RADIO ASTRONOMY PROJECT

Record of Meeting at the National Science Foundation
November 22, 1957

Present: National Science Foundation:

J. M. Mitchell
E. A. Eckhardt
Geoffrey Keller
A. J. Leigh
J. E. Luton
C. B. Ruttenberg
F. C. Sheppard

Associated Universities, Inc.:

N. L. Ashton
L. R. Burchill
F. J. Callender
J. J. Carroll
C. F. Dunbar
R. M. Emberson
D. S. Heeschen
M. M. Small
M. L. Westman

1. History of Project:

Mitchell suggested that, as a preface to the afternoon discussion on supplementary funding for the 140' telescope and other items, it would be helpful to have a brief informal account of the Radio Astronomy Project from its inception up to the present time. In view of the various changes in NSF personnel, many of the people present are unfamiliar with earlier events which have a bearing on the decisions which must be made in the very near future. In response to this request, Emberson made a statement, a summary of which, and of the subsequent discussion, is attached hereto.

2. Agenda for Afternoon:

Emberson said that in the afternoon Berkner would join the meeting and AUI would present a detailed account of its negotiations for the procurement of the 140' radio telescope and AUI's plans for completing the Observatory and a statement of its financial needs. Mitchell said it would be impossible for Dr. Waterman to be present in the afternoon, but that a full account of the meeting would be given to him.

NSF-AUI STAFF MEETING - NOVEMBER 22, 1957

1:30 P.M.

In addition to the persons who attended the morning session of the joint

meeting, Mr. Lloyd V. Berkner, President of Associated Universities, Inc., and Dr. John W. Findlay, of the Observatory staff, were present.

The afternoon session was devoted to the consideration of AUI's need for additional capital funds for the procurement of the 140' radio telescope and other phases of the construction and site development program. The discussion was based on financial tables prepared by AUI, attached as exhibits to these minutes, as follows:

A - Summary - Funding of Capital Items Based on Full Utilization of 140' Telescope
B - Summary of Existing Appropriations and Commitments
C - Summary of Estimates of the 140' Telescope
D - Summary - Site Development Completion Program
E - Summary of Estimated Cost of Electronics Program for Full Utilization of the 85' and 140' Telescope and Equipment of Electronics Laboratories

1. Available Funds:

Emberson pointed out that Exhibit A was a summary and hence an index to the other more detailed exhibits. He then proceeded to discuss Exhibit B, which shows a balance available for all capital expenditures, including the 140' telescope, of $3,096,000. The contingency of $50,000 provided for the items designated as "expended or earmarked" is on a small percentage basis, but in view of the fact that so much of the work listed has either been actually finished or contracted for on a fixed price basis, it is considered to be sufficeint. Emberson pointed out that on a cash basis only a little more than $3,000,000 is actually available because there have already been expenditures for the 140' telescope, principally the payments to Ned L. Ashton and Franklin Institute for design and engineering services.

2. Procurement of 140' Radio Telescope:

2.1 Bid Solicitation:

Emberson reminded the meeting that invitations for proposals for the fabrication and erection of the 140' telescope were issued on August 1, 1957 to about 100 different companies. A bidders' conference was held on September 12, 1957, and the final date for receiving proposals was October 21, 1957. Berkner pointed out that AUI distinctly preferred to have the work done by a single responsible and competent prime contractor and not divided among several contractors. In the latter event, AUI would need to build up a substantial engineering staff, with proportionate expense, to say nothing of loss of time. In the invitation for proposals and at the September 12th conference, therefore, it was specified that a prime contractor must show an established skill in at least one of the three critical elements of the work; namely, steel fabrication and erection, alumium fabrication and erection, and fabrication and installation of drive and control mechanism. The remaining major division, the concrete foundation, calls for no unusual skill.

