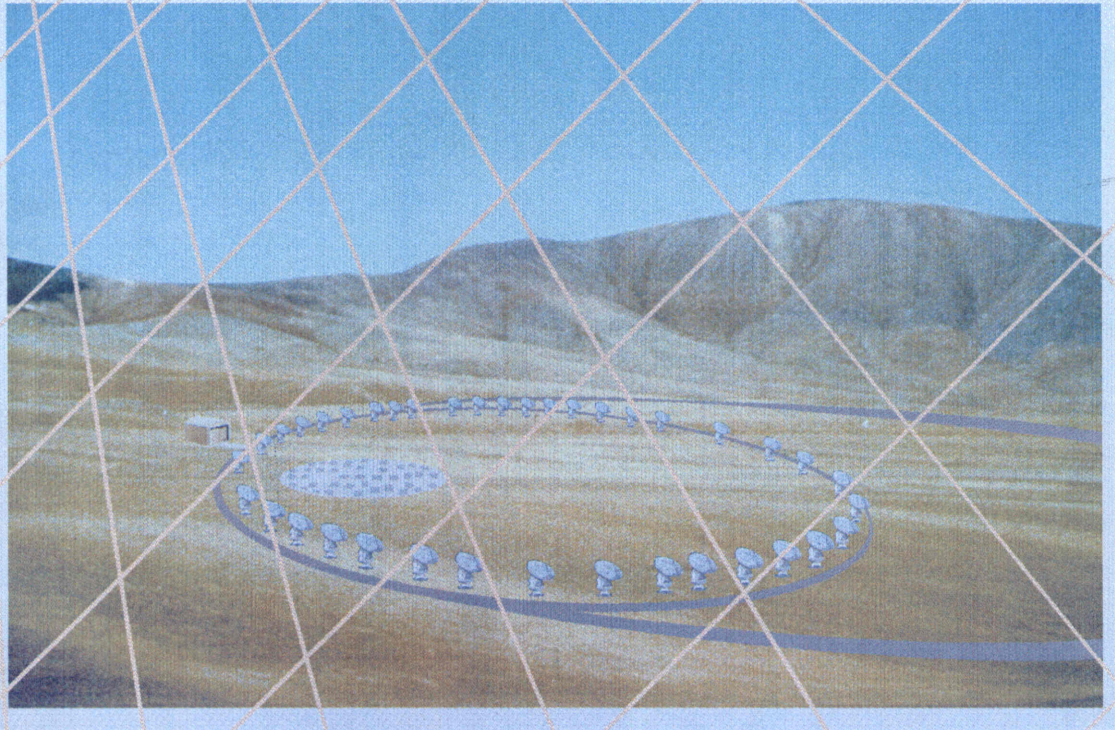
Millimeter Array

Construction Cost of the U.S. Reference Project

Cost Estimation Data Tables

July 1999



NATIONAL RADIO ASTRONOMY OBSERVATORY
A facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

Millimeter Array

Construction Cost of the U.S. Reference Project

Cost Estimate Data Tables

July 1999

National Radio Astronomy Observatory
National Science Foundation

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

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MMA Cost Estimation Data Input Table

WBS Number 1.1 *e.g., 1.1.4.45*

Title Project Management *e.g., Project Management and Tracking*

Estimator R. L. Brown *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical ____ *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost ____ *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule ____ *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical ____ *(2 or 4 are valid)*

Cost ____ *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Includes the personnel costs, only, of the Project management team: specifically, the Project Director, Project Manag Scheduler, Scheduling Administrative Aide, Business Manager, Project Scientist, Project Secretary/Archivist, and Man of Operations in Chile. In 2002 the Manager of Operations in Chile is transferred from MMA construction to the MMA operations budget. In 2003 two administrative aides are added to the Chilean staff; one individual to handle business contracts in Santiago, and the other to handle imports/exports from the port of Antofagasta. Both these individuals wo under the Manager of operations in Chile and both are assigned as hired to the MMA operations budget.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	60	60	60	60	60	60	60	35.0
			Ops.								
		Chile	Constr.	12							1.0
			Ops.		12	12	12	12	12	12	6.0
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	24	24	24	24	24	24	24	14.0
			Ops.								
		Chile	Constr.								
			Ops.			24	24	24	24	24	10.0

WBS Number 1.1

Title Project Management

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.1.1 *e.g., 1.1.4.45*

Title Management, Planning, and Oversight *e.g., Project Management and Tracking*

Estimator R. L. Brown *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

A budget category used to consolidate the travel budgets of all the Project staff under the supervision of the Project Manager. Travel costs are budgeted separately for relocation of new employees, travel for personal advancement (professional meetings), and assignments for work in Chile. Costs for assignment in Chile include a fixed cost associated with the airfare and an in-country expense that is proportional to the number of days worked. For the former a cost of $2k per trip is budgeted; for the latter the cost is the sum: $50 per diem, $50 lodging, $50 transport (½ the daily rental car cost).

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.1

Title Management, Planning, and Oversight

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Relocation Expense	persons	10	10	10						200
Travel for Professional Advancement										
Technician level personnel	persons	2	15	20	25	25	25	25	25	320
Engineer, scientist, programmer	persons	8	25	30	35	35	35	35	35	1,840
Assignment to Chile										
Trips	trips	2	24	36	48	60	60	60	60	696
Per diem	days/trip	N/A	12	15	15	20	20	20	20	0
	days	0.15	288	540	720	1200	1200	1200	1200	952
									Total (1999 $K):	4,008

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
MMAOC Expense	per year	50	1	1	1	1	1	1	1	350
Consultants	per year	25	1	1	1	1	1	1	1	175
									Total (1999 $K):	525

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MMA Cost Estimation Data Input Table

WBS Number	1.1.2	*e.g., 1.1.4.45*
Title	Business Operations	*e.g., Project Management and Tracking*
Estimator	R. L. Brown	*Name*
Basis of Estimate	EN	**EN** -*Engineering/Bottom Up/ Parametric;* **VQ** - *Vendor Quote;* **PO** - *Place Order; or* **AC** - *Actual Cost*

Assigned Risk factors

Technical		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical		*(2 or 4 are valid)*
Cost		*(1 or 2 are valid)*
Calculated Contingency:	15%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Includes the costs of shipping to Chile all the NRAO-provided hardware. The principal hardware to be shipped include reveiver packages with cryogenics systems, two racks of control instrumentation per antenna, the LO reference hardw approximately 30 racks of corrrelator hardware, tools, vehicles and furnishings. All hardware will be shipped in standa ocean containers and delivered to the OSF in San Pedro de Atacama. Does not include shipping costs of the antenna this is the responsibility of the antenna contractor. Does not include shipment of electrical and optical fiber cables; thi the responsibility of the site development contractor.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.2
Title Business Operations

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Surface Freight										
NRAO to US West Coast Port	number	0.95	4	6	10	12	12	12	12	65
US West Coast Port to Antofagasta	number	2.85	4	6	10	12	12	12	12	194
Antofagasta to OSF (San Pedro)	number	0.7	4	6	10	12	12	12	12	48
Packing	number	0.5	4	6	10	12	12	12	12	34
Air Freight	loads	1	15	15	30	30	30	30	30	180
Surface in Chile	loads	0.5	10	10	20	20	20	20	20	60

Total (1999 $K): 580

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MMA Cost Estimation Data Input Table

WBS Number 1.1.3 *e.g., 1.1.4.45*

Title Chilean Operations *e.g., Project Management and Tracking*

Estimator R. L. Brown *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

General office expense for the Santiago and Antofagasta offices. The charges for legal services are based on experience over the past two years.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.3

Title Chilean Operations

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Santiago Office Supplies	year	15	1	(to ops)	(to ops)	(to ops)	(to ops)	(to ops)	(to ops)	15
Antofagasta Office Supplies	year	10			(to ops)	(to ops)	(to ops)	(to ops)	(to ops)	
									Total (1999 $K):	15

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lease: Santiago office	year	25	1	(to ops)	(to ops)	(to ops)	(to ops)	(to ops)	(to ops)	25
Lease: Antofagasta Office	year	12			(to ops)	(to ops)	(to ops)	(to ops)	(to ops)	
Santiago Legal Services	year	15	1	1	1	1	1	1	1	105
									Total (1999 $K):	130

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MMA Cost Estimation Data Input Table

WBS Number	**1.1.4**	*e.g., 1.1.4.45*
Title	Safety and Health	*e.g., Project*
Estimator	R. L. Brown	*Name*
Basis of Estimate	EN	**EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical		*(2 or 4 are valid)*
Cost		*(1 or 2 are valid)*
Calculated Contingency:	15%	*(See defintions)*

Task Description (*Text for the WBS dictionary*): The NRAO Officer for Safety and Health, Mr. Jody Bolyard, is responsible for these functions for the MMA Project. There is no incremental charge made to the Project.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.4
Title Safety and Health

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.1.5 *e.g., 1.1.4.45*

Title Personnel *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

The personnel tasks for the MMA Project are the responsibility of the NRAO Personnel Manager, Mr. Monroe Petty, and his staff. No incremental charge is made to the Project for these services.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.5

Title Personnel

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.1.6 *e.g., 1.1.4.45*

Title Project Science Office *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate [ ] **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

The Project Scientist has the responsibility to maintain liaison with the U.S. scientific community and to facilitate the flow of information to that community. The salary of the Project Scientist and his travel expense are included in WBS 1.1 and 1.1.1 respectively. The scientific committee structure for the MMA is incorporated in the NRAO committee structure and imposes no additional expense on the Project.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.6

Title Project Science Office

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number	1.1.7	*e.g., 1.1.4.45*
Title	AUI Management	*e.g., Project*
Estimator	R. L. Brown	*Name*
Basis of Estimate	EN	**EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical		*(2 or 4 are valid)*
Cost		*(1 or 2 are valid)*
Calculated Contingency:	15%	*(See defintions)*

Task Description (*Text for the WBS dictionary*): Annual fee for Management oversight of the MMA Project by Associated Universities, Inc. (AUI). The fee noted here is an estimate. The amount of the fee will be the result of a negotiation between AUI and NSF.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.1.7
Title AUI Management

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Negotiated Fee	year	350	1	1	1	1	1	1	1	2,450

Total (1999 $K): 2,450

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MMA Cost Estimation Data Input Table

WBS Number 1.2 *e.g., 1.1.4.45*

Title Engineering *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical		*(2 or 4 are valid)*
Cost		*(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Salaries of the system engineering staff. Includes the system engineer; an aide to the system engineer who is responsible for maintenance of engineering documentation, standards, interfaces and the archive of engineering drawings; and a production engineer who is responsible for planning and engineering oversight of the fabrication of production MMA hardware, both hardware fabricated at the NRAO and that fabricated elsewhere under contract.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	24	24	24	24	24	24	24	14.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12	12	12	12	12	12	12	7.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.2
Title Engineering

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Drawing Archive Materials and Supplie	year	20	1	1	1	1	1	1	1	140

Total (1999 $K): 140

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.2.1 *e.g., 1.1.4.45*

Title System Engineering--Phase II *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

This task incorporates the work of the System Engineering team identified in WBS 1.2. Phase II refers to the construction phase of the MMA, to be distinguished from Phase I, the Design and Development phase of the project. Salaries of the System engineering team are included in 1.2; travel expense is included in WBS 1.1.1.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.2.1

Title System Engineering--Phase II

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.2.2 *e.g., 1.1.4.45*

Title Documentation System *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate [ ] **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Documentation of the engineering system is the responsibility of the System Engineer and is carried out functionally by the aide to the system engineer. Salaries of these two people are rolled up in WBS 1.2; the materials and supplies expense of maintaining the engineering drawing archive is also included in WBS 1.2.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.2.2

Title Documentation System

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number	1.2.3	*e.g., 1.1.4.45*
Title	Production Engineering	*e.g., Project*
Estimator	R. L. Brown	*Name*
Basis of Estimate		**EN** -*Engineering/Bottom Up/ Parametric;* **VQ** - *Vendor Quote;* **PO** - *Place Order; or* **AC** - *Actual Cost*

Assigned Risk factors

Technical		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical		*(2 or 4 are valid)*
Cost		*(1 or 2 are valid)*
Calculated Contingency:	15%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Engineering for the production fabrication of MMA hardware, whether this hardware is built by the MMA staff or done elsewhere under contract, is the responsibility of the System Engineer. Functionally, the responsibility is assigned to the Production engineer. The salary of these two individuals is rolled up in WBS 1.2.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.2.3
Title Production Engineering

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.3 *e.g., 1.1.4.45*

Title US Facilities *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Facilities in the United States for fabrication of the MMA hardware exist at three NRAO sites: at the NRAO headquarters and Central Development Laboratory (CDL) in Charlottesville, VA; at the Array Operations Center in Socorro, NM; and at the NRAO Millimeter Wave Laboratory in Tucson, AZ. Office and laboratory space sufficient for the MMA design and development, and construction, at the Array Operations Center were provided in the design and development phase of the Project. Facilities at the other two sites are provided in the subsections to WBS 1.3 below.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.3

Title US Facilities

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 1.3.1 *e.g., 1.1.4.45*

Title CDL Permanent Facilities *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost		*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical		*(2 or 4 are valid)*
Cost		*(1 or 2 are valid)*
Calculated Contingency:	0%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Provision for laboratory space for fabrication, testing and maintenance of the SIS mixers, the correlator and the multiplier chain local oscillator. Includes office space and incremental machine shop space. Work to be done as part of the planned addition to the NRAO Edgemont Road headquarters in Charlottesville, VA. The MMA Project will provide a net 15,000 square feet for the CDL at a fixed negotiated cost of $200 per square foot. The CDL will support MMA electronics development throughout the operational phase of the instrument. (agreement in place)

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.3.1

Title CDL Permanent Facilities

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Construct CDL facilities	year	600	1	1	1	1	1			3,000
									Total (1999 $K):	3,000

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MMA Cost Estimation Data Input Table

WBS Number 1.3.2 *e.g., 1.1.4.45*

Title Manufacturing Facilities *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate [ ] **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 10% *(See defintions)*

Task Description (*Text for the WBS dictionary*) Rent of space provided by the University of Arizona to be used for the production assembly of the integrated receivers.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.3.2

Title Manufacturing Facilities

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Laboratory Rental Space	year	115	1	1	1	1	1	1	1	805

Total (1999 $K): 805

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MMA Cost Estimation Data Input Table

WBS Number 1.3.3 *e.g., 1.1.4.45*

Title Common Infrastructure *e.g., Project*

Estimator R. L. Brown *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 15% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Computing equipment for information flow among the Project staff members. Budgeted at $2k per person per year. Includes communication equipment and expense to/from Chile and within the United States for the construction (not operational) needs of the project.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 1.3.3

Title Common Infrastructure

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Personal Computing Equipment	person	2	50	50	50	50	50	50	50	700
Communications	year	100	1	1	1	1	1	1	1	700
									Total (1999 $K):	1,400

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 3.1 *e.g., 1.1.4.45*

Title Antenna Engineering Support *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical 2 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost 2 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule 8 *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical 2 *(2 or 4 are valid)*

Cost 1 *(1 or 2 are valid)*

Calculated Contingency: 14% *(See defintions)*

Task Description ('ext for the WBS dictionary) Includes the cost of 4 antenna design engineers for the two years 2001-2002 while they are engaged in designing NRA supplied equipment, testing the prototype antennas and transporter and drafting the specifications and terms of the contract for the production run of antennas.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	48	48						8.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.1

Title Antenna Engineering Support

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 3.8.10 *e.g., 1.1.4.45*

Title Sign Transporter Contract *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (text for the WBS dictionary)

This is the contract for the first of the two antenna transporters needed. This first transporter will be delivered to the VLA site so that it can be used in the evaluation of the transportability of the two prototype antennas. When the test interferometer is disassembled this first antenna transporter will be shipped to Chile (see 3.81.1).

