Construction Plan for VLBA Electronics

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This memorandum outlines a plan for the construction of the VLBA receiving electronics, and thus provides a basis for estimating the total manpower requirement. It represents the most feasible plan as envisaged at this time, but is intended to be flexible and subject to modification if more efficient or convenient ways of getting jobs done become apparent.

Items to be Constructed

The construction requirement for the receiving electronics can be specified on a per-antenna basis. Ten sets of electronics, or possibly eleven to include spares, are required. The list of items for each antenna, including options which will be constructed if funds permit, is as follows:

1.) Feeds for each of eleven frequency bands as specified in VLBA Memoranda Nos. 295 and 354.

2.) Front-end units for the above bands including polarizers, amplifiers, and cryogenics as required.

3.) One frequency converter module, including IF amplifier stages, for each front end.

4.) One control module for each front end.

5.) Three 2-16 GHz LO Synthesiser modules (or two such modules and one 9.4 GHz LO module) as specified in VLBA Memorandum No. 303.

6.) One 32-34 GHz LO module.

7.) One LO Transmitter module that generates the frequencies sent to the vertex room.

8.) One LO Receiver module which terminates the LO cable at the vertex room. This module and the LO Transmitter module incorporate the round-trip phase measuring system for the cable.

9.) One IF Switching Panel which selects the signals sent to the recording system.

10.) One LO Switching Panel which connects the LO modules to the required front ends.

11.) One Switch Driver module that controls the switching functions on the above two panels.

12.) One Water radiometer.

13.) Racks (one or two in each vertex room) and bins.

14.) Power supply modules.

15.) Vacuum pump and helium compressor system including lines, manifolds etc.

Note that a unit or module designated above may be combined with another unit, or may be implemented as two more units, in the final design.

Construction and Installation Timetable

The approximate dates for installation of the equipment on each antenna are shown in Fig. 1. These installation times are the deadlines for completion of construction or procurement of the required electronics items. However, in the plan the goal will be to have all items on hand three months ahead of the installation date to allow adequate time for testing, and to cover any emergencies that may arise. The equipment for the different receiving bands is broken down into five groups as follows:

A. 1.5, 4.8 and 15 GHz

B. 330 and 610 MHz

C. 2.3 and 8.4 GHz

D. 23 and 43 GHz

E. 6.1 and 10.7 GHz

Groups A and B are installed simultaneously on each antenna, and the others are installed later as indicated in Fig. 1. The initial installation should include two 2-16 GHz Synthesiser modules, the LO Transmitter and Receiver modules, the IF and LO Switching Panels, Switch Driver module, racks, power supplies, and cryogenics plumbing for three front ends.

Some of these items may not be essential to bring an antenna into operation for initial testing, but the goal should be to have them all ready for installation. The water radiometers are not included in the project PERT plan and are likely to be one of the last items installed on each antenna. Note that the installation dates in Fig. 1 agree with those in the PERT plan except that for antennas 1 to 4 the installation of the 2.3 GHz front ends in group C is delayed, and takes place during the group D installation. This allows all ten front ends for a given band to be constructed in a single sequence, which is more efficient than building, say, three for each band and than repeating the whole procedure.

In establishing an overall schedule for construction, it will be assumed that work on each item should begin about one year ahead of installation. The design and development phase for each item should begin at least two years before the date of installation on the first antenna.

Construction Groups and Related Schedules

People who are involved in the VLBA electronics construction, or who will become involved as the project develops, are located at Charlottesville, Green Bank and the VLA Site. It is therefore convenient to plan the operation in terms of various groups defined by their location and the electronic subsystem involved. Tables 1 to 6 show the positions involved and the construction schedules. Draftsmen and machinists are shown attached to various groups, and these positions should include about the right overall level of manpower. However those at one location may also provide parts and drawings for construction at another location, as appears most expedient at the time.

