NATIONAL RADIO ASTRONOMY OBSERVATORY

November 18, 2002

M E M O R A N D U M

To: F. Lo

From: K. Kellermann, P. Napier, F. Owen, R. Perley, J. Ulvestad

Subject: Los Alamos VLBA/NMA Antenna

As you are probably aware, over past year or so, several of us had heard informally from colleagues at Los Alamos that due to increasing security, combined with planned increasing activity by LANL in TA 33, that after some point in time, they would like us to remove the VLBA at the current site on the grounds of LANL.

On October 30, KIK received a call from Bill Press, LANL Deputy Director, confirming their desire to have us move off the current site. The purpose of Press's call was to inquire about how to initiate the negotiations and procedures to remove the antenna. He was told to write to the NRAO Director.

In the course of discussion, Press communicated the following.

There are plans for greatly increased highly classified activity in and around TA 33 .

Increased security in effect since Sept. 11, 2001 makes future co-occupation unfeasible.

There is no rush to get rid of us. They will respect the terms of the current agreement signed last year which he stated has four years to run. We should not expect the agreement to be renewed.

LANL understands that it will b e expensive to move the antenna and they are "willing to help." Press mentioned $1 million. KIK responded that we had a budgetary estimate of about $3 million. Press responded that there was room for negotiation. KIK replied that NRAO didn't have any funds with which to negotiate. The current $3 million estimate is consistent with a $2 million estimate for relocating the antenna that was communicated in a 1986 letter from the NSF to LANL.

Other sites at LANL may be considered. He mentioned Fenton Hill which is on nearby Forest Service land leased by LANL. But we are concerned about rfi at this exposed site.

Subsequent discussions among us noted the following.

Even now, NRAO access to the LA antenna site is limited to U.S. citizens, and this is already an operational difficulty.

We note, that contrary to Press's understanding, that the current lease is for ten years and is in effect until December 2011. However, there is also a clause in the agreement that says that either party may cancel the agreement with only 30 days notice. Also, upon vacating the site, NRAO is required to restore it to its previous condition.

Independent, of LANL's security concerns, it appears that the cost of introducing fiber to the current site might be prohibitive. So moving the antenna is not undesirable from our perspective. LANL does not know this and it is probably best to keep it to ourselves. However, we are quite reluctant to move to Fenton Hill as it may also entail prohibitive fiber costs.

If we want to be prepared to move the antenna in 2006, we need to identify the new site in 2003 and begin the EIS process.

A copy of the lease agreement between the NSF and DOE is attached.

After you have received some formal communication from LANL, we would like to get together with you to help formulate a response. These lease agreements were negotiated between the NSF and DOE with little regard for NRAO input. Moreover, NRAO efforts to negotiate an MOU between NRAO and LANL to cover ongoing operations and access has met with no success.

Subject: Los Alamos antenna meeting summary
From: Jim Ulvestad <julvesta@aoc.nrao.edu>
Date: Wed, 19 Feb 2003 11:19:39 -0700
To: flo@zia.aoc.NRAO.EDU, brodrigu@zia.aoc.NRAO.EDU
CC: jdesmond@zia.aoc.NRAO.EDU, kkellerm@zia.aoc.NRAO.EDU, mmckinno@zia.aoc.NRAO.EDU, fowen@zia.aoc.NRAO.EDU, rperley@zia.aoc.NRAO.EDU, gtaylor@zia.aoc.NRAO.EDU, cwalker@zia.aoc.NRAO.EDU, wpriedhorsky@lanl.gov

February 19, 2003

TO: K. Y. Lo

FROM: Jim Ulvestad

SUBJECT: Los Alamos antenna meeting summary

CC: Jim Desmond, Ken Kellermann, Mark McKinnon, Frazer Owen, Rick Perley, Bill Priedhorsky, Greg Taylor, Craig Walker

Frazer Owen and I met today with Bill Priedhorsky of Los Alamos to begin the discussion of options for the future of the Los Alamos VLBA antenna. We discussed the need for LANL and its customers to have Technical Area 33 be "clean" for classified work. We also discussed the need of NRAO and its users to have the short baselines to Los Alamos available in the VLBA, as well as the need for this antenna as part of the New Mexico Array in the EVLA phase 2. Beyond these stage-setting exercises, the following major issues were considered.