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.8.10

Title Sign Transporter Contract

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 3.8.30 *e.g., 1.1.4.45*

Title Accept Transporter #2 at OSF *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (ext for the WBS dictionary)

This item covers the cost of the 2nd antenna transporter which will be delivered to San Pedro

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.8.30

Title Accept Transporter #2 at OSF

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 3.8.35 *e.g., 1.1.4.45*

Title Contract for Transporter #1 Move to site *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate VQ *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	3	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (ext for the WBS dictionary)

Contract shipment of antenna transporter #1 from the test interferometer at the VLA site to the OSF.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.8.35

Title Contract for Transporter #1 Move to site

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Ship Transporter #1 to OSF		20					1			20
									Total (1999 $K):	20

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MMA Cost Estimation Data Input Table

WBS Number 3.15 *e.g., 1.1.4.45*

Title Procurement of Antenna 2 *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate VQ *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	27%	*(See defintions)*

Task Description (ext for the WBS dictionary)

Antenna #2 is obtained by exercising an option written in to the contract for the first prototype antenna. Antenna #2, like antenna #1, will be delivered to, and erected at, the VLA site. The two antennas will be connected interferometrically so that precise tests can be made of the performance of the prototype antennas.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.15

Title Procurement of Antenna 2

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 3.20 *e.g., 1.1.4.45*

Title Sign Contract for Production Antennas *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate VQ *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (text for the WBS dictionary)

This item covers one time costs related to the production of antennas. Items included are the cost of the production tooling, NRAO instrumentation needed to check and adjust antennas and critical antenna spare components.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.20

Title Sign Contract for Production Antennas

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Production Tooling		1000			1					1,000
NRAO Measurement Instruments		200			1					200
Antenna spares		415			1					415
									Total (1999 $K):	1,615

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MMA Cost Estimation Data Input Table

WBS Number 3.21 *e.g., 1.1.4.45*

Title Antenna Contract Supervision *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (text for the WBS dictionary)

This item covers the cost of the engineering manpower required to oversee the antenna production contract.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			12	27	36	27		8.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.21

Title Antenna Contract Supervision

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 3.23 *e.g., 1.1.4.45*

Title Accept Antenna #3 at OSF *e.g., Project Management and Tracking*

Estimator P.Napier *Name*

Basis of Estimate VQ *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	27%	*(See defintions)*

Task Description (text for the WBS dictionary)

Antenna #3 is the first of the production series of antennas to be delivered. The contract will call for it to be delivered and erected at the OSF in Chile. The MMA Project will accept it there. The engineering time assigned to this acceptance task is the time of MMA Project antenna engineers supervising the assembly of the anten witnessing acceptance tests.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.				1.5				0.1
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.23

Title Accept Antenna #3 at OSF

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 3.25, 3.27, 3.29, ..., 3.89 *e.g., 1.1.4.45*

Title Accept Antennas #4 through #36 *e.g., Project Management and Tracking*

Estimator P. Napier and R. Simon *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	27%	*(See defintions)*

Task Description (ext for the WBS dictionary)

This is the production series of antennas to be delivered. The contract will call for them to be delivered and erected at the OSF in Chile. The MMA Project will accept them there. The engineering time assigned to this acceptance task is the time of MMA Project antenna engineer supervising assembly and witnessing acceptance tests [1.5 months of effort per antenna].

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.				4.5	13.5	18	13.5	4.1
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 3.25, 3.27, 3.29, ..., 3.89
Title Accept Antennas #4 through #36

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Production Antenna contract	antenna	2754				3	9	12	9	90,882
									Total (1999 $K):	90,882

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.1.2 *e.g., 1.1.4.45*

Title Fabricate PPRC *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	28%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Fabricate Prototype Production Receiver Cryogenics. Fabricate and assemble a high capacity helium compressor to operate at 5000 Metres on Chilean power of 380 volts 3 phase 50 Hz. Fabricate and assemble (NRAO) 4K refrigeration system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	8							0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.1.2

Title Fabricate PPRC

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Helium Scroll Compressors	1	1.3	3							4
Mechanical hardware	1 set	4.6	1							5
Electrical	1 set	5.1	1							5
Gauges	1 set	5.2	1							5
Sensors	1 set	5.5	1							6
Valves	1 set	2	1							2
Filters	1 set	7	1							7
Helium Storage Tank	1	0.2	1							0
Regulators	1 set	1.4	1							1
Helium Fittings	1 set	3.5	1							4
Control/Monitoring Electronics	1 set	2.5	1							3
Charcoal Trap	1	0.5	1							1
4K JT System (NRAO)	1	4	1							4
Refrigerator + special cable	1	20	1							20
Heat Exchangers	1 set	0.5	3							2
Fans and motors	1 set	0.5	3							2
Helium Hoses and fittings	1 set	0.7	1							1
									Total (1999 $K):	69

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.1.3 *e.g., 1.1.4.45*

Title Test PPRC *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Test Prototype Production Receiver Cryogenics. Extensive environmental and performance testing of Complete Cryogenic System using a computer controlled test set.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.1.3
Title Test PPRC

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Computer	1	3	1							3
Hardware interface	1 set	4	1							4
Software	1	3	1							3
									Total (1999 $K):	10

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.2.1 *e.g., 1.1.4.45*

Title PPR Dewar Design *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	17%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Prototye Production Receiver Dewar Design. A complete thermal, mechanical and electrical interface design of the MMA prototype Dewar to hold the receiver Inserts.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	4							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	4							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.2.1
Title PPR Dewar Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.1.2.2 *e.g., 1.1.4.45*

Title PPR Dewar Fabrication and Vacuum Testing *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	40%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Prototype Production Receiver Dewar Fabrication and Vacuum Testing. Machine and fabricate stainles steel Dewar and vacuum test final product.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.2.2

Title PPR Dewar Fabrication and Vacuum Testing

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Stainless Steel parts	1 set	5	1							5
Hardware	1 set	1.5	1							2
Vacuum fittings	1 set	1.5	1							2
									Total (1999 $K):	8

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.2.3 *e.g., 1.1.4.45*

Title PPR Vacuum Windows and IR Filters *e.g., Project Management and Tracking*

Estimator J. Webber and R. Simon *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	6	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (*Text for the WBS dictionary*) Manufacture and test prototype vacuum windows and IR filters. These windows and filters wil be completed in sets where each set will cover the frequency bands for the prototype production receiver. Each window will be tested for vacuum integrity. The vacuum windows are made of crystal quartz with two layers of teflon on each side and the IR filters are made of layers of expanded teflon heat sunk to the refrigerator first stage.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.2.3
Title PPR Vacuum Windows and IR Filters

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Vacuum window	1 set	8	1							8
Mounting Frames	1 set	0.1	1							0
IR filter	1 set	2	1							2
Mounting Hardware	1 set	2	1							2
									Total (1999 $K):	12

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.2.4 *e.g., 1.1.4.45*

Title PPR Cryogenics/Dewar Assembly and Testing *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	13%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Cryogenics/Dewar Assembly and Testing. Assemble the 4K refrigerator system into the Dewar complete with thermal insulation, vacuum and IR windows, radiation shields and heat straps. Carry out extensive thermal load and stability tests using a computer driven test set and data logger.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.2.4

Title PPR Cryogenics/Dewar Assembly and Testing

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Temperature sensors	1 set	4	1							4
Assembly hardware	1 set	2	1							2
Internal wiring and hermetic connectors	1 set	3	1							3
Computer interface	1	3	1							3
Thermal mounting plates	1 set	2	1							2
Radiation shields, etc	1 set	2.5	1							3
Pressure sensors	1 set	1.5	1							2
									Total (1999 $K):	18

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.3.1 *e.g., 1.1.4.45*

Title PPR Control-Monitoring and Bias Electronics Design *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	21%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Prototype Production Receiver Control-Monitoring and Bias Electronics Design. Design the electronics with an associated housing system for the Receiver Inserts' SIS, LNA Bias and Control and Monitoring functions. Also included in this electronics will be the overall Receiver Control and Monitoring System and power system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.3.1

Title PPR Control-Monitoring and Bias Electronics Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.1.3.2 *e.g., 1.1.4.45*

Title PPR Control-Monitor and Bias Electronics Construction *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	44%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Construct the electronics modules and mounting hardware to support the Prototype Production Receiver and the three (3) Receiver Inserts planned for the Prototype Production Receiver.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	5							0.4
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.3.2

Title PPR Control-Monitor and Bias Electronics Construction

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Electronic Components	1 set +3	8	1							8
Printed circuit boards	1 set +3	2	1							2
Card cages	1 set	3	1							3
Connectors-wiring	1 set +3	5	1							5
Module hardware	1 set +3	4	1							4
									Total (1999 $K):	22

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.4.1 *e.g., 1.1.4.45*

Title Insert Mechanical-Thermal Design, Bands <275 GHz (Waveguid *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	48%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Design the mechanical structure of the receiver Inserts (for the Dewar) covering frequency bands less than 275 GHz. This involves a complete thermal and mechanical analysis of the structure allowing for the mounting of either SIS mixers or HEMT LNAs using a waveguide OMT and lens corrected Feedhorn. All thermal loads due to wiring and LO components must also be considered. Design will use waveguide, for bands 67-90 GHz and 211-275 GHz.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.4.1

Title Insert Mechanical-Thermal Design, Bands <275 GHz (Waveguide)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.1.4.2 *e.g., 1.1.4.45*

Title Insert Component Fabrication for Bands <275 GHz *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	56%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Machine and fabricate and purchase all components, except for Mixer and LNA modules, required to assemble two (2) complete receiver Inserts. One (1) for the 67 to 90 Ghz Band and one (1) for the 211 to 275 GHz Band.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	8							0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.4.2

Title Insert Component Fabrication for Bands <275 GHz

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Feedhorns-Lens assembly	1	0.5	2							1
OMT	1	0.5	2							1
Waveguide components	1 set	2	2							4
LO coupler and components	1 set	2	2							4
1st stage mixer-IF for LNA Insert	1 set	12	1							12
Thermal Isolation components	1 set	3	2							6
Connectors and wiring	1 set	2	2							4
Temperature sensors	1 set	1	2							2
Assembly hardware	1 set	1.5	2							3
									Total (1999 $K):	37

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.4.3 *e.g., 1.1.4.45*

Title Insert Mechanical-Thermal Design for Bands >275 GHz (Quasi o *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	48%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Insert Mechanical-Thermal Design for Bands >275 GHz (Quasi optical). Design the mechanical structure of the receiver Insert (for the Dewar) covering frequency bands greater than 275 GHz. This involves a complete thermal and mechanical analysis of the structure allowing for the mounting of SIS mixers coupling to quasi-optical polarisation splitters. All thermal loads due to wiring and LO components such as multipliers must also be considered.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.4.3

Title Insert Mechanical-Thermal Design for Bands >275 GHz (Quasi optical)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.1.4.4 *e.g., 1.1.4.45*

Title Insert Component Fabrication for Bands >275 Ghz *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	56%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Machine and fabricate and purchase all components required to assemble one (1) complete receiver Insert for the 602 to 720 GHz Band.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.4.4

Title Insert Component Fabrication for Bands >275 Ghz

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Polarisation Splitter	1	3	1							3
Thermal isolation components	1 set	3	1							3
Connectors and wiring	1 set	2	1							2
Temperature sensors	1 set	1	1							1
Assembly Hardware	1 set	1.5	1							2
LO Waveguide components	1 set	2	1							2
									Total (1999 $K):	13

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.4.8 *e.g., 1.1.4.45*

Title PPR Insert Assembly (3 Bands) *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	44%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Insert Assembly (3 Bands). Assemble the three (3) Inserts required for the Prototype Receiver. This will include the mounting of the SIS mixers or HEMT LNAs Modules, cooled post-IF amplifiers, LO injection components, feedhorn-lens combinations and connectors and wiring. Fabrication of special alignment tools and jigs.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.4.8

Title PPR Insert Assembly (3 Bands)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Special tools	1 set	2	1							2
Jigs	1 set	3	1							3
									Total (1999 $K):	5

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.4.9 *e.g., 1.1.4.45*

Title PPR Insert Testing (3 Bands) *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Insert Testing (3 bands). Extensive RF and mechanical-thermal testing of the three Inserts for the Prototype Production Receiver using the Insert Test Set and data logger referred to in WBS # 4.1.1.5

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.4.9

Title PPR Insert Testing (3 Bands)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.1.5.1 *e.g., 1.1.4.45*

Title PPR Vacuum System Assembly *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	8%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Vacuum System Assembly. Assemble and test the complete vacuum system for the Prototype Receiver from commercially available components. This is an automatically controlled and monitored evacuation system using a roughing and turbo-molecular pump.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.5.1
Title PPR Vacuum System Assembly

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Assembly hardware	1 set	2	1							2
Vacuum valves and fittings	1 set	3	1							3
Scroll roughing pump	1	7	1							7
Turbo-molecular drag vacuum pump	1	8	1							8
Vacuum hoses (stainless steel)	1 set	2	1							2
Vacuum Sensors	1 set	2	1							2
Control-monitoring Electronics	1 set	2	1							2
									Total (1999 $K):	26

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.7.1 *e.g., 1.1.4.45*

Title PPR Post IF System Design *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	22%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Post IF System Design. Design of the IF amplification, filtering and switching distribution after the SIS mixer detector module and HEMT LNA Detector Module in the Receiver Inserts but terminating within the Prototype Production Receiver.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.7.1

Title PPR Post IF System Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.1.7.2 *e.g., 1.1.4.45*

Title PPR Post IF System Construction and Testing *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Post IF System Construction and Testing. Construction and testing of the IF system from the output of the receiver Inserts to the Bulkhead connectors on the Prototype Production Receiver. Initially the IF system will handle the outputs of three (3) receiver Inserts in the Prototype Production Receiver.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.7.2

Title PPR Post IF System Construction and Testing

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
IF amplifiers	1 set	3	3							9
Filters	1 set	3	1							3
RF switches	1 set	3.5	1							4
Coaxial cable and connectors	1 set	1.5	3							5
Temperature stabilisation electronics	1 set	1	3							3
Total Power monitoring	1 set	2	1							2
Misc. Hardware	1 set	2	1							2
Test Set	1	5	1							5
									Total (1999 $K):	32

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.8.1 *e.g., 1.1.4.45*

Title PPR Frame Design *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Prototype Production Receiver Frame Design. Design the Frame for the Prototype Production Receiver that supports all above Dewar optics, Dewar with refrigeration system, LO mounting plate, IF system, Electronics card cages and modules, power supplies and the Vacuum system. Suitable transport and antenna interface mechanics must also be designed.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.8.1
Title PPR Frame Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 4.1.8.2 *e.g., 1.1.4.45*

Title PPR Frame Fabrication *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Prototype Production Receiver Frame Fabrication. Machine and fabricate all components required to assemble the Prototype Receiver Package complete with transport system and antenna interface hardware.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	5							0.4
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.8.2

Title PPR Frame Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Frame and mounting plates	1 set	4	1							4
Transport - lifting system	1	8	1							8
Antenna interface hardware	1 set	2	1							2
Assembly hardware	1 set	1	1							1
Plating and Painting	1	1	1							1
Assembly Jigs	1 set	2	1							2
									Total (1999 $K):	18

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.9.1 *e.g., 1.1.4.45*

Title Prototype Production Receiver Integration *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Assemble all sub systems into the Prototype Production Receiver package.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	4							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.9.1

Title Prototype Production Receiver Integration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Alignment jigs	1 set	2	1							2
Tools	1 set	5	1							5
Assembly hardware	1 set	3	1							3
									Total (1999 $K):	10