Green Bank Cryogenic Front-End Group: Roger Norrod and Rich Bradley will be responsible for the front ends for 1.5, 4.8, 2.3 and, if built, the 6.1 GHz front ends. These will all use cooled FET amplifiers. With the schedule shown it should not be necessary to work on more than two of the frequencies at any one time. The 43 GHz front end, including the 32-34 GHz Local Oscillator module, is assigned to Chuck Brockway. It is not yet clear whether this front end will use a maser, SIS mixer, or even a FET (HEMT). A decision on the best approach for both the 23 and 43 GHz front ends will be made at the end of this year. If an SIS mixer is

used the prototype will probably be developed by Tony Kerr's group in Charlottesville. Work on the 43 GHz front end is not expected to commence until mid-1985. Note that engineers and technicians with ongoing responsibilities for Green Bank projects have been assigned no more than 3/4 time on any VLBA project. One technician position to assist with assembly of the front ends is included.

Green Bank Local Oscillator Group: Bob Mauzy will be in charge of the local oscillator subsystem, of which the most critical development task is the 2-16 GHz synthesiser. The 9.4 GHz oscillator can be regarded as a simplified version of the 2-16 GHz synthesiser, and if funds allow it will be changed to become an additional 2-16 GHz unit to reduce the number of spares required. One technician position is included for assembly of the modules.

Charlottesville Cryogenic Front-End Group: This group is concerned with the front ends for 8.4, 15, 10.7 and 23 GHz. Two 8.4 GHz front ends will be completed by the end of 1985 and will be used as prototypes for the VLA-Voyager project. It is also planned to develop one 10.7 GHz front end by about the end of 1984 for use in early tests on the Pie Town antenna. However the 10.7 GHz front ends for the other antennas remain optional. The 23 GHz front end is currently assigned to this group on the grounds that it will most likely be a HEMPT amplifier. However, the possibility remains that the 23 and 43 GHz front ends may both be masers on the same Dewar, in which case the plan must be modified.

Charlottesville General Construction Group: Erick Schlecht, who will be joining NRAO in the Fall of this year, will work with Dick Thompson on the design and development of the 330 and 610 MHz ambient-temperature front ends, the frequency converter modules, and miscellaneous items. Two assemblers are included in this group to construct the large number of modules required.

VLA-Site Construction Group: Several separate tasks within the electronics construction will be performed at the VLA site. Procurement and testing of feeds will be carried out by an engineer and technician working with Peter Napier. A water radiometer design is being developed by Jack Campbell for the VLA. Water radiometers for the VLBA can thus be most efficiently constructed by a technician at the VLA site who would follow the same design. The water radiometers are considered to be optional items and construction of

them would not begin until 1986. Radio link engineer D. L. Narayana is developing the local oscillator and IF links between the Pie Town and VLA sites. The Front End Control modules and the Switch Driver modules, which will interface with the monitor and control system, will be specified in detail by the electronics group but chip-level design will be performed by the monitor and control engineer at the VLA Site. One assembly technician will be provided by VLBA electronics funding for assembly of these modules under the supervision of the monitor and control group.

Installation Group: Installation and maintenance of the electronics will be performed by personnel based at Socorro or the VLA Site. In the latter half of 1988 and 1989 two groups will be required for this work. The feeds will be installed by the antenna group, but the front ends, helium and vacuum systems for the cryogenics, and all other units of the receiving electronics will be installed by these two three-person teams.

Manpower Totals and Budget Constraints

The positions in Tables 1 and 5 are charged to the VLBA construction budget, with the exception of the figures that are circled which are charged to operations. The installation and maintenance group in Table 6 is charged entirely to VLBA operations. Position totals are given in Tables 7 and 8. It is estimated that operations funding may be \$0.5M in 1986 increasing to \$2M in 1987 and 1988. The total electronics positions assigned to operations would consume about 12% of the operations funds. They are chosen to include, so far as is possible, appropriate tasks such as outfitting, maintenance and testing. Comparison of the totals for construction with those in the cost plan as of May 1984 (see memo from W. Porter to A. R. Thompson dated 5/16/84) indicates that the present plan increases the manpower budget by 5.25 man-quarters for engineers, and a total of 15 man-quarters for technicians, draftsmen, and machinists. However, the budget for manpower should be increased by the 8.5 man-quarters represented by the radio link engineer since the justification given for the cost of the radio link is that it is offset by the price of a hydrogen maser. Thus, overall, the manpower overrun is quite small: less then 3.5% of the total construction manpower.

