Final Report
VERITAS 4-Telescope Construction Project
Cost, Schedule, and Management Review
January 31-February 1, 2003

Introduction

A cost, schedule, and management review of the Very Energetic Radiation Imaging Telescope Array System 4-Telescope Construction Project (VERITAS-4) was conducted on behalf of the Department of Energy (DOE) and National Science Foundation (NSF) on January 31-February 1, 2003, at the NSF. The review committee was charged with evaluating the management arrangements and cost and schedule goals of the VERITAS-4 Construction Project. The review committee membership, charge, and agenda are included as appendices to this report.

VERITAS is a ground-based gamma-ray observatory designed to provide significant advances in our understanding of extreme astrophysical processes in the Universe. The present proposal for the observatory, VERITAS-4, comprises four large-aperture (12 m diameter) Cherenkov telescopes, each equipped with an imaging camera. VERITAS-4 science has been reviewed previously, and has been found to be highly compelling.

The VERITAS-4 project office provided documents to the review committee in advance of the review and presented information that responded to the charge. The presentations along with a discussion session provided the information the committee needed for an evaluation. The committee was pleased with the quality of the presentations.

General Conclusions

1. The VERITAS-4 project is ready to proceed with construction. The cost estimates and schedules are sufficiently developed, and the management structure is mature and operational.

2. The collaboration is composed of highly experienced and capable scientists and engineers who should be able to complete this project successfully.

3. The cost estimates are reasonable but the contingency estimate of ~11% of the cost-to-go is very tight. In addition to this cost contingency some scope contingency may be needed to complete the project. The specified cost contingency, combined with the identified scope contingency and the commissioning/pre-operations period recommended below, should be adequate for successful completion of the project.

4. The aggressive schedule is desirable for project management purposes but the corresponding milestone for project completion, defined as first light for the fourth telescope, has very little schedule contingency. The schedule should include an integrated commissioning/pre-operational period, possibly of six months duration, after construction completion.

5. The schedule and cost baseline are highly dependent on the proposed annual funding plan, and delays in funding may jeopardize the schedules and increase the cost of the project.

6. Timely base program support for collaborating groups is essential.

Response to Questions in the Charge

(1) Are the technical, cost, and schedule goals of the construction project well defined, understood and agreed to by all participants?

Presentations and background written material were given to the panel on all these issues.

The technical goals are very clearly defined and well mapped to the scientific goals of the project.

The cost is unusually well defined for a project of this type and at this stage of development, mainly because of knowledge gained from building the prototype telescope. In many cases precise cost quotes are available for key parts of the construction, reducing the overall uncertainty in total cost estimation.

The project schedule is well defined, but aggressive. Important uncertainties in the schedule come from factors outside the control of the VERITAS management group - for example, the funding profile will inevitably have any impact on how well the project can keep to the schedule, which itself inevitably has some cost impact. Nevertheless, we support the aggressive schedule.

Based on the evidence presented to us, the technical, cost and schedule goals of the construction project have all been very well defined and understood - probably rather better defined that most projects of this type at this stage of their life cycle. Not all participants - in particular the European collaborators - were represented at our review meeting, but the project managers have ensured that reasonably good communication is maintained between all partners, so we are confident that all partners have agreed to these goals.

(2) Are the project management arrangements appropriately structured to meet the project goals?

The VERITAS-4 collaboration consists of full members from ten institutions (Iowa State, McGill, N.U.I. Dublin, Purdue, Chicago, U.C.L.A., Leeds, Utah, and Washington University) plus approximately a dozen Associate members. McGill is a recent addition to the collaboration, joining after the proposal was submitted. A detailed and complete Teaming Agreement, spelling out the management plan, has been signed by all collaborating institutions and was made available to the panel. The VERITAS project office consists of the Project Manager (Criswell), Deputy Project Manager (Gibbs), Project Scientist (Weekes), Project Engineer (Williams) and Administrative Assistant (Gardner). The VERITAS Executive Committee (VEC), which consists of 11 senior members of the collaboration, sets policy on issues such as scientific policy, membership, publications, and provides guidance to the project office. The VEC has monthly telephone conference calls.

The Collaboration is mature. The core group has been working together on ground-based gamma-ray astrophysics for more than 20 yrs. The full team now has experience with the prototype telescope. The addition of the Deputy Project Manager has helped to form a strong management team. The VERITAS Project Office is fully staffed, and has been operating for 2-3 yrs.

The construction project is organized in a WBS consisting of 22 subprojects. Each subproject has a designated leader, and the subproject leaders report to the Project Office. The Project Manager holds the contingency for the entire project. In addition, technical Group Coordinators are assigned to ensure that the technical activities and interfaces between the subprojects are coherent. The Groups are Optics/Mechanics, comprising 3 subprojects; Camera, comprising 12 subprojects; Software, comprising 4 subprojects; and Management, comprising 3 subprojects.