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.9.2 *e.g., 1.1.4.45*

Title PPR Testing and Evaluation *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	36%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype Production Receiver Testing and Evaluation. Comprehensive testing of the Prototype Production Receiver Package with three (3) receiver Inserts covering the bands 67 to 90 GHz, 211 to 275 GHz and 602 to 720 GHz. The tests include feed pattern, total power stability, 1/F noise, system temperature, tunability across the bands, remote control and monitoring, mechanical stability and anything else you can think of all under the supervision of a PC driven test set and data logger. A G-force and vibration test jig will have to be constructed.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	2	1						0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	3						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	4	4						0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.9.2
Title PPR Testing and Evaluation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Test Set	1	25	1							25
PC and software	1 set	5	1							5
Hot-cold loads	1 set	2		1						2
Environmental chamber	hire	10		1						10
Interface hardware	1 set	3	1							3
Plotter-printer	1	5	1							5
Vibration test jig	1	25		1						25
									Total (1999 $K):	75

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.10.1 *e.g., 1.1.4.45*

Title Design and build Prototype and Production Receiver Test Set *e.g., Project Management and Tracking*

Estimator G.Moorey & J.Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	36%	*(See defintions)*

Task Description (*Text for the WBS dictionary*) Design and build a Final Test Set capable of testing and commissioning the complete cooled Receiver Package. Test procedures will include the mapping of beam patterns at all bands, the band shape and stability of the IF outputs and system temperature measurements across all bands.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12							1.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.10.1

Title Design and build Prototype and Production Receiver Test Set

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Near Field Test Set (Phase & Amplitud	1	360	1							360
Computer and software	1	6	1							6
Precission X-Y stage	1	15	1							15
MMA LO Multipliers	1 set	CDL	1							0
Fundamental LOs	1 set	35	1							35
Assembly Hardware & Mounting Frame	1 set	10	1							10
Optics and Loads	1 set	18	1							18
									Total (1999 $K):	444

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.10.2 *e.g., 1.1.4.45*

Title Design and Fabricate Receiver Insert Test Set *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	11%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Design and Fabricate a computer controlled Insert Test Set. The Insert being a single band dual polarisation receiver insert. This test set comprises a test Dewar, 4K helium refrigerator system, IF backend and RF test equipment complete with control and monitoring electronics. This test set to be used in conjunction with the antenna range for measuring the feed-lens radiation patterns of the receiver inserts at 4K temperatures.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	4							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	4							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	8							0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.10.2

Title Design and Fabricate Receiver Insert Test Set

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
4K refrigerator system & compressor	1	69	1							69
Dewar and Hardware	1	10	1							10
Bias and Control-monitoring electronics	1 set	6	1							6
LO system	1	25	1							25
IF and backend	1	15	1							15
RF and general test equipment	1 set	40	1							40
Quasi-optical test equipment	1 set	25	1							25
Dedicated PC and software	1 set	8	1							8
Vacuum System	1	15	1							15
									Total (1999 $K):	213

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.1.10.3 *e.g., 1.1.4.45*

Title General Test Equipment *e.g., Project Management and Tracking*

Estimator G.Moorey & J.Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	13%	*(See defintions)*

Task Description (*Text for the WBS dictionary*) To select and purchase test equipment that is shared across the Receiver development and construction phases of the MMA project.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.1.10.3
Title General Test Equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Power Meters										
Power Supplies										
Spectrum Analyser										
General Test Equipment	est total	360	1							360
									Total (1999 $K):	360

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.1 *e.g., 1.1.4.45*

Title MMA Receiver (MMA Rx) Design Refinement *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	28%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Complete review of the Prototype Production Receiver resulting in the final design for the MMA Production Receiver (MMA Rx).

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		6						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2						0.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.1

Title MMA Receiver (MMA Rx) Design Refinement

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 4.2.2 *e.g., 1.1.4.45*

Title MMA Receiver (MMA Rx) Documentation *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	18%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Writing of comprehensive documentation to enable the MMA Receivers to be sub contracted out, assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	2						0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	4	4						0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.2

Title MMA Receiver (MMA Rx) Documentation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Drafting and publication materials.	1 set	5	1	1						10
									Total (1999 $K):	10

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.1 *e.g., 1.1.4.45*

Title MMA Rx Dewar Fabrication *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Machine, fabricate and electropolish Production Dewars assemble and vacuum test.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			1	1	1	1	1	0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			6	10	10	9	4	3.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.1

Title MMA Rx Dewar Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Stainless steel components & plating	1 set	5			6	10	10	9	3	190
Hardware	1 set	1			6	10	10	9	3	38
Vacuum fittings	1 set	1			6	10	10	9	3	38
									Total (1999 $K):	266

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.2 *e.g., 1.1.4.45*

Title MMA Rx Cryogenics Fabrication *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Machine, fabricate, assemble the Helium compressor systems and the 4K refrigerator systems. Test both systems using the Test Set described in WBS# 4.1.1.3

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			2	3	3	3	1	1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			18	30	30	27	12	9.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.2

Title MMA Rx Cryogenics Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
4K system	1	3			6	10	10	9	3	114
Crosshead	1	15			6	10	10	9	3	570
Helium compressor	1	48			6	10	10	9	3	1,824
									Total (1999 $K):	2,508

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.3 *e.g., 1.1.4.45*

Title Vacuum Windows and IR Filters Fabrication *e.g., Project Management and Tracking*

Estimator G. Moorey, J. Payne, J. Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Manufacture and test vacuum windows and IR filters. These windows and filters wil be completed in sets where each set will cover frequency bands 1 to 9 to facilitate receiver production. Each window will be tested for vacuum integrity. The vacuum windows are made of crystal quartz with two layers of teflon on each side and the IR filters are made of layers of expanded teflon heat sunk to the refrigerator first stage.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2	2	2	2	2	2	1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		11	11	11	11	11	11	5.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.3

Title Vacuum Windows and IR Filters Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Vacuum window	1 set (9)	7		6	10	10	9	3		266
Mounting Frames	1 set (9)	0.1		6	10	10	9	3		4
IR filter	1 set (9)	1		6	10	10	9	3		38
Mounting Hardware	1 set (9)	1		6	10	10	9	3		38
									Total (1999 $K):	346

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.4 *e.g., 1.1.4.45*

Title Receiver Insert Fabrication *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	22%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Machine and fabricate the Receiver inserts for ech frequency band. Bands < 275 Ghz (bands 1 to 6) use an OMT with waveguide input and bands > 275 GHz use a crossed grid polarisation splitter. Bands 1,2, and 3 will have the RF-IF conversion stages built into the Insert.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			2	2	2	2	2	0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			68	80	80	80	50	29.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.4

Title Receiver Insert Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Insert band 1 (HEMT)	1	9			10	10	10	8		342
Insert band 2 (HEMT)	1	9			9	10	10	9		342
Insert band 3	1	9			10	10	10	8		342
Insert band 4	1	9						20	18	342
Insert band 5	1	9				10	10	10	8	342
Insert band 6	1	9			14	15	9			342
Insert band 7	1	9			15	15	8			342
Insert band 8	1	9					10	10	18	342
Insert band 9	1	9			9	10	10	9		342
								Total (1999 $K):		3,078

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
								Total (1999 $K):		

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.5 *e.g., 1.1.4.45*

Title MMA Receiver Frame Fabrication and assembly *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Fabricate Receiver Package (frame) and assemble using jigs from WBS # 4.1.8.2 Include antenna interface mountings and transport mechanics.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1	1	1	1	1	0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			12	20	20	18	8	6.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.5

Title MMA Receiver Frame Fabrication and assembly

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Frame and mounting plates	1	4			6	10	10	9	3	152
Transport - Lifting system	1	8			6	10	10	9	3	304
Assembly and interface hardware	1 set	3			6	10	10	9	3	114
									Total (1999 $K):	570

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.6 *e.g., 1.1.4.45*

Title Vacuum System Fabrication and testing. *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Fabricate, purchase commercial components and assemble receiver vacuum system and test.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			6	5	5	5		1.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.6

Title Vacuum System Fabrication and testing.

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Vacuum valves, fittings and hoses	1 set	4			9	10	10	9		152
Scroll roughing pump	1	6			9	10	10	9		228
Turbo-molecular drag pump	1	7			9	10	10	9		266
Vacuum sensors and C-M electronics	1 set	3			9	10	10	9		114
Assembly hardware	1 set	1								
									Total (1999 $K):	760

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.7 *e.g., 1.1.4.45*

Title Bias and Control-Monitoring Electronics Construction *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Construct and test the electronics modules with their mounting hardware to support a complete receiver package including the 9 receiver Inserts and all control and monitoring.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1	1	1	1		0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2	4	4	4	4		1.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.7

Title Bias and Control-Monitoring Electronics Construction

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Electronic components & hardware	1 set	15			9	10	10	9		570
Card cages and module hardware	1 set	4			9	10	10	9		152
Connectors and wiring	1 set	5			9	10	10	9		190
									Total (1999 $K):	912

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.9 *e.g., 1.1.4.45*

Title Assemble Receiver Inserts and Test *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Assemble receiver Inserts by fitting all modules. These modules comprise the lens corrected feedhorns, waveguide OMT or wire-grid polarisers, SIS mixers, LNAs, LO and purchased RF-IF components etc. Test the Insert as a complete unit using the Test SET described in WBS# 4.1.10.2

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			34	40	40	40	25	14.9
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			68	80	80	80	50	29.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.9

Title Assemble Receiver Inserts and Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Insert band 1 (HEMT)	1	28			10	10	10	8		1,064
Insert band 2 (HEMT)	1	33			10	10	10	8		1,254
Insert band 3	1	1			9	10	10	9		38
Insert band 4	1	1						20	18	38
Insert band 5	1	1				10	10	10	8	38
Insert band 6	1	1			14	15	9			38
Insert band 7	1	1			15	15	8			38
Insert band 8	1	1					10	10	18	38
Insert band 9	1	1			9	10	10	9		38
									Total (1999 $K):	2,584

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.4.10 *e.g., 1.1.4.45*

Title Assemble MMA Rx IF System *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	6	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Purchase and fabricate the complete MMA Receiver IF and switching system. Test IF system mechanically and electrically using test set described in WBS# 4.1.7.2

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			1	1	1	1	1	0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			4	5	5	5	2	1.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.4.10

Title Assemble MMA Rx IF System

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
IF components	1 set	12			6	10	10	9	3	456
Connectors and Wiring	1 set	1.5			6	10	10	9	3	57
Assembly Hardware	1 set	1			6	10	10	9	3	38
									Total (1999 $K):	551

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.2.6.1 *e.g., 1.1.4.45*

Title Integrate Test & Commission MMA Receivers *e.g., Project Management and Tracking*

Estimator G. Moorey & J. Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Assemble all subassemblies into receiver frame, carry out extensive RF, mechanical and environmental tests and commission using jigs and test set described in WBS#4.1.9.2 and WBS#4.1.10.2

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			9	15	15	13	6	4.8
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			18	30	30	27	12	9.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.2.6.1

Title Integrate Test & Commission MMA Receivers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Assembly Hardware	1 set	3			6	10	10	9	3	114
									Total (1999 $K):	114

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.5.1 *e.g., 1.1.4.45*

Title Construct and test Cryo system for 2nd Evaluation Receiver *e.g., Project Management and Tracking*

Estimator G.Moorey & J.Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Fabricate 2nd Evaluation Receiver Cryogenics. This involves the construction and assembly of a NRAO type 4K refrigeration system and a high capacity helium compressor. Test the combination of refrigerator and compressor. The testing assumes there already exists some inhouse cryogenic and vacuum test equipment.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	7							0.6
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	11							0.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.5.1

Title Construct and test Cryo system for 2nd Evaluation Receiver

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Helium Scroll Compressors	1	1.3	3							4
Mechanical hardware	1 set	4.6	1							5
Electrical	1 set	5.1	1							5
Gauges	1 set	5.2	1							5
Sensors	1 set	5.5	1							6
Valves	1 set	2	1							2
Filters	1 set	7	1							7
Helium Storage Tank	1	0.2	1							0
Regulators	1 set	1.4	1							1
Helium Fittings	1 set	3.5	1							4
Control/Monitoring Electronics	1 set	2.5	1							3
Charcoal Trap	1	0.5	1							1
4K JT System (NRAO)	1	4	1							4
Refrigerator + special cable	1	20	1							20
Heat Exchangers	1 set	0.5	3							2
Fans and motors	1 set	0.5	3							2
Helium Hoses and fittings	1 set	0.7	1							1
									Total (1999 $K):	69

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.5.2 *e.g., 1.1.4.45*

Title Fabrication and assembly of 2nd Evaluation Receiver. *e.g., Project Management and Tracking*

Estimator G.Moorey & J.Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*) Fabricate and assemble all subsystems for the 2nd Evaluation Receiver. This includes the Receiver Frame, Dewar, four (4) Receiver Inserts complete with SIS mixers or LNAs , LO system, Post IF system, Bias and Control-Monitoring electronics, Power supplies and Vacuum system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	50							4.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.5.2

Title Fabrication and assembly of 2nd Evaluation Receiver.

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lots of bits	1 set	292	1							292
									Total (1999 $K):	292

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.5.3 *e.g., 1.1.4.45*

Title Test and Commission 2nd Evaluation Receiver *e.g., Project Management and Tracking*

Estimator G.Moorey & J.Payne *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (*Text for the WBS dictionary*) Comprehensive testing of the integrated receiver package and cryogenics both mechanically and electrically. This assumes there is some inhouse RF and cryogenic test equipment available.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.5.3

Title Test and Commission 2nd Evaluation Receiver

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.1.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 211-275 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*

Calculated Contingency: 52% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

The design of a sideband-separating, balanced mixer for the 211-275 GHz band will be refined from the status expected at the end of the D&D phase to a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6.5							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.1.1

Title Design, Fab, and Test 211-275 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10	2							20
Parts kit (connectors, components)	each	1.9	8							15.2
Consumables (LHe, LN2)	kiloliters	1	2							2
Lab supplies	misc	10	1							10
Software maintenance	each	10	1							10
Prototype mixer blocks – fabrication	each	0.9	10							9
									Total (1999 $K):	66

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer waver fab–UVA	wafer	30	1							30
									Total (1999 $K):	30

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MMA Cost Estimation Data Input Table

WBS Number 4.3.1.3 *e.g., 1.1.4.45*

Title Fabricate 211-275 GHz mixer blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The mixer blocks needed for the 211-275 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	5	5						0.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.1.3

Title Fabricate 211-275 GHz mixer blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1	3.5	2.1						6
Electroforming & plating materials	misc	1	1	0.4						1.4
									Total (1999 $K):	7

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.1.4 *e.g., 1.1.4.45*

Title Fabricate & test 211-275 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 80 211-275 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	9	9						1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	22	22						3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.1.4

Title Fabricate & test 211-275 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10	2							20
Parts kit (connectors, components)	each	1.9	40	36						144.4
Consumables (LHe, LN2)	kiloliters	1	7	7						14
Lab supplies	misc	10	4	4						80
									Total (1999 $K):	258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer waver fab--UVA	wafer	30	5	5						300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.2.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 602-720 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The design of a sideband-separating, balanced mixer for the 602-720 GHz band will be completed starting with the design achieved at the end of the D&D phase. This design will continue to be developed into a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	24							2.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	38							3.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.2.1

Title Design, Fab, and Test 602-720 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10	3							30
Parts kit	each	1.9	12							22.8
Consumables (LHe, LN2)	kiloliters	1	7							7
Lab supplies	misc	10	2							20
Test equipment	misc	50	1							50
Prototype mixer blocks – fabrication	each	0.18	12							2.16
									Total (1999 $K):	132

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS wafer development--Stony Brook	each	250	1							250
SIS wafer development--UVA	each	250	1							250
									Total (1999 $K):	500

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MMA Cost Estimation Data Input Table

WBS Number 4.3.2.3 *e.g., 1.1.4.45*

Title Fabricate 602-720 GHz mixer blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The mixer blocks needed for the 602-720 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		7	7					1.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.2.3

Title Fabricate 602-720 GHz mixer blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1		3	10					13
Electroforming & plating materials	misc	1		0.3	1.1					1.4
									Total (1999 $K):	14

