ALMA COST ESTIMATING PLAN

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DRAFT

1.O SCOPE

This cost estimating plan defines the guidelines and methodology that will be used to produce and update the ALMA cost estimate. Since the ALMA Project involves both a wide range of tasks, from civil works to superconducting detectors, and it involves many institutional participants through the international partnership, clear guidance is required to assure that the cost estimate is complete, consistent and documented.

2.0 OBJECTIVES

2.1 Total ALMA Project Cost

The primary objective is to develop a cost estimate for the ALMA Project that includes the cost of both Phase 1 and Phase 2 activities. Phase 1, the Design and Development phase, involves the design and prototyping of major system components including procurement and delivery of two prototype antennas. Phase 2, the Construction phase, involves procurement, fabrication, assembly, integration and commissioning of the ALMA hardware together with the management function for these activities. All costs are accumulated in a single spreadsheet for ease of manipulation.

The cost estimate, initially, will be reported as a single sum in year 2000 U.S. dollars. The spending profile will be developed as the funding profiles of the participating ALMA partners is received from those partners.

2.2 Schedule for Delivery of Project Cost

The ALMA Project Cost will be delivered to the ALMA Coordinating Committee (ACC) at the 7 April 2000 meeting of the ACC in Washington, D.C. The schedule for preparation of the cost estimate is attached in the form of a Gantt Chart as Appendix A. Intermediate milestones include delivery of an interim cost estimate on 1 March 2000.

3.0 WORK BREAKDOWN STRUCTURE

The Work Breakdown Structure (WBS) for the joint U.S.-European ALMA Project identifies the Project tasking and the hierarchies and dependencies of the tasks. The WBS has been developed by the ALMA-U.S. Division Heads and the ALMA-Europe Team Managers with approval by the ALMA Executive Committee. The ALMA WBS is

attached in abbreviated form as Appendix B. It includes the following eleven level-1 WBS tasks:

1. Management
2. Site Development
3. Antenna Subsystem
4. Receiver Subsystem
5. Local Oscillator Subsystem
6. Backend Subsystem
7. Correlator
8. Computing Subsystem
9. System Engineering and Integration
10. Science
11. Operations and Maintenance

Costs and contingencies are developed for each subtask of the WBS and rolled up as the summed costs of tasks; the task costs are subsequently rolled up as the summed Project cost.

4.0 BASIS

The basis for the cost estimate is a bottom-up sum of the costs associated with each subtask of the Project-wide WBS. Each cost estimator will develop for the task product tree estimates of (1) the number of staff weeks of effort needed; (2) the materials, supplies, and contracts expense; and (3) the travel expense required.

5.0 COSTING METHODOLOGY

Each WBS cost estimator will complete data input forms detailing information to be entered into the cost database. An example of the *ALMA Cost Data Sheet* given to the cost estimators is attached as Appendix C. The Data Sheet requires the cost estimators to enter the following information for each WBS costed subtask:

- Task description;
- Task duration (or start and stop dates and predecessor tasks);
- Currency used for materials, supplies and contract expense;
- Basis of the estimate;
- Contingency;
- Staff Effort;
- List of materials and estimated cost of each;
- List of contracts and estimated cost of each;
- Cost parameterization.

5.1 Cost Estimators

The cost estimators were selected by agreement between the U.S. and European Project managers. For each subtask the cost estimators are usually the U.S. Division Heads or the European Team Leaders who have responsibility for the relevant tasks within their respective Projects.

5.2 Task Description

The task descriptions are written by the cost estimators for each task and subtask. The descriptions define what elements are included in each task and they note the dependencies of the task on deliveries from other Project tasks and subtasks. All such descriptions are compiled into the WBS dictionary which is a comprehensive summary of the Project.

5.3 Task Duration

Each cost estimator will estimate the duration of the task or subtask assuming that the resources he or she tabulates on the ALMA Cost Data Sheet—both staff effort and M&S funds--are available. In some cases it may be necessary for the cost estimator to associate the task to specific dates rather than state a duration; this option is available.

5.4 Currency

At his discretion, the cost estimator may state the cost of materials, supplies, and contracts in U.S. dollars, Euros, or pounds sterling. The conversion to U.S. dollars will be made by the Project management. All costs are estimated in year 2000 currency.

5.5 Basis of the Estimate

Each cost item within the lowest WBS subtask will be associated with a descriptor that identifies the cost basis on which the cost estimate was made. Four categories of descriptors are being used for the ALMA Project:

- Engineering estimate, bottom-up or parametric analysis (EN);
- Vendor Quotations (VQ);
- Placed Order (PO);
- Actual Cost (AC).

5.6 Contingency

Contingency cost estimation and analysis shall be performed by the cost estimator for each WBS subtask. The results of this analysis will be tabulated for each such subtask.

The contingency methodology to be used is a *bottom-up* computation of the sum of three separately calculated contingencies. These three contingencies correspond to three different risk factors: the technical risk (how difficult is the task?), the cost risk (what is the uncertainty on the cost?), and the schedule risk (how does this task affect the overall

schedule?). Estimators will evaluate the technical, cost and schedule risk factors for a particular WBS task and then enter these factors in the ALMA Cost Data Sheet. Definitions of the risk factors are given in the table below.