ALTERNATIVE ANTENNA LOCATIONS

We identified four possible alternatives for location of the antenna. These are listed below, with some pros and cons:

(1) Stay at Technical Area 33
-- Incompatible with LANL needs for classified work.

(2) Move to another LANL Technical area
-- Negatives are cost of fiber access, and the possibility that long-term site access issues similar to those in Technical Area 33 could arise in the future.

(3) Move to Fenton Hill Observatory, at about 9000 feet in the Jemez Mountains, west of LANL (used by LANL for other astronomical experiments such as searching for optical transients)
-- Negatives are availability and cost of fiber access, site infrastructure/ownership (currently leased from the Forest Service by LANL), winter weather, and possible RFI. Positive is the possibility of permanent access.

(4) Move to New Mexico Array site near Corona (ESE of Albuquerque)
-- Negatives are losing the LANL connection and the hook to expand the SKA to the north. Positives are possible fiber access, and immunity from future LANL needs.

ANTENNA DISPOSITION

We discussed the possibility of LANL taking over the current antenna, with a new antenna/station being built elsewhere. Our best estimate of the cost differential is that building a new antenna would cost about $2.7M more than moving the current antenna ($6.2M vs. $3.5M for

antenna structure and site infrastructure, not including receivers). It seems unlikely that the possible R&D users of the antenna at LANL could come up with that cost differential.

TIME SCALE

A quasi-independent issue is time scale. If the antenna needs to be moved before 2008, there is little or no chance of any new New Mexico Array antennas being available, implying that the VLBA would lose ~40% of its short/intermediate baselines for a period of six months or longer. If the antenna move could be delayed until 2009 or later, there is some chance that the first New Mexico Array antenna might be available, and could be used to replace the current Los Alamos antenna for (at least) some VLBA programs. It appears that a fixed date of January 1, 2009 (for instance) for removing the antenna might be compatible with LANL needs; the question is whether another antenna could be available to the VLBA in that time frame.

ACTION ITEMS

LANL: (AI1) Look into possible alternatives to the only fiber access route NRAO has found for the Los Alamos area.
(AI2) Look into site ownership/maintenance issues at Fenton Hill.
(AI3) Look into possibility of guaranteeing long-term access to another LANL Technical Area.

NRAO: (AI1) Investigate the RFI issues at Fenton Hill more thoroughly. (E.g., what is the nature of the visible microwave facility, and the likelihood of it causing RFI? Can LOFAR-related measurements that have been made below 1 GHz tell us anything useful?)
(AI2) JSU to write title and abstract for a talk to give at astrophysics lunch at LANL, then use that talk as a venue for a visit to LANL and further discussions.

SUMMARY

We seem to be on track toward producing a report with detailed alternatives and costs by summer 2003.

Subject: LANL summary, for reference
From: Jim Ulvestad <julvesta@aoc.nrao.edu>
Date: Thu, 07 Aug 2003 13:19:53 -0600
To: flo@revere.aoc.nrao.edu, brodrigu@zia.aoc.NRAO.EDU

file

Brief summary of what the LANL memo will say (jsu, 8/7/03)

Discarded options

Option 1: Leave antenna where it is.
------ Unacceptable to LANL
Option 2: Move antenna elsewhere on LANL.
------ No obvious location
------ Same issue may arise again in 5-10 years
------ No inexpensive fiber access
Option 3: Move antenna to location in National Forest (Fenton Hill)
where Los Alamos has optical transient telescope
------ No existing fiber access
------ NRAO would become responsible for infrastructure
------ High elevation (9000 feet); winter access may be an issue
Option 4: Give antenna to LANL, build another one elsewhere
------ Cost of new antenna (not counting electronics) is
$5-6 million; LANL has no need for the antenna that
would be worth more than a few hundred k$.
Option 5: Dismantle antenna, build another antenna elsewhere.
------ Cost of new antenna is $5-6 million, plus $0.5 million
for infrastructure replacement, plus dismantling cost
for old antenna. Total around $6M. Cost of moving
old antenna and re-erecting elsewhere is $4M, including
dismantling, moving, re-erecting, replacing infrastructure,
and 15% contingency. Difference between moving old
antenna and building new one is at least $2M.