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.2.4 *e.g., 1.1.4.45*

Title Fabricate & test 602-720 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	78%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 602-720 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		9	9					1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		22	22					3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.2.4

Title Fabricate & test 602-720 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10		2						20
Parts kit (connectors, components)	each	1.9		38	38					144.4
Consumables (LHe, LN2)	kiloliters	1		7	7					14
Lab supplies	misc	10		4	4					80
									Total (1999 $K):	258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer wafer fab--Stony Brook	each	30	5	5						300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.3.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 275-370 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The design of a sideband-separating, balanced mixer for the 275-370 GHz band will be started and completed. This design will be developed into a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	24	24						4.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	29	29						4.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.3.1

Title Design, Fab, and Test 275-370 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10	2	2						40
Parts kit (connectors, components)	each	1.9	10	10						38
Consumables (LHe, LN2)	kiloliters	1	7	7						14
Lab supplies	misc	10	2	2						40
Test equipment	misc	50	1							50
Software maintenance	each	10		1						10
Prototype mixer blocks – fabrication	each	0.18	6	6						2.16
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS wafer development--UVA	each	250		1						250
									Total (1999 $K):	250

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MMA Cost Estimation Data Input Table

WBS Number 4.3.3.3 *e.g., 1.1.4.45*

Title Fabricate 275-370 GHz mixer blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The mixer blocks needed for the 275-370 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		5	5					0.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.3.3

Title Fabricate 275-370 GHz mixer blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1		3.5	2.1					6
Electroforming & plating materials	misc	1		1	0.4					1.4
									Total (1999 $K):	7

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.3.4 *e.g., 1.1.4.45*

Title Fabricate & test 275-370 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 275-370 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		12	6					1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		30	14					3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.3.4

Title Fabricate & test 275-370 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10		2						20
Parts kit (connectors, components)	each	1.9		50	26					144.4
Consumables (LHe, LN2)	kiloliters	1		9	5					14
Lab supplies	misc	10		5	3					80
									Total (1999 $K):	258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer wafer fab--UVA	each	30		7	3					300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.4.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 89-116 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The design of a sideband-separating, balanced mixer for the 89-116 GHz band will be started and completed. This design will be developed into a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		32	16					4.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		39	19					4.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.4.1

Title Design, Fab, and Test 89-116 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10		2	2					40
Parts kit (connectors, comp each	each	1.9		10	10					38
Consumables (LHe, LN2)	kiloliters	1		7	7					14
Lab supplies	misc	10		2	2					40
Test equipment	misc	50		1						50
Software maintenance	each	10			1					10
Prototype mixer blocks – fabrication	each	0.18		6	6					2.16
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS wafer development--Stony Brook	each	250		1	1					500
									Total (1999 $K):	500

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MMA Cost Estimation Data Input Table

WBS Number 4.3.4.3 *e.g., 1.1.4.45*

Title Fabricate 89-116 GHz mixer blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The mixer blocks needed for the 89-116 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			3	7				0.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.4.3

Title Fabricate 89-116 GHz mixer blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1			2.1	3.5				6
Electroforming & plating materials	misc	1			0.4	1				1.4
									Total (1999 $K):	7

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.4.4 *e.g., 1.1.4.45*

Title Fabricate 89-116 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 89-116 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			6	12				1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			14	30				3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.4.4

Title Fabricate 89-116 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10			2					20
Parts kit (connectors, components)	each	1.9			30	46				144.4
Consumables (LHe, LN2)	kiloliters	1			5	9				14
Lab supplies	misc	10			3	5				80
									Total (1999 $K):	258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer wafer fab--Stony Brook	each	30			3	7				300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.5.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 163-211 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The design of a sideband-separating, balanced mixer for the 163-211 GHz band will be started and completed. This design will be developed into a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			32	16				4.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			39	19				4.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.5.1

Title Design, Fab, and Test 163-211 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10			2	2				40
Parts kit (connectors, components)	each	1.9			10	10				38
Consumables (LHe, LN2)	kiloliters	1			7	7				14
Lab supplies	misc	10			2	2				40
Test equipment	misc	50			1					50
Software maintenance	each	10				1				10
Prototype mixer blocks – fabrication	each	0.18			6	6				2.16
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS wafer development--UVA	each	250				1				250
									Total (1999 $K):	250

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MMA Cost Estimation Data Input Table

WBS Number 4.3.5.3 *e.g., 1.1.4.45*

Title Fabricate 163-211 GHz Mixer Blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*

Calculated Contingency: 16% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

The mixer blocks needed for the 163-211 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				5	5			0.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.5.3

Title Fabricate 163-211 GHz Mixer Blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1				3.5	2.1			6
Electroforming & plating materials	misc	1				1	0.4			1.4
									Total (1999 $K):	7

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.5.4 *e.g., 1.1.4.45*

Title Fabricate & test 163-211 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 80 163-211 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				8	10			1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				20	24			3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.5.4

Title Fabricate & test 163-211 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10				2				20
Parts kit (connectors, components)	each	1.9				40	36			144.4
Consumables (LHe, LN2)	kiloliters	1				7	7			14
Lab supplies	misc	10				4	4			80
									Total (1999 $K):	258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer wafer fab--UVA	each	30				5	5			300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.6.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 385-500 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The design of a sideband-separating, balanced mixer for the 385-500 GHz band will be started and completed. This design will be developed into a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			20	28				4.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			20	38				4.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.6.1

Title Design, Fab, and Test 385-500 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10			2	2				40
Parts kit (connectors, components)	each	1.9			10	10				38
Consumables (LHe, LN2)	kiloliters	1			7	7				14
Lab supplies	misc	10			2	2				40
Test equipment	misc	50			1					50
Prototype mixer blocks – fabrication	each	0.18			6	6				2.16
									Total (1999 $K):	184

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS wafer development--Stony Brook	each	250				1				250
									Total (1999 $K):	250

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MMA Cost Estimation Data Input Table

WBS Number 4.3.6.3 *e.g., 1.1.4.45*

Title Fabricate 385-500 GHz mixer blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*

Calculated Contingency: 16% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

The mixer blocks needed for the 385-500 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					7	3		0.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.6.3

Title Fabricate 385-500 GHz mixer blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1					8	5		13
Electroforming & plating materials	misc	1					0.9	0.5		1.4
									Total (1999 $K):	14

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.6.4 *e.g., 1.1.4.45*

Title Fabricate & Test 385-500 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 385-500 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.					12	6		1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					30	14		3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.6.4

Title Fabricate & Test 385-500 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10					2			20
Parts kit (connectors, components)	each	1.9					50	26		144.4
Consumables (LHe, LN2)	kiloliters	1					9	5		14
Lab supplies	misc	10					5	3		80
									Total (1999 $K):	258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer wafer fab--Stony Brook	each	30					6	4		300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.7.1 *e.g., 1.1.4.45*

Title Design, Fab, and Test 125-163 GHz Mixer Design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	52%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The design of a sideband-separating, balanced mixer for the 125-163 GHz band will be started and completed. This design will be developed into a design optimized for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				16	32			4.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				20	38			4.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.7.1

Title Design, Fab, and Test 125-163 GHz Mixer Design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10				2	2			40
Parts kit (connectors, components)	each	1.9				8	12			38
Consumables (LHe, LN2)	kiloliters	1				6	8			14
Lab supplies	misc	10				2	2			40
Test equipment	misc	50				1				50
Software maintenance	each	10					1			10
Prototype mixer blocks – fabrication	each	0.18				6	6			2.16
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS wafer development--UVA	each	250					1			250
									Total (1999 $K):	250

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MMA Cost Estimation Data Input Table

WBS Number 4.3.7.3 *e.g., 1.1.4.45*

Title Fabricate 125-163 GHz mixer blocks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The mixer blocks needed for the 125-163 GHz mixers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					2	7	1	0.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.7.3

Title Fabricate 125-163 GHz mixer blocks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Tooling & materials	misc	1					1	3.6	1	6
Electroforming & plating materials	misc	1					0.2	1	0.2	1.4
									Total (1999 $K):	7

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.7.4 *e.g., 1.1.4.45*

Title Fabricate & Test 125-163 GHz SIS Mixer Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	1	*(2 or 4 are valid)*
Cost	4	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 125-163 GHz Nb SIS sideband-separating, balanced mixers will be fabricated, tested, and shipped to Tucson for assembly into receiver modules.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.					2	12	4	1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					5	29	10	3.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.7.4

Title Fabricate & Test 125-163 GHz SIS Mixer Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
SIS mixer wafer masks	each	10					2			20
Parts kit (connectors, components)	each	1.9					10	50	16	144.4
Consumables (LHe, LN2)	kiloliters	1					1	9	4	14
Lab supplies	misc	10					1	5	2	80
Software maintenance	each	10						1	1	20
									Total (1999 $K):	278

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Nb SIS mixer wafer fab–UVA	each	30					2	6	2	300
									Total (1999 $K):	300

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.1 *e.g., 1.1.4.45*

Title Build SIS Fabrication Equipment *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The fabrication equipment needed to manufacture the large quantities of SIS mixers will be procured, installed, and adapted to the specific needs of the project as required. This equipment includes computer-controlled milling machines, lathes, and dicing saws; a lapping machine; an inductively coupled etching machine capable of producing re-entrant cuts on quartz substrates; and microscopes, manipulation tools, bonders, welders, hot plates, hand tools, and other related items.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	24							2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.1
Title Build SIS Fabrication Equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Refurbish old dicing saw	each	50	1							50
New dicing saw	each	100	1							100
Precision CNC milling machine	each	100	1							100
Precision CNC lathe	each	70	1							70
Lapping machine	each	30	1							30
Inductively coupled RIE (etcher)	each	300	1							300
Stereo Microscopes + illuminators	each	6	5							30
Measuring Microscope	each	26	1							26
Wire bonders	each	30	2							60
Welders	each	20	2							40
Lab parts	misc	40	1							40
									Total (1999 $K):	846

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.2 *e.g., 1.1.4.45*

Title Build SIS Test Dewar & Rack #1 *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

A closed-cycle 4K SIS test dewar and controlling equipment rack identical to those used for design and development will be built, outfitted, and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	24							2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.2

Title Build SIS Test Dewar & Rack #1

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Fabricated parts (NRAO)	each	27	1							27
Instrumented Dewar & Pumps	each	88	1							88
Refrigerator & compressor	each	50	1							50
Oscilloscopes Tek 3052	each	10	2							20
RF spectrum analyzer Tek 2784	each	62	1							62
IF spectrum analyzer HP E4408B	each	20	1							20
Other OTS equipment	each	36	1							36
									Total (1999 $K):	303

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.3 *e.g., 1.1.4.45*

Title Build SIS Test Dewar & Rack #2 *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*) A closed-cycle 4K SIS test dewar and controlling equipment rack identical to those used for design and development will be built, outfitted, and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	4	2						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	14	10						2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.3

Title Build SIS Test Dewar & Rack #2

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Fabricated parts (NRAO)	each	27	1							27
Instrumented Dewar & Pumps	each	88	1							88
Refrigerator & compressor	each	50	1							50
Oscilloscopes Tek 3052	each	10	2							20
RF spectrum analyzer Tek 2784	each	62	1							62
IF spectrum analyzer HP E4408B	each	20	1							20
Other OTS equipment	each	36	1							36
									Total (1999 $K):	303

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.4 *e.g., 1.1.4.45*

Title Build SIS Test Dewar & Rack #3 *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

A closed-cycle 4K SIS test dewar and controlling equipment rack identical to those used for design and development will be built, outfitted, and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	4						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	10	14						2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.4

Title Build SIS Test Dewar & Rack #3

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Fabricated parts (NRAO)	each	27	1							27
Instrumented Dewar & Pumps	each	88	1							88
Refrigerator & compressor	each	50	1							50
Oscilloscopes Tek 3052	each	10	2							20
RF spectrum analyzer Tek 2784	each	62	1							62
IF spectrum analyzer HP E4408B	each	20	1							20
Other OTS equipment	each	36	1							36
									Total (1999 $K):	303

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.5 *e.g., 1.1.4.45*

Title Build SIS Test Dewar & Rack #4 *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

A closed-cycle 4K SIS test dewar and controlling equipment rack identical to those used for design and development will be built, outfitted, and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	4						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	4	20						2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.5

Title Build SIS Test Dewar & Rack #4

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Fabricated parts (NRAO)	each	27	1							27
Instrumented Dewar & Pumps	each	88	1							88
Refrigerator & compressor	each	50	1							50
Oscilloscopes Tek 3052	each	10	2							20
RF spectrum analyzer Tek 2784	each	62	1							62
IF spectrum analyzer HP E4408B	each	20	1							20
Other OTS equipment	each	36	1							36
									Total (1999 $K):	303

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.6 *e.g., 1.1.4.45*

Title Build Wafer Evaluation Test Sets *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	18%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Nb tri-layer SIS wafers and InP IF amplifier wafers must be probed before being used in mixers, in order to avoid costly wasted effort. Equipment will be purchased which allows basic device testing.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.6

Title Build Wafer Evaluation Test Sets

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Capacitance meter	each	12	1							12
Amplifier probe station	each	30	1							30
Test dewar	each	20	1							20
Instrumentation	misc	5	1							5
Pumping station	each	12	1							12
									Total (1999 $K):	79

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.7.1 *e.g., 1.1.4.45*

Title General SIS Test Equipment *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Procure two general-purpose 1-40 GHz frequency synthesizers, 4 oscilloscopes, and dry nitrogen storage cabinets.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.7.1
Title General SIS Test Equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
HP83630B 1-40 GHz synthesizer	each	50	1	1						100
Oscilloscopes	each	6	2	2						24
Dry-Nitrogen storage cabinets	each	1	1	1						2
									Total (1999 $K):	126

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.7.2 *e.g., 1.1.4.45*

Title Equip Network Analyzer to 330 GHz *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	15%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

An HP85106 Vector Network Analyzer equipped with extender modules to reach 330 GHz will be procured and installed.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	1	2	1				0.6
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.7.2

Title Equip Network Analyzer to 330 GHz

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
HP85106 opt010 VNA (110 GHz)	each	250	1							250
Oleson VNA extenders:										
170-260 GHz	each	76	1							76
220-330 GHz	each	104		1						104
90-140 GHz	each	46			1					46
140-220 GHz	each	63			1					63
110-170 GHz	each	55				1				55
									Total (1999 $K):	594

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.7.3 *e.g., 1.1.4.45*

Title Near-Field Feed Measurement Equipment *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	15%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

A near-field measurement system for frequencies from 90 to 700 GHz will be built and installed. It will use test signal generation equipment from the development apparatus.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	12						1.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		12						1.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.7.3

Title Near-Field Feed Measurement Equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
X-Y-Theta positioner	each	21	1	1	1					63
Vector voltmeter	each	8.5	1	1	1					26
									Total (1999 $K):	89

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.8 *e.g., 1.1.4.45*

Title Build 211-275 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO source and sideband plates needed to equip two 211-275 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.8

Title Build 211-275 GHz Source Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	60	2							120
Parts for sideband plates	each	60	2							120
									Total (1999 $K):	240

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.9 *e.g., 1.1.4.45*

Title Build 602-720 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO source and sideband plates needed to equip two 602-720 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.9

Title Build 602-720 GHz Source Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	65	2							130
Parts for sideband plates	each	65	2							130
									Total (1999 $K):	260

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.10 *e.g., 1.1.4.45*

Title Build 275-370 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO source and sideband plates needed to equip two 275-370 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		6						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		6						0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.10

Title Build 275-370 GHz Source Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	60		2						120
Parts for sideband plates	each	60		2						120
									Total (1999 $K):	240

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.11 *e.g., 1.1.4.45*

Title Build 89-116 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO source and sideband plates needed to equip two 89-116 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			6					0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			6					0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.11

Title Build 89-116 GHz Test Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	55			2					110
Parts for sideband plates	each	55			2					110
									Total (1999 $K):	220