Emberson said that some 40 proposals were received, of which nine were for the entire job; i.e., for a prime contract. These nine proposals are summarized in the following table:

Name	Price	
Blount Brothers Construction Company	$ 3,960,000	
Malan Construction Corporation	$ 4,760,000	
Judson Pacific-Murphy Company	$ 5,590,000	
E. W. Bliss Company	$ 5,770,000	
John F. Beasley Construction Company	$ 6,420,000	
Blaw-Knox Company	$ 6,550,000	
Loewy-Hydropress Division of Baldwin-Lima-Hamilton Corporation	$ 8,450,000	
American Machine and Foundry Company	$10,020,000	(estimated cost on CPFF basis)
Air Reduction Company	$12,020,000	

2.2. Analysis of Proposals and Subsequent Negotiations:

Emberson said that all nine proposals were carefully analyzed by the AUI staff to determine the competence of the bidder and the degree to which the proposal conformed to the invitation. By this process and subsequent exchanges of correspondence and discussion, Air Reduction Company, Beasley Construction Company, and Malan Construction Corporation were advised that their proposals would not be accepted. The proposal from Blount Construction Corporation was unsatisfactory, but Blount insisted on an interview. Therefore, a conference was held at which Blount and its principal subcontractor, O. G. Kelley Company of Boston were represented. It appeared that Blount and Kelley might both be competent in their particular fields (conventional heavy construction and metal tank fabircation and welding, respectively). However, neither appeared to have an adequate engineering force or any particular competence in the so-called critical areas of this job. When the conference ended, Blount and Kelley indicated that they might submit a joint proposal at a later date.

American Machine and Foundry Company declined to make a proposal on a fixed-price basis, or to reduce the estimated cost of the work on a cost-plus-fixed-fee basis.

AUI decided to negotiate on equal terms with the remaining four proposers, and separate conferences were held with each one. It was pointed out at each of these meetings that the price named in the proposal exceeded the funds available and that AUI was to obtain a price as close as possible to $3,000,000. The work was broken down into 17 different items, and each one of these was considered in detail to see what savings could be effected and perhaps what portions of the work could be postponed without serious detriment to the finished instrument. It became apparent that a choice would have to be made between Judson Pacific-Murphy Company and E. W. Bliss Company. The Bliss proposal is more attractive, in that Bliss will perform most of the work itself. The foundation will be handled by subcontract with Bliss, as will the erection of the instrument. The drive and control mechanism will also have to be designed and manufactured elsewhere, also under subcontract with Bliss. The bulk of the work will be done by Bliss in its own plant and in the field. AUI representatives visited the Bliss plant in Canton, Ohio. The shops and engineering department both appear to be completely adequate, and Bliss is in a position to start work at once. The result of the negotiations with Bliss are described in the next section.

During the negotiations, AUI representatives considered the possibility of achieving a substantial reduction in price by adopting another design configuration. Blaw-Knox was asked to give an estimate on a 140' telescope meeting AUI's performance specifications but based on the configuration of the Blaw-Knox 85' telescope. Blaw-Knox expressed the opinion that it might possibly be able to reduce the price by somewhere between $500,000 and $1,000,000 below the negotiated estimate in the table that follows. Also, Continental Copper & Steel Corporation submitted a design, with the assertion that it could build a telescope based on it for $1,000,000 less than it could build a telescope based on the AUI design. However, Continental Copper & Steel submitted no proposal on the AUI design, and so the assertion is meaningless. Furthermore, a year before, Mr. Husband proposed the identical design suggested by Continental Copper & Steel (essentially a blow-up of the Mount Palomar Telescope) and the AUI Engineering Committee did not favor it.

The result of the negotiations on price are shown in the following table:

Name.	Original Price	Negotiated Price
Judson Pacific-Murphy	$ 5,590,000	$ 4,940,000
Bliss	$ 5,770,000	$ 4,750,000
Blaw-Knox	$ 6,550,000	$ 5,650,000*
Loewy-Hydropress	$ 8,450,000	$ 6,300,000

*On December 10, Blaw-Knox representatives, during a meeting on the 85' telescope, inquired about their standing. When advised that Blaw-Knox was considerably higher than two reputable competitors, Blaw-Knox reviewed its negotiated price and advised AUI orally on December 12 that $5,150,000 would have to be its bottom figure.