Remaining option

Preferred option: Move antenna to location near Corona/Vaughn, southeast of Albququerque, northwest of Roswell. Cost is $4M, including 15% contingency. Project management, etc., is included. Personnel costs to contractor included. Personnel costs to NRAO beyond moving and re-erecting the antenna are not included, because we assume that the cost of bringing up the old antenna and bringing up the new antenna (e.g., scientist test time) are the same. Cost of upgrading receivers and electronics from VLBA to EVLA capability is not included, because this is included in the EVLA-2 proposal, and will be done only if EVLA-2 is funded.

Time scale: Moving the antenna would require significant preparation, going out to bid, etc. Can't go to bid without some guarantee of funding. So my scenario is that the earliest we could go out to bid would be late FY 2004. FY 2005 would include negotiation, planning, and site preparation at the new location. FY 2006 would be the year for moving the antenna and re-erecting it. It's hard for me to see this going any faster.

file

October 7, 2003

TO: K. Y. Lo, W. Press

FROM: W. Priedhorsky, J. Ulvestad

SUBJECT: The Fate of the VLBA antenna at LANL TA-33

ABSTRACT

Los Alamos National Laboratories (LANL) has requested the removal of the antenna of the Very Long Baseline Array that currently is operated from LANL Technical Area 33. A number of options have been investigated, and the preferred option is to relocate the antenna to a site near Corona, New Mexico. Operation of the antenna at the Corona site would preserve the current imaging capability of the VLBA and enable integration of the antenna into the proposed New Mexico Array of the Expanded Very Large Array. The estimated cost for relocation of the antenna to the proposed new site, including an Environmental Impact Study, is approximately $4.26 million in FY 2003 dollars. This compares to a cost of $7.90 million for erecting a new antenna at the Corona site. If an Environmental Impact Study and detailed site selection could begin in FY 2004, it is likely that the antenna could be moved in FY 2006 or FY 2007. This would significantly impact the scientific performance of the VLBA for the period during which the Los Alamos/Corona antenna is unavailable.

1.0 Introduction

The Very Long Baseline Array (VLBA) is a continent-wide array of radio telescopes, part of the National Radio Astronomy Observatory, which is operated by Associated Universities, Inc., under a cooperative agreement with the National Science Foundation (NSF). NSF has an agreement with the Department of Energy (DOE) that permits use of Los Alamos National Laboratory (LANL) Technical Area 33 (TA-33) for the placement and operation of one of the ten antennas of the VLBA. Because of increased use of TA-33 for other programs, LANL desires that the VLBA antenna be removed from the VLBA site within the next few years. The VLBA antenna currently at LANL is integral to the operation of the VLBA, and also critical to the design and construction of the New Mexico Array. The New Mexico Array is the major component of the concept for Phase II of the Expanded Very Large Array (EVLA), for which a proposal to NSF is in the final stages of preparation. The antennas of the New Mexico Array would be operated at high bandwidth in conjunction with the VLA, requiring affordable real-time fiber connections that supply approximately 120 Gbits per second per antenna station to the remote VLA site west of Magdalena.

This memo outlines the different options for disposition of the antenna currently sited at LANL, recommends the most viable option, and assesses the cost of that option.

2.0 Antenna Disposition Options

2.1 Continue VLBA Operation at TA-33

One option is to leave the VLBA antenna at TA-33 for the indefinite future, with continued operation as part of the VLBA. This option is not feasible for more than a few years beyond 2003, due to the increased use of TA-33 by other customers. Leaving the antenna in place until its removal is "forced" runs the risk of a hurried operation to move the antenna, which would be satisfactory to neither NRAO nor LANL.

2.2 Continue VLBA Operation at Another LANL Technical Area

There may be other "less-popular" technical areas within LANL property that could be used for placement and operation of the VLBA antenna. However, such underutilized sites have essentially the same character as TA-33 when the VLBA antenna first was placed there, and may become popular sites for other programs in the future. This could lead to a repeat of the current situation a few years in the future, another expensive antenna move, and another disruption to VLBA operations. The desire on both sides to eliminate a repetition of the current situation makes this option undesirable.