Optional Construction Items

Adjustment of various items within the overall VLBA budget ceiling is necessary to balance the varying estimates of manpower and hardware costs and maintain an appropriate contingency figure. The final status of the various electronics items that are currently listed as optional will eventually be decided by these considerations. At the present time the budget includes only one of the group C (6.1 and 10.7 GHz) front end systems. However the manpower level in the present plan should be approximately sufficient to build them both. Items within the electronics currently identified as optional, and corresponding cost savings, are listed below. The cost figures are taken from the VLBA Project Book (version of 850401).

	Cost Savings (1984 Dollars)
6.1 or 10.7 GHz receiving system (feeds and front ends)	$300k (each band)
Water radiometers for 10 antennas	$500k
Change of 23 and 43 GHz from masers to FET amplifiers	$ 1M (approximate only)

The value of the water radiometers in estimating the atmospheric path length has not been demonstrated. It would therefore be logical to implement them on a small number of antennas, at sites at which the greatest water vapor variability is expected, to investigate their utility. The estimated cost of the water vapor radiometers is $50k each, so the savings could be any multiple of this up to $500k. In conclusion it appears that the optional items allow sufficient flexibility to cover any foreseeable variations in the electronics estimates.

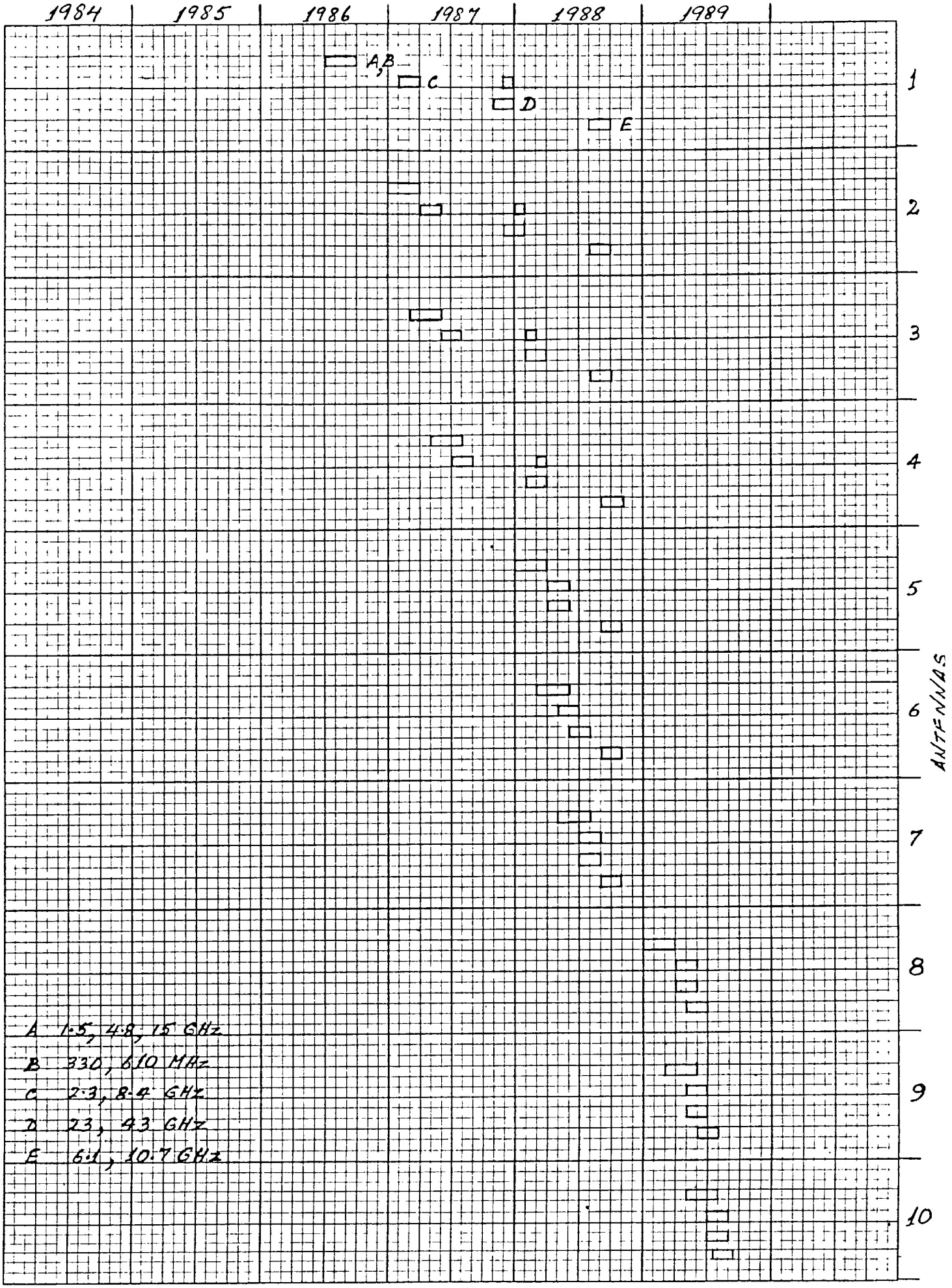

FIG 1. ANTENNA OUTFITTING PLAN.

JULY 1 1984.