2.3 Revised Proposal by E. W. Bliss Company:

Small gave a detailed account of the negotiations with E. W. Bliss Company, which resulted in a reduced price of $4,750,000. In Small's opinion, this fugure is the lowest which can be achieved consistent with ethical business practices, After lengthy discussion with Bliss of the various items involved in the work, the following schedule was arrived at:

Cost Break-down

	Item	Builder	Cost
1.	Foundation excavation)	Darin & Armstrong	$ 442,000
2.	Foundation concrete)		
3.	Foundation reinforcing) steel		
4.	Elevator	Omitted at AUI direction	
5.	Handrail	Omitted at AUI direction	
6.	Polar bearing	Bliss	$ 322,000
7.	Main polar shaft	Bliss	$ 593,000
8.	Counterweight concrete	Darin & Armstrong	$ 90,000
9.	Steel yoke	Bliss	$ 592,000
10.	Polar gear	Bliss	$ 256,000
11.	Declination shaft	Bliss	$ 141,000
12.	Structural aluminum	Bliss	$1,078,000

13.	Reflector surface	Bliss	$ 662,000
14.	Focal truss	Bliss	$ 33,000
15.	Declination machinery	Bliss	$ 242,000
16.	Polar machinery	Bliss	$ 176,000
17.	Electric or hydraulic synchronizing drive and control mechanism	Uncertain - General Electric? Electric Boat? Other?	$ 350,000
			$4,977,000

The reduction from $4,977,000 to $4,750,000 was achieved after further discussion. Small emphasized that he had pointed out to Bliss the opportunity to do detailed engineering in accordance with its standard commercial practice. This should make it possible to eliminate uncertainties from the design before fabrication is begun. There are still some elements of uncertainty in the price quoted. It may be possible to reduce the aluminum fabrication costs by as much as $80,000, if a stretching technique is not needed to achieve the 1/16" tolerance specified.

One of the features of the revised proposal by Bliss is that, in Bliss's judgment, the work can be completed within 14 months if a start is made in the near future, thereby permitting all the site eredtion to be done in the summer and fall of 1958.

The figure of $4,750,000 includes no escalation, and if a contract can be signed within a reasonable time (perhaps as much as 60 days) no escalation will be necessary. However, if execution of the contract is delayed appreciably, it will be necessary to include escalation, based on the BLS index of labor and material costs from December 1, 1957 to the start of the work. Also, Bliss's present union contract calls for a wage increase in September 1958, and the Bliss proposal is based on the assumption that most of the shop work can be completed before this increase becomes effective.

Berkner and Emberson joined in recommending that the Bliss proposal be accepted, for the following reasons:

1. By selecting a responsible prime contractor, it will be unnecessary for AUI to recruit a large engineering force of its own;

2. The nature of the Bliss proposal focuses responsibility clearly on the prime contractor;

3. If the work can be completed within 14 months, as Bliss is prepared to agree, close to a year will be saved over any other proposal;

4. Bliss will assume responsibility for dealing with a difficult labor situation;

5. Bliss gives every indication of being fully qualified to do the work and is eager to proceed at once.

Berkner pointed out that if a 140' telescope is to be acquired, close to

$4,750,000 will be necessary, whether a contract is made with Bliss or whether AUI undertakes to act as its own prime contractor. In the latter case, it might be possible to enter into several contracts covering all 17 items of work, totaling perhaps $3,900,000. However, if this course were followed, it would be necessary for AUI to increase its staff, and this added cost, plus an allowance for contingencies, would bring the total cost up to at least $4,500,000.

As to the reasons for the discrepancy between AUI's original estimate and the Bliss figure, Berkner pointed out that although the estimate was certainly much too low, nevertheless there were extenuating factors. Thus, the figure of $2,200,000 was arrived at in July 1955, when the performance specifications were looser and no design of the instrument was in existence. Since then, there has been a substantial rise in the general price level. Finally, the established method of arriving at total cost by using a formula based on the tonnage of metal involved produced, in this case, unrealistic results. However, there is no denying that the telescope now under consideration is a much better instrument than was originally contemplated.