2.3 Transfer the VLBA Antenna to LANL; Build a Replacement

The VLBA antenna could be transferred to LANL for its own research activities, with a new VLBA antenna to be built elsewhere to replace it. A recent cost estimate for eight new antennas identical to the VLBA antennas has been made for the proposal for phase II of the EVLA. The total cost of eight antennas (from Table 5.4 of the EVLA Phase II proposal)is $35.493 million in FY 2003 dollars, or $4.44 million per antenna. Adding $0.78 million for site work (Table 5.6 of the EVLA Phase II proposal) gives a cost of $5.22 million. In addition, there is the cost of outfitting the new antenna with receiving and electronics systems, assuming that the old VLBA antenna is left at Los Alamos with its full set of integrated receiving systems. The cost of a full EVLA electronics system for the New Mexico Array is approximately $1.55 million per antenna. This includes front ends, local oscillators, intermediate-frequency systems, and fiber optics, but does not include new wideband low-frequency systems. Adding 15% contingency then gives a total cost of $7.79 million. If the new antenna were built for the VLBA prior to EVLA Phase II approval, a separate Environmental Impact Study will be required, at an approximate additional cost of $0.1 million, or $0.115 million with 15% contingency. The total cost thus is $7.90 million.

If the EVLA Phase II is not approved, outfitting of the new antenna with receiving and electronics systems compatible with the current VLBA would cost somewhat less than $1.55 million. However, this would be balanced by the fact that the price for acquiring only one new antenna most likely would be 10%-20% higher than the cost per antenna for nine antennas. In fact, even if EVLA Phase II ultimately is approved, the time when LANL would like NRAO to leave TA-33 appears to be earlier than when an antenna contract for might be place for EVLA Phase II, in

which case quantity "discounts" would not be applicable. Therefore, $7.90 million may be a fairly low estimate for the cost of a new antenna, either with or without the ultimate approval of EVLA Phase II. Since there is another option that costs nearly $4 million less, building a replacement antenna is not favored.

2.4 Move VLBA Antenna to Fenton Hill

LANL operates a facility on U.S. Forest Service land in the Jemez Mountains, at Fenton Hill, 60 km west of Los Alamos. This facility hosts a high-energy cosmic-ray detector as well as the Raptor telescope that is used to detect optical transients. It is at considerably higher elevation than TA-33 (roughly 2650 meters vs. 1970 meters) and would have somewhat more difficult winter access and operating conditions. Since NRAO desires to use the telescope as part of the New Mexico Array, proposed for EVLA Phase II, locating the antenna at Fenton Hill would require affordable fiber access at over 100 Gigabits per second between Fenton Hill and the VLA site west of Magdalena. Fenton Hill is approximately 30 kilometers from the nearest fiber access, which is operated by Qwest Communications. The cost and complexity of running fiber between Fenton Hill and the nearest trunk line, as well as the cost of leasing sufficient bandwidth from Qwest, is thought to be at least several times higher than any of the other New Mexico Array sites, such as the one near Corona, New Mexico (see Section 2.6).

2.5 Scrap the VLBA Antenna without Replacement

The option of scrapping the VLBA antenna is included for completeness. The number of baselines available for an N-antenna array is N(N-1)/2, or 45 for the 10-antenna VLBA. Reducing N to 9 would reduce the number of baselines to 36, a 20% degradation in the sensitivity and aperture-plane coverage of the array. Even worse, the VLBA contains 10 baselines under 1000 km, 4 of which involve the Los Alamos antenna. Thus 40% of the short baselines, crucial to useful imaging of any extended VLBI sources, would be lost. The cost of scrapping the antenna would be relatively small, but the loss of scientific capability for the VLBA implies that this is not a viable option.

In the EVLA Phase II proposal, the Los Alamos antenna (moved) is assumed to be one of the ten antennas of the New Mexico Array. If EVLA Phase II is approved, it would need to be replaced. The additional cost to the EVLA Phase II Project, not currently budgeted in their proposal, would be at least $7.79 million, as outlined above in Section 2.3.

2.6 Move the VLBA Antenna to Another New Mexico Location

The VLBA antenna could be moved to another location in New Mexico, significantly removed from LANL. Studies for the EVLA Phase II proposal have identified a location near Corona, New Mexico, southeast of Albuquerque and roughly 250 kilometers by road from TA-33. The Corona location has been selected because it preserves the current mix of short and long baselines in the VLBA, and also enabled the design of

a New Mexico Array configuration that has optimal imaging characteristics when combined with the current VLA. This site has been investigated as part of the planning for the EVLA Phase II proposal, and locations have been identified where there is access to suitable land, as well as power and low-cost fiber access from local telephone companies. The option of moving to the Corona site would have a similar cost to that of moving to Fenton Hill (Section 2.4). However, the Corona site has current fiber access, and much lower annual fiber costs, so this location is favored over Fenton Hill.

