VLA Expansion Project

Management Plan

The Very Large Array Expansion Project

Management Plan
Version 1.0

September 2001

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

VLA EXPANSION PROJECT MANAGEMENT PLAN

Version 1.0 – September 2001

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I. OVERVIEW

1.1 Introduction

The goal of the Very Large Array Expansion (EVLA) Project is to improve most of the key observational capabilities of the Very Large Array (VLA) by at least an order of magnitude. The Project is divided into two Phases. Phase I will, by the application of modern technologies, improve the sensitivity, bandwidth, spectral resolution and frequency coverage of the existing 27 element array. Initial funding has been provided for planning and design of Phase I. Phase II will increase the angular resolution of the existing VLA by adding additional array elements around New Mexico. Also to be considered in Phase II are the addition of a condensed array configuration smaller than the existing D array and the addition of low frequency observing bands to the existing antennas. This Management Plan will describe only Phase I of the project. This Plan will be expanded to include Phase II when it becomes appropriate.

The design, construction and operation of the EVLA is being carried out by the scientists, engineers and staff of the National Radio Astronomy Observatory (NRAO). The NRAO is a facility of the National Science Foundation (NSF) for research in radio astronomy; it is operated under a Cooperative Agreement[1] by Associated Universities, Inc., (AUI).

The EVLA has been endorsed by the Astronomy Decade Review[2] for this decade and is described in the EVLA Proposal[3] submitted to the NSF by AUI in May 2000. Additional information concerning the project was provided to the NSF by AUI in a document[4] submitted in February 2001, in response to questions arising from the NSF Site Review held in Socorro on 14-15 December, 2000. This management plan updates and expands upon some of the material provided in that document [4]. This plan addresses the design and construction of EVLA Phase I instrumentation and its installation on the VLA.

1.2 Objectives and Scope

1.2.1 Scientific Objectives

The science which will be enabled by the EVLA has been described in detail in Appendix A of the Proposal[3]. In summary, the scientific objectives of the EVLA Phase I Project are to make an order of magnitude improvement in the key observational capabilities of the VLA, except for angular resolution, in order to enable a wide range of new scientific studies. Examples of some of the unique programs that will be made possible by the project include:

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[1] Cooperative Agreement No AST9223814 between the National Science Foundation, Arlington, VA 22230 and Associated Universities, Inc., Washington, D.C. 20036, dated January 1994.

[2] C. McKee, J. Taylor "*Astronomy and Astrophysics in the new millennium / Astronomy and Astrophysics Survey Committee, Board on Physics and Astronomy-Space Studies Board, Commission on Physical Sciences, Mathematics, and Applications, National Research Council. Washington, D.C.: National Academy Press, 2001.*

[3] *VLA Expansion Project: Phase I The Ultrasensitive Array,* proposal submitted to the National Science Foundation by Associated Universities, Inc., May 2000.

[4] *VLA Expansion Project: Response to NSF Request for Additional Information*, document submitted to the National Science Foundation by Associated Universities, Inc., February 2000.

[5] *NRAO Environmental, Health and Safety Manual*

[6] *NRAO New Mexico Environmental, Safety and Health Manual*

- providing accurate positions, sizes, and expansion estimates for up to 100 gamma-ray bursts every year
- disentangling starburst from black hole activity in the early universe
- mapping the magnetic fields in individual galaxy clusters
- looking through the enshrouding dust to image the formation of high-redshift galaxies
- observing ambipolar diffusion and thermal jet motions in young stellar objects
- measuring the three-dimensional motions of ionized gas and stars in the center of the Galaxy
- conducting unbiased searches for redshifted atomic and molecular absorption lines
- measuring the three-dimensional structure of the magnetic field on the Sun
- using the scattering of radio waves to map the changing structure of the dynamic heliosphere
- measuring the rotation speeds of asteroids

1.2.2 Technical Objectives

The key technical objectives resulting from the scientific objectives can be summarized as the improvements required for each of the following seven performance parameters of the VLA:

- **Sensitivity** A goal of 1 microJy rms in 12 hours observing between 2 and 40 GHz is set by consideration of the system temperature, bandwidth, and system efficiency which can be provided by implementing modern technologies. For all of these, ambitious, but realistic and achievable goals have been set and are shown in Table 1. For nearly every band, the system temperature goal is dominated by one of ground spillover, galactic emission, or atmospheric thermal emission. The proposed bandwidths include nearly all the frequency span of each band, and the proposed antenna efficiency is the best that can be expected for the VLA's existing antennas.
- **Spectral Coverage** The goal will be to make available to the astronomer the entire spectral range between 1 and 50 GHz. This can be achieved, with the sensitivity goal listed above, with the eight Cassegrain receiver systems shown in Table 1.
- **Bandwidth** Modern technologies enable efficient, cost-effective transport of up to 8 GHz of IF bandwidth in each polarization. This is the bandwidth goal of the ALMA project, and its implementation into the EVLA means that nearly all of the available information in any one of the eight Cassegrain frequency bands will be instantaneously available to the correlator for processing.
- **Phase Stability** The phase stability design goal of the VLA was 1 degree per GHz of observing frequency. This ensured that the effective phase stability of the array is often dominated by atmospheric instabilities. Since the EVLA LO system will be redesigned, the instrumental phase stability will be improved by a factor of approximately two to ensure the instrumental phase instability is smaller than the atmospheric instability at all times.
- **Polarization accuracy** The polarization purity of the present feed systems is 2 – 5% over the bands of the existing receivers, and this will also be the goal for the wider bands of the new receivers. The new equipment will be designed so that the instrumental polarization is not time-variable and can be removed using polarization calibration techniques, allowing polarization measurements to be made to an accuracy of < 0.1%.
- **Frequency resolution** The highest frequency resolution required for cold emission or absorption lines is about 500 Hz. A much more demanding frequency specification is based on reflected radar signals from planetary bodies (bistatic radar), for which frequency

resolution of about 1 Hz is desirable. The new correlator is designed to meet these specifications, as well as providing sufficient numbers of spectral channels to allow accurate measurement (and subsequent subtraction) of the surrounding continuum emission. This very high frequency resolution will also enable containment and removal of RFI signals within the observing bands.

- **Bandpass Stability** A key factor which limits the VLA's ability to image weak spectral lines in the presence of strong continuum signals is the stability of the analog transmission link between the antennas and the correlator. The EVLA will employ a digital transmission system to improve bandpass stability by approximately an order of magnitude.

Table 1. Principal performance requirements for the EVLA

Band Center Frequency (GHz)	Frequency Range (GHz)	System Temperature (K)	Total System Efficiency	Maximum IF Bandwidth (GHz)
1.5	1.0-2.0	26	0.50	2x1
3.0	2.0-4.0	29	0.62	2x2
6.0	4.0-8.0	31	0.60	2x4
10	8.0-12.0	34	0.56	2x4
15	12.0-18.0	39	0.54	2x6
22	18.0-26.5	54	0.51	2x8
33	26.5-40.0	45	0.39	2x8
45	40.0-50.0	66*	0.34	2x8
* At low frequency end of the band				

1.2.3 Project Objectives

The project objective is to upgrade the VLA to provide the improved performance specified for the EVLA. This objective is to be achieved under the constraint that during the project, while the VLA is in transition to the EVLA, the VLA will remain in operation, except for short scheduled outages, with degradation to its scientific capabilities minimized to the extent possible. A summary of the major tasks to be carried out to reach the objective include the following:

- Design, prototype and test on two antennas the new feeds, receivers and antenna structural modifications required to support the new EVLA observing bands.
- Design, prototype and test on two antennas the new Intermediate Frequency (IF), Local Oscillator (LO) and Fiber Optic Transmission (FO) systems needed to support the new receiver bands and increased bandwidth of the EVLA.
- After prototype testing, build and install on all VLA antennas all of the above listed equipment.
- Design, build, test and install a new Monitor and Control (M/C) system, both hardware and software, to support the new EVLA equipment, including the correlator. The new M/C system must also allow operation of old and new antennas during the transition period.
- Design, prototype, test, produce and commission a new correlator meeting EVLA requirements. The new correlator will be installed in a new correlator room in the VLA

Control Building so that it can be installed and commissioned while the VLA continues to operate. The new correlator will be designed and built by the Herzberg Institute of Astrophysics, NRC, Canada, at Canadian expense.

- Design and implement new data management software, including software to prepare and submit proposals, prepare observations, schedule observations, provide an imaging pipeline, provide a data archive and provide a post-processing package. The data management software will be provided by the NRAO Data Management Division as part of their "End-to-end" project.
- Perform careful astronomical observations to verify that all new EVLA hardware and software is functioning correctly.
- Contribute to the VLA/VLBA Education and Public Outreach (EPO) program to ensure that full use is made of the exciting scientific and technical innovations of the EVLA to advance public science education.

1.2.4 Budget and Schedule

The budget and schedule for achieving the above listed objectives are discussed in detail in Sections V and VI below. In summary, the total cost of Phase I of the EVLA Project is projected to be $76.5M (FY2001 dollars), with funding to be provided by the following sources:

New NSF funds	$51.4 M
NRAO Operations Redirected Effort	$12.1 M
Canadian Contribution	$11.0 M
Mexican Contribution	$ 2.0 M
Total	$76.5 M

The project will be completed in 9 years.

II. ORGANIZATIONAL RESPONSIBILITIES

2.1 Institutional Roles and Responsibilities

The EVLA Phase I Project is an upgrade to an existing instrument of the National Radio Astronomy Observatory. The EVLA project is conducted in accordance with the Cooperative Agreement[1] between the National Science Foundation and Associated Universities, Inc.

The NSF is responsible for providing funding, general oversight, monitoring and evaluation to help assure project performance in accordance with approved plans. The NSF will provide funding for the project as an increment to NRAO's annual operating budget and will strive to make this funding available to the AUI in a timely fashion and to provide the necessary document reviews and approvals as required. Within the NSF the EVLA Project contact is the NRAO Program Manager.

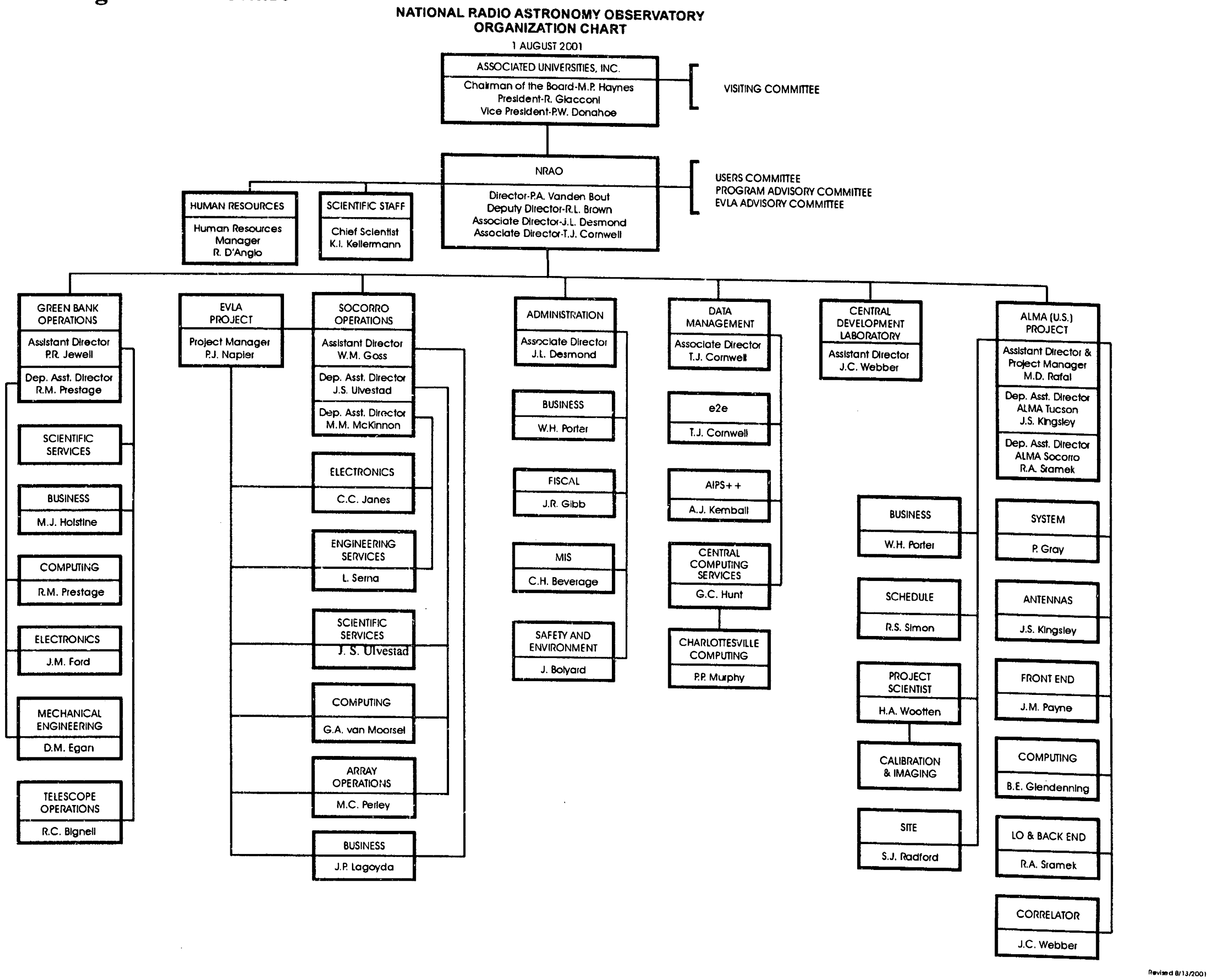
AUI is accountable, as the awardee, for the performance of the EVLA Project in accordance with this Management Plan. As shown in Figure 1, the EVLA Project is the responsibility of the NRAO Director in an organizational relationship identical to the operation of NRAO user facilities and other currently on-going observatory projects. The NRAO has the responsibility of staffing the project, providing institutional support to the project and ensuring adequate oversight of the execution and performance of the project.