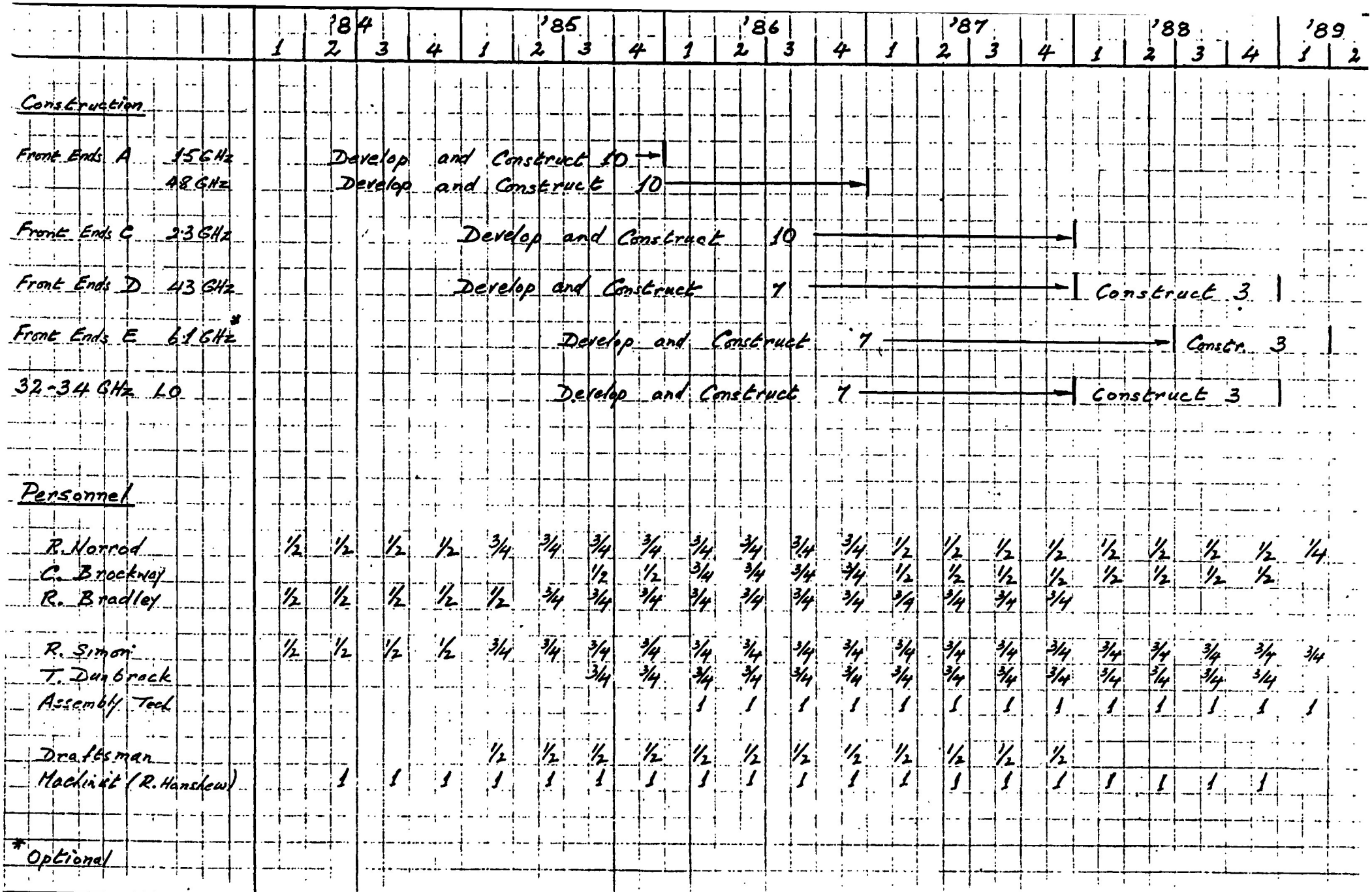

Table 1. Green Bank Cryogenic Front-End Group.

ART 6/19/84

	'84				'85				'86				'87				'88				'89	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Construction																						
2-16 GHz Synthesiser			Develop and Constr					2		Constr		9			Constr 9							
L O Transmitter			Develop and Constr					1		Constr		9										
L O Receiver			"		"		"	1		Constr		3			Constr 6							
9.4 GHz Oscillator*			Develop and Constr					2	→				Constr 8									
Personnel																						
R. Mauzy		1/4	1/4	1/4	3/4	3/4	3/4	3/4	3/4	1/2	1/2	1/2	1/2	1/4	1/4	1/4						
L. Beale		1/4	1/4	1/4	3/4	3/4	3/4	3/4	3/4	1/2	1/2	1/2	1/2	1/4	1/4	1/4						
Assembly Tech									1	1	1	1	1	1	1	1						

*If funds allow this will be charged to a third 2-16 GHz Synth. at each antenna.

Table 2. Green Bank Local Oscillator Group.