The management structure has obviously served the collaboration very well. The individual subprojects have developed their work and spending plans under the guidance and coordination of the Project Office; and the technical design is coherent, appropriate in scope, and well thought through. Despite severe lack of funding of several key institutions, fiscal upheaval due to partial withdrawal of Smithsonian, and great uncertainty over the full life of the project, the team is strong, coherent, and ready to move from R&D to construction.

To reduce costs and risks, flexible procurement strategies will be desirable and should be accommodated by the managing organization (SAO) and the other collaborating institutions, e.g., contracts with multi-year funding options.

Given the inherent difficulties of multi-agency oversight, and the tight schedule and tight contingency, the panel suggests that the agencies very quickly begin working together with the managing organization (Smithsonian) to form an agency oversight group. The oversight group should work with the VERITAS-4 team to define modes of

reporting and spending authority. It would be simplest if the group could designate a single point of contact for the VERITAS-4 team and to organize the group meetings. The panel recommends a modest review of the project soon after Telescope 1 is complete and verified, and then status reviews approximately annually at appropriate milestones. Furthermore, there should be some formal mechanism for the Project Office to communicate project status, including change control actions and use of contingency, to the agencies at regular intervals. It is very important that this mechanism be appropriate in scope, given the relatively small size of the project, so that it is not too burdensome on the VERITAS-4 team. This could be in the form of quarterly reports to the agency oversight group.

(3) Are the project cost estimates well defined, the cost risks understood, and the management systems in place for controlling costs?

The budget for the project was presented. The project cost estimate was well defined and the cost risks seem to be well understood. There are appropriate management systems in place for controlling the costs.

A contingency (management reserve) of around 11% for the project was presented. At first sight this seems very low. However there are two reasons that this contingency is reasonable. One is that much of the construction is modular – it calls for the construction of four identical telescope and camera systems. The second is that the project is quite advanced – essentially all of the pieces of a prototype telescope have been designed and procured, so that the cost experience of this prototype, which is identical to the telescopes to follow, gives a good guide to the costs of the project. They assigned a 5 to 10% contingency to components for which they already have firm orders or quotes for, 20% on items designed but without firm quotes, and 50% on remaining engineering design work.

The overall project schedule presented was an aggressive "success oriented" schedule, and the committee felt some slippage of the final completion date was not unlikely. The collaboration should estimate the financial implications of such a schedule delay. Based on the discussion during the review it seemed that the cost implication might be of the order of $250k per six months of delay.

The possibility of de-scoping the project as a response to either cost overruns or schedule delays was discussed during the review. The collaboration suggested two possibilities. One was reducing the number of mirrors by 100 in each telescope, for a saving of $400k. The second was to omit the outer ring of PMTs in the camera, for a possible total savings of $600k. While de-scoping, with the consequent loss of science capability, is always unattractive, these two possibilities have the advantage that they could be implemented later in the project if the fiscal realities demanded it, and that the omitted mirrors or PMTs could be added at a later time relatively easily.

The committee was a little surprised at the estimated cost (~$850k) of the planned support building at the site of the telescopes; it was explained to the committee that the

Forestry Commission places severe constraints on construction, which results in the relatively high cost. Nevertheless, especially given the possible de-scoping options to be considered, which would potentially have some impact on VERITAS-4 science, we urge the team to look into possibilities of cost savings on the building.

In conclusion the committee feels the specified cost contingency, combined with the identified scope contingency and the recommended commissioning/pre-operations period, is adequate for successful completion of the project.

(4) Are the schedules adequately detailed, integrated, and appropriate for measuring progress and are the schedule risks understood?

The schedule presented appears to be detailed, well integrated and provides reasonable ability to track the project (although a few modifications are planned for tracking purposes). It certainly demonstrates that the project has the necessary tools and personnel in place to proceed. The schedule is very success oriented. In general, critical path tasks do not include explicit schedule contingency. The reason for this is to attempt to inhibit the tendency for comfortable schedules to become self-fulfilling. Although the committee has no objection to this approach, we believe that some slippage is possible.

The presented schedule included three "Decision Dates" which are nominally to be used for the purpose of deciding to proceed with further construction based on successful completion and testing of previous construction. However, due to the desire for a rapid schedule, these dates in fact generally come later than the actual decisions that must be taken to commit to further construction. The dates called out are in fact important milestones and should remain. However, additional "Decision Dates" should be defined.

One approach to new decision dates would be to slightly re-cast the schedule so that the first telescope can be completed, including some evaluation and then proceed with the remaining telescope construction as a single "three telescope" package. This will almost certainly reduce the cost of contracts with vendors and, if done carefully may result in no net slip in the completion date of the project. (Though it may result in some slip in the date for deployment of the second telescope.) Since there appears to be non-trivial budget pressure, this approach may help forestall the need for de-scoping should costs run beyond the currently estimated base plus contingency. The construction of the first telescope and site infrastructure should proceed as rapidly as possible in any case. We urge that during this period the collaboration investigate the possibility of this approach.

Consistent with the scope contingency option, an additional decision point will be required prior to placing the orders for these items.

To prevent delay of Telescope #1 and hence of the overall project, funding is required by 4/1/03.