There are two international partners joining NRAO in the EVLA Project:

The Herzberg Institute of Astrophysics (HIA), funded by the National Research Council (NRC) of Canada, has agreed to build the EVLA correlator under the terms defined in the Memorandum of Understanding (MOU) included in Appendix A1. This MOU is currently being circulated for signature. HIA is preparing, with the University of Calgary, a proposal to the Canadian Foundation for Innovation (CFI) for full funding of the correlator and expects to have a commitment from the CFI by the end of 2001. In the meantime, NRC has made initial funds available to HIA so that recruitment of the necessary design engineers can begin. The specifications and schedules for the correlator contained in this Management Plan have been agreed to by the NRAO EVLA Project Manager and the HIA EVLA Correlator Project Manager (Dr. P. Dewdney).

The Mexican National Council for Science and Technology (CONACYT) has agreed to contribute 20 M Mexican Pesos ($2.2 M at current exchange rate). The letter from CONACYT announcing the availability of the funds and summarizing the conditions of the partnership is included in Appendix A2. At the request of the Mexican partner no more detailed MOU is planned. The NRAO EVLA Project Manager and the Mexican EVLA Project Manager (Dr. L. Rodriguez) have agreed to start using the Mexican funds in the last quarter of 2002 and have started to discuss production work which can be performed in Mexico. The funds will be administered by Dr. Rodriguez's institute, the Instituto de Astronomia, UNAM, in Morelia, Mexico.

Figure 1. NRAO Organization Chart



2.2 Oversight of the EVLA Project

Oversight of the EVLA Project will occur at a number of levels:

AUI Board of Trustees
The Board will receive periodic reports from the Project Manager on the status of the Project. The NRAO Visiting Committee, which reviews the whole of NRAO for the Board, will review the status of the project at the annual Visiting Committee meetings.

NRAO EVLA Advisory Committee
An advisory committee consisting of experienced scientists and engineers from outside of the NRAO will advise the NRAO Director on the scientific and technical priorities of the Project. Membership will include representation from the partner countries. This committee will be convened by the Project Scientist and will be chaired by one of its members and will meet once or twice a year. An important function of this committee will be oversight of the software aspects of the EVLA Project, so committee members will be chosen to provide expertise with astronomical software systems. This committee is currently being appointed.

NRAO Users Committee
The NRAO Users' Committee will be briefed on the EVLA at its annual meeting. This will be an important mechanism for the astronomical community to provide comment to the Project concerning the EVLA performance requirements and the plan for keeping the VLA in operation during the transition to the full EVLA.

Reports to the NSF
Written quarterly reports to the NSF giving the technical and financial status of the project will be included as part of the NRAO Quarterly Report.

Internal Advisory Committee
A committee of experienced NRAO scientists and engineers from outside the Project will provide advice to the Project Manager and Project Scientist concerning priorities and decisions. Membership will include the partner organizations. The committee will be convened by the Project Manager and chaired by one of its members.

Design Reviews
Preliminary (PDR) and Critical Design Reviews (CDR) will be conducted for all hardware and software subsystems under Design Review Guidelines which will provide a balance of project and external review. The guidelines for execution of these Reviews are included in Appendix B. The reports of the reviews will be given to the reviewing bodies listed above and it will be the responsibility of the Project Manager to act on the findings of the reviews.

2.3 Organization of the EVLA Project

The relationship between the EVLA Project and the other operational units and projects at the NRAO is indicated in the NRAO organization chart shown in Figure 1. This shows that the EVLA Project, NRAO Data Management, and ALMA Project, each have their own management structure. The EVLA Project will be managed by a Project Manager reporting to the Assistant Director for Socorro Operations. The manpower resources required to accomplish the EVLA tasks will be supplied by the existing Socorro Divisions with new positions added to these Divisions as necessary using EVLA Project funding. The Socorro Divisions will also continue to provide operations and maintenance support for the VLA and VLBA under the management of the two Socorro Deputy Assistant Directors.

The EVLA Project organization is shown in more detail in Figure 2. The Socorro Electronics Division, Socorro Engineering Services Division, Socorro Computing Division, Socorro Business Division and Socorro Scientific Staff provide services to the EVLA Project as authorized and managed by the EVLA Project Manager. All expenditures of EVLA Project funds, either for new personnel positions or for materials and services, will be directly under the authority of the EVLA Project Manager. The allocation of personnel funded by the VLA Operations budget to EVLA tasks (the so-called "Redirected Effort" positions) will be negotiated by the EVLA Project Manager and the two Deputy Assistant Directors and will be documented in the EVLA and VLA Operations WBS's. Personnel in the Redirected Effort category will be assigned to EVLA tasks according to the work plan approved by the EVLA Project Manager.

Certain EVLA software tasks, will be performed by an NRAO Data Management team under contract to the EVLA Project. These contracts will be managed for the EVLA by the Socorro Computing Division Head. The activities of the Canadian and Mexican partners will be coordinated by the EVLA Project Manager as contracts to the EVLA project.

Since all EVLA work will be carried out within the existing Socorro Divisions, it will be performed within the existing Safety Program already in place for NRAO's New Mexico activities. All NRAO rules concerning Environmental, Health and Safety regulations, reviews, oversight and enforcement will be followed for all EVLA work, as required by NRAO's Safety Manuals. [5,6]

2.3.1 Management Personnel

The responsibilities of the key positions identified in Figure 2, and the names of the people currently assigned to these positions, are given below:

NRAO Assistant Director for Socorro Operations (M. Goss)

Responsible for all NRAO activities associated with the operation and further development of the VLA and VLBA telescopes.

EVLA Project Manager (P. Napier)

Overall responsibility for accomplishing the EVLA Project on budget and on time with all performance requirements achieved. Responsible for the execution of this management plan.

EVLA Project Scientist (R. Perley)

Responsible for communicating with the scientific community, both inside and outside NRAO, to ensure that the performance requirements for the EVLA match the community's priorities and maximize the scientific capabilities achievable with the available budget.

EVLA Electronics Systems Engineer (J. Jackson)

Responsible for overview of the EVLA electronics system to ensure that the interfaces between all electronic subsystems are correct and that the design will ensure that all performance requirements will be met. Works closely with the EVLA Software Systems Engineer to ensure that all interfaces between hardware and software are correct.

EVLA Software Systems Engineer (G. Hunt)

Responsible for overview of the EVLA software system to ensure that the interfaces between all software subsystems are correct and that the design will ensure that all performance requirements will be met. Works closely with the EVLA Electronics Systems Engineer to ensure that all interfaces between hardware and software are correct.

EVLA Schedule/Budget Planning (E. Cole)
Under the direction of the EVLA Project Manager, establishes and maintains the Project Work Breakdown Structure (WBS), Budget and Schedule.

Socorro Electronics Division Head (C. Janes)
Responsible for the design and production of the Feed, Receiver, Local Oscillator, Intermediate Frequency and Data Transmission Subsystems required for the EVLA.

Socorro Engineering Services Division Head (L. Serna)
Responsible for all modifications to the VLA antennas required for the EVLA.

Socorro Scientific Staff Head (J. Ulvestad)
Responsible for all scientific studies required to set performance requirements for all hardware and software subsystems, and for all astronomical tests required for system commissioning and specification verification.

Socorro Computing Division Head (G. van Moorsel)
Responsible for ensuring that software and computing hardware required for the EVLA is provided on schedule and budget. Supervises the Manager of the EVLA Monitor and Control Software team. Manages those software packages produced by the NRAO Data Management team as contracts to the EVLA Project.

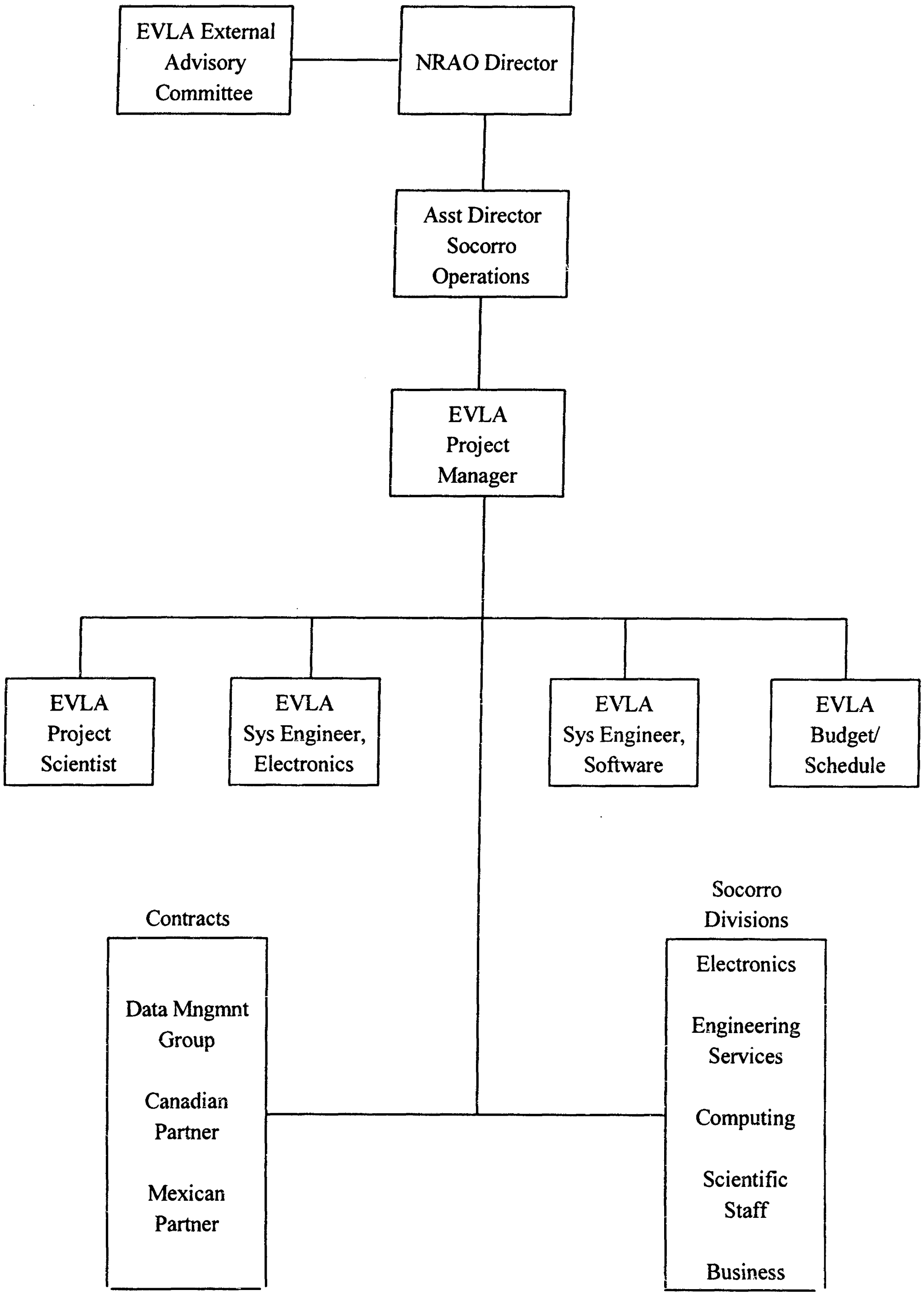
Socorro Business Division Head (S. Lagoyda)
Responsible for accomplishing all procurement activities required for the EVLA and for ensuring that these activities are carried out according to NRAO's standard procurement regulations. Responsible for the preparation of the monthly Project Financial Statement.