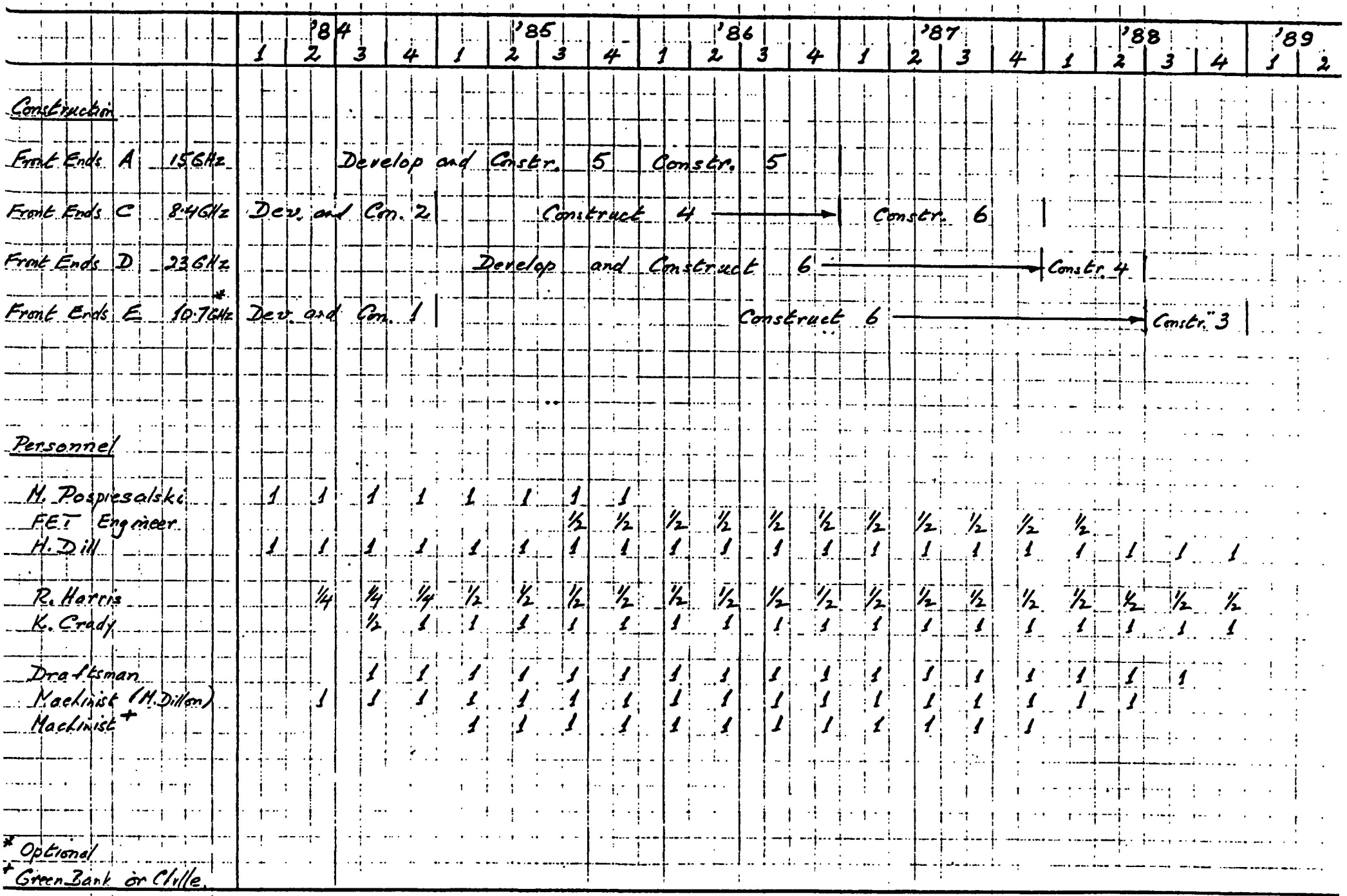

Table 3. Charlottesville Cryogenic Front-End Group.

	'84				'85				'86				'87				'88				'89	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Construction																						
Front End (B) 330 MHz					Devel. and Constr. 1				Constr. 3				Constr 3					Constr. 3				
610 MHz					" " " 1				" 3				" 3					" 3				
Converter Modules					Devel. and Constr. 6				Devel. 5, Constr. 33				Constr. 33					Constr. 33				
Racks, Powr Supplies, IF Switching Panel, LO Switching Panel (ONE SET PER ANT.)					Devel. and Constr 1				Constr. 3				Constr. 3					Constr. 3				
Personnel																						
A. R. Thompson					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
E. Schlecht					1	1	1	1	1	1	1	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)		
R. W. Harris			1/4		1/4	1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2		
Assembler (1)								1	1	1	1	1	1	1	1	1	1	1	1	1		
" (2)								1	1	1	1	1	1	1	1	1	1	1	1	1		

(1) Indicates positions charged to operations.

Table 4. Charlottesville General Construction Group.

ODT 6/18/84 6/19/84

	'84				'85				'86				'87				'88				'89	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Construction																						
Feeds, Group A		Design and Procure 3								Proc. 9				Proc. 9				Proc. 9				
B		" " " 2								" 6				" 6				1 6				
C			Design and Procure						8 →					" 6				' 6				
D													Design and Proc. 14 →				Proc. 6					
E														Design and Proc 14 →					Proc 6			
Water Radiometers*									Develop and Construct 1				Constr. 4.				Constr. 5					
Digital Modules:																						
Front-End Control			Construct 5							Constr. 35				Constr. 35				Constr. 35				
Switch Control					" 1					" 3				" 3				" 3				
Personnel																						
Feed Engineer		1	1	1	1	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	½	½	½	½	½	
Radio Link Engineer	½	1	1	1	1	1	1	1	1													
Feed Tech.				1	1	1	1	1	1	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	
Water Rad. Tech.									1	1	1	1	1	1	1	(1)	(1)	(1)	(1)			
(Digital) Assembly Tech								1	1	1	1	1	1	1	1	1	1	1	1			
Draftsman				½	½	½	½	½	½	½	½	½	½									
Machinist				1	1	1	1	1	1	1	1	1	1									

* Optional

(1) Indicates positions charged to operations.