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.12 *e.g., 1.1.4.45*

Title Build 163-211 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO source and sideband plates needed to equip two 163-211 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			6					0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			6					0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.12

Title Build 163-211 GHz Source Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	60			2					120
Parts for sideband plates	each	60			2					120
									Total (1999 $K):	240

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.13 *e.g., 1.1.4.45*

Title Build 385-500 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO source and sideband plates needed to equip two 385-500 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				6				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				6				0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.13

Title Build 385-500 GHz Source Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	65				2				130
Parts for sideband plates	each	65				2				130
									Total (1999 $K):	260

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.8.14 *e.g., 1.1.4.45*

Title Build 125-163 GHz Source Plates *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO source and sideband plates needed to equip two 125-163 GHz mixer test stations will be built from commercial parts according to an existing design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.					6			0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					6			0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.8.14
Title Build 125-163 GHz Source Plates

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for LO plates	each	60					2			120
Parts for sideband plates	each	60					2			120
									Total (1999 $K):	240

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.9.1 *e.g., 1.1.4.45*

Title Obtain and evaluate InP IF amplifier wafers *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Indium Phosphide wafers with either MMIC IF amplifiers or discrete transistors will be ordered from an established vendor using IF preamp and postamp designs proven in the D&D phase. The devices will be tested in working amplifiers to verify performance before commencing the production run.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12							1.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.9.1

Title Obtain and evaluate InP IF amplifier wafers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
InP IF amplifier wafers	each	100	2							200
									Total (1999 $K):	200

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.3.9.2 *e.g., 1.1.4.45*

Title Build IF amplifiers *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The InP IF amplifiers which follow the SIS mixers and HFET front end mixers will be fabricated and tested. There are 1600 amplifiers required.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6	6	6	6	6	6	6	3.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12	32	32	32	32	32	24	16.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.3.9.2

Title Build IF amplifiers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts kit (connectors, R, C, etc.)	each	0.4	130	260	260	260	260	260	90	608
									Total (1999 $K):	608

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.4.1 *e.g., 1.1.4.45*

Title Contract for HFET wafer *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The specifications of an InP wafer containing devices suitable for use in low-noise front end amplifiers will be determined and an order placed for custom fabrication.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.4.1

Title Contract for HFET wafer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
InP transistor wafer	each	100	1							100
									Total (1999 $K):	100

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.4.2 *e.g., 1.1.4.45*

Title Receive and evaluate InP LNA wafer *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The InP wafer to be used for front end low-noise amplifiers will be received and evaluated by building sample amplifiers using devices from several parts of the wafer.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.4.2

Title Receive and evaluate InP LNA wafer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amplifier parts kit	1	1	10							10
Lab supplies	misc	1	2							2
									Total (1999 $K):	12

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.4.3.1 *e.g., 1.1.4.45*

Title Build 31-45 GHz HFET Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 required 31-45 GHz amplifiers will be built and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	9						1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	8	23						2.6
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.4.3.1

Title Build 31-45 GHz HFET Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amplifier parts kit	each	1	20	60						80
LN2	kiloliters	0.5	1	4						3
Other supplies	misc	4	1	3						16
									Total (1999 $K):	99

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.4.4.1 *e.g., 1.1.4.45*

Title Design 67-90 GHz amplifier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

A new amplifier design optimized for 67-90 GHz will be produced, tested, and refined.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	4						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2	4						0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.4.4.1

Title Design 67-90 GHz amplifier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amplifier parts kit	each	1	5							5
lab supplies	misc	4	0.5	0.5						4
									Total (1999 $K):	9

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 4.4.4.2 *e.g., 1.1.4.45*

Title Build 67-90 GHz HFET Detector Modules *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 80 required newly-designed 67-90 GHz amplifiers will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		6	6					1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		18	18					3.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 4.4.4.2

Title Build 67-90 GHz HFET Detector Modules

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amplifier parts kit	each	1	20	60						80
LN2	kiloliters	0.5	1	4						3
Other supplies	misc	4	1	3						16
									Total (1999 $K):	99

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

MMA Cost Estimation Data Input Table

WBS Number 5.1 *e.g., 1.1.4.45*

Title LO Reference: Prototype Systems *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (ext for the WBS dictionary)

LO Reference Prototype for Test Interferometer

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	12	12						2.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	24	24						4.0
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 5.1

Title LO Reference: Prototype Systems

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
REF GEN AND DIST		0	2							0
RT PHASE METER 5.2.12]		0	3							0
PLO 8 GHZ [5.2.3]		0	3							0
PLO 10 GHZ [5.2.4]		0	3							0
PLO 12 GHZ [5.2.5]		0	3							0
PLO 14 GHZ [5.2.6]		0	3							0
PLO 16 GHZ [5.2.15]		0	3							0
PLO 26 GHZ [5.2.16]		0	3							0
PLO 4 GHZ [5.2.9]		0	3							0
3.2-5.2 SYNTH [5.2.7]		0	3							0
2ND FRINGE GEN [5.2.8]		0	3							0
10-15 SYNTH [5.2.13]		0	3							0
1ST FRINGE GEN 5.2.14]		0	3							0
LO CLEAN-UP [5.2.18]		0	3							0
POWER SUP [5.2.19]		0	3							0
SUB TOTAL		0								

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
BINS (3 PER ANTENNA)		1	6							6

Total (1999 $K): 6

MMA Cost Estimation Data Input Table

WBS Number 5.2.1 *e.g., 1.1.4.45*

Title Production test and lab equipment *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Test equipment needed for the production phase of the project.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.2.1

Title Production test and lab equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
GENERAL EST EQ										
Sweep Gen		27		1						27
Microwave Counter		18		1						18
Power Meter		8		1						8
LO Noise Test Set		135		1						135
Spectrum Analyzer		36		1						36
Misc Lab Equipment		10		1						10
SPECIAL TEST EQ										
5 MHz LO Ref		3		1						3
LO Dist Subsystem		16		1						16
RT Delay Set		10		1						10
Delay Line		2		1						2
Milli-Hz Counter		10		1						10
COMPUTERS										
Computer		4		1						4
Interfaces		1		1						1
Labview		2		1						2
SUB TOTAL		282								

Total (1999 $K): 282

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

MMA Cost Estimation Data Input Table

WBS Number 5.2.2 *e.g., 1.1.4.45*

Title H-maser Frequency Standard (& Rb) *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	8%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Primary frequency reference for the array. Output is 5 MHz.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.			1					0.1
			Ops.								
Technician	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.			1					0.1
			Ops.								

WBS Number 5.2.2

Title H-maser Frequency Standard (& Rb)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
MASER		300		1						300
SUB TOTAL		300								

Total (1999 $K): 300

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

MMA Cost Estimation Data Input Table

WBS Number 5.2.3 *e.g., 1.1.4.45*

Title 8 GHz PL Oscillator & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This oscillator is used with the IF Demultiplexer in the CEB. Identify a commercial unit that meets specs, or, if none is available, design and build a unit.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1	1	1	1	1	1	1	0.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.	1	2	2	2	2	2	1	1.0
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.3

Title 8 GHz PL Oscillator & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
8 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
		5.1								
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.4 *e.g., 1.1.4.45*

Title 10 GHz PL Oscillator & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This oscillator is used with the IF Demultiplexer in the CEB. Identify a commercial unit that meets specs, or, if none is available, design and build a unit.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1	1	1	1	1	1	1	0.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.	1	2	2	2	2	2	1	1.0
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.4
Title 10 GHz PL Oscillator & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
10 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		5.1								

Total (1999 $K): 194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.5 *e.g., 1.1.4.45*

Title 12 GHz PL Oscillator & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This oscillator is used with the IF Demultiplexer in the CEB. Identify a commercial unit that meets specs, or, if none is available, design and build a unit.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1	1	1	1	1	1	1	0.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.	1	2	2	2	2	2	1	1.0
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.5

Title 12 GHz PL Oscillator & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
12 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		5.1								

Total (1999 $K): 194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.6 *e.g., 1.1.4.45*

Title 14 GHz PL Oscillator & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This oscillator is used with the IF Demultiplexer in the CEB. Identify a commercial unit that meets specs, or, if none is available, design and build a unit.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1	1	1	1	1	0.5
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		2	2	2	2	2	1	0.9
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.6
Title 14 GHz PL Oscillator & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
14+A4 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		5.1								
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.7 *e.g., 1.1.4.45*

Title 3.2-5.2 GHz Synthesizer *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

This module set supplies the local oscillator for the Baseband Converter (BBC). The final lobe rotation is applied at th point by adding the phase of the fringe generator to the synthesizer in a phase lock loop.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2	2	1	1	1	2	0.8
			Ops.								
		Chile	Constr.				1			2	0.3
			Ops.								
Technician	months	US	Constr.		12	12	12	12	12	2	5.2
			Ops.								
		Chile	Constr.				1			2	0.3
			Ops.								

WBS Number 5.2.7
Title 3.2-5.2 GHz Synthesizer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
10 MHZ PLO SUBSYS		3.4		32	28	28	28	28	8	517
MICRO SUBSYS		0.3		32	28	28	28	28	8	45.6
PLL SUBSYS		0.1		32	28	28	28	28	8	15.2
3-6 GHZ YIG		0.5		32	28	28	28	28	8	76
6 GHZ DET		0.2		32	28	28	28	28	8	30.4
6 GHZ 4-WAY SPLIT		0.2		32	28	28	28	28	8	30.4
10 MHZ HARM MIX		0.4		32	28	28	28	28	8	60.8
2-48 MHZ IF AMP		0.1		32	28	28	28	28	8	15.2
100 MHZ HARM MIX		1.6		32	28	28	28	28	8	243.2
DIGITAL ATTN		1.4		32	28	28	28	28	8	212.8
PRESCALER		0.4		32	28	28	28	28	8	60.8
CABLES		1		32	28	28	28	28	8	152
ENCLOSURE		1		32	28	28	28	28	8	152
PCB		0.2		32	28	28	28	28	8	30.4
HARDWARE		0.2		32	28	28	28	28	8	30.4
POWER CONDX		0.2		32	28	28	28	28	8	30.4
YIG SHIELD		0.5		32	28	28	28	28	8	76
ISOLATOR		0.3		32	28	28	28	28	8	45.6
SUB TOTAL		12								
									Total (1999 $K):	1,824

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.8 *e.g., 1.1.4.45*

Title 3.2 -5.2 GHz PLO and Fringe Generator *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This is a signal generator used to provide the highly accurate 5 MHZ reference to the 3.2-5.2 GHz synthesizer and shift it in 1 milli-Hz steps to provide for fringe rotation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	1	1	1	1	1	0.7
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		6	6	6	6	6	1	2.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.8

Title 3.2 -5.2 GHz PLO and Fringe Generator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
MICROPROC SUBSYS		0.5		32	28	28	28	28	8	76
DSP SUBSYS		1		32	28	28	28	28	8	152
MIXERS		0.4		32	28	28	28	28	8	60.8
PHASE SPLITTER		0.2		32	28	28	28	28	8	30.4
MISC PARTS		0.2		32	28	28	28	28	8	30.4
PCB's		0.2		32	28	28	28	28	8	30.4
CABLES & CONN		0.2		32	28	28	28	28	8	30.4
DETECTOR		0.1		32	28	28	28	28	8	15.2
POWER CONDX		0.2		32	28	28	28	28	8	30.4
ENCLOSURE		1		32	28	28	28	28	8	152
FT PANEL		0.2		32	28	28	28	28	8	30.4
SUB TOTAL		4.2								

Total (1999 $K): 638

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.9 *e.g., 1.1.4.45*

Title Sampler Clock 4 GHz PL Osc & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This Local oscillator supplies the 4 GHz clock signal to the sampler and digital filters for the antenna. It will be a purchased item and will be a standard off-the-shelf phase locked oscillator.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1	1	1	1	1	1	1	0.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.	1	3	3	3	3	3	1	1.4
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 5.2.9
Title Sampler Clock 4 GHz PL Osc & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
4 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		5.1								
								Total (1999 $K):		194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
								Total (1999 $K):		

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.10 *e.g., 1.1.4.45*
Title LO Ref Generator *e.g., Project Management and Tracking*
Estimator JOHN BATTLE *Name*
Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)
The reference generator produces several reference frequencies based on the fundamental frequency standard(e.g., 1 Hz, 50 MHZ, 16 GHz). In addition, a reference distributor module will be developed to supply the reference signals to modules in the CEB and to the fiber optic transmitter which sends the reference signals to the antennas.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								
Technician	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 5.2.10
Title LO Ref Generator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
INPUT BUFFER		0.8		1					1	2
SIGNAL SEPARATOR		1		1					1	2
16 GHZ PHASE DET		0.8		1					1	1.6
PLL SUBSYSTEM		0.5		1					1	1
LO MULT SUBSYSTEM		8.2		1					1	16.4
16 GHZ 2-WAY SPLIT		0.3		1					1	0.6
16 GHZ DIR COUP		0.3		1					1	0.6
50 MHZ SPLIT		0.1		1					1	0.2
50 MHZ PHASE DET		0.1		1					1	0.2
MICROPROC SUBSYS		0.5		1					1	1
ENCLOSURE		1		1					1	2
CABLES		1		1					1	2
FRT PANEL		0.2		1					1	0.4
PCB		0.1		1					1	0.2
POWER CONDX		0.2		1					1	0.4
5 MHZ X4 MULT		0.1		1					1	0.2
SUB TOTAL		15.2								
									Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.11 *e.g., 1.1.4.45*

Title LO Ref Distributor - Control Bldg *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Used to distribute the reference signal to the various lasers to be transmitted to the antennas.B50

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								
Technician	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 5.2.11

Title LO Ref Distributor - Control Bldg

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
FRONT PANEL		0.2		1					1	0
MICROPROC SYBSYS		0.5		1					1	1
INPUT BUFFER		0.5		1					1	1
8-WAY SPLITTERS		6		1					1	12
WIDEBAND AMPS		5		1					1	10
SIGNAL READY DET		2		1					1	4
CABLES		5		1					1	10
DIR COUPLER		1		1					1	2
ENCLOSURE		1		1					1	2
POWER CONDX		0.3		1					1	0.6
SUB TOTAL		21.5								
									Total (1999 $K):	43

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.12 *e.g., 1.1.4.45*

Title Microwave Round-trip Phase Measurement *e.g., Project Management and Tracking*

Estimator Ron Beresford *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	49%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

This subsystem delivers the 16GHz RF Local Oscillator from the central master local oscillator to the antennas via fib optics. A 16GHz return signal from the antennas provides round trip phase measurement . The scheme is limited to Direct Detection Intensity Modulation. No coherent photonics are involved .The design uses commercially available components but polarization requirements and wavelength selection will necessitate special procurement. All aspects of construction will be in-house. The cost of unjacketed Polarization Maintaining fiber included. Performance at 800GHz and 4.7km of fiber span is dubious and at best will require substantial experimentation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	2	2	2	2			0.9
			Ops.								
		Chile	Constr.			1	1	1	1	1	0.4
			Ops.								
Technician	months	US	Constr.	3	3	3	3				1.0
			Ops.								
		Chile	Constr.				3	3	3	2	0.9
			Ops.						12	12	2.0

WBS Number 5.2.12

Title Microwave Round-trip Phase Measurement

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
16GHz Phse Locked Mul		4.1		8	7	7	7	7	2	156
16GHz 20dB Amplifier		0.9		8	7	7	7	7	2	34.2
16GHz Mixer		0.8		8	7	7	7	7	2	30.4
Phase Meter Processor		1.2		8	7	7	7	7	2	45.6
YIG Based 10 KHz Fltr		4.2		8	7	7	7	7	2	159.6
50 MHz LPF		0.2		8	7	7	7	7	2	7.6
SUB TOTAL		11.4								
									Total (1999 $K):	433

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Module Fabrication etc	76	1.5		19	19	19	19			114
									Total (1999 $K):	114