NRAO Associate Director for Data Management (T. Cornwell)
Responsible for the coordination of all Data Management software projects within NRAO. Manages the activities of the NRAO Data Management (DM) team. Responsible for those EVLA software packages provided by the NRAO DM team under contract from the EVLA Project.

Canadian Partner Correlator Project Manager (P. Dewdney)
Responsible for the design and construction of the WIDAR (Wideband Interferometric Digital Architecture) correlator as the contribution of the Canadian Partner to the EVLA Project

Mexican Partner Project Manager (L. Rodriguez)
Responsible for managing those components that are produced in Mexico as part of the contribution of the Mexican Partner to the EVLA Project, and for sending to the EVLA Project any remaining funds from the Mexican contribution.

Figure 2. Planned EVLA Management Structure



III. WORK BREAKDOWN STRUCTURE (WBS)

The EVLA Project is the 6th activity within the overall NRAO WBS. The Project is subdivided into the 12 principal Level 2 tasks shown in Table 2.

Table 2. EVLA Project WBS Level 2 tasks

WBS No.	Task Name	Task Description
6.01	Project Management	Project management and advisory committee activities.
6.02	System Integration and Testing	System technical management, provision of shared systems, testing.
6.03	Civil Construction	Fiber optics burial and new correlator room construction.
6.04	Antennas	Structural modifications to VLA antennas.
6.05	Front End Systems	Provision of all feeds and receivers.
6.06	Local Oscillator System	Provision of central reference oscillators and antenna remote LO.
6.07	Fiber Optic System	Provision of all fiber optics systems for LO distribution, IF transmission and M/C.
6.08	Intermediate Frequency System	Provision of all frequency converters and digitizers.
6.09	Correlator	Construction and installation of the EVLA correlator, supplied by Canada, and NRAO interfaces.
6.10	Monitor and Control System	Provision of hardware and software for array monitor and control.
6.11	Data Management and Computing	Provision of software and hardware for observation preparation and scheduling and for data post-correlation processing.
6.12	Education and Public Outreach	EVLA contribution to NRAO's EPO program.

The detailed WBS task list, down to Level 4, is included in Appendix C. Also shown in this detailed WBS are the names of the engineers appointed within the Socorro Electronics, Engineering Services and Computing Divisions to be responsible for the Level 2 tasks.

IV. WORK PLAN

The detailed specifications for the EVLA subsystems, and the designs which will be used to achieve these requirements, will be contained in the EVLA Project Book which is currently in preparation and scheduled for release in November 2001. The EVLA Project Book consists of the 12 Chapters listed in Table 3. Each author has designated scientific liaisons whose role it is to ensure that the scientific requirements are being met.

Table 3. EVLA Project Book Plan

Chapter No.	Chapter Title	Authors
1	Introduction	P. Napier
2	Science	R. Perley
3	System Integration	J. Jackson
4	Antennas and Feeds	J.Ruff, E. Szpindor, S. Srikanth
5	Receivers	R. Hayward, D. Mertely
6	LO and IF Systems	T. Cotter
7	Fiber Optic System	J. Jackson
8	Correlator	B. Carlson
9	EVLA Monitor and Control System	W. Koski, G. Peck, W. Sahr
10	Data Management	T. Cornwell, F. Owen, G. van Moorsel
11	Transition Plan	J. Ulvestad
12	Schedule and Budget	P. Napier

The detailed plan for the EVLA Project Book chapters is included in Appendix D. After all subsystems have passed their Preliminary Design Reviews the Project Book will be placed under

Change Control and changes will then be allowed only after approval of the EVLA Change Control Board. The EVLA Change Control Board will be chaired by the Project Manager and will include the EVLA Project Scientist and the two System Engineers.

V. BUDGET

The detailed budget for the EVLA Project was produced using a bottom-up process in which a WBS Cost Data Sheet was completed by the responsible engineer for every Level 3 and Level 4 entry in the WBS. The Cost Data Sheet contains estimates of the personnel and materials and services requirements needed to accomplish the defined task over the 9 year period of the EVLA project. An example of a completed EVLA Cost Data Sheet is included in Appendix E1.

The summary budget for the EVLA Project, obtained by rolling up all of the detailed Cost Data Sheets, is shown below as Table 4. The detailed Budget Plans for each of the Level 2 Tasks is included in Appendix E2. Note that all budget numbers in this document are in FY 2001 dollars. Where necessary, conversion from FY 2000 dollars, the costing basis for the budget contained in the EVLA Proposal[3] , to FY 2001 dollars has been made using the change in the Consumer Price Index (CPI). The CPI increased by 3% from FY2000 to FY2001. Thus, the total funds requested from the NSF in Table 4, $51.4 M (FY2001) is equivalent to the Proposal request of $49.9M (FY2000).

In Table 4, the overall contingency level of 15% is the same as the level contained in the Proposal. This contingency will be held at two levels: i) the Project Manager, to be allocated as needed based on Change Board recommendations and ii) in a reserve held by the Observatory Director against unforeseen major problems, and/or opportunities, as requested by the Project Manager. In the event that additional contingency is required, a number of descope options are available with varying impact on the scientific performance of the EVLA. These options, which would reduce the sensitivity, bandwidth or frequency coverage of the EVLA, will remain open until the middle of 2004, when the quantity production of EVLA electronic equipment is scheduled to begin. By that time the budget risk should be significantly reduced because all design and prototype testing will be complete.

Table 4 EVLA Project Budget obtained by rolling up WBS Level 3 and Level 4 estimates

VLA EXPANSION PROJECT BUDGET

Note: All monetary amounts are listed in $k (FY2001)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.01 Project Management	76.1	119.1	169.1	220.3	177.8	155.6	144.4	99.8	40.8	1203
6.02 System Integration & Testing	268.2	572.2	88.4	52.1	44.1	44.1	42.6	26.6	24.6	1163
6.03 Civil Construction	0.0	770.4	221.0	145.0	445.0	40.0	0.0	0.0	0.0	1621
6.04 Antennas	47.7	222.2	725.6	432.7	242.3	196.3	155.0	149.4	15.2	2186
6.05 Front End Systems	239.4	460.8	1414.6	2602.9	1650.0	683.0	378.7	167.3	0.0	7597
6.06 Local Oscillator System	30.0	132.0	492.5	429.8	403.5	398.5	393.5	393.5	393.5	3067
6.07 Fiber Optic System	10.8	1084.4	1269.6	1044.3	924.3	924.3	824.3	700.0	0.0	6782
6.08 Intermediate Frequency System	20.0	494.0	499.0	586.0	586.0	586.0	586.0	586.0	586.0	4529
6.09 Correlator	149.0	366.3	159.3	622.3	38.3	4276.8	1879.0	45.0	17.0	7553
6.10 Monitor & Control System	19.2	367.9	441.1	406.4	255.0	237.7	204.3	172.1	64.0	2168
6.11 Data Management & Computing	0.0	10.3	114.5	266.5	85.5	33.0	184.0	126.0	526.0	1346
6.12 Education & Public Outreach							250.0	250.0		500
Sub-Total M&S	860	4600	5595	6808	4852	7542	5042	2716	1667	39715
NRAO Wages & Benefits	448	2915	3603	3612	2976	2544	2386	2288	1700	22470
Canadian Labor	54	383	641	490	468	365	624	321	136	3482
Total M&S+W/B	1362	7898	9838	10911	8296	10451	8051	5325	3503	65667
Contingency (15%)	204	1185	1476	1637	1244	1568	1208	799	525	9850
Redirected NRAO Effort	-275	-1585	-2070	-2065	-1523	-1319	-1158	-1165	-857	-12019
Canadian Contribution	-203	-749	-800	-1113	-506	-4642	-2503	-366	-153	-11035
Mexican Contribution			-1000	-1000						-2000
ELVA Project Funds	1088	6748	7443	8370	7511	6057	5598	4592	3019	50464
AUI Fee 2%	22	135	149	167	150	121	112	92	60	1009
Project Total (MSF Funds)	1110	*6883	7592	8537	7661	6178	5710	4684	3079	51473
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	

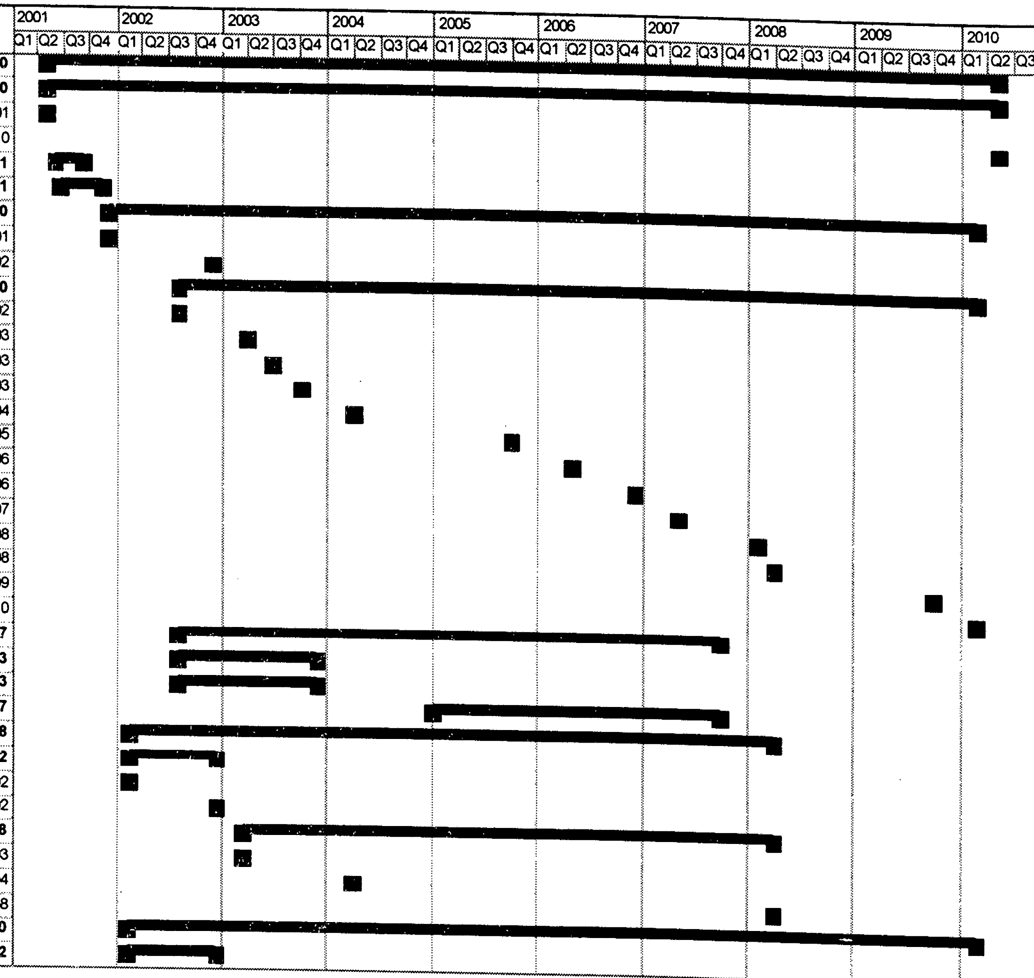
* Project Total (NSF Funds) in 2002 made up of $5000k in new funds from NSF plus uncommitted carryover from 2001.