Table 5 VLA-Site Construction Group.

D.O.T. 6/8/84 21010U

	'84				'85				'86				'87				'88				'89	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Installation																						
General + F.E. A and B										Inst. 1				Inst. 3				Inst. 3			Inst 3	
F.E. C														" 4				" 3			" 3	
F.E. D																	Inst. 6				" 3	
F.E. E																	" 7				" 3	
Personnel																						
Group 1:																						
Lead Tech											1/4	1/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1
Elect. Tech											1/4	1/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1
Cryo Tech											1/4	1/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1
Group 2:																						
Lead Tech																			1	1	1	1
Elect. Tech																			1	1	1	1
Cryo Tech																			1	1	1	1

NOTE - ALL POSITIONS CHARGED TO OPERATIONS

Table 6. Installation and Maintenance Group (Operates from Socorro/VLA-Site).

ART. 6/18/84

	'84 1	'84 2	'84 3	'84 4	'85 1	'85 2	'85 3	'85 4	'86 1	'86 2	'86 3	'86 4	'87 1	'87 2	'87 3	'87 4	'88 1	'88 2	'88 3	'88 4	'89 1	'89 2
Engineers																						
G.B. Cryo	1	1	1	1	1¼	1½	2	2	2¼	2½	2¾	2¾	1¾	1¾	1¾	1¾	1	1	1	1	¼	
G B LP		¼	¼	¼	¾	¾	¾	¾	¾	½	½	½	½	¼	¼	¼						
CVL Cryo	2	2	2	2	2	2	2½	2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1	1	1		
CVL Constr.			2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1		
VLA Constr.		½	2	2	2	2	2	2	1	1												
	3	3¾	7½	7½	8	8½	9½	9½	7½	7½	6½	6½	4¾	4½	4½	4½	3½	3	3	3	¼	
																					114.25 MQ ✓	
																					(109)	
Technicians																						
G B Cryo	½	½	½	½	¾	¾	1½	1½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	1¾	
G B LP		¼	¼	¼	¾	¾	¾	¾	1¾	1½	1½	1½	1½	1½	1½	1½						
CVL Cryo		¼	¾	1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
CVL Constr.		¼	¼	¼	½	½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½			
VLA Constr					1	1	1	1	2	3	3	3	2	2	2	2	1	1	1	1		
VLA Outfitting																						
	½	1¼	1¾	2¼	4½	4½	7¼	7¼	10¼	11	11	11	10	9¾	9¾	9¾	7½	7½	7½	5	1¾	
																					141 MQ ✓	
																					(123)	
Draftsman			1	1	2	2	2	2	2	2	2	2	2	2	1½	1½	1	1	1		28 MQ ✓	
																					(27)	
Machinists		2	2	2	4	4	4	4	4	4	4	4	4	4	3	3	2	2	1	1	58 MQ ✓	
																					(62)	

CIRCLED FIGS. ARE MAN-QUARTERS IN COST ESTIMATE MEMO - W. PORTER MAY 4 1984

Table 7. Manpower Estimate, Construction

D.R.T 6/18/84 6/19/84

	'84				'85				'86				'87				'88				'89	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Engineers																						
Charlottesville Contr.													1	1	1	1	1	1	1	1		
VLA-Site Contr.									1	1	1	1	1	1	1	1	½	½	½	½		
									1	1	1	1	2	2	2	2	1½	1½	1½	1½		
																					18 MQ	
Technicians																						
VLA-Site Contr													1	1	1	1	2	2	2	2	1	
Outfitting											¾	¾	2¼	2¼	2¼	2¼	3	3	6	6	6	6
											¾	¾	3¼	3¼	3¼	3¼	5	5	8	8	7	6
																					53½ MQ	

Table 8. Manpower Estimate, Operations

NOT LIKELY