECT
TOTAL WORKPOWER
(MANMONTHS)

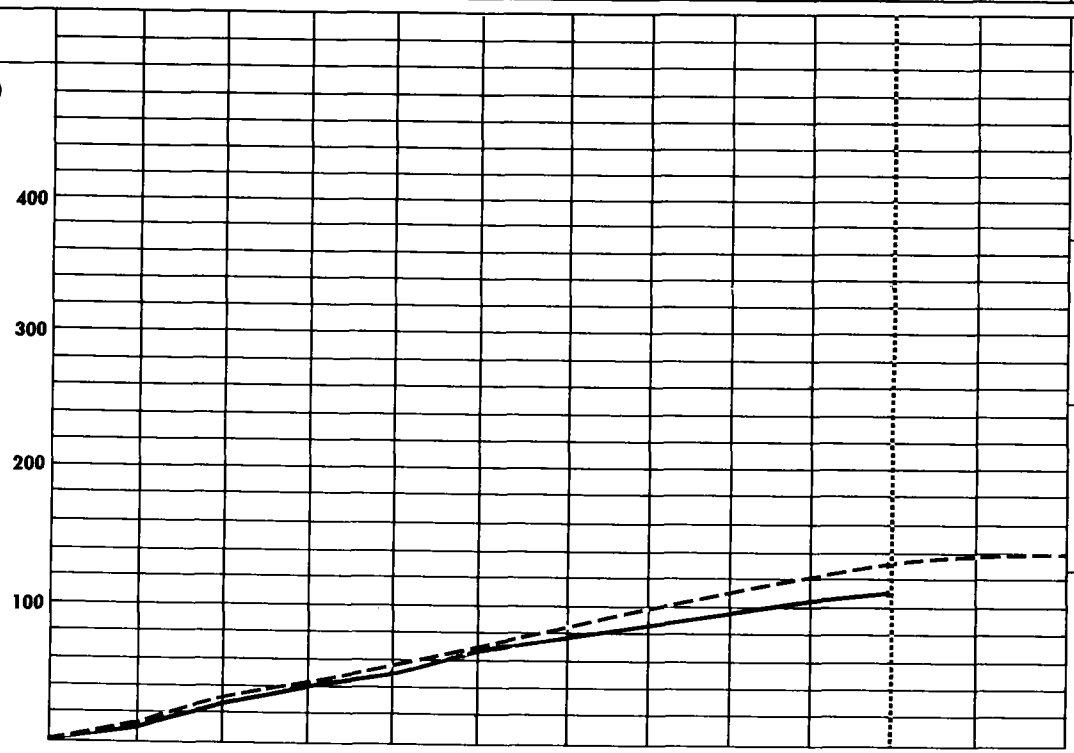
7. Months	O	N	D	J	F	M	A	M	J	J	A	S	8. FY 84

11. Workpower Status

a. WorkMonths (WM)

Legend:

- – – – Planned & Approved
- ——— Actual
- ..... Reporting Date



e. Actual Workpower Prior FYs

310.5 WY

f. Planned Workpower Prior FYs

314.0 WY

g. Total Estimated Workpower for Contract

NA for ongoing Contract

h. Total Contract Workpower

NA for ongoing Contract

Workpower															
	b. Planned	14	14	14	14	14	14	13	12	12	10	5	1	b. Planned	Workpower
	c. Actual	13	13	14	13	13	11	9	8	8	7			c. Actual	
	d. Variance	⟨1⟩	⟨1⟩	0	⟨1⟩	⟨1⟩	⟨3⟩	⟨4⟩	⟨4⟩	⟨4⟩	⟨3⟩			d. Variance	

12. Remarks

JET PROPULSION LABORATORY
4800 Oak Grove Drive
Pasadena, California 91109

FY 1984

	MILESTONES
1	Organic Rankine Module
2	Development
3	Stirling Module Development
4	
5	Brayton Module Development
6	
7	Small Community Experiments
8	
9	Innovative Concentrator PON
10	
11	Test Operations
12	
13	Documentation
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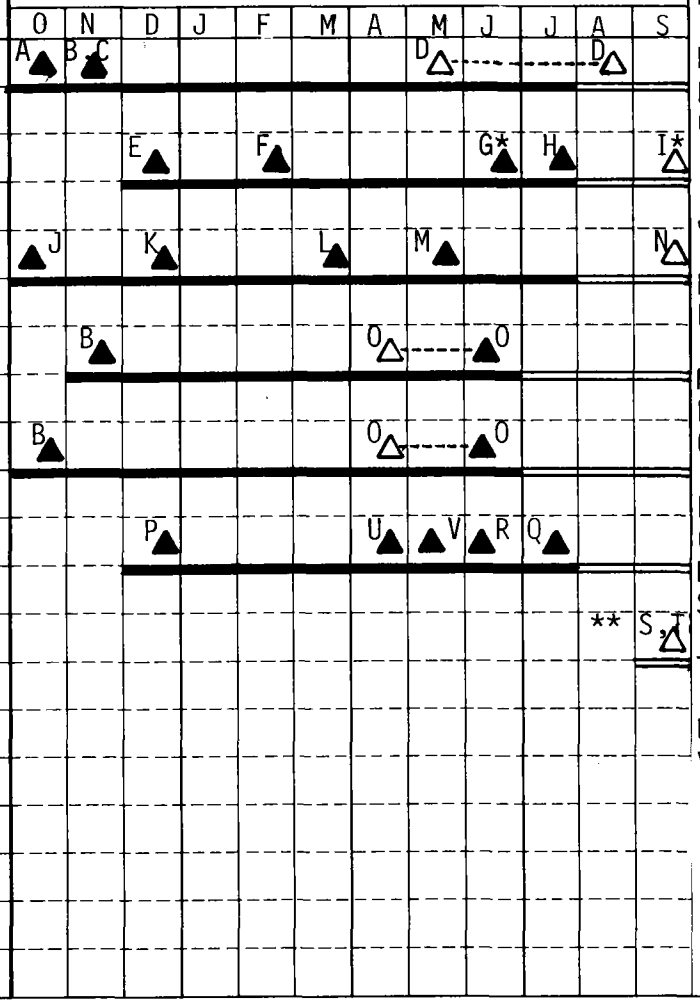
20	



SCHEDULED NOTES

A. Completed 100-hour PCS-1 hot test at B-N
B. Transferred responsibility to SNLA
C. DOE/FACC negotiations for SC-1 terminated
D. Complete technical closeout of JPL/FACC subcontract
E. Complete Vanguard I module installation
F. Complete checkout of Vanguard Module
G. Complete Vanguard performance evaluation
H. Transfer responsibility to SNLA
I. Complete Vanguard endurance tests
J. Transferred 2nd generation technology responsibility to SNLA
K. Initiate testing of DTM subsystems
L. Complete installation of LaJet concentrator at Sanders Associates.
M. Critical design review
N. Complete fabrication of SABC module
O. Provide support to DOE on evaluation of PON proposals.
P. TBC-1 moved to SNLA
Q. Support SNLA to bring TBC-1 on line
R. Closedown PDTS
S. Publish report on dish techno-economic projections.
T. Publish report on dish overview assessment.
U. Move TBC-2 to SNLA
V. Move PDC-1 to SNLA

NOTES

* This schedule incorporates a three month extension requested by Advanco Corporation
** Rescheduled to November

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