VI. SCHEDULE

The EVLA Project Summary Schedule, which identifies the major milestones for each of WBS Level 2 Tasks, is shown below:

EVLA PROJECT
9 Year Plan Summary

WBS	Task Name	Start	Finish
6.01	**PROJECT MANAGEMENT**	**5/1/01**	**5/10/10**
6.01.05	**Management, Planning**	**5/1/01**	**5/10/10**
6.01.05.05	Start Project	5/1/01	5/1/01
6.01.05.08	EVLA Operational	5/10/10	5/10/10
6.01.05.10	**Detailed Project Mgmt Plan**	**6/4/01**	**9/7/01**
6.01.06	**Project Book**	**6/18/01**	**11/15/01**
6.02	**SYSTEM INTEGRATION AND TESTING**	**12/4/01**	**2/26/10**
6.02.02	System PDR	12/4/01	12/4/01
6.02.03	System CDR	12/2/02	12/2/02
6.02.04	**Transition [Commissioning] Plan**	**8/5/02**	**2/26/10**
6.02.04.05	Start fiber cabling on Array	8/5/02	8/5/02
6.02.04.10	Install system on EVLA test antenna	4/1/03	4/1/03
6.02.04.15	Start interferometry tests - EVLA & VLA	7/1/03	7/1/03
6.02.04.20	Freeze electronics design/Start production	10/6/03	10/6/03
6.02.04.25	Start antenna outfitting	4/5/04	4/5/04
6.02.04.30	Prototype correlator tests begin	10/3/05	10/3/05
6.02.04.35	Begin new correlator room hardware outfitting	5/1/06	5/1/06
6.02.04.40	First new correlator tests	12/4/06	12/4/06
6.02.04.45	First shared risk observations	5/7/07	5/7/07
6.02.04.50	Full new correlator installed	2/4/08	2/4/08
6.02.04.55	Last antenna converted to EVLA Design	3/31/08	3/31/08
6.02.04.60	Completion of full new correlator tests	10/2/09	10/2/09
6.02.04.65	Final receiver installed	2/26/10	2/26/10
6.03	**CIVIL CONSTRUCTION**	**8/1/02**	**10/1/07**
6.03.05	**Fiber Optic Cable**	**8/1/02**	**12/2/03**
6.03.05.05	**Trench & Install FO cable (200kft)**	**8/1/02**	**12/2/03**
6.03.10	**New Correlator Room**	**1/3/05**	**10/1/07**
6.04	**ANTENNAS**	**2/13/02**	**3/31/08**
6.04.01	**Management/Subsystem Engineering**	**2/13/02**	**12/18/02**
6.04.01.05	Feed Cone PDR	2/13/02	2/13/02
6.04.01.10	Feed Cone CDR	12/18/02	12/18/02
6.04.05	**Feed Cone Production**	**3/17/03**	**3/31/08**
6.04.05.03	Prototype structure available for test antenna	3/17/03	3/17/03
6.04.05.05	Start feed cone installation	4/5/04	4/5/04
6.04.05.50	Last antenna converted to EVLA Design	3/31/08	3/31/08
6.05	**FRONT END SYSTEMS**	**2/12/02**	**2/26/10**
6.05.01	**Management/Subsystem Engineering**	**2/12/02**	**12/17/02**

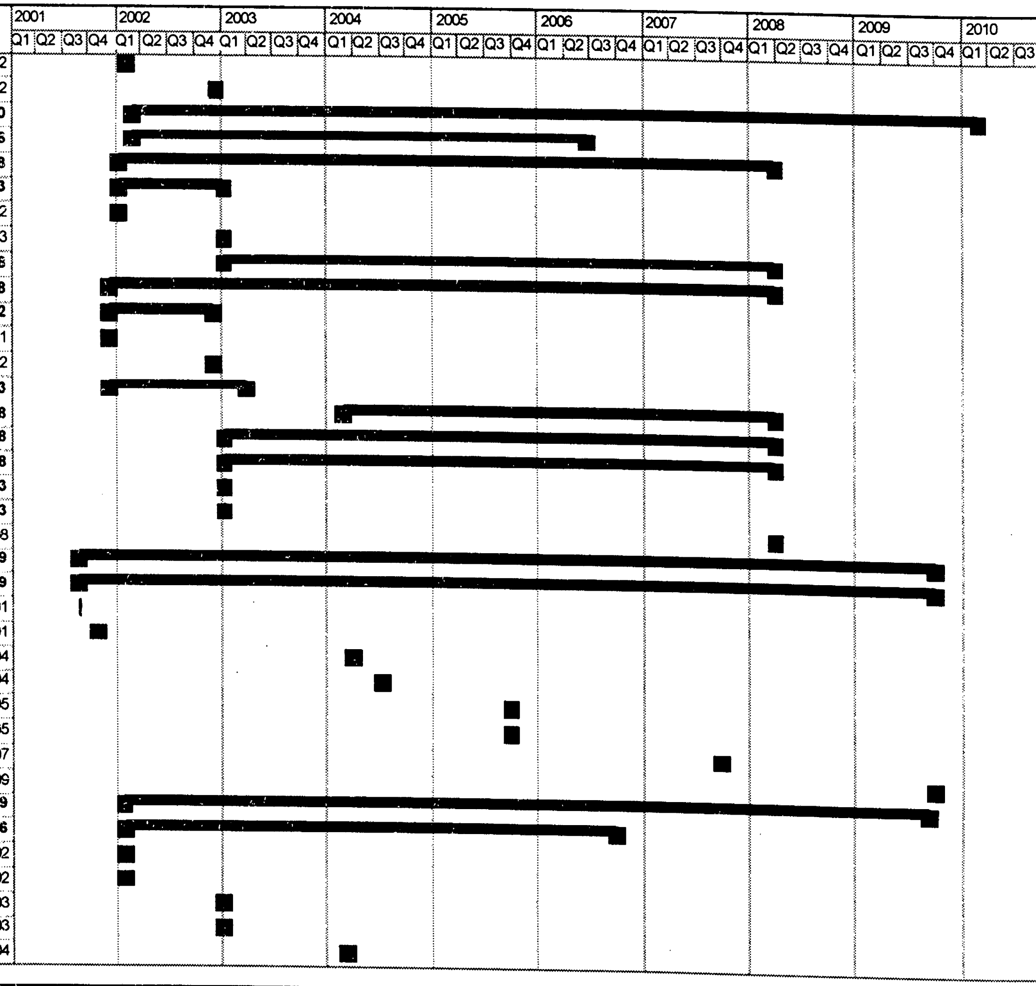


Project: EVLA 9 yr plan
Date: 9/17/01

Task		Summary		Rolled Up Progress		Project Summary	
Progress		Rolled Up Task		Split		Group By Summary	
Milestone		Rolled Up Milestone		External Tasks			

EVLA PROJECT
9 Year Plan Summary

WBS	Task Name	Start	Finish
6.05.01.05	Receiver/Feed PDR	2/12/02	2/12/02
6.05.01.10	Receiver/Feed CDR	12/17/02	12/17/02
6.05.05	**Receiver Build & Installation**	**3/4/02**	**2/26/10**
6.05.10	**Feeds**	**3/4/02**	**6/23/06**
6.06	**LOCAL OSCILLATOR SYSTEMS**	**1/14/02**	**3/31/08**
6.05.01	**Management/Subsystem Engineering**	**1/14/02**	**1/13/03**
6.06.01.05	LO/IF PDR	1/14/02	1/14/02
6.06.01.10	LO/IF CDR	1/13/03	1/13/03
6.06.05	**LO production**	**1/13/03**	**3/31/08**
6.07	**FIBER OPTICS SYSTEM**	**12/10/01**	**3/31/08**
6.07.01	**Management/Subsystem Engineering**	**12/10/01**	**12/9/02**
6.07.01.05	Fiber Optics System PDR	12/10/01	12/10/01
6.07.01.10	Fiber Optics System CDR	12/9/02	12/9/02
6.07.05	**Fiber Optics System Production**	**12/10/01**	**4/1/03**
6.07.10	**Antenna Outfitting**	**3/1/04**	**3/31/08**
6.08	**INTERMEDIATE FREQUENCY SYSTEM**	**1/13/03**	**3/31/08**
6.08.01	**Management/Subsystem Engineering**	**1/13/03**	**3/31/08**
6.08.05	**Band Switches**	**1/13/03**	**1/14/03**
6.08.10	**Samplers**	**1/13/03**	**1/14/03**
6.08.50	Last antenna converted to EVLA design	3/31/08	3/31/08
6.09	**CORRELATOR**	**8/27/01**	**10/2/09**
6.09.01	**Management/Subsystem Engineering**	**8/27/01**	**10/2/09**
6.09.01.05	New Correlator planning session	8/27/01	8/28/01
6.09.01.10	New Correlator Conceptual Design Review	11/2/01	11/2/01
6.09.01.15	User manual available	4/5/04	4/5/04
6.09.01.20	New Correlator PDR	7/16/04	7/16/04
6.09.01.25	New Correlator prototype testing w/ 3 baselines	10/3/05	10/3/05
6.09.01.30	New Correlator CDR	10/3/05	10/3/05
6.09.01.35	Start new Correlator installation	10/1/07	10/1/07
6.09.01.40	New Correlator operational	10/2/09	10/2/09
6.10	**MONITOR AND CONTROL SYSTEM**	**2/1/02**	**9/11/09**
6.10.01	**Management/Subsystem Engineering**	**2/5/02**	**10/2/06**
6.10.01.05	Monitor&Control Software PDR	2/6/02	2/6/02
6.10.01.10	Monitor&Control Hardware PDR	2/5/02	2/5/02
6.10.01.15	Monitor&Control Software CDR	1/7/03	1/7/03
6.10.01.20	Monitor&Control Hardware CDR	1/8/03	1/8/03
6.10.01.25	Full Monitor& Control capabilities available	3/15/04	3/15/04

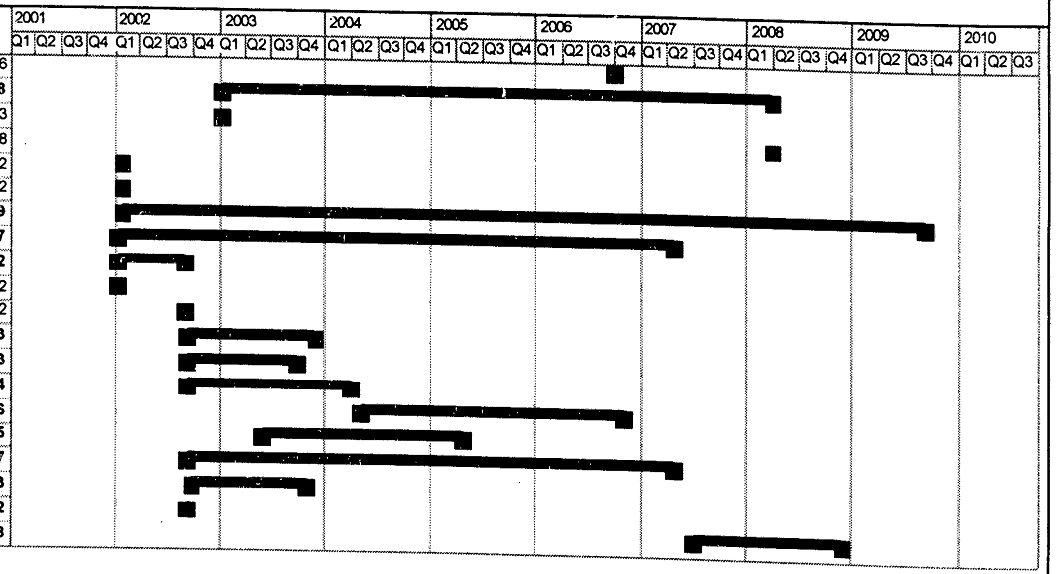


Project: EVLA 9 yr plan
Date: 9/17/01

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary

EVLA PROJECT
9 Year Plan Summary

WBS	Task Name	Start	Finish
6.10.01.30	Monitor&Control system ready for archive	10/2/06	10/2/06
6.10.05	**M&C Electronic Hardware**	**1/8/03**	**3/31/08**
6.10.05.05	Start Physical Interface Production	1/8/03	1/8/03
6.10.05.50	Last antenna converted to EVLA Design	3/31/08	3/31/08
6.10.10	Start M&C Network, Hardware & Software	2/1/02	2/1/02
6.10.15	Start M&C Computing Systems Hardware & Software	2/1/02	2/1/02
6.10.20	**M&C EVLA Software**	**2/1/02**	**9/11/09**
6.11	**DATA MANAGEMENT AND COMPUTING**	**1/15/02**	**5/1/07**
6.11.01	**Management/Subsystem Engineering**	**1/15/02**	**9/9/02**
6.11.01.05	Data Processing Architecture PDR	1/15/02	1/15/02
6.11.01.10	Data Processing Architecture CDR	9/9/02	9/9/02
6.11.05	**Proposal preparation and submission**	**9/10/02**	**12/1/03**
6.11.10	**Observation Preparation Software**	**9/10/02**	**10/1/03**
6.11.15	**Observation scheduling**	**9/10/02**	**4/1/04**
6.11.20	**Image Pipeline**	**5/3/04**	**11/1/06**
6.11.25	**Data archive**	**6/2/03**	**5/2/05**
6.11.30	**Data Post Processing**	**9/10/02**	**5/1/07**
6.11.35	**Networking**	**10/1/02**	**11/1/03**
6.11.40	**Computing hardware**	**9/10/02**	**9/12/02**
6.12	**EDUCATION AND PUBLIC OUTREACH**	**7/2/07**	**11/28/08**



Project: EVLA 9 yr plan
Date: 9/17/01

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary

VII. EVLA PROJECT PERSONNEL

The EVLA personnel requirements, obtained as summaries of the estimates made on the Cost Data Sheets, is included below as Table 5. Personnel labeled as NRAO Redirected Effort are NRAO employees currently on the NRAO operating budget who have been working on VLA development whose efforts will be redirected to EVLA Tasks, as proposed in the EVLA Proposal[3]. EVLA FTE's are new positions which will be directly paid by the EVLA Project budget.

