

**Review of Differential Costs for the Two-  
Antenna Implementation of the  
Atacama Large Millimeter Array  
(Delta Review)**

*Submitted to the ALMA Board, 30 January 2006*

## **Report on the Review of Differential Costs for 2-Antenna Implementation the Atacama Large Millimeter Array (ALMA)**

### ***ALMA Differential Cost Review Committee (D-CRC):***

Steven Beckwith (Chair)	Johns Hopkins University
James Crocker	Lockheed Martin Corporation
Thijs de Graauw (Deputy Chair)	Netherlands Institute for Space Research (SRON)
Peter Dewdney	Herzberg Institute of Astrophysics
Rolf Guesten	Max-Planck-Institut für Radioastronomie
Thomas Phillips	California Institute of Technology
Jean Turner	University of California, Los Angeles

## Executive Summary

The Atacama Large Millimeter Array (ALMA) Delta Review Committee reviewed material presented by the ALMA Project to assess the cost impact of using two different antenna manufacturers for the ALMA interferometer. The project managers estimate an additional cost of approximately \$8M to develop a mixed-antenna array – 25 antennas from Vertex and 25 antennas from the AIM consortium – compared to their original estimate for an array of 50 Vertex antennas, exclusive of contract savings that would have accrued from a single Vertex contract. This differential cost is approximately 1% of the estimated \$800M development cost for ALMA. In addition, they estimate conservatively that maintenance costs for the antennas in the operations phase may increase by approximately 10% relative to early estimates, amounting to a few percent of the operations cost over the lifetime of the project.

The committee looked at the detailed costs presented by the project managers and concurs with their estimates. We made an independent order of magnitude estimate of the cost differential to arrive at a similar result. The change in cost brought about by the decision to purchase two types of antennas is therefore small compared to other uncertainties in the development of the project – for example, it is only one-tenth of the \$69M contingency for ALMA construction. With a high degree of confidence, we conclude the use of two antenna types poses no major risk to the successful development of ALMA or to meeting its science goals and represents an inconsequential change in the project cost.

We recommend the ALMA managers include this 1% in their new baseline for cost to complete.

## I. Report

The Differential Cost Review Committee (D-CRC) met in Arlington, VA on 26 January 2006 to review the impact of the decision to operate two separate types of antennas in the ALMA observatory. This committee was a subset of a larger Cost Review Committee (CRC) that met in Garmisch, Germany in 2005 October to review the entire cost basis for ALMA assuming a single vendor (Vertex) for the antennas. The report of the CRC expressed confidence in the cost estimates for ALMA subject to a number of caveats for management of the project and governance of the international partnership.

The D-CRC heard presentations on the current project status, the science impact of using two antenna types, a risk analysis and mitigation strategy for array construction, challenges to the systems engineering and integration team, and an analysis of the changes in project costs in each Integrated Product Team (IPT) area. The presentations included detailed explanations of cost increases and decreases in all project areas with resolution as small as \$10k.

Most of the recommendations of the CRC have either been implemented or are underway. The D-CRC was pleased to hear that the ALMA Board solved two of its most difficult unresolved policy issues in the two months since the CRC report was issued, a policy to employ local labor in Chile and firm contracts for all 50 antennas for ALMA. The contracts are with two separate vendors – Vertex Corporation and the AIM consortium led by Alcatel – meaning that there will be two different types of antennas used to build ALMA. Although the contracts create great confidence in the cost estimates reviewed by the CRC, they imply somewhat different assumptions than used by the CRC in October, hence the need for the differential cost review.

The total cost increase associated with the decision to use two different antenna types is approximately \$8M in a project with a total development cost of approximately \$800M, or about a 1% change. Members of the D-CRC with extensive experience building large projects noted that this increment is less than the typical uncertainty in project estimates. It is approximately 10% of the contingency carried by the ALMA project for construction and could in principle be absorbed in their current budget. Therefore, the D-CRC concentrated on affirming that the cost calculation was of the correct order of magnitude (as opposed to checking each item in detail) and that there were no oversights that would imply substantial cost growth beyond the cost presented to us. We concluded that the 1% cost differential is correct and the use of two antenna types poses no major risk to the successful development of ALMA or to meeting its science goals.

The implementation of 2 different antennas (with later than planned arrival dates of the AIM antennas) results in a delay of operational readiness of the full ALMA by 5-6 months. This delay represents a large unaccounted cost to science from the project that would be mitigated if the Project can recover this delay, as they stated. We support these recovery efforts and consider them important to the overall success of ALMA.

The committee fully endorses the cost estimates presented during this review. We suggest that this additional money be included in the total project cost and not be taken from the current contingency.