A conservative cost estimate for moving the Los Alamos antenna from TA-33 has been derived by discussions with commercial companies, and is detailed in the table below. All costs are in FY 2003 dollars. For appropriate comparison with the estimate for a replacement antenna (Section 2.3), it is assumed that all front end systems are moved with the antenna or else transferred to a new antenna, so no cost of such systems is included here.

TABLE 1: COST ESTIMATE FOR MOVING VLBA ANTENNA TO CORONA

Antenna Move & Re-Erection:	
Program Management and engineering	$0.345M
Antenna disassembly	$0.761M
Antenna installation	$1.584M
Shipping (within 100 miles)	$0.078M
Addition for more distant shipping	$0.051M
Site Work (contractor)	$0.695M
Site Work (NRAO)	$0.087M
Environmental Impact Study (see note)	$0.100M
SUBTOTAL	$3.701M
Contingency @ 15%	$0.555M
TOTAL	$4.256M

NOTE TO TABLE: In the EVLA Phase II Proposal, the Environmental Impact Study was estimated as a single item for the entire New Mexico Array. If the Los Alamos VLBA antenna were moved to Corona prior to the start of EVLA Phase II, a separate study would be necessary for this single site. An estimated cost of $100K has been added for this study.

3.0 Time Scale and Closing Remarks

We have investigated various possibilities for the disposition and/or replacement of the VLBA antenna currently sited at LANL TA-33. The preferred alternative is to move the antenna to a site near Corona, New Mexico, at an incremental cost of $4.26 million in FY 2003 dollars. Given the fact that an Environmental Impact Study (EIS) would need to be prepared for this new site, we expect that a lead time of roughly two years would be required to move the antenna. If funding were made available to begin the EIS process in FY 2004, we anticipate that it might be possible to move the antenna in FY 2006 or FY 2007. It should be noted that moving the VLBA antenna to ANY new location, including

Subject: Total Move Costs for Los Alamos VLBA Antenna
From: Jim Ulvestad <julvesta@nrao.edu>
Date: Tue, 9 Mar 2004 11:15:01 -0700 (MST)
To: David Hogg <dhogg@nrao.edu>, Ted Miller <tmiller@nrao.edu>
CC: Jim Ulvestad <julvesta@nrao.edu>, Mark McKinnon <mmckinno@nrao.edu>, <madams@nrao.edu>, Fred Lo <flo@nrao.edu>, Peter Napier <pnapier@nrao.edu>, Frazer Owen <fowen@nrao.edu>, Rick Perley <rperley@nrao.edu>, Greg Taylor <gtaylor@nrao.edu>

March 9, 2004

TO: Dave Hogg, Ted Miller

FROM: Jim Ulvestad, Mark McKinnon

SUBJECT: Total Move Costs for Los Alamos VLBA Antenna

CC: Mark Adams, Fred Lo, Peter Napier, Frazer Owen, Rick Perley, Greg Taylor

SUMMARY

This memo outlines the total cost for moving the Los Alamos VLBA antenna to a new site near Corona, New Mexico. Previous memos identified only the contractor costs. Here, we have added NRAO costs for program management, antenna outfitting and engineering, site development, and scientific testing to bring the antenna back up to operational status. On this basis, including a 15% contingency, the total cost in FY04 dollars is estimated to be $5.01 million.

(1) CONTRACTOR COSTS

The following table includes cost estimates that have been provided informally or taken from our previous experience with VLBA antennas. Costs have been inflated from previous estimates to arrive at FY04 dollars.

TABLE 1. CONTRACTOR COSTS

Antenna Move & Erection at New Site:	
Program management & engineering	$355K
Antenna disassembly	785K
Antenna installation	1630K
Shipping (within 100 miles)	80K
Addition for more distant shipping ..	50K
Site Work (contractor)	725K
Environmental Impact Study (guess)	100K
TOTAL CONTRACTOR COSTS (NO CONTINGENCY)	$3725K

(2) NRAO COSTS

Most NRAO costs were not included in our previous estimate, consistent with what had been common practice at NRAO. As we move into more rigorous accounting

practices, it is important to account for the complete cost of NRAO personnel, which now is included in this section.