Berkner proposed that AUI be authorized to enter into a contract providing for the performance of the work in two phases. The first phase would consist of detailed engineering, for which Bliss has quoted a price of $145,000. The second phase, commencement of which would be contingent on satisfactory completion of the detailed engineering and also on availability of funds, would consist of fabrication and erection. There would also be provision for re-negotiation of prices in light of the detailed engineering.

2.4 Reasons for Building a 140' Telescope:

Berkner pointed out that one of the fundamental questions is whether a telescope of this sort should be built for the price quoted. In his opinion, there is no question but that it should. The basic laws of physics and motion are all derived from the study of astronomy, which is far from being a theoretical science. The telescope which AUI wants to build, by reason of the shorter frequency on which it will operate and the higher gain it will achieve, will enable scientists to penetrate to points in space which can not be reached by any other instrument known to be in existence or under construction. The information obtained is bound to increase practical knowledge, just as has been the case in the past. The telescope under consideration is smaller than the British 250' instrument but because it is more precise by a factor of at least seven, the 140' telescope will have short wave-length capabilities unique among instruments of which we have knowledge.

2.5 Non-Contract Items:

Emberson called attention to Exhibit C., with particular reference to what are entitled "Non-Prime Proposal Items". The estimated cost of these, including $500,000 for escalation and $200,000 for West Virginia taxes, comes to $1,175,000, thus bringing the total cost of the telescope to $5,925,000. $3,096,000 is available from the contract as it now stands, and so an additional $2,829,000 will be necessary for the telescope. He and Berkner both pointed out that the escalation item hopefully includes a reserve for contingencies. The possibility of exemption from the West Virginia taxes will be carefully explored.

3. Site Development:

Emberson then called attention to Exhibit D, indicating requirements for site development, with priorities. Berkner said the estimated costs were worked out by the architect-engineers and reviewed by Westman. The top priority is given to the Central Section of the Central Laboratory, with the cafeteria and partial housing coming second. The housing is particularly important for the accommodation of visiting scientists.

4. Electronics Program;

Berkner asked Findlay to discuss the electronics program contemplated for full utilization of the 85' and 140' telescopes. Findlay pointed out that to make the best use of the two instruments, AUI must acquire receivers for very high frequencies (10 to 3 centimeters). AUI must also make sure than an adequate program for the development of receivers is carried forward. One essential feature of the equipment is ease in changing from one experiment to another. Multiple feeds should be developed. Data reduction equipment is also necessary, and here again there must be an adequate development program. The Laboratory equipment items totaling $90,000 are seff- explanatory.

5. Large Antennas:

Berkner called attention to the item of $250,000 in Exhibit A entitled "Engineering for Large Antenna." He pointed out that the Observatory must not be a static institution, but must continue to grow, and planning for larger instruments should begin at the earliest possible date. Heeschen has already done some informal exploration along this line, with a view to determining the feasibility of building a 1200' antenna of limited steerability. In Berkner's opinion, the importance of an adequate development program is very great.

6. Requirements for Additional Funds:

Berkner said Exhibit A sets forth in summary form what AUI considers it needs to complete the program discussed. In AUI's judgment, this requirement is about $6,000,000. In response to questions, he pointed out that this estimated requirement contains a contingency factor of close to $1,000,000, provided a contract for the 140' telescope can be made in the near future. This contingency factor is made up as follows:

Escalation and contingency under Bliss's proposal	$ 500,000
Contingency in estimate in Exhibit D	$ 231,000
Contingency in appropriations and commitments set out in Exhibit B	$ 50,000
West Virginia taxes	$ 200,000
	$ 981,000

It should be emphasized that tax item is a doubtful one, since it remains to be determined whether an exemption can be obtained.

Some doubt was expressed about the adequacy of the contingency reserves

thus provided. Thereupon, Berkner proposed that funds should be requested now for the three construction items in Exhibit D which might be postponed until 1960, on the express understanding that work on these items will not be started until all items of work required earlier have progressed to a point where the ultimate cost can be predicted with sufficient accuracy to make it reasonably certain that no part of the $568,000 will be required for their completion.

Accepted on behalf of National Science Foundation

Prepared and submitted on behalf of Associated Universities, Inc.