Table 5 EVLA Personnel Requirements

EVLA FTE Estimates											
		TOTAL PROJECT EFFORT									
WBS		2001	2002	2003	2004	2005	2006	2007	2008	2009	9 yr Avg
6.01	Project Management	1.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.3	2.9
6.02	System Integration & Testing	0.4	3.8	4.1	4.5	4.6	4.5	4.5	4.0	2.9	3.7
6.03	Civil Construction	0.1	1.6	4.5	4.4	6.1	3.5	2.0	0.0	0.0	2.5
6.04	Antennas	0.7	4.2	5.9	5.0	4.9	4.7	4.5	4.5	2.7	4.1
6.05	Front End Systems	1.0	6.2	8.5	12.2	11.2	10.7	8.7	6.0	0.1	7.2
6.06	Local Oscillator System	0.6	5.3	5.2	4.9	4.2	4.2	4.0	4.0	4.0	4.0
6.07	Fiber Optic System	0.6	3.8	3.2	3.1	3.1	1.6	1.6	1.5	1.0	2.2
6.08	Intermediate Frequency System	0.1	4.7	5.1	5.3	4.4	4.4	4.4	4.4	4.4	4.1
6.09	Correlator	0.0	0.4	0.4	0.6	0.8	1.8	1.3	0.0	0.0	0.6
6.10	Monitor & Control System	1.4	9.5	12.8	12.2	5.7	2.6	4.4	5.4	4.0	6.4
6.11	Data Management & Computing	0.0	2.6	4.0	3.8	2.6	1.8	1.8	1.8	1.3	2.2
6.12	Education & Public Outreach							0.0	0.0		0.0
	Total FTE's	6.1	45.2	56.8	59.4	50.7	43.1	40.5	35.0	22.6	39.9
	Redirected NRAO Effort	3.5	21.4	29.8	32.4	24.8	22.3	20.1	17.4	10.2	20.2
	EVLA FTE's	2.6	23.8	27.1	26.9	25.9	20.8	20.4	17.6	12.4	19.7
		EVLA FTE's by Division									
	Project Mgmt	0.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.7
	Electronics	0.8	10.9	10.5	11.4	10.5	8.9	8.9	7.7	5.1	8.3
	Eng Services	0.0	4.3	7.8	6.3	7.8	5.7	4.3	2.8	1.9	4.6
	Data/Computing	1.0	5.6	5.7	6.1	4.5	3.2	4.1	4.1	3.4	4.2
	Scientific Staff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	EVLA Total	2.6	23.8	27.1	26.9	25.9	20.8	20.4	17.6	12.4	19.7
		Redirected NRAO FTE's by Division									
	Project Mgmt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Electronics	2.0	12.6	14.2	17.2	15.8	16.2	13.6	10.3	5.4	11.9
	Eng Services	0.9	1.4	2.5	3.0	3.1	2.6	2.2	1.7	0.8	2.0
	Data/Computing	0.4	5.5	11.1	9.9	3.7	1.2	2.1	3.1	1.8	4.3
	Scientific Staff	0.3	1.9	2.0	2.2	2.2	2.3	2.2	2.3	2.2	2.0
	NRAO Total	3.5	21.4	29.8	32.4	24.8	22.3	20.1	17.4	10.2	20.2

APPENDIX A. PARTNERSHIP AGREEMENTS

Appendix A1
Memorandum of Understanding With Canadian Partner

Memorandum of Understanding between the Herzberg Institute of Astrophysics and the National Radio Astronomy Observatory to establish a North American Program in Radio Astronomy

Recognizing

- that the purpose of the Herzberg Institute of Astrophysics (HIA), funded by the National Research Council (NRC) of Canada, is to conduct a broad program of research in ground-based astronomy;

- that the purpose of the National Radio Astronomy Observatory (NRAO), operated by Associated Universities Inc.(AUI), funded by the National Science Foundation (NSF) of the United States, is to design, build, and operate large radio telescope facilities for the scientific community;

- that the HIA has a strong program in centimeter-wavelength radio astronomy with a skilled team in the design and construction of signal correlators and an interest in long-term development work for the Square Kilometer Array (SKA);

- that the NRAO has as a high priority the Very Large Array Expansion (EVLA) project, including the installation of a new signal correlator, as a step toward the development of the SKA; and

- that the astronomical communities in the United States and Canada have a long tradition of close cooperation; and

Noting

- the economic and technical advantages to the United States and Canada of establishing a joint venture for the design, development, and construction of instrumentation for the EVLA;

- the scientific benefits of continuing to promote the policy of no national boundaries in applications for observing time on astronomical telescopes; and

- the common scientific goals of our astronomical communities; HIA and NRAO

Resolve

- to seek funds to contribute to the EVLA and if successful;

- to establish the North American Program in Radio Astronomy (NAPRA) under the terms given in the following Articles of this Memorandum of Understanding (MOU).

Article 1. The signatories to this MOU are on the one hand, NRAO, and on the other hand, HIA.

Article 2. The duration of this partnership is for ten years, or through the first five years of operation of the new correlator to be installed at the VLA, whichever is longer. The partnership is renewable upon conclusion of mutually satisfactory negotiations between the participants and the concurrence of the funding agencies.

Article 3. The contributions to NAPRA of the participants are as follows:

In consideration of this MOU and the letter of intent signed in the year 2000 between NRC and NSF concerning a North American ALMA partnership, the NRAO will regard applications from scientists at Canadian institutes for telescope time on all its major telescopes, including ALMA, on the same basis as applications from scientists at institutions in the United States.

Canada will contribute a new signal correlator to the EVLA to be built by HIA. The value of this correlator is expected to be approximately US$10,000,000.

The formation of NAPRA is contingent upon NRC becoming a partner with NSF in ALMA, as described above.

No contribution from Canada toward operations of the expanded VLA is expected. Work done in Canada and the United States toward the development of the SKA is to be recognized as a joint contribution.

Article 4. NRAO and NRC agree to explore possibilities of NRC participation in correlator design and construction for future projects such as ALMA and the SKA. Any innovative correlator design features that result from HIA's construction of the ELVA correlator may be incorporated into an ALMA correlator, if both signatories agree that it is of mutual benefit to do so.

Article 5. AUI/NRAO will recognize Canadian participation in NAPRA by appointing Canadians to relevant advisory and governing bodies such as the AUI Board of Trustees and the NRAO Visiting, Program Advisory, and Users Committees. These appointments will be made in consultation with HIA.

Similarly, HIA will recognize US participation in NAPRA by appointing US representatives to advisory bodies relevant to correlators and SKA development.

Article 6. Canada will receive recognition in promotional material regarding the EVLA. Correspondingly, the United States will be given recognition in promotional material for the SKA as a result of its contribution through NAPRA to the upgrade of the VLA, which is a first step to the SKA.

Article 7. NAPRA can be expanded by adding participants, on the same general principles set out in this MOU, with the agreement by the signatories to revisions of the MOU.

Article 8. The intention of the participants is that any intellectual property generated under NAPRA be available to all participants for the NAPRA program, and that procurement procedures be openly conducted on both sides, without provisions that would unfairly impair the ability of industry on either side to compete.

Article 9. Activities conducted under NAPRA will be organized into projects, with defined scope, cost, and schedule.

For the VLA Expansion, the leader of the Canadian component will coordinate with the NRAO EVLA Project Manager. The definition of requirements, specifications, and deliverables by Canada to the EVLA will be a joint activity of a team with representatives from the United States and Canada.

The United States will have representation on the corresponding body defining Canadian SKA development work.

The specific management arrangements for these activities are to be detailed in a series of letters between the participants that achieve mutual agreement within six months of the signing of an agreement for the EVLA and SKA development work.

Article 10. While the intention is to make contributions to NAPRA in the form of deliverables rather than cash, nothing in this MOU should be taken to exclude the possibility of cash exchanges in either direction when that would benefit the NAPRA activity and has the approval of the participants.

Article 11. Irresolvable disputes between the HIA and the NRAO will be referred to the funding agencies for resolution. Failure by the funding agencies to resolve a dispute within one year will result in automatic termination of the MOU. Should this occur before completion of the new VLA correlator, unfinished correlator hardware would be transferred to NRAO.

Signatories:

____
Simon Lilly, Director General
Herzberg Institute of Astrophysics

____
Paul A. Vanden Bout, Director
National Radio Astronomy Observatory

____
Date

Date ______________________________

____
Riccardo Giacconi, President
Associated Universities Inc.

____
Date

Appendix A2

Letter from Mexican CONACYT

SEP · CONACYT
Consejo Nacional de Ciencia y Tecnología

Mexico City, April 4, 2000

DR. PAUL VANDEN BOUT
Director
National Radio Astronomy Observatory
520 Edgemont Rd.
Charlottesville, VA 22903-2475
USA

Dear Dr. Vanden Bout:

I am very pleased to inform you that the project *"Radio Astronomical Interferometry"* has been approved for funding by the National Council for Science and Technology (CONACyT) as a result of our call for proposals in New Fields of Research.

CONACyT will fund this project with a total of $20,000,000 (Twenty Million Mexican Pesos) distributed over four years. The money will be used for the Very Large Array Expansion, a project that will make this instrument ten times more powerful than at present. As part of this collaboration, mexican astronomers and engineers will participate in the initial testing and use of the Expanded Very Large Array (EVLA) and will have access to the Atacama Large Millimeter Array (ALMA) during the first decade after completion, in equal conditions to those of astronomers located in US institutions.

We request that every effort is made to spend as much as possible of this funding in Mexico.

The principal investigator in this proposal is Dr. Luis F. Rodríguez, of the Institute de Astronomia, UNAM, in its Morelia Campus.

We look forward to a most productive collaboration.

Sincerely,

J Martuscelli

Jaime Martuscelli, PhD
Deputy Director for Science

APPENDIX B. GUIDELINES FOR DESIGN REVIEWS

EVLA PDR and CDR Definitions

Version 2 - 2001-Jul-30
P. J. Napier

Preliminary Design Review (PDR)

To be held early enough in the Design Phase so that a change in direction is still possible if the need for such a change is identified by the review.

The purpose of the PDR of an EVLA Subsystem is principally to review 3 questions:

(1) Are the top level performance requirements for the subsystem complete and adequate?

(2) Have the correct design solutions been selected for study and development during the EVLA Design Phase? Are there important alternate solutions that are not being studied?

(3) Has an adequate procurement plan been identified for the subsystem?

The PDR will be organized and chaired by the EVLA Division Head responsible for the subsystem. The Review Board will include the following:

(a) At least 2 experts from outside the EVLA Project. In the event that the Review cannot be scheduled because of difficulty in arranging the attendance of a second expert, it will be acceptable to solicit the opinions of the second expert in writing after his/her review of all of the materials presented at the Review.

(b) The Project Manager and/or the Project Systems Engineer.

(c) The Project Scientist or his/her designee.

(d) At least one representative of any EVLA Division potentially impacted by the design of the subsystem.

Critical Design Review (CDR)

To be held before expenditure of significant funds on the construction of production equipment which will be incorporated into the EVLA.

The purpose of the CDR of an EVLA Subsystem is principally to review 4 questions:

(1) Are the detailed requirements for the subsystem complete and adequate?

(2) Will the design selected for implementation meet the requirements?

(3) Are interfaces to other subsystems defined adequately and completely?

(4) Has adequate attention been given to the produceability and maintainability of the subsystem?

Meeting organization and attendance to be the same as a PDR.

Review Documentation (All Reviews)

(1) Minutes will be kept of the Review.

(2) As the last activity of the Review all Review Board members will be asked to answer the key questions and to identify any important Issues.

(3) The responsible Division Head must arrange for written responses to all Issues within one month of the Review. These responses will become part of the Review documentation package.

(4) It is the responsibility of the EVLA Project Manager to determine what further action is required as follow-up to the Issues and Responses.