A. Labor to outfit a VLBA antenna

Antenna mechanic, 4 @ 4wks	16
Cryogenics technician, 2 @ 4 wks	8
HVAC technician, 1 @ 4 wks	4
Servo technician, 1 @ 4 wks	4
Electronics technician, 2 @ 4 wks	8
Electrician, 1 @ 2 wks	2
Labor Subtotal	42 wks = 0.81 FTE

The total labor required to remove equipment from the antenna at its present location and then reinstall the equipment at the new location is twice this amount, or 2 * 0.81 = 1.62 FTE.

B. Engineering

The project will require a mechanical engineer to oversee the disassembly and reassembly of the antenna. Also, a civil engineer will be needed at the new site to oversee the installation of the foundations, new building, and fence.

Mechanical Engineer	44 wk
Civil Engineer	50 wk
Engineering total	94 wk = 1.81 FTE

C. Program Management

NRAO will require a program manager to oversee the move. This includes site selection and acquisition, procurement, overseeing the Environmental Impact Study (or Environmental Assessment) and the actual move, and coordinating the tests to bring the antenna to operational status. Some program management also will be done by the civil engineer costed above. We estimate an individual working an average of 30% time for 2.5 years.

Program Manager, 0.3 @ 2.5 yr	39 wk
Program Management total	39 wk = 0.75 FTE

D. Scientific Testing and Integration

Integration of the relocated antenna into the VLBA will require a variety of scientific tests. These include pointing tests, receiver performance tests and calibration, baseline runs to determine the antenna location, and other such activities generally required to make an antenna work as part of the VLBA. Integration also requires updating operational software (e.g., for correlator and scheduling) with the new antenna coordinates, calibration and pointing parameters, and so on. We estimate 0.5 FTE for a scientist doing the testing, and 0.25 FTE for a scientific programmer to update software. In addition, we estimate 0.5 FTE

for operations personnel (data analysts and correlator operators) to process tests and update various operational parameters.

Scientist	26 wk
Scientific Programmer	13 wk
Data Analyst	26 wk
Testing and Integration total	65 wk = 1.25 FTE

E. Lodging & Per Diem

For the purposes of this estimate, we assume that the AOC/VLA is the duty station of all employees working on the project. The total number of days to pay lodging and per diem is as follows:

Outfitting labor force, 84 wks x 5 days	420 days
Civil & mechanical engineers, 70 wks x 5 days	350 days
Program manager, 8 wks x 5 days	40 days
Scientific tester, 4 wks x 5 days	20 days

Per diem (830d x $40/d)	$33K
Lodging (830d x $70/d)	$58K
Subtotal	$91K

F. Materials Costs

Materials costs will be minimized by utilizing existing mounting hardware and electrical cables. However, some of these materials will be destroyed in the process of disassembling and reassembling the antenna. In addition, new electrical materials will be needed to provide site power at the new location. The total cost of these materials is estimated at $45K.

TABLE 2. NRAO COSTS

Wages:	
Antenna Labor, 1.62 FTE @ $45K	$73K
Engineering, 1.81 FTE @ $80K	145K
Program Management, 0.75 FTE @ $100K	75K
Scientist, 0.5 FTE @ $80K	40K
Programmer, 0.25 FTE @ $80K	20K
Data Analyst, 0.5 FTE @ $40K	20K
Wages Subtotal	$373K
Benefits @ 32.5%	$121K
Total Personnel Costs	$494K
Lodging & Per Diem	91K
Materials	45K
TOTAL NRAO COSTS (NO CONTINGENCY)	$630K

(3) OVERALL COST ESTIMATE

Here, we add the Contractor and NRAO costs, plus contingency, to arrive at a total cost estimate for moving the Los Alamos VLBA antenna to a location near Corona, NM. Note that these

costs do not include any NRAO overhead to pay for items such as electricity costs in the AOC, procurement, fiscal, human resources, overall NRAO management, and so on. If NRAO were to go into a complete system of full-cost accounting, such costs would need to be added, possibly at some standard overhead rate.

TABLE 3. OVERALL COST ESTIMATE	
Contractor Costs (from Table 1)	$3725K
NRAO Personnel Costs (from Table 2)	494K
NRAO M&S Costs (from Table 2)	136K
Subtotal	$4355K
Contingency @ 15%	653K
FINAL COST ESTIMATE	$5008K