Note: Purchases and Labor in 2007 are for Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.13 *e.g., 1.1.4.45*

Title 10-15 GHz Frequency Synthesizer *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	49%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This synthesizer is a) the input signal for the Multiplier LO system or b) is used in the control loop in the photonic system to establish the frequency difference of the two lasers. In the Multiplier LO option, this module will be at the antenna. In the Photonic LO option, this module will be in the CEB and supply frequency f1 as part of the laser frequency control loop. This may be the same module in either LO option.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2	1	1	1	1	1	0.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		7	6	6	6	6	2	2.8
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 5.2.13

Title 10-15 GHz Frequency Synthesizer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
MICRO SUBSYS		0.3		8	7	7	7	7	2	11.4
PLL SUBSYS		0.1		8	7	7	7	7	2	3.8
10-15 GHZ YIG		0.5		8	7	7	7	7	2	19
15 GHZ DET		0.2		8	7	7	7	7	2	7.6
15 GHZ 4-WAY SPLIT		0.2		8	7	7	7	7	2	7.6
1 GHZ HARM MIX		1.7		8	7	7	7	7	2	64.6
1-1000 MHZ IF AMP		0.1		8	7	7	7	7	2	3.8
20 MHZ HARM MIX		1.1		8	7	7	7	7	2	41.8
DIGITAL ATTN		1.7		8	7	7	7	7	2	64.6
PRESCALER		0.8		8	7	7	7	7	2	30.4
CABLES		1		8	7	7	7	7	2	38
ENCLOSURE		1		8	7	7	7	7	2	38
PCB		0.2		8	7	7	7	7	2	7.6
HARDWARE		0.2		8	7	7	7	7	2	7.6
POWER CONDX		0.2		8	7	7	7	7	2	7.6
YIG SHIELD		0.5		8	7	7	7	7	2	19
ISOLATOR		0.3		8	7	7	7	7	2	11.4
SUBTOTAL		10.1								
								Total (1999 $K):		384

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
								Total (1999 $K):		

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.14 *e.g., 1.1.4.45*

Title First LO Fringe Generator *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This subsystem provides the 5 MHZ reference signal with a highly accurate offset to the first synthesizer to provide for lobe rotation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	1				1	0.4
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		6	6	6	6	6	1	2.6
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.14

Title First LO Fringe Generator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
MICROPROC SUBSYS		0.5		32	28	28	28	28	8	76
DSP SUBSYS		1		32	28	28	28	28	8	152
MIXERS		0.4		32	28	28	28	28	8	60.8
PHASE SPLITTER		0.2		32	28	28	28	28	8	30.4
MISC PARTS		0.2		32	28	28	28	28	8	30.4
PCB's		0.2		32	28	28	28	28	8	30.4
CABLES & CONN		0.2		32	28	28	28	28	8	30.4
DETECTOR		0.1		32	28	28	28	28	8	15.2
POWER CONDX		0.2		32	28	28	28	28	8	30.4
ENCLOSURE		1		32	28	28	28	28	8	152
FT PANEL		0.2		32	28	28	28	28	8	30.4
SUB TOTAL		4.2								
									Total (1999 $K):	638

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.15 *e.g., 1.1.4.45*

Title 16 GHz PL Oscillator & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This module supplies the fixed LO for the IF Converter in the antenna.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1				1	0.3
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		2	2	2	2	2	1	0.9
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.15

Title 16 GHz PL Oscillator & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
16+A4 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		5.1								
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.16 *e.g., 1.1.4.45*

Title 26 GHz PL Oscillator & Distributor *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This module supplies the 2nd LO for the HFET amplifier receivers. Design and fabricate this module or identify and test a commercial equivalent.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1				1	0.3
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		2	2	2	2	2	1	0.9
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.16
Title 26 GHz PL Oscillator & Distributor

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
26 GHZ PLO		3.4		8	7	7	7	7	2	129
2-WAY SPLITTER		0.3		8	7	7	7	7	2	11.4
CABLES		0.1		8	7	7	7	7	2	3.8
ENCLOSURE		0.5		8	7	7	7	7	2	19
COUPLER		0.2		8	7	7	7	7	2	7.6
DETECTOR		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		5.1								
									Total (1999 $K):	194

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.17 *e.g., 1.1.4.45*

Title LO Ref Distributor - Antenna *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	18%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Distributes the processed LO reference signal within an antenna's electronics

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1					1	0.2
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		2	2	2	2	2	1	0.9
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.17

Title LO Ref Distributor - Antenna

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
BUFFER AMPS		2		8	7	7	7	7	2	76
SPLITTERS		2		8	7	7	7	7	2	76
CABLES		1		8	7	7	7	7	2	38
ENCLOSURE		1		8	7	7	7	7	2	38
COUPLERS		0.2		8	7	7	7	7	2	7.6
DETECTORS		0.2		8	7	7	7	7	2	7.6
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
SUB TOTAL		6.8								

Total (1999 $K): 258

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.18 *e.g., 1.1.4.45*

Title VXCO Clean-up Loop *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost [ ] *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule [ ] *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical [ ] *(2 or 4 are valid)*

Cost [ ] *(1 or 2 are valid)*

Calculated Contingency: 100% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

Used to stabilize and remove noise from the LO reference signal arriving at the antenna via the fiber optic link.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1				1	0.3
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.		2	2	2	2	2	1	0.9
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.18

Title VXCO Clean-up Loop

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
INPUT BUFFER		0.8		8	7	7	7	7	2	30
SIGNAL SEPARATOR		1		8	7	7	7	7	2	38
16 GHZ PHASE DET		0.8		8	7	7	7	7	2	30.4
PLL SUBSYSTEM		0.5		8	7	7	7	7	2	19
LO MULT SUBSYSTEM		8.2		8	7	7	7	7	2	311.6
16 GHZ 2-WAY SPLIT		0.3		8	7	7	7	7	2	11.4
16 GHZ DIR COUP		0.3		8	7	7	7	7	2	11.4
50 MHZ SPLIT		0.1		8	7	7	7	7	2	3.8
50 MHZ PHASE DET		0.1		8	7	7	7	7	2	3.8
MICROPROC SUBSYS		0.5		8	7	7	7	7	2	19
ENCLOSURE		1		8	7	7	7	7	2	38
CABLES		1		8	7	7	7	7	2	38
FRT PANEL		0.2		8	7	7	7	7	2	7.6
PCB		0.1		8	7	7	7	7	2	3.8
POWER CONDX		0.2		8	7	7	7	7	2	7.6
5 MHZ X4 MULT		0.1		8	7	7	7	7	2	3.8
SUB TOTAL		15.2								

Total (1999 $K): 578

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.19 *e.g., 1.1.4.45*

Title Power supply module *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical 1 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost 1 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule 2 *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical 2 *(2 or 4 are valid)*

Cost 1 *(1 or 2 are valid)*

Calculated Contingency: 5% *(See defintions)*

Task Description (*Text for the WBS dictionary*) Power supplies for LO system

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1	2	1				1	0.4
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								
Technician	months	US	Constr.	1	2	1	1	1	1	1	0.7
			Ops.								
		Chile	Constr.				1			1	0.2
			Ops.								

WBS Number 5.2.19

Title Power supply module

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
POS SWTCH PWR SUP		0.8		8	7	7	7	7	2	30
NEG SWTCH PWR SUP		0.8		8	7	7	7	7	2	30.4
RACK ADDAPTOR		0.5		8	7	7	7	7	2	19
MICROPROC SUBSYS		0.4		8	7	7	7	7	2	15.2
ENCLOSURE		0.2		8	7	7	7	7	2	7.6
SUB TOTAL		2.7								

Total (1999 $K): 103

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Note: Purchases and Labor in 2001 are for the Test Interferometer and those in 2007 are Spares

MMA Cost Estimation Data Input Table

WBS Number 5.2.20 *e.g., 1.1.4.45*

Title Bins / Racks (assemble and test) *e.g., Project Management and Tracking*

Estimator JOHN BATTLE *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical 1 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost 8 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule 4 *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical 2 *(2 or 4 are valid)*

Cost 1 *(1 or 2 are valid)*

Calculated Contingency: 14% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

Enclosures for holding the various modules used in the LO system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 5.2.20

Title Bins / Racks (assemble and test)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
HARDWARE		0.2		24	21	21	21	21	6	23
SUB TOTAL		0.2								

Total (1999 $K): 23

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
BINS (3 PER ANTENNA)		1	1	8	7	7	7	7	2	39

Total (1999 $K): 39

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MMA Cost Estimation Data Input Table

WBS Number 5.3.1 *e.g., 1.1.4.45*

Title LO Source Design and System Integration *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	36%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier chain work begun in the design and development phase will be completed. This involves design and test of new LO sources for the 65-85 GHz and 87-108 GHz bands, and refinement of all the LO source designs for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	12	12	12	12	12	6		5.5
			Ops.						6	12	1.5
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	18	18	18	18	18	9		8.3
			Ops.						9	18	2.3
		Chile	Constr.								
			Ops.								

WBS Number 5.3.1

Title LO Source Design and System Integration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lab supplies	each	10	1	1	1	1	1	(to ops)	(to ops)	50
Bodies, diodes, parts	each	10	1	1	1	1	1	(to ops)	(to ops)	50
Simulation Software	each	50	1	0.1	0.1	0.1	0.1	(to ops)	(to ops)	70
									Total (1999 $K):	170

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.3.2.1 *e.g., 1.1.4.45*

Title 72-95 GHz LO Source Procurement & Fabrication *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The components for production 72-95 GHz LO sources will be procured. Some components which are not commercially available will be fabricated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	2	1					0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12	12	10					2.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.2.1

Title 72-95 GHz LO Source Procurement & Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
YIG-tuned oscillator (VQ)	each	2.55	16	16	6					97
18-23.75 GHz amplifier (VQ)	each	2.5	16	16	6					95
18-23.75 GHz X2 multiplier (VQ)	each	2.5	16	16	6					95
36-47.5 GHz amplifier (NRAO)	each	1.2	16	16	6					46
36-47.5 GHz X2 multiplier (NRAO)	each	0.675	16	16	6					26
Mechanical & shielding (NRAO)	each	0.2	16	16	6					8
Waveguide parts	each	0.4	16	16	6					15
Harmonic mixer (VQ)	each	2.2	16	16	6					84
Lock board (NRAO)	each	0.3	16	16	6					11
IF parts (NRAO)	each	0.5	16	16	6					19
YIG driver & power supply (NRAO)	each	0.5	16	16	6					19
Control circuitry and CAN bus (NRAO)	each	0.4	16	16	6					15
Thermal control	each	0.3	16	16	6					11
Output splitter	each	0.1	16	16	6					4
72-95 GHz amplifier (NRAO)	each	0.5	16	16	6					19
									Total (1999 $K):	563

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
72-95 GHz amplifier chip	each	150	1							150
									Total (1999 $K):	150

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MMA Cost Estimation Data Input Table

WBS Number 5.3.2.2 *e.g., 1.1.4.45*

Title 72-95 GHz LO Source Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 72-95 GHz LO source modules will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	2	1					0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3	2	2					0.6
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.2.2

Title 72-95 GHz LO Source Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Cables, connectors, parts	each	0.31	16	16	6					12
									Total (1999 $K):	12

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.3.3.1 *e.g., 1.1.4.45*

Title 102-120 GHz LO Source Procurement & Fabrication *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The components for production 102-120 GHz LO sources will be procured. Some components which are not commercially available will be fabricated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	2	1					0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12	12	10					2.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.3.1

Title 102-120 GHz LO Source Procurement & Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
YIG-tuned oscillator (VQ)	each	2.55	16	16	8					102
15-30 GHz amplifier (VQ)	each	2.5	16	16	8					100
15-30 GHz X2 multiplier (VQ)	each	2.5	16	16	8					100
50-60 GHz amplifier (NRAO)	each	1.2	16	16	8					48
50-60 GHz X2 multiplier (NRAO)	each	0.675	16	16	8					27
Mechanical & shielding (NRAO)	each	0.2	16	16	8					8
Waveguide parts	each	0.4	16	16	8					16
Harmonic mixer (VQ)	each	2.2	16	16	8					88
Lock board (NRAO)	each	0.3	16	16	8					12
IF parts (NRAO)	each	0.5	16	16	8					20
YIG driver & power supply (NRAO)	each	0.5	16	16	8					20
Control circuitry and CAN bus (NRAO)	each	0.4	16	16	8					16
Thermal control	each	0.3	16	16	8					12
Output splitter	each	0.1	16	16	8					4
102-120 GHz amplifier (NRAO)	each	0.5	16	16	6					19
									Total (1999 $K):	592

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
102-120 GHz amplifier chip	each	150	1							150
									Total (1999 $K):	150

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MMA Cost Estimation Data Input Table

WBS Number 5.3.3.2 *e.g., 1.1.4.45*

Title 102-120 GHz LO Source Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 102-120 GHz LO source modules will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3	2	1					0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3	2	2					0.6
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.3.2

Title 102-120 GHz LO Source Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Cables, connectors, parts	each	0.31	16	16	8					12
									Total (1999 $K):	12

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.3.4.1 *e.g., 1.1.4.45*

Title 87-108 GHz LO Source Procurement & Fabrication *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The components for production 87-108 GHz LO sources will be procured. Some components which are not commercially available will be fabricated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			2	2	1			0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			12	12	10			2.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.4.1

Title 87-108 GHz LO Source Procurement & Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
YIG-tuned oscillator (VQ)	each	2.55			16	16	6			97
21.75-27 GHz amplifier (VQ)	each	2.5			16	16	6			95
21.75-27 GHz X2 multiplier (VQ)	each	2.5			16	16	6			95
43.5-54 GHz amplifier (NRAO)	each	1.2			16	16	6			46
43.5-54 GHz X2 multiplier (NRAO)	each	0.675			16	16	6			26
Mechanical & shielding (NRAO)	each	0.2			16	16	6			8
Waveguide parts	each	0.4			16	16	6			15
Harmonic mixer (VQ)	each	2.2			16	16	6			84
Lock board (NRAO)	each	0.3			16	16	6			11
IF parts (NRAO)	each	0.5			16	16	6			19
YIG driver & power supply (NRAO)	each	0.5			16	16	6			19
Control circuitry and CAN bus (NRAO)	each	0.4			16	16	6			15
Thermal control	each	0.3			16	16	6			11
Output splitter	each	0.1			16	16	6			4
87-108 GHz amplifier (NRAO)	each	0.5			16	16	6			19
									Total (1999 $K):	563

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
87-108 GHz amplifier chip	each	150		1						150
									Total (1999 $K):	150

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MMA Cost Estimation Data Input Table

WBS Number 5.3.4.2 *e.g., 1.1.4.45*

Title 87-108 GHz LO Source Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 87-108 GHz LO source modules will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			3	2	1			0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			3	2	2			0.6
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.4.2

Title 87-108 GHz LO Source Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Cables, connectors, parts	each	0.31			16	16	6			12
									Total (1999 $K):	12

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.3.5.1 *e.g., 1.1.4.45*

Title 65-86 GHz LO Source Procurement & Fabrication *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The components for production 65-86 GHz LO sources will be procured. Some components which are not commercially available will be fabricated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			2	2	1			0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			12	12	10			2.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.5.1

Title 65-86 GHz LO Source Procurement & Fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
YIG-tuned oscillator (VQ)	each	2.55			16	16	6			97
16.25-21.25 GHz amplifier (VQ)	each	2.5			16	16	6			95
16.25-21.25 GHz X2 multiplier (VQ)	each	2.5			16	16	6			95
32.5-42.5 GHz amplifier (NRAO)	each	1.2			16	16	6			46
32.5-42.5 GHz X2 multiplier (NRAO)	each	0.675			16	16	6			26
Mechanical & shielding (NRAO)	each	0.2			16	16	6			8
Waveguide parts	each	0.4			16	16	6			15
Harmonic mixer (VQ)	each	2.2			16	16	6			84
Lock board (NRAO)	each	0.3			16	16	6			11
IF parts (NRAO)	each	0.5			16	16	6			19
YIG driver & power supply (NRAO)	each	0.5			16	16	6			19
Control circuitry and CAN bus (NRAO)	each	0.4			16	16	6			15
Thermal control	each	0.3			16	16	6			11
Output splitter	each	0.1			16	16	6			4
65-85 GHz amplifier (NRAO)	each	0.5			16	16	6			19
									Total (1999 $K):	563

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
65-85 GHz amplifier chip	each	150		1						150
									Total (1999 $K):	150

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MMA Cost Estimation Data Input Table

WBS Number 5.3.5.2 *e.g., 1.1.4.45*

Title 65-86 GHz LO Source Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 65-86 GHz LO source modules will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			3	2	1			0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			3	2	2			0.6
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.3.5.2

Title 65-86 GHz LO Source Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Cables, connectors, parts	each	0.31			16	16	6			12

Total (1999 $K): 12

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 5.4.1 *e.g., 1.1.4.45*

Title LO Multiplier Chain Design & System Integration *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	36%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier chain work begun in the design and development phase will be completed. High-frequency frequency multipliers for 68-84 X2, 87-108 X2, 72-95 X2, 144-190 X2, and 130-170 X2 GHz will be designed, tested, and refined for production. Isolators for all input bands will be designed, tested, and refined for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	18	18	18	18	18	9		8.3
			Ops.						9	18	2.3
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	18	18	18	18	18	9		8.3
			Ops.						9	18	2.3
		Chile	Constr.								
			Ops.								