APPENDIX C. DETAILED WORK BREAKDOWN STRUCTURE

EVLA WBS Level Four Summary

As of 8/29/01 — 8/30/01 9:09

ACDS#	WBS		TASK NAME
6.01	**P. Napier**		**Project Management**
	6.01.05		Management/Subsystem Engineering
	6.01.06		Project Book
	6.01.10		Office Equipment & Supplies
	6.01.15		Drafting and Lab Services
	6.01.20		Advisory Comm Support
6.02	**J. Jackson**		**System Integration and Testing**
	6.02.01		Management/Subsystem Engineering
	6.02.05		Test and Lab Equipment
		6.02.05.05	Production Test and Lab Equipment, FO
		6.02.05.10	Production Test and Lab Equipment, FE
		6.02.05.15	Production Test and Lab Equipment, LO
		6.02.05.20	Test and Lab Equipment General
		6.02.05.25	Engineering Software
	6.02.10		Power Supply System
		6.02.10.05	Central Electronics Room
		6.02.10.10	Master LO Power Supply
		6.02.10.15	Antenna Vertex Room Power Supply
		6.02.10.20	Antenna Pedestal Room Power Supply
	6.02.15		RFI Characterization
		6.02.15.05	Shielded Chamber Development
		6.02.15.10	RFI Survey and Analysis
		6.02.15.15	Module RFI/EMC Analysis
		6.02.15.20	Site RFI Mitigation
	6.02.20		Scientific Support
		6.02.20.05	Specification Development
		6.02.20.10	Acceptance Test Development
	6.02.25		Modules, Bins and Racks
	6.02.30		Transition Planning
6.03	**G. Stanzione**		**Civil Construction**
	6.03.01		Management/Subsystem Engineering
	6.03.05		FO Cable, Trench, Install
		6.03.05.05	FO Cable, Trench and Install (200 kft)
		6.03.05.10	FO Cable (550kft)
	6.03.10		New Correlator Room
		6.03.10.05	New Correlator Shielded Chamber
		6.03.10.10	Remodeling and Demolition
		6.03.10.15	Chiller
		6.03.10.20	Power Distribution
		6.03.10.25	Install New Correlator
	6.03.15		IPG Shielded Chamber
	6.03.20		Transition Planning
6.04	**J. Ruff**		**Antennas**
	6.04.01		Management/Subsystem Engineering
	6.04.05		Feed Cone
		6.04.05.05	Structure
		6.04.05.10	HVAC
		6.04.05.15	Electrical service
	6.04.10		Antenna Structural Modifications
	6.04.15		FRM for Prime focus Mock-up
	6.04.20		Pointing Improvements

	6.04.30		Cryogenics
		6.04.30.05	Vacuum Pump and Manifolds
		6.04.30.10	Compressors & He Lines
		6.04.30.15	Refrigerators
6.05	**D. Mertely**		**Front End Systems**
	6.05.01		Management/Subsystem Engineering
	6.05.05		Receivers
		6.05.05.05	L Band
		6.05.05.10	S Band
		6.05.05.15	C Band
		6.05.05.20	X Band
		6.05.05.25	Ku Band
		6.05.05.30	K Band
		6.05.05.32	K Band Completion (7 units)
		6.05.05.35	Ka Band
		6.05.05.40	Q Band
		6.05.05.45	Q Band Completion (5 units)
	6.05.10		Feeds
		6.05.10.05	L Band
		6.05.10.10	S Band
		6.05.10.15	C Band
		6.05.10.20	X Band
		6.05.10.25	Ku Band
		6.05.10.32	K Band
		6.05.10.30	K Band Completion (7 units)
		6.05.10.35	Ka Band
		6.05.10.40	Q Band
		6.05.10.45	Q Band Completion (5 units)
6.06	**T. Cotter**		**Local Oscillator System**
	6.06.01		Management/Subsystem Engineering
	6.06.05		Central Reference System
		6.06.05.05	H Maser Frequency Standard (&Rb)
		6.06.05.10	PPS Generator & Distributor
		6.06.05.15	Time Code Generator & Distributor
		6.06.05.20	GPS Receiver
		6.06.05.25	LO Ref Generator
		6.06.05.30	LO ref Distributor - Control Bldg
	6.06.10		First LO System
		6.06.10.05	First LO Generator
	6.06.15		Second LO System
		6.06.15.05	Second LO Synthesizer
	6.06.20		Antenna Reference System
		6.06.20.05	Antenna LO Reference Generator
		6.06.20.10	Antenna LO Reference Distributor
		6.06.20.15	PCAL Generator
		6.06.20.20	Round Trip Phase Stabilizer
6.07	**J. Jackson**		**Fiber Optic System**
	6.07.01		Management/Subsystem Engineering
	6.07.05		Fiber System
		6.07.05.05	DTS
		6.07.05.10	LO/Reference
		6.07.05.15	Monitor and Control
		6.07.05.20	Fiber Infrastructure
	6.07.10		Antenna Outfitting
6.08	**T. Cotter**		**Intermediate Frequency System**
	6.08.01		Management/Subsystem Engineering
	6.08.05		Band Switches
		6.08.05.05	8-12 GHz Band Switch

		6.08.05.10	1 GHz Band Switch
		6.08.05.15	IF Down Converter
	6.08.10		Samplers
		6.08.10.05	2-4 GHz Sampler
		6.08.10.10	1 GHz Sampler
	6.08.15		Transition Hardware
6.09	**P. Dewdney**		**Correlator**
	6.09.01		Management/Subsystem Engineering
	6.09.05		NRAO Correlator Interface
	6.09.10		Pre-project Tooling/Setup
	6.09.15		Station Board H/W Development
		6.09.15.02	Station Board
		6.09.15.05	FIR Filter Chip Development
		6.09.15.10	Course Delay Module
	6.09.20		Sub-band Distribution Backplane
	6.09.25		Station Data Fanout Board
	6.06.30		Basline Entry Backplane
	6.09.35		Baseline Board H/W Development
		6.09.35.02	Baseline Board
		6.09.35.05	Correlator Chip Development
	6.09.40		Phasing Board
	6.09.45		Phasing Board Entry Backplane H/W Development
	6.09.50		TIMECODE Generator Box H/W Development
	6.09.55		Real-time S/W Development
	6.09.60		System Design (Racks, Main Pwr, Cabling, Computer)
	6.09.65		Production Model Test/Burn-in
	6.09.70		System Integration & Test (Penticton)
	6.09.75		System Integration & Test (VLA off-line)
	6.09.80		Online Dedug, Test (VLA on-line)
6.10	**B. Sahr**		**Monitor & Control System**
	6.10.01		Management/Subsystem Engineering
	6.10.05		M&C Electronic Hardware
		6.10.05.05	Physical Interface
		6.10.05.10	Battery Backed Utility
	6.10.10		M&C Network, Hardware & Software
	6.10.15		M&C Computing Systems Hrdwre & Sftwre
	6.10.20		M&C EVLA Software
		6.10.20.05	Stabilization of the VLA
		6.10.20.10	Requirements
		6.10.20.15	High Level Software Architecture & Design
		6.10.20.20	Test & Devel Support, Enhanced Antennas
		6.10.20.25	Mid Level Analysis & Design
		6.10.20.30	Test & Devel Support, Correlator
		6.10.20.35	Detailed Design & Coding
	6.10.25		M&C Voice Communications
	6.10.30		M&C Transistion Hardware
6.11	**G. van Moorsel**		**Data Management and Computing**
	6.11.01		Management/Subsystem Engineering
	6.11.05		Proposal Preparation and Submission
		6.11.05.05	Requirements
		6.11.05.10	Proposal submission toolkit
	6.11.10		Observation Preparation Software
		6.11.10.05	Requirements
		6.11.10.10	Observation description toolkit
		6.11.10.15	Observation planning toolkit
	6.11.15		Observation Scheduling
		6.11.15.05	Requirements
		6.11.15.10	Observation scheduling toolkit
		6.11.15.15	Observing toolkit

		6.11.15.20	EVLA-specific Observing toolkit
	6.11.20		Image Pipeline
		6.11.20.05	Requirements
		6.11.20.10	Pipeline toolkit
		6.11.20.15	Pipeline heuristics
		6.11.20.20	EVLA-specific pipeline heuristics
	6.11.25		Data Archive
		6.11.25.05	Requirements
		6.11.25.10	Archive toolkit
	6.11.30		Data Post Processing
		6.11.30.05	Requirements
		6.11.30.10	EVLA AIPS++ package
	6.11.35		Networking
		6.11.35.05	Upgrade Servers
		6.11.35.10	Replace copper by optical fiber
		6.11.35.15	Upgrade Clients
		6.11.35.20	Update VLA/AOC Datalink
		6.11.35.25	Update Non-Operations VLA Network
	6.11.40		Computing Hardware
		6.11.40.05	Development hardware
		6.11.40.10	Archive hardware
		6.11.40.15	Pipeline hardware
	6.11.45		System Administration Support
		6.1145.05	Upgrade System Administration Support
6.12	**R. Harrison**		**Education and Public Outreach**
	6.12.05		EVLA Contribution to new Visitor Center

APPENDIX D. PROJECT BOOK PLAN

VLA Project Book, Chapter 1

EVLA Project Book: Introduction

Peter Napier
Last changed 2001-Aug-01

Revision History:
2001-Aug-01: Initial release

The goal of the Very Large Array Expansion (EVLA) Project is to improve most of the key observational capabilities of the Very Large Array (VLA) by at least an order of magnitude. The Project is divided into two Phases. Phase I will, by the application of modern technologies, improve the sensitivity, bandwidth, spectral resolution and frequency coverage of the existing 27 element array. Initial funding has been provided for Phase I and work has commenced on planning and design for this phase. Phase II will increase the angular resolution of the existing VLA by adding additional array elements around New Mexico. Also to be considered in Phase II are the addition of a condensed array configuration smaller than the existing D array and the addition of low frequency observing bands to the existing antennas. Initially, this Project Book will describe only the Phase I project. When the Phase II project commences, this book will be expanded to include it.

This Project Book is intended to satisfy several functions. It is the principal description of the science requirements, the technical specifications, the design selected to achieve the specifications, the schedule on which tasks are to be accomplished, and the task responsibilities. Where one task interacts with another either in the design or integration, the interface requirements are specified.

After an initial period of project definition, when all subsystems have completed Preliminary Design Review (PDR), the Project Book will be placed under configuration control. At that time specifications in the Project Book – technical specifications, interface specifications or schedule – will be controlled by EVLA System Engineering. Changes will not be made to the configuration without the process specified by System Engineering, through the Control Board, being followed and approval granted.

The Project Book is the fundamental reference for what is, and is not, in the Project. As decisions are made and implemented those decisions will be incorporated into the Project Book. The Project Book is kept electronically and is always available on-line for reference by the Project and interested others. A revision history is included to aid change tracking. Although it is a living document and will evolve, it is at all times the current, and complete, Project configuration. Maintenance of the Project Book is the responsibility of EVLA Systems Engineering.

EVLA Project Book, Chapter 2

SCIENCE

Rick Perley
Last changed 2001-July-24

Revision History
2001-July-25: Initial release

Summary

SYSTEM INTEGRATION

Jim Jackson
Last changed- 2001 July-19

Revision History
2001-July-19: Initial release

Summary

EVLA Project Book, Chapter 4

ANTENNAS AND FEEDS

Jim Ruff, Ed Szpindor, S. Srikanth
Last changed 2001-August 14

Revision History:
2001-August 14: Initial release

Summary:

EVLA Project Book, Chapter 5.

RECEIVERS

Robert Hayward and Daniel J. Mertely
Last changed 2001 July-01

Revision History
2001-July-01: Initial release

EVLA Project Book, Chapter 6

LOCAL OSCILLATOR AND INTERMEDIATE FREQUENCY SYSTEMS

Terry Cotter
Last changed 2001-June-20

Revision History:
2001 -July-20: Initial Release

Summary

FIBER OPTICS SYTEM

Jim Jackson
Last Changed 19-July-2001

Revision History
2001-July-19: Initial release

Summary

EVLA Project Book, Chapter 8.

CORRELATOR

Brent Carlson
Last changed 2001-June-06

Revision History:
2001-August 14: Initial release.

EVLA MONITOR AND CONTROL SYSTEM

Wayne Koski, George Peck, William Sahr
Last changed 2001-July-16

Revision History
2001-July-16: Initial release

Summary

EVLA Project Book, Chapter 10

DATA MANAGEMENT

Tim Cornwell, Frazer Owen, and Gustaaf van Moorsel
Last changed 2001-July-18

Revision history
2001-July-18: Initial version

Summary

EVLA Project Book, Chapter 11

Transition Plan

Jim Ulve
Last changed 2001-Au

Revision History
2001-Aug-15: Initial Release

Summary

Peter J. N
Last changed 2001-Jul

SCHEDULE AND BUDGET

Revision History
2001-July –23: Initial release

Appendix E PROJECT BUDGET

Appendix E1
An example of an EVLA Cost Data Sheet

EVLA Cost Data Sheet | Last Saved 09/05/01 | Note: All monetary amounts are listed in $K

Task Name: Ka - Band
WBS Number: 6.05.05.35 | **ACDS #** 46801.7183.050535
Start Date Sep-02
End Date Oct-02
Duration Mar-00
Name/Estimator: Daniel J. Mertely | Phone: 505 835-7128
Basis of Estimate: History/Eng judgement | Date: 28 June, 2001

Assigned Risk Factors:

Technical	1.0	(1,2,3,4,6,8,10,15)
Cost	1.0	(1,2,3,4,6,8,10,15)
Schedule	2.0	(2,4,8)

Multipliers for Contingency:

Technical Multiplier:	2.0	(2,4)
Cost Multiplier:	1.0	(1,2)
Calc. Contingency.:	5.0%	

Task Description:
(Text for the WBS dictionary)
Design, build, test and install 28+2, 26 - 40 GHz (Ka-band), VLA low-noise receiver front ends, including down-converting mixer sections to the 8-12 GHz 1st IF, and 2 full, 4 GHz-wide instantaneous IF bandwidth channels for both polarizations.
Each of the 2 polarization pairs should be independently tunable.