Charles F. Dunbar,
Secretary

Date

A

Summary
Funding of Capital Items
Based on Full Utilization of
140-foot Telescope

Available from Prior Financing.....	$3,096,000
140-foot Telescope, including non-prime contract items	5,925,000
Required to complete 140-foot Telescope and auxiliary construction	2,829,000
Site Development Program	2,551,000
Engineering for Large Antenna*	250,000
Receivers and other data processing equipment	530,000
Total to complete scheduled programs	$6,160,000
Possible Tax Savings	200,000
	$5,960,000

*This item is not included in the operating funds for FY 1958-59 or 60; present NSF plans call for funding of FY 59-60 operations from a single appropriation in 1958 to establish the desired two-year lead on operations.

November 21, 1957

B

Summary of Existing Appropriations and Commitments

November 21, 1957

Funds available FY 57-58:	$5.130 million	
Less operations' (FY 57 - 60; FY 58 - 250)	.310	
Funds Available for Capital Expenditures		4.820
Expended or Earmarked:		
Site Acquisition	.650	
85-ft. Telescope (instrument, foundation, paving)	.310	
Roads and parking areas	.090	
Temporary electric power	.106	
Remodeling and furnishing existing buildings	.083	
85-ft. Control Building	.030	
21-cm Receiver	.035	
*Traveling Wave Tube Receiver	.080	
*Other Receiving Equipment	.080	
*Other Equipment or Tools	.135	
Architect-Engineer	.075	
	1.674	
Contingency	.050	
		1.724
Remainder, including contingency, for application to the 140-foot telescope		3.096

*Discussion Stage; Not fully formally committed at this date.

C

Summary of Estimates on the 140-foot Telescope

November 21, 1957

Prime Proposal 140-foot Telescope (E.W. Bliss Co.)		$4.750 M
Non-prime proposal items:		
AUI Engineering Costs	0.200	
Escalation	0.500	
Inspection and Testing	0.075	
Finish Structure Interior	0.050	
Elevator, hand-rails, Electrical, Paving, Drains, etc.	0.100	
Stand-by Generator	0.050	
	0.975	
West Virginia Taxes (4%)	0.200	
		1.175
Total		$5.925 M

D

Summary
Site Development
Completion Program

Item	Estimated Costs: Rec. Immed. Construct.	Equip, Mach, & Furniture	Rec. Later Construct.	Priority
Central Laboratory				
Central Section	$466,300	$ 88,000		1
Wing 1	257,300	43,000		5
Wing 2	postpone		$310,100	
Auditorium	postpone		146,700	
Works Area		140,000		
Central Section	96,800			3
Shops	146,900			6
Heavy Machines	114,500			4
Housing & Cafeteria				
Cafeteria and partial housing	627,000	92,000		2
Remainder housing	postpone		111,900	
Utilities				
Electrical*				
Phase II	43,400			
Phase III	71,100			
Sewerage				
85-foot installation	2,400			
140-foot installation	3,300			
Central laboratory	17,000			
Storm	2,300			
Water				
85-foot installation	1,200			
140-foot installation	4,100			
Central laboratory	2,500			
**Interconnect 8" wells	13,000			
Housing & fire tank	55,000			
Hot-top Road	32,000			
	$1,956,100	$363,000	$568,700	
SUB TOTAL	$2,319,100			
CONTINGENCY	231,900			
GRAND TOTAL	$2,551,000			

*Phase I already financed $106,400

**First step to interconnect wells with fire tanks for complete system.

November 21, 1957

E

Summary of Estimated Cost of Electronics Program for Full Utilization of the 85-foot and 140-foot Telescopes and Equipment of Electronics Laboratories

Receiving Equipment

Two receivers for 1420 Mc	$200,000	
One SHF receiver	120,000	
Special feeds	50,000	
Low frequency receiver	35,000	
Data processing equipment	35,000	
		$440,000

Laboratories

(1) Test equipment, signal sources, etc., for three laboratories	$ 75,000	
(2) Components, cable, tubes, etc., for three laboratories	15,000	
		90,000
	Total	$530,000

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