WBS Number 5.4.1

Title LO Multiplier Chain Design & System Integration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lab supplies	each	10	1	1	1	1	1	1	1	70
Bodies, masks, parts	each	10	1	1	1	1	1	1	1	70
Computers	each	(inc in Admin)		5				5		0
Software maintenance	each	5	1	1	1	1	1	1	1	35
									Total (1999 $K):	175

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Diode development	each	200	1	1	1	1	1	(to ops)	(to ops)	1,000
Integrated substrate development	each	110	1	1	1	1	1	(to ops)	(to ops)	550
									Total (1999 $K):	1,550

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MMA Cost Estimation Data Input Table

WBS Number 5.4.2.1 *e.g., 1.1.4.45*

Title 211-275 GHz Receiver LO multiplier Parts *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 211-275 GHz receiver, namely a frequency tripler for the 72-95 GHz LO source, will be procured and/or fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		5						0.4
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.2.1

Title 211-275 GHz Receiver LO multiplier Parts

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Metal, tools, fixtures	each	0.3		38						11
Diode arrays	each	0.2		38						8
Bias & control circuits	each	0.3		38						11
									Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.2.2 *e.g., 1.1.4.45*

Title 211-275 GHz Receiver LO Multiplier Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 211-275 GHz receiver, namely a frequency tripler for the 72-95 GHz LO source, will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		0.5	1	0.5				0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2	7	2				0.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.2.2

Title 211-275 GHz Receiver LO Multiplier Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 5.4.2.3 *e.g., 1.1.4.45*

Title 275-370 GHz LO integrate source & multiplier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 72-95 GHz LO source and the 72-95 GHz frequency tripler will be integrated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			3	3				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			8	8				1.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.2.3

Title 275-370 GHz LO integrate source & multiplier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
72-95 GHz isolator	each	0.5			20	18				19
									Total (1999 $K):	19

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.3.1 *e.g., 1.1.4.45*

Title 602-720 GHz Receiver LO multiplier Parts *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 602-720 GHz receiver, namely a frequency doubler for the 102-120 GHz LO source and a frequency tripler for 200-240 GHz, will be procured and/or fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2						0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		8						0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.3.1

Title 602-720 GHz Receiver LO multiplier Parts

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Metal, tools, fixtures	each	0.3		76						23
Diode arrays	each	0.2		76						15
Bias & control circuits	each	0.3		76						23
									Total (1999 $K):	61

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.3.2 *e.g., 1.1.4.45*

Title 602-720 GHz Receiver LO multiplier Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 602-720 GHz receiver, namely a frequency doubler for the 102-120 GHz LO source and a frequency tripler for 200-240 GHz, will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	2	1				0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2	12	8				1.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.3.2

Title 602-720 GHz Receiver LO multiplier Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 5.4.3.3 *e.g., 1.1.4.45*

Title 602-720 GHz LO integrate source & multiplier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 100-120 GHz LO source, the 100-120 GHz frequency doubler, and the 200-240 GHz tripler will be integrated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			4	4				0.7
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			12	12				2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.3.3

Title 602-720 GHz LO integrate source & multiplier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
100-120 GHz isolator	each	0.5			20	18				19
200-240 GHz isolator	each	0.5			20	18				19
									Total (1999 $K):	38

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.4.1 *e.g., 1.1.4.45*

Title 275-370 GHz Receiver LO multiplier Parts *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO multiplier components for the 275-370 GHz receiver, namely a frequency doubler for the 72-95 GHz LO source and a frequency doubler for 144-190 GHz, will be procured and/or fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2						0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		8						0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.4.1

Title 275-370 GHz Receiver LO multiplier Parts

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Metal, tools, fixtures	each	0.3		76						23
Diode arrays	each	0.2		76						15
Bias & control circuits	each	0.3		76						23
									Total (1999 $K):	61

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.4.2 *e.g., 1.1.4.45*

Title 275-370 GHz Receiver LO multiplier Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO multiplier components for the 275-370 GHz receiver, namely a frequency doubler for the 72-95 GHz LO source and a frequency doubler for 144-190 GHz, will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			2	1	1			0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			9	12	1			1.8
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.4.2

Title 275-370 GHz Receiver LO multiplier Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 5.4.4.3 *e.g., 1.1.4.45*

Title 275-370 GHz LO integrate source & multiplier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 72-95 GHz LO source, the 72-95 GHz frequency doubler, and the 144-190 GHz doubler will be integrated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			4	4				0.7
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			12	12				2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.4.3

Title 275-370 GHz LO integrate source & multiplier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
72-95 GHz isolator	each	0.5			20	18				19
144-190 GHz isolator	each	0.5			20	18				19
									Total (1999 $K):	38

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.5.1 *e.g., 1.1.4.45*

Title 163-211 GHz Receiver LO multiplier Parts *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*

Calculated Contingency: 34% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 163-211 GHz receiver, namely a frequency doubler for the 87-108 GHz LO source, will be procured and/or fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			5					0.4
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.5.1

Title 163-211 GHz Receiver LO multiplier Parts

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Metal, tools, fixtures	each	0.3			38					11
Diode arrays	each	0.2			38					8
Bias & control circuits	each	0.3			38					11
									Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.5.2 *e.g., 1.1.4.45*

Title 163-211 GHz Receiver LO multiplier Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 163-211 GHz receiver, namely a frequency doubler for the 87-108 GHz LO source, will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				1	1			0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				5	5	1		0.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.5.2

Title 163-211 GHz Receiver LO multiplier Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 5.4.5.3 *e.g., 1.1.4.45*

Title 163-211 GHz LO integrate source & multiplier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 87-108 GHz LO source and the 87-108 GHz frequency doubler will be integrated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			3	3				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			8	8				1.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.5.3

Title 163-211 GHz LO integrate source & multiplier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
87-108 GHz isolator	each	0.5			20	18				19
									Total (1999 $K):	19

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.6.1 *e.g., 1.1.4.45*

Title 385-500 GHz Receiver LO multiplier Parts *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 385-500 GHz receiver, namely a frequency doubler for the 65-85 GHz LO source and a frequency tripler for 130-170 GHz, will be procured and/or fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			2					0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			8					0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.6.1

Title 385-500 GHz Receiver LO multiplier Parts

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Metal, tools, fixtures	each	0.3			76					23
Diode arrays	each	0.2			76					15
Bias & control circuits	each	0.3			76					23
									Total (1999 $K):	61

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.6.2 *e.g., 1.1.4.45*

Title 385-500 GHz Receiver LO multiplier Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO multiplier components for the 385-500 GHz receiver, namely a frequency doubler for the 65-85 GHz LO source and a frequency tripler for 130-170 GHz, will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				1	1			0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				5	5	1		0.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.6.2

Title 385-500 GHz Receiver LO multiplier Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 5.4.6.3 *e.g., 1.1.4.45*

Title 385-500 GHz LO integrate source & multiplier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 65-85 GHz LO source, the 65-85 GHz frequency doubler, and the 130-170 GHz frequency tripler will be integrated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				4	4			0.7
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				12	12			2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.6.3

Title 385-500 GHz LO integrate source & multiplier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
65-85 GHz isolator	each	0.5				20	18			19
130-170 GHz isolator	each	0.5				20	18			19
									Total (1999 $K):	38

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.7.1 *e.g., 1.1.4.45*

Title 125-163 GHz Receiver LO multiplier Parts *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO multiplier components for the 125-163 GHz receiver, namely a frequency doubler for the 65-85 GHz LO source, will be procured and/or fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			0.5	0.5				0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			3	2				0.4
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.7.1

Title 125-163 GHz Receiver LO multiplier Parts

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Metal, tools, fixtures	each	0.3			30	8				11
Diode arrays	each	0.2			30	8				8
Bias & control circuits	each	0.3			30	8				11
									Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.7.2 *e.g., 1.1.4.45*

Title 125-163 GHz Receiver LO multiplier Assembly & Test *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The LO multiplier components for the 125-163 GHz receiver, namely a frequency doubler for the 65-85 GHz LO source, will be assembled and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				0.5	1	0.5		0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				2	7	2		0.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.7.2

Title 125-163 GHz Receiver LO multiplier Assembly & Test

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 5.4.7.3 *e.g., 1.1.4.45*

Title 125-163 GHz LO integrate source & multiplier *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 65-85 GHz LO source and the 65-85 GHz frequency doubler will be integrated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				1	2	3		0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				2	6	8		1.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.7.3

Title 125-163 GHz LO integrate source & multiplier

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
65-85 GHz isolator	each	0.5					20	18		19
									Total (1999 $K):	19

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.8.1 *e.g., 1.1.4.45*

Title Design & fab 31-45 GHz receiver LO coupling *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The LO for the 31-45 GHz receiver is derived by tapping an intermediate stage of the 100-120 GHz LO source. This coupling will be worked out in detail including how to route the intermediate signal to the 31-45 GHz receiver, which is assumed to be mounted separately from the main 4K dewar. The parts will be fabricated and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	4	4						0.7
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6	6						1.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.8.1

Title Design & fab 31-45 GHz receiver LO coupling

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Couplers and waveguide	each	0.5	20	18						19
									Total (1999 $K):	19

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.9 *e.g., 1.1.4.45*

Title LO Multiplier Fabrication Equipment *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	11%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Fabrication equipment required to produce the LO sources and frequency multipliers will be procured and installed.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.9

Title LO Multiplier Fabrication Equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Precision CNC milling machine	each	100	1							100
Production workstation	each	23.5	1	1						47
Development workstation	each	23.5	1							24
Miscellaneous tools	each	10	1							10
									Total (1999 $K):	181

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 5.4.10 *e.g., 1.1.4.45*

Title LO Multiplier Test Equipment *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical 1 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost 1 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule 8 *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical 2 *(2 or 4 are valid)*

Cost 1 *(1 or 2 are valid)*

Calculated Contingency: 11% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

Dedicated test facilities and equipment required to test the LO sources, high frequency multipliers, and complete LO chains will be procured and installed. This will permit measurements of LO power, amplitude noise, and phase noise as a function of frequency.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	1						0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 5.4.10

Title LO Multiplier Test Equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Oscilloscope	each	3.5	1							4
Power meters	each	16	4	3						112
Reference sources	each	10	2							20
Test benches	each	1.5	2							3
Fixtures and test boxes	each	3	1							3
Computers and interfaces	each	5	2							10
Frequency counter	each	12	1							12
Spectrum analyzer + harmonic mixers	each	60	1	1						120
Dewars	each	20	1	1						40
Refrigerators & compressors	each	35	1	1						70
									Total (1999 $K):	394

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 6.1 *e.g., 1.1.4.45*

Title IF Field Prototype for Test Interferometer of 2 antennas. *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Test and rework the bench prototypes from D&D. Purchase components and build field prototypes for the 2-antenna test interferometer. Test and refine design of field prototypes for final design and documantation. Release for construction. Build and test for 1 polarization and 1 baseband converter per antenna to minimize cost and prototype redundancy.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	12	6	2					1.7
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	12	9	3					2.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 6.1

Title IF Field Prototype for Test Interferometer of 2 antenna Cost for 1 polarization & 1 baseband per antenna, plus 25% for rework and for small quantities.

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Purchase & build field prototypes 2 ant	ant sys									
IF multiplexer (see 6.3) 1/ant	antenna	43.9	2							88
IF demultiplexer (see 6.4) 1/ant	antenna	14.7	2							29
IF matrix switch 4x4 (see 6.5) 1/ant	antenna	8.7	2							17
IF baseband convert (see 6.6) 1/ant	antenna	9.3	2							19
IF power supplies (see 6.7) 1/ant	antenna	2.6	2							5
IF bins & rack (see 6.8) 1/ant	antenna	0.9	2							2
									Total (1999 $K):	160

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Module & shield build to print 4/ant	antenna	5	2							10
Bin build to print 2/ant	antenna	2.5	2							5
									Total (1999 $K):	15

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MMA Cost Estimation Data Input Table

WBS Number 6.2 *e.g., 1.1.4.45*

Title IF Construction test & lab equipment *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Electronic test equipment and production test fixtures for assembly and test of the production IF system. Some equipment will carry over from D&D. No test sets and equipment in Chile.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6	3	1					0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6	3	2					0.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 6.2

Title IF Construction test & lab equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Multiplexer bench test set		13	1	0	0	0	0	0	0	13
PLO 16 GHz	set	1								
Power supply	set	1								
Cables, connectors, interface, etc	set	1								
PC, I/O boards, LabView 1 for all sets	set	5								
Temperature control, variable	set	5								
Demultiplexer bench test set		16	1	0	0	0	0	0	0	16
PLOs 8, 10,12,14 GHz	set	4								
Power supply	set	1								
Cables, connectors, interface, etc	set	1								
PC, I/O boards, LabView 1 for all sets	set	5								
Temperature control, variable	set	5								
4x4 Matrix switch bench test set		12	1	0	0	0	0	0	0	12
Power supply	set	1								
Cables, connectors, interface, etc	set	1								
PC, I/O boards, LabView 1 for all sets	set	5								
Temperature control, variable	set	5								
Baseband converter bench test set	set	32	1	0	0	0	0	0	0	32
Power supply	set	1								
Synthesizer 3.2-5.2 GHz, LO module	set	20								
Cables, connectors, interface, etc.	set	1								
PC, I/O boards, LabView 1 for all sets	set	5								
Temperature control, variable	set	5								
IF system test bed		51	1	0	0	0	0	0	0	51
Power supply	bed	1								
PLOs 8, 10,12,14, 16 GHz	bed	5								
Synthesizer 3.2-5.2 GHz, LO module	bed	20								
Bins, rack, interconnecting cables	bed	10								
PC, I/O boards, LabView	bed	5								
Temperature control, variable	bed	10								

General test equipment		118	1	0	0	0	0	0	0	118
PC, I/O boards, LabView 1 for all sets	system	5								
Vector network analyzer .1-12 GHz	system	48								
Synthesized sweeper .1-12 GHz	system	26								
Spectrum analyzer .1-16 GHz	system	21								
Power meter, sensor .1-16 GHz	system	4								
Noise source, calibrated .1-16 GHz	system	2								
Attenuator, programmable, interface	system	5								
DSO, 2ch, 100 Mhz, FFT 10K, I/O	system	4								
Bench DMM	system	3								
									Total (1999 $K):	242

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
None										
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 6.3 *e.g., 1.1.4.45*