Labor: In Person Months

Position Type	SG	Job Desc	SS	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total FTE's
Dan Mertely	3	Manager	ED		0.3	0.3	0.5	0.5	0.5	0.5	0.5		0.3
Raul Armendariz	3		ED										0.0
Robert Hayward	3	Design Eng	ED		2.3	2.3	2.1	2.1	1.8	1.8	1.8		1.2
Everett Callan	3		ED										0.0
Rey Serna	3		ED		2.0	1.8	2.3	2.3	1.8	1.8	1.8		1.2
Robert Smith	3		ED										0.0
Brent Willoughby	3		ED		2.0	1.8	2.5	1.8	1.8	1.8	1.8		1.1
Greg Chavez	4		ED										0.0
Darrell Hicks	4		ED		1.0	1.3	1.3	1.3	1.3	1.3	1.3		0.7
Troy Jensen	4		ED				0.6	0.6	0.6	0.6	0.6		0.3
Paul Lilie	2		EV		2.0	1.0	0.5	0.5					0.3
Edward Szpindor	3		EV										0.0
FE Installation Technicain	4		EV			1.5	1.5	1.5	1.5	1.5	1.5		0.8
Machinist (1.1 FTE avail)	4		ES										0.0
Machinist (0.55 FTE avail)	4		GB										0.0
Labor Totals ($K):				0.0	62.7	53.8	55.0	50.7	41.3	41.3	49.9	0.0	354.8
TOTAL FTEs:				0.0	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.0	5.8
TOTAL EV FTEs:				0.0	0.2	0.0	0.2	0.2	0.1	0.1	0.1	0.0	0.9
Off Budget FTEs:				0.0	0.6	0.8	0.8	0.7	0.7	0.7	0.7	0.0	4.9
TOTAL EV LABOR ($k):				0.0	18.3	10.7	6.1	6.1	1.5	1.5	6.1	0.0	50.3

Materials: In $K

Material Description:	2001 Cost	2002 Cost	2003 Cost	2004 Cost	2005 Cost	2006 Cost	2007 Cost	2008 Cost	2009 Cost	Total Cost
Fab mtl & tooling costs			7.0	7.0	14.0					28.0
RF Components		20.0	57.0	366.0	1100.0					1543.0
Control Components		17.0	17.0	44.0	99.0					177.0
Cryo Components		0.2								0.2
Test Equipment		12.0	50.0	50.0						112.0
CDL LNA costs (mtl & labor)		15.0	15.0	30.0	30.0	30.0	30.0	30.0		180.0
										0.0
										0.0
										0.0
										0.0
										0.0
										0.0
										0.0
Materials Total ($K):	0.0	64.2	146.0	497.0	1243.0	30.0	30.0	30.0	0.0	2040.2

Contracts (Committed):

Contract Description:	2001 Cost	2002 Cost	2003 Cost	2004 Cost	2005 Cost	2006 Cost	2007 Cost	2008 Cost	2009 Cost	Total Cost
										0.0
										0.0
										0.0
										0.0
										0.0
Contracts Total ($K):	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Travel (weeks):	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total Cost
										0.0
Cost:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Appendix E2 Detailed Budget Plans for each Level 2 Task.

Note: All monetary amounts are listed in $k (FY2001)

6.01	Project Management	2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.01.05	Mgmt/Subsystem Eng	25.0	40.0	60.0	75.0	70.0	68.0	60.0	55.0	30.0	483.0
6.01.06	Project Book	0.3	0.8	1.0	1.2	0.7	0.5	0.5	1.0		6.0
6.01.10	Office Equipment & Supplies	20.0	36.2	53.0	74.0	36.0	18.0	30.8	2.0		270.0
6.01.15	Drafting and Lab Services	5.0	7.0	10.0	10.0	8.0	12.0	3.0	1.0		56.0
6.01.20	Advisory Comm Support	15.0	20.0	30.0	45.0	48.0	42.0	35.0	30.0		265.0
	Sub-Total M&S	65.3	104.0	154.0	205.2	162.7	140.5	129.3	89.0	30.0	1080.0
	Travel	10.8	15.1	15.1	15.1	15.1	15.1	15.1	10.8	10.8	123.0
	Sub-total M&S+T	76.1	119.1	169.1	220.3	177.8	155.6	144.4	99.8	40.8	1203.0
	Labor	131.5	269.4	269.4	269.4	269.4	269.4	269.4	269.4	216.5	2233.8
	Sub-Total M&S+T+L	207.6	388.5	438.5	489.7	447.2	425.0	413.8	369.2	257.3	3436.8
	Redirected Ops Effort	-27.5	-27.5	-27.5	-27.5	-27.5	-27.5	-27.5	-27.5	-27.5	-247.5
	Total	180.1	361.0	411.0	462.2	419.7	397.5	386.3	341.7	229.8	3189.3
	EVLA FTE's:	0.8	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	23.8
	Off Budget FTE's:	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.2
	Total FTE's	1.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2	2.2	26.1

6.02	System Integration & Testing										
		2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sub-total**
6.02.01	Mgmt/Subsystem Eng	10.5	29.7	8.0	16.0	8.0	8.0	12.5	4.5	2.5	99.7
6.02.05	Test and Lab Equipment	233.3	466.4	32.2	9.2	9.2	9.2	9.2	9.2	9.2	787.1
6.02.10	Power Supply System	10.0	29.0	31.0	14.0	14.0	14.0	8.0			120.0
6.02.15	RFI Characterization	1.5	19.1								20.6
6.02.20	Scientific Support										0.0
6.02.25	Transition Planning										0.0
	Sub-Total M&S	255.3	544.2	71.2	39.2	31.2	31.2	29.7	13.7	11.7	1,027.4
	Travel	12.9	28.0	17.2	12.9	12.9	12.9	12.9	12.9	12.9	135.5
	Sub-total M&S+T	268.2	572.2	88.4	52.1	44.1	44.1	42.6	26.6	24.6	1,162.9
	Labor	42.5	288.2	303.0	350.2	352.5	343.3	343.3	308.7	240.3	2,572.0
	Sub-Total M&S+T+L	310.7	860.4	391.4	402.3	396.6	387.4	385.9	335.3	264.9	3,734.9
	Redirected Ops Effort	-33.3	-158.9	-164.6	-238.3	-236.4	-227.3	-227.3	-215.1	-179.2	-1,680.4
	Total	277.4	701.5	226.8	164.0	160.2	160.1	158.6	120.2	85.7	2,054.5
	EVLA FTE's:	0.1	1.7	2.0	1.4	1.5	1.5	1.5	1.1	0.6	11.4
	Off-Budget FTE's:	0.3	2.1	2.1	3.1	3.1	3.0	3.0	2.9	2.4	22.0
	Total FTE's	0.4	3.8	4.1	4.5	4.6	4.5	4.5	4.0	2.9	33.3

6.03 Civil Construction		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.03.05	FO Cable, Trench, Install		760.4	221.0							981.4
6.03.10	New Correlator Room				145.0	445.0	40.0				630.0
6.03.15	IPG Shielded Chamber		10.0								10.0
6.03.20	Transition Planning										0.0
	Sub-Total M&S	0.0	770.4	221.0	145.0	445.0	40.0	0.0	0.0	0.0	1621.4
	Travel										
	Sub-total M&S+T	0.0	770.4	221.0	145.0	445.0	40.0	0.0	0.0	0.0	1621.4
	Labor	9.4	55	179.4	204.4	263.5	150.5	79.4			941.6
	Sub-Total M&S+T+L	9.4	825.4	400.4	349.4	708.5	190.5	79.4	0.0	0.0	4184.4
	Redirected Ops Effort	-9.4	-6.1	-32.8	-57.8	-68	-41.9	-30.5			-246.5
	Total	0.0	819.3	367.6	291.6	640.5	148.6	48.9	0.0	0.0	3937.9
	EVLA FTE's:	0.0	1.5	4.0	3.5	5.0	2.8	1.5	0.0	0.0	18.3
	Off-Budget FTE's:	0.1	0.1	0.5	0.9	1.1	0.7	0.5	0.0	0.0	3.8
	Total FTE's	0.1	1.6	4.5	4.4	6.1	3.5	2.0	0.0	0.0	22.2

6.04	Antennas	2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.04.01	Mgmt/Subsystem Eng	0.2	8.5	32.0	8.0	8.2	8.5	12.0	8.0	8.2	93.6
6.04.05	Feed Cone		45.0	228.0	102.0	52.0	32.0	22.0	17.0		498.0
6.04.10	Antenna Structural Modifications		52.0	12.0	15.0	15.0	15.0	12.0	12.0		133.0
6.04.15	FRM for Prime focus Mock-up			130.0	40.0						170.0
6.04.20	Pointing Improvements		69.0	79.0	65.0	10.0					223.0
6.04.30	Cryogenics	47.5	43.3	240.3	202.7	157.1	140.8	109.0	112.4	7.0	1060.1
	Sub-Total M&S	47.7	217.8	721.3	432.7	242.3	196.3	155.0	149.4	15.2	2177.7
	Travel		4.4	4.3							8.7
	Sub-total M&S+T	47.7	222.2	725.6	432.7	242.3	196.3	155.0	149.4	15.2	2186.4
	Labor	36	191.7	226.3	226.3	220.2	222.9	210.7	210.7	144.9	1689.7
	Sub-Total M&S+T+L	83.7	413.9	951.9	659.0	462.5	419.2	365.7	360.1	160.1	3876.1
	Redirected Ops Effort	-36	-161.9	-188.3	-188.3	-182.2	-182.2	-170	-170	-106.9	-1385.8
	Total	47.7	252.0	763.6	470.7	280.3	237.0	195.7	190.1	53.2	2490.3
	EVLA FTE's:	0.0	1.8	2.8	1.8	1.8	1.8	1.8	1.8	0.9	14.8
	Off-Budget FTE's:	0.7	2.3	3.0	3.1	3.0	2.9	2.7	2.7	1.8	22.1
	Total FTE's	0.7	4.2	5.9	5.0	4.9	4.7	4.5	4.5	2.7	36.9

6.05 Front End Systems

		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.05.01	Mgmt/Subsystem Eng										0.0
6.05.05	Receivers										0.0
6.05.05.05	L Band			101.8	281.1	12.0	12.0	12.0			418.9
6.05.05.10	S Band			238.8	591.4	12.0	12.0	12.0	12.0		878.2
6.05.05.15	C Band			295.1	484.1	15.0	15.0	15.0	15.0		839.2
6.05.05.20	X Band			77.4	185.4	23.4	23.4	23.4			333.0
6.05.05.25	Ku Band			504.3	369.6	22.5	22.5	22.5	22.5		963.9
6.05.05.30	K Band		44.6	127.6							172.2
6.05.05.32	K Band Completion (7 units)	149.9	150.0								299.9
6.05.05.35	Ka Band			30.0	579.2	1341.0	30.0	30.0	30.0		2040.2
6.05.05.40	Q Band			1.3	18.1	130.1	474.1	169.8	18.0		811.4
6.05.05.45	Q Band Completion (5 units)	89.5	249.4								338.9
6.05.10	Feeds		16.8	38.3	94.0	94.0	94.0	94.0	69.8		500.9
	Sub-Total M&S	239.4	460.8	1414.6	2602.9	1650.0	683.0	378.7	167.3	0.0	7596.7
	Travel										
	Sub-total M&S+T	239.4	460.8	1414.6	2602.9	1650.0	683.0	378.7	167.3	0.0	7596.7
	Labor	18.3	399.0	553.1	564.0	539.9	511.4	415.4	320.9	79.4	3401.4
	Sub-Total M&S+T+L	257.7	859.8	1967.7	3166.9	2189.9	1194.4	794.1	488.2	79.4	10998.1
	Redirected Ops Effort	-6.1	-307.6	-360.0	-378.1	-353.9	-336.9	-246.9	-181.6	-67.4	-2238.5
	Total	251.6	552.2	1607.7	2788.8	1836.0	857.5	547.2	306.6	12.0	8759.6
	Total EVLA FTE's:	1.0	1.7	1.0	2.5	2.5	2.3	2.3	1.5	0.0	15.0
	Total Off-Budget FTE's:	0.0	4.5	7.5	9.7	8.7	8.4	6.4	4.5	0.1	49.7
	Total FTE's:	1.0	6.2	8.5	12.2	11.2	10.7	8.7	6.0	0.1	64.6