A final point of importance is the NSF "base" funding of the institutions. These groups have been working with no base funds and that has now stretched about as thin as is possible. It is critical that a decision on whether to proceed is made promptly and that if favorable that the base program requests are expedited. These contributions are of great importance to the overall plan and success of the project. The committee endorses this funding and suggests proceeding with no additional delays.

(5) Are the plans and cost estimates for operations reasonable including on-site facility operations and support for the scientific effort?

The plans and cost estimates for operations are reasonable for this stage of the project. The estimates should be evaluated again in about a year. The collaboration proposed a cost sharing arrangement for the funding agencies. The actual funding agreements for operations must be developed by the agencies.

The construction of VERITAS-4 is complete when all four telescopes are operational. First light for the final telescope is planned for the end of FY 2005 and FY 2006 is planned as the first year of VERITAS-4 operations.

The proposed operations budget for VERITAS-4 in FY2006 is ~$1,600k. This budget estimate has four components: contributions by international collaborators of ~$200k; Smithsonian infrastructure support of $200k; support of the project office at ~$400k (four positions); and, operational support from the VERITAS-4 base program funding of ~$800k (40% of the total base program funding of ~$2,000k). The proposed total annual operations budget is roughly ten percent of the capital cost to construct VERITAS-4.

The Smithsonian support of the Whipple observatory is expected to provide power, water, communications, road and building maintenance, and security for VERITAS as it does for other telescopes.

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REVIEW COMMITTEE MEMBERSHIP

Charles Baltay, Yale University
Darrel Emerson, National Radio Astronomy Observatory
Doug Michael, California Institute of Technology
Steven Ritz, National Aeronautics and Space Administration
Jim Yeck, Chair, Department of Energy

CHARGE

The panel is charged with evaluating the management arrangements and cost and schedule goals of the VERITAS 4-Telescope Array Construction Project. Specific elements of the charge include a response to the following

Questions:

(1) Are the technical, cost, and schedule goals of the construction project well defined, understood and agreed to by all participants?

(2) Are the project management arrangements appropriately structured to meet the project goals?

(3) Are the project cost estimates well defined, the cost risks understood, and the management systems in place for controlling costs?

(4) Are the schedules adequately detailed, integrated, and appropriate for measuring progress and are the schedule risks understood?

(5) Are the plans and cost estimates for operations reasonable including on-site facility operations and support for the scientific effort?

The panel review is scheduled for Friday, January 31, 2003. A closeout is tentatively planned for Saturday, February 1, 2003.

At least one week prior to the review the VERITAS-4 project will make available to the panel a number of key project documents that relate to the charge including the work breakdown structure, cost estimates, schedules, management plan, and a brief response to recommendations from previous agency sponsored reviews.

APPENDIX

As a guide for the review committee, the VERITAS-4 project team is asked to address the following items in their presentation to the panel:

Cost

1) The basis of the cost estimates and the uncertainties in these estimates.
2) The major areas of cost risk.
3) The basis of the contingency estimates.
4) A contingency budget that is commensurate with the uncertainties in the cost estimate and the cost risks.

Schedule and Funding

1) The key elements of the project schedule and the basis for the task duration estimates.
2) The critical path(s) and the schedule float.
3) The major areas of schedule risk.
4) The reasonableness of the summary schedule, the tracking milestones, and the final project completion milestone.
5) The milestones proposed for tracking by the agencies' program managers.
6) The cost and obligation plans.

Management

1) The management structure and strategy for implementing the project.
2) The roles and responsibilities of the project participants.
3) The management systems to be used for configuration control, baseline management, and performance measurement.
4) The status of the project documentation including management plans, quality assurance procedures, and environmental permits, safety authorizations, and ES&H systems.
5) The responses to recommendations to previous reviews sponsored by the agencies.
6) The major items of risk, both internal and external to the project.

VERITAS-4
Cost, Schedule, and Management Review Agenda[i]
NSF Conference Room 309(Main NSF Building)
4201 Wilson Boulevard, Arlington, Virginia 22230

January 31- February 1, 2003

Friday, January 31st

08:30-09:00	Executive Session • Review of the Charge • DOE, NSF, and Smithsonian Perspectives	Jim Yeck
09:00-09:20	VERITAS Overview	Trevor Weekes
09:20-10:00	Management Structure	Steve Criswell
10:00-10:10	Break	
10:10-11:00	Project Costs	Ken Gibbs
11:00-11:30	Project Schedule	Steve Criswell
11:30-11:50	Operational Costs	Simon Swordy & Dave Kieda
11:50-12:00	Summary	Frank Krennrich
12:00-13:00	Lunch	
13:00-14:00	Committee Discussion	
14:00-16:00	Committee Interactions with VERITAS Team	
16:00-	Committee Discussion	

Saturday, February 1st

08:00-10:00	Committee Writing
10:00	Closeout[ii]

[i] Presentations are planned to use half of the allotted time to permit adequate time for questions and discussion. The review will not cover VERITAS science, technique, design, history or outreach.

[ii] The committee plans to provide a draft of the review report at the closeout.