Definition of Risk Factors

Risk Factor	Technical	Cost	Schedule
1	Existing design and off the shelf hardware.	Off the shelf or catalog item.	Not used.
2	Minor modifications to an existing design.	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design.	Vendor quote with some design sketches	Not used
4	New design within established product line	In-house estimate for item within current product line.	Delays completion of non-critical path subsystem item.
6	New design different from established product line. Existing technology.	In-house estimate for item with minimal company experience but related to existing capabilities.	Not used.
8	New design. Requires some R&D development but does not advance the state-of-the-art.	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item.
10	New design. Development of new technology with advances the state of the art.	Top down estimate from analogous programs.	Not used
15	New design way beyond the current state of the art.	Engineering judgement.	Not used.

The actual contingencies are arrived at by multiplying each risk factor by a risk percentage. The technical risk percentages differentiate between risks that affect either design or manufacturing as opposed to risks that affect both design and manufacturing. The cost risk percentages differentiate between risks that affect either materials or labor as opposed to risks that affect both materials and labor. Estimators shall assign the technical and cost risk percentages based on the guidance given in the table below and they will enter these percentages into the ALMA Cost Data Sheet. [The schedule risk percentage is a fixed 1%].

Definition of Risk Factors

	Condition	Risk Percentage
Technical	Design or mfg concerns only Design and mfg concerns	2% 4%
Cost	Material cost or labor rate concern Material and labor rate concern	1% 2%
Schedule		1%

Once the risk factors and risk percentages have been estimated the spreadsheet calculates the resulting contingencies which are added together to establish the total contingency for a particular WBS subtask or task. The minimum contingency percentage under this approach is 5%; the maximum is 98%.

There may be special cases where the parameters defined above are inappropriate. In these cases, at the discretion of the estimator, a single percentage contingency may be directly entered into the Cost Data Sheet in the box labeled *Calculated Contingency*. Justification for these cases must be provided in the estimator's basis of estimate.

5.7 Staff Effort

The staff effort is tabulated for each WBS task or subtask either as *task effort* or as *level of effort*. Task effort refers to actual time at the bench spent by a staff member; it is estimated in work-weeks. This is the usual way of accounting for staff time spent on tasks with deliverables. Corrections to this time to account for inefficiencies due to vacation time, sick leave and the like will be made globally by the Project management—the cost estimator tabulates only work-weeks, meaning 5 days of work employed on the task full-time. Level of effort tasking refers to those tasks requiring the presence of an individual in a supervisory or management function. Level of effort tasking usually does not involve a deliverable other than the continuing attention of a staff member.

Staff effort is tabulated separately for five salary grades of employees. These are:

- Grade 5: Secretarial, administrative aides, support technicians;
- Grade 4: Junior engineer or programmer, mid-level technician, machinist, post-doctoral fellows, administrators;
- Grade 3: Senior technician, mid-level engineer or programmer, senior administrator, staff scientist;
- Grade 2: Senior engineer or programmer, senior scientist
- Grade 1: Top level managers and scientists.

The cost estimators specify the effort, in work-weeks, for employees needed on their tasks in each of the above five categories. Separate estimates are made for the effort involved with recurring and non-recurring tasks. In the case of recurring tasks, the estimator will provide the staff effort required for unit production (i.e. production of a quantity of one). The Project management will be responsible for estimating the total staff effort required by including both the production quantity and an assessment of the effect of learning-curve efficiencies.

The Project management will assign a cost per actual work-week. That cost will be a fully burdened cost. That is, the personnel cost will include personnel benefits and a percentage, also established by the Project management, of institutional indirect costs. The institutional indirect cost will be a uniform percentage derived from the major partner institutions; this is done to make the personnel cost independent of where the work is performed.

The cost estimators shall also provide an indication of whether the staff effort estimated for a particular task would likely be done under contract. That is, by contract employees, not by individuals on the ALMA Project staff.

5.8 Materials and Supplies

The cost estimator shall provide an estimate of the materials needed for each WBS task or subtask and the cost of those materials. Estimates of the cost of materials needed for recurring and non-recurring tasks will be provided separately. For recurring materials costs, the estimator will provide the unit cost and the number of units required by the baseline ALMA project. The Project management will compute the total cost keeping the number of acquired units a variable for use in parametric analyses of Project options involving a change in scope.

5.9 Contracts

The cost estimator shall provide an estimate of the contracts needed in support of each WBS task or subtask and the cost of those materials. Estimates of the contract costs needed for recurring and non-recurring tasks will be provided separately. For recurring materials costs, the estimator will provide the contract cost per unit and the number of units required by the baseline ALMA project. The Project management will compute the total cost keeping the number of acquired units a variable for use in parametric analyses of Project options involving a change in scope.

5.10 Cost Parameterization

The costs for both staff effort and for materials, supplies and contracts are, first, separated by the cost estimators into recurring and non-recurring costs; and second, parameterized by the number of units to be produced. In addition, the cost estimators are asked to specify how their costs depend on the technical specifications of the baseline ALMA Project in the following 10 ways:

- Number of antennas;
- Number of antenna stations;
- Maximum array baseline (size of array configuration);
- Number of antennas equipped with nutating subreflectors;
- Number of antenna transporters;
- Number of IF bands;
- IF bandwidth per IF channel;

- Number of IF channels per IF band;
- Duration of Phase 2 of the ALMA Project in years.

These parameters will be used to establish a *cost equation* for the ALMA Project in spreadsheet form. The cost equation will be used to answer *what if* questions regarding the cost implications of changes to the Project baseline scope.

APPENDICES

Appendix A: ALMA Cost Estimate Planning Schedule

Appendix B: WBS for the ALMA Project, condensed task tabulation.

Appendix C: ALMA Cost Data Sheet