6.06 Local Oscillator System

		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.06.01	Mgmt/Subsystem Eng										0.0
6.06.05	Central Reference System		40.0	79.0	12.0						131.0
6.06.10	First LO System	10.0	20.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	870.0
6.06.15	Second LO System	20.0	30.0	180.0	180.0	180.0	180.0	180.0	180.0	180.0	1310.0
6.06.20	Antenna Reference System		42.0	113.5	113.5	103.5	98.5	93.5	93.5	93.5	751.5
	Sub-Total M&S	30.0	132.0	492.5	425.5	403.5	398.5	393.5	393.5	393.5	3062.5
	Travel				4.3						4.3
	Sub-total M&S+T	30.0	132.0	492.5	429.8	403.5	398.5	393.5	393.5	393.5	3066.8
	Labor	40.7	311.5	305.4	293.2	244.3	244.3	232.1	232.1	232.1	2135.7
	Sub-Total M&S+T+L	70.7	443.5	797.9	723.0	647.8	642.8	625.6	625.6	625.6	5202.5
	Redirected Ops Effort	-24.4	-164.9	-158.8	-146.6	-97.7	-97.7	-85.5	-85.5	-85.5	-946.6
	EVLA Total	46.3	278.6	639.1	576.4	550.1	545.1	540.1	540.1	540.1	4255.9
	EVLA FTE's:	0.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	20.2
	Off-Budget FTE's:	0.3	2.8	2.7	2.4	1.7	1.7	1.5	1.5	1.5	16.0
	Total FTE's	0.6	5.2	5.2	4.9	4.2	4.2	4.0	4.0	4.0	36.2

6.07	Fiber Optic System										
		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.07.01	Mgmt/Subsystem Eng										0.0
6.07.05	Fiber System		1065.0	1261.0	1040.0	920.0	920.0	820.0	700.0		6726.0
6.07.10	Antenna Outfitting										0.0
	Sub-Total M&S	0.0	1065.0	1261.0	1040.0	920.0	920.0	820.0	700.0	0.0	6726.0
	Travel	10.8	19.4	8.6	4.3	4.3	4.3	4.3			56.0
	Sub-total M&S+T	10.8	1084.4	1269.6	1044.3	924.3	924.3	824.3	700.0	0.0	6782.0
	Labor	52.5	234.2	185.1	179	179	83.3	83.3	79.2	48.9	1124.5
	Sub-Total M&S+T+L	63.3	1318.6	1454.7	1223.3	1103.3	1007.6	907.6	779.2	48.9	7906.5
	Redirected Ops Effort	-22	-63.2	-14	-7.9	-7.9	-1.8	-1.8	-1.8		-120.4
	Total	41.3	1255.4	1440.7	1215.4	1095.4	1005.8	905.8	777.4	48.9	7786.1
	EVLA FTE's:	0.4	3.0	3.0	3.0	3.0	1.6	1.6	1.5	1.0	18.1
	Off Budget FTE's	0.2	0.8	0.2	0.1	0.1	0.0	0.0	0.0	0.0	1.5
	Total FTE's	0.6	3.8	3.2	3.1	3.1	1.6	1.6	1.5	1.0	19.6

6.08 Intermediate Frequency System

		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.08.01	Mgmt/Subsystem Eng	20.0	20.0								40.0
6.08.05	Band Switches		429.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	3089.0
6.08.10	Samplers		20.0	94.0	161.0	161.0	161.0	161.0	161.0	161.0	1080.0
6.08.15	Transition Hardware		25.0	25.0	45.0	45.0	45.0	45.0	45.0	45.0	320.0
	Sub-Total M&S	20.0	494.0	499.0	586.0	586.0	586.0	586.0	586.0	586.0	4529.0
	Travel										0.0
	Sub-total M&S+T	20.0	494.0	499.0	586.0	586.0	586.0	586.0	586.0	586.0	4529.0
	Labor	6.1	262.7	283.0	307.4	264.7	264.7	264.7	264.7	264.7	2182.7
	Sub-Total M&S+T+L	26.1	756.7	782.0	893.4	850.7	850.7	850.7	850.7	850.7	6711.7
	Redirected Ops Effort	-6.1	-42.8	-63.1	-87.6	-93.7	-93.7	-93.7	-93.7	-93.7	-668.1
	Total	20.0	713.9	718.9	805.8	757.0	757.0	757.0	757.0	757.0	6043.6
	Total EVLA FTE's:	0.0	4.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	27.0
	Total Off-Budget FTE's:	0.1	0.7	1.1	1.3	1.4	1.4	1.4	1.4	1.4	10.2
	Total FTE's	0.1	4.7	5.1	5.3	4.4	4.4	4.4	4.4	4.4	37.2

6.09 Correlator

		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.09.01	Mgmt/Subsystem Eng	25.0	70.0	30	150.0	30.0	30.0	30.0	15.0		380.0
6.09.05	NRAO Correlator Interface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.09.10	Pre Project Tooling Setup	124.0	167.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	291.0
6.09.15	Station Board	0.0	0.0	0.0	122.0	0.0	1830.0	0.0	0.0	0.0	1952.0
6.09.20	Sub-Band Distributor Backplane	0.0	0.0	0.0	4.0	0.0	12.0	0.0	0.0	0.0	16.0
6.09.25	Station Data Fanout Board	0.0	0.0	0.0	3.5	0.0	290.0	0.0	0.0	0.0	293.5
6.09.30	Baseline Entry Backplane	0.0	0.0	0.0	4.0	0.0	33.0	0.0	0.0	0.0	37.0
6.09.35	Baseline Board	0.0	125.0	125.0	287.0	0.0	2000.0	0.0	0.0	0.0	2537.0
6.09.40	Phasing Board	0.0	0.0	0.0	22.0	0.0	70.0	0.0	0.0	0.0	92.0
6.09.45	Phasing Board Entry Backplane	0.0	0.0	0.0	1.0	0.0	3.5	0.0	0.0	0.0	4.5
6.09.50	TIMECODE Generator Box	0.0	0.0	0.0	4.5	0.0	4.0	0.0	0.0	0.0	8.5
6.09.55	Real-time S/W development	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.09.60	System Design (racks, power, cabling, computing)	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	20.0
6.09.65	Production model test/burn-in	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.09.70	System Integration + Test ---Penticton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.09.75	System Integration + Test ---VLA off-line	0.0	0.0	0.0	0.0	4.0	0.0	1849.0	30.0	17.0	1900.0
6.09.80	On-line debug, test --VLA on -line	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total M&S	149.0	362.0	155.0	618.0	34.0	4272.5	1879.0	45.0	17.0	7531.5
	Travel		4.3	4.3	4.3	4.3	4.3				21.5
	Sub-total M&S+T	149.0	366.3	159.3	622.3	38.3	4276.8	1879.0	45.0	17.0	7553.0
	Labor		30.5	30.5	42.8	55.0	128.3				287.1
	Sub-Total M&S+T+L	149.0	396.8	189.8	665.1	93.3	4405.1	1879.0	45.0	17.0	7840.1
	Redirected Ops Effort		-30.5	-30.5	-42.8	-55.0	-128.3				-287.1
	Total	203.1	749.4	800.1	1112.7	506.4	4641.9	2502.9	365.7	152.9	11035.1

6.09 Correlator (Cont'd)										
EVLA FTE's:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NRAO Off-Budget FTE's	0.0	0.4	0.4	0.6	0.8	1.8	1.2	0.0	0.0	5.2
Canadians FTE's:	0.4	5.0	8.8	6.6	7.5	6.7	7.9	3.2	1.4	47.5
Total FTE's	0.4	5.4	9.2	7.2	8.2	8.4	9.2	3.2	1.4	52.7
Total Labor $	54.1	413.6	671.3	533.2	523.1	493.4	623.9	320.7	135.9	3769.2
NRAO Ops Effort		-30.5	-30.5	-42.8	-55.0	-128.3				-287.1
Canadian Labor	54.1	383.1	640.8	490.4	468.1	365.1	623.9	320.7	135.9	3482.1

6.10 Monitor and Control

		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.10.01	Mgmt/Subsystem Eng										0
6.10.05	M&C Electronic Hardware	17.0	13.0	100.0	100.0	100.0	100.0	100.0	100.0		630
6.10.10	M&C Network, Hdwre & Sftware		59.0	65.5	13.0	22.0			25.0	43.0	227.5
6.10.15	M&C Computing Systems Hrdwre & Sftwre		173.0	94.3	140.1	93.6	102.6	80.0	22.8	18.8	725.2
6.10.20	M&C EVLA Software										0
6.10.25	M&C Voice Communications										0
6.10.30	M&C Transistion Hardware		10.0	20.0	20.0	20.0	20.0	20.0	20.0		130
	Sub-Total M&S	17.0	255.0	279.8	273.1	235.6	222.6	200.0	167.8	61.8	1712.7
	Travel	2.2	112.9	161.3	133.3	19.4	15.1	4.3	4.3	2.2	455.0
	Sub-total M&S+T	19.2	367.9	441.1	406.4	255.0	237.7	204.3	172.1	64.0	2167.7
	Labor	110.5	753.9	1085.1	999.0	468.4	206.4	368.1	483.4	381.7	4856.5
	Sub-Total M&S+T+L	129.7	1121.8	1526.2	1405.4	723.4	444.1	572.4	655.5	445.7	7024.2
	Redirected Ops Effort	-110.5	-612.6	-958.4	-823.7	-391.5	-172.9	-265.7	-380.9	-296.9	-4013.1
	Total	19.2	509.2	567.8	581.7	331.9	271.2	306.7	274.6	148.8	3011.1
	EVLA FTE's:	0.0	2.1	1.9	2.4	1.0	0.5	1.4	1.4	1.2	11.8
	Off-Budget FTE's:	1.4	7.4	10.9	9.8	4.6	2.2	3.0	4.0	2.8	46.3
	Total FTE's	1.4	9.5	12.8	12.2	5.7	2.6	4.4	5.4	4.0	58.2

6.11 Data Management & Computing

		2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.11.01	Mgmt/Subsystem Eng										0.0
6.11.05	Proposal Preparation and Submission										0.0
6.11.10	Observation Preparation Software										0.0
6.11.15	Observation Scheduling										0.0
6.11.20	Image Pipeline										0.0
6.11.25	Data Archive										0.0
6.11.30	Data Post Processing										0.0
6.11.35	Networking			102	254	29.5	27	34	26	26	498.5
6.11.40	Computing Hardware		6	6	6	56	6	150	100	500	830.0
	Sub-Total M&S	0.0	6.0	108.0	260.0	85.5	33.0	184.0	126.0	526.0	1328.5
	Travel		4.3	6.5	6.5						17.3
	Sub-total M&S+T	0.0	10.3	114.5	266.5	85.5	33.0	184.0	126.0	526.0	1345.8
	Labor		119.1	182.2	176.1	119.1	119.1	119.1	119.1	91.6	1045.4
	Sub-Total M&S+T+L	0.0	129.4	296.7	442.6	204.6	152.1	303.1	245.1	617.6	2391.2
	Redirected Ops Effort		-9.2	-72.3	-66.2	-9.2	-9.2	-9.2	-9.2		-184.5
	Total	0.0	120.2	224.4	376.4	195.4	142.9	293.9	235.9	617.6	2206.7
	Total EVLA FTE's:	0.0	2.5	2.8	2.8	2.5	1.8	1.8	1.8	1.2	17.1
	Off-Budget FTE's:	0.0	0.1	1.2	1.1	0.1	0.1	0.1	0.1	0.0	2.7
	Total FTE's:	0.0	2.6	4.0	3.8	2.6	1.8	1.8	1.8	1.2	19.8

6.12 Education & Public Outreach

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Sub-total
6.12.05 EVLA Contribution to new Visitor Center							250.0	250.0		500.0
Sub-Total M&S							250.0	250.0		500.0
Travel										
Sub-total M&S+T	0.0	0.0	0.0	0.0	0.0	0.0	250.0	250.0	0.0	500.0
Labor										0.0
Sub-Total M&S+T+L	0.0	0.0	0.0	0.0	0.0	0.0	250.0	250.0	0.0	500.0
Redirected Ops Effort										
Total	0.0	0.0	0.0	0.0	0.0	0.0	250.0	250.0	0.0	500.0

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