Title IF Multiplexer (2/antenna) *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	2	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The IF multiplexer consists of commercial diode non-reflective switches, diode variable non-reflective phase-invariant attenuators, power dividers, power combiners, low group-delay bandpass filters, amplifiers, gain and phase equalizers, a frequency upconverter, total power detectors with isolation amps and ADCs, drivers, DC/DC converters, and interface to the monitor & control system. There are 2 multiplexers at each antenna, one for each polarization. They select the IF inputs of 4-12 GHz or 2 sidebands of 4-8 GHz each into the demultiplexer for division into 2 GHz bandwidths. Assembly and test, and integration with the M&C, LO-reference, front-end, and correlator systems, will be done in-house.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	6	6	5	5	4	2.4
			Ops.								
		Chile	Constr.				1	1	1	1	0.3
			Ops.				1	2	3	1	0.6
Technician	months	US	Constr.		6	11	12	12	12	11	5.3
			Ops.					1	1	1	0.3
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 6.3

Title IF Multiplexer (2/antenna)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amp 4-12GHz 2dBnf 23dBg 4/ant	antenna	6.8		8	7	7	7	7	0	245
Amp 4-12GHz 31dBg 8/ant	antenna	6.4		8	7	7	7	7	0	230
Amp 4-12GHz 10dBg +16dBm 2/ant	antenna	1		8	7	7	7	7	0	36
Amp 4-12GHz 30dBg +16dBm 4/ant	antenna	4		8	7	7	7	7	0	144
Amp 4-8GHz 36dBg 4/ant	antenna	2		8	7	7	7	7	0	72
Amp 4-8GHz 16dBg 2/ant	antenna	0.6		8	7	7	7	7	0	22
Amp 4-8GHz 25dBg +16dBm 2/ant	antenna	1		8	7	7	7	7	0	36
Atten non-ref ph-invar dig 4-12G 4/ant	antenna	6.8		8	7	7	7	7	0	245
Atten non-ref ph-invar dig 4-8GHz2/ant	antenna	2.8		8	7	7	7	7	0	101
Atten non-ref ph-invar dig 8-12G 2/ant	antenna	3		8	7	7	7	7	0	108
Bandpass filter 4-12Ghz 6/ant	antenna	4.8		8	7	7	7	7	0	173
Bandpass filter 4-8Ghz 4/ant	antenna	2		8	7	7	7	7	0	72
Bandpass filter 8-12Ghz 2/ant	antenna	1		8	7	7	7	7	0	36
Detector sq law 8-12GHz 8/ant	antenna	4		8	7	7	7	7	0	144
Divider2-way 4-12GHz 18dBiso 5/ant	antenna	1.75		8	7	7	7	7	0	63
Equalizer ampl 4-12 GHz 4/ant	antenna	3.2		8	7	7	7	7	0	115
Equalizer ampl 4-8 GHz 2/ant	antenna	1.2		8	7	7	7	7	0	43
Equalizer ampl 8-12 GHz 2/ant	antenna	1.4		8	7	7	7	7	0	50
Mixer RL4-16GHz, I 8-12GHz 2/ant	antenna	2		8	7	7	7	7	0	72
Switch non-refl SP2T 4-12GHz 4/ant	antenna	2.8		8	7	7	7	7	0	101
Switch non-refl SP3T 4-12GHz 4/ant	antenna	3.2		8	7	7	7	7	0	115
Coax phase-stable SMA conn 44/ant	antenna	1.32		8	7	7	7	7	0	48
EMI filter 40/ant	antenna	0.8		8	7	7	7	7	0	29
Amp DC isolation pwr mon PCB 8/ant	antenna	0.8		8	7	7	7	7	0	29
ADC tot pwr 12bit 1kSps PCB 8/ant	antenna	3.2		8	7	7	7	7	0	115
Total power interface 2/ant	antenna	0.4		8	7	7	7	7	0	14
Driver-monitor PCB 2/ant	antenna	0.4		8	7	7	7	7	0	14
Monitor&control interface PCB 2/ant	antenna	0.4		8	7	7	7	7	0	14
DC/DC converters, regulators 8/ant	antenna	0.8		8	7	7	7	7	0	29
Module coax connectors 6/ant	antenna	0.18		8	7	7	7	7	0	6
Module multipin connectors 6/ant	antenna	0.18		8	7	7	7	7	0	6
Spares @ 5% * 36ant=2ant=4IFmux	antenna	70.23		0	0	0	0	0	2	140
									Total (1999 $K):	2,669

Contracts

	Unit of	1999 Unit	2001	2002	2003	2004	2005	2006	2007	Totals

Contract Description	Measure	Cost ($K)	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	(1999 $K)
Module & shields build to print 2/ant	antenna	2		8	7	7	7	7	2	76
									Total (1999 $K):	76

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MMA Cost Estimation Data Input Table

WBS Number 6.4 *e.g., 1.1.4.45*

Title IF Demultiplexer (2/antenna) *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The IF Demultiplexer takes the output of the IF Multipexer, separates the 4-12 GHz IF band into 2 GHz band segments, and sends 2-4 GHz outputs to 4 baseband converters. There are 2 demultiplexers per antenna, one for each polarization. A demultiplexer consists of commercial power dividers, couplers, bandpass filters, amplifiers, gain and phase equalizers, frequency downconverters, DC/DC converters, and interface to the montor & control system. Assembly and test, and integration with the M&C system, is done in-house.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	5	4	4	3	3	1.8
			Ops.								
		Chile	Constr.				1	1	1	1	0.3
			Ops.				1	2	2	1	0.5
Technician	months	US	Constr.		4	11	12	12	12	8	4.9
			Ops.					1	1	1	0.3
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 6.4

Title IF Demultiplexer (2/antenna)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amp 2-4 GHz 36 dBg +16 dBm 8/ant	antenna	4		8	7	7	7	7	0	144
Detector power mon 2-4GHz 8/ant	antenna	0.8		8	7	7	7	7	0	29
Divider 2way 2-4 GHz 18dBiso 8/ant	antenna	2.4		8	7	7	7	7	0	86
Divider 4way 4-12GHz 18dBiso 2/ant	antenna	0.8		8	7	7	7	7	0	29
Filter bandpass 2-4GHz 8/ant	antenna	3.2		8	7	7	7	7	0	115
Filter bandpass 4-6GHz 2/ant	antenna	0.8		8	7	7	7	7	0	29
Filter bandpass 6-8GHz 2/ant	antenna	0.8		8	7	7	7	7	0	29
Filter bandpass 8-10GHz 2/ant	antenna	0.8		8	7	7	7	7	0	29
Filter bandpass 10-12GHz 2/ant	antenna	0.8		8	7	7	7	7	0	29
Isolator 2-4GHz 18dBiso 8/ant	antenna	1.6		8	7	7	7	7	0	58
Isolator 4-8GHz 18dBiso 4/ant	antenna	0.5		8	7	7	7	7	0	18
Isolator 7-12.6GHz 18dBiso 4/ant	antenna	0.5		8	7	7	7	7	0	18
Mixer R&L4-14GHz I 2-4GHz 8/ant	antenna	2.4		8	7	7	7	7	0	86
Coax phase stable SMA conn 40/ant	antenna	1.2		8	7	7	7	7	0	43
EMI filter 24/ant	antenna	0.48		8	7	7	7	7	0	17
Amp DC isolation pwr mon PCB 8/ant	antenna	0.8		8	7	7	7	7	0	29
Monitor&control interface PCB 2/ant	antenna	0.4		8	7	7	7	7	0	14
DC/DC converters, regulators *8/ant	antenna	0.8		8	7	7	7	7	0	29
Module coax connectors *9/ant	antenna	0.27		8	7	7	7	7	0	10
Module multipin connectors *6/ant	antenna	0.18		8	7	7	7	7	0	6
Spares @ 5% * 36 ant=2ant=4IFmux	antenna	23.53							2	47
									Total (1999 $K):	894

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Module & shields build to print 2/ant	antenna	2		8	7	7	7	7	2	76
									Total (1999 $K):	76

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MMA Cost Estimation Data Input Table

WBS Number 6.5 *e.g., 1.1.4.45*

Title IF Matrix Switch (2/antenna) *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	6%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The 4x4 IF Matrix Switch follows the IF demultiplexer. Under computer control via the monitor & control system, it connects any of 4 outputs to any of 4 inputs with minimum reflections at all inputs and maximum isolation from other inputs and outputs. There are 2 matrix switches per antenna. The matrix switch consists of commercial 1x4 power dividers, absoptive (non-reflective) 4x1 diode switches, drivers/monitors, DC/DC converters and interface to the monitor & control system. Assembly and test, and integration with the M&C system, is done in-house.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	2	1	1	1	1	0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		4	6	5	6	6	3	2.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 6.5

Title IF Matrix Switch (2/antenna)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Divider 4way 2-4GHz 18dBiso 8/ant	antenna	2		8	7	7	7	7	0	72
Swich 4x1 non-refl 2-4GHz 8/ant	antenna	8		8	7	7	7	7	0	288
Coax phase-stable SMA conn 48/ant	antenna	1.44		8	7	7	7	7	0	52
EMI filters 8/ant	antenna	0.16		8	7	7	7	7	0	6
Driver-monitor PCB 2/ant	antenna	0.4		8	7	7	7	7	0	14
Monitor&control interface PCB 2/ant	antenna	0.4		8	7	7	7	7	0	14
DC/DC converters, regulators 8/ant	antenna	0.8		8	7	7	7	7	0	29
Module coax connectors 16/ant	antenna	0.48		8	7	7	7	7	0	17
Module multipin connectors 6/ant	antenna	0.18		8	7	7	7	7	0	6
Spares @ 5% * 36ant=2ant=4IFmux	antenna	13.86							2	28
								Total (1999 $K):		527

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Module & shields build to print 2/ant	antenna	2		8	7	7	7	7	2	76
								Total (1999 $K):		76

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MMA Cost Estimation Data Input Table

WBS Number 6.6 *e.g., 1.1.4.45*

Title IF Baseband Converter (8/antenna) *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical 4 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost 4 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule 4 *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical 2 *(2 or 4 are valid)*

Cost 2 *(1 or 2 are valid)*

Calculated Contingency: 20% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

The baseband converters translate the 2-4 GHz outputs of the matrix switch to baseband at 0.1-2 GHz via a 3.2-5.2 GHz synthesizer from the LO-reference system. The output of each baseband converter drives the digitizer (sampler), which is part of the correlator system. There are 4 baseband converters for each polarization, which is 8 baseband converters per antenna. A converter consists of commercial amplifiers, a mixer, a diode variable non-reflective phase-invariant attenuator and driver, an amplitude and phase equalizer, power divider, coupler, total power detector-isolator-ADC, DC/DC converters, and interface to the monitor & control system. The assembly, test and integration will be done in-house, although a contract to design and build an integrated assembly of the RF portion may be cost effective.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	6	5	5	5	4	2.3
			Ops.								
		Chile	Constr.				1	1	1	1	0.3
			Ops.				1	2	2	1	0.5
Technician	months	US	Constr.		4	11	12	12	12	11	5.2
			Ops.					1	1	1	0.3
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 6.6

Title IF Baseband Converter (8/antenna)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Amplifier 0.1-2GHz 20dBg 10dBm 8/an	antenna	3.2		8	7	7	7	7	0	115
Amplifier 0.1-2GHz 30dBg 13dBm 8/an	antenna	4		8	7	7	7	7	0	144
Amplifier 0.1-2GHz 14dBg 20dBm 8/an	antenna	2.4		8	7	7	7	7	0	86
Atten fixed 6dB 8/ant	antenna	0.24		8	7	7	7	7	0	9
Atten non-ref ph-invar dig 0.1-2G 8/ant	antenna	13.6		8	7	7	7	7	0	490
Detector sq law 0.1-2GHz 8/ant	antenna	4		8	7	7	7	7	0	144
Divider2-way 0.1-2GHz 18dBiso 8/ant	antenna	2.8		8	7	7	7	7	0	101
EMI filter 96/an	antenna	1.92		8	7	7	7	7	0	69
Equalizer ampl&phase 0.1-2GHz 8/ant	antenna	8		8	7	7	7	7	0	288
Filter bandpass 0.1-2GHz 8/ant	antenna	4		8	7	7	7	7	0	144
Isolator 2-4GHz 18dBiso 8/ant	antenna	1.6		8	7	7	7	7	0	58
Mixer R&L 2-4GHz IF 0.1-2Ghz 8/ant	antenna	2.4		8	7	7	7	7	0	86
Coax phase-stable SMA conn 26/ant	antenna	0.78		8	7	7	7	7	0	28
Amp DC isolation pwr mon PCB 8/ant	antenna	0.8		8	7	7	7	7	0	29
ADC tot pwr 12bit 1kSps PCB 8/ant	antenna	3.2		8	7	7	7	7	0	115
Total power interface 8/ant	antenna	1.6		8	7	7	7	7	0	58
Driver-monitor PCB 8/ant	antenna	1.6		8	7	7	7	7	0	58
Monitor&control interface PCB 8/ant	antenna	1.6		8	7	7	7	7	0	58
DC/DC converters, regulators 8/ant	antenna	0.8		8	7	7	7	7	0	29
Module coax connectors 6/ant	antenna	0.18		8	7	7	7	7	0	6
Module multipin connectors 24/ant	antenna	0.72		8	7	7	7	7	0	26
Spares @ 5% * 36ant=2ant=4IFmux	antenna	59.44							2	119
									Total (1999 $K):	2,259

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Integrated RF assembly, if cost effectiv										
Module & shields build to print 2/ant	antenna	2		8	7	7	7	7	2	76
									Total (1999 $K):	76

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MMA Cost Estimation Data Input Table

WBS Number 6.7 *e.g., 1.1.4.45*

Title IF Power Supply module *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN,VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Commercial swiching power supplies, N+1 redundancy, with EMI suppression, unregulated output + 28-32 volts at 4-6 amps feed all IF system modules. DC/DC converters or linear regulators within each IF module deliver appropriate regulated voltages to its components. Supplies will be mounted in individual modules with monitor & control interfaces for failure alarm and uninteruptible replacement. Assembly and integration will be done in-house.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1					0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2	1	1	1	1		0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 6.7

Title IF Power Supply modı (1 set/antenna)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Swtching power supply, module, 2/ant	antenna	1.3		8	7	7	7	7	0	47
Rack adapter, 1/ant	antenna	0.54		8	7	7	7	7	0	19
M&C interface, connectors, 1/ant	antenna	0.2		8	7	7	7	7	0	7
5% spares = 2 ant	antenna	2.04							2	4
									Total (1999 $K):	78

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
None										
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 6.8 *e.g., 1.1.4.45*

Title Bins / Racks (assemble and test) *e.g., Project Management and Tracking*

Estimator W. D. Brundage *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

All IF modules installed in the MMA standard bins which are in the MMA standard antenna rack. The bins and rack are commercial products built to MMA specifications in contract machine shops. The IF system modules will occupy 2 bins (1 bin per polarization) and 1 power supply adapter within one antenna rack. Inter-module wiring and phase-stable coax assembly will be done in-house.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2	1	1				0.3
			Ops.				1				0.1
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		4	3	2	2	2		1.1
			Ops.								
		Chile	Constr.				1				0.1
			Ops.								

WBS Number 6.8

Title Bins / Racks (assemble and test)

Materials

Material Description		Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Wire bin	2 bin/ant	antenna	0.1		8	7	7	7	7	0	4
Build & install phase stable coax & connectors in bin	2 bin/ant	antenna	0.4		8	7	7	7	7	0	14
Wire & install coax in rack	1/ant	antenna	0.2		8	7	7	7	7	0	7
Spare bins & rack = 1 antenna		antenna	0.7							1	1
										Total (1999 $K):	26

Contracts

Contract Description		Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Build bins	2/ant	antenna	2		8	7	7	7	7	0	72
Build rack	1/ant	antenna	2		8	7	7	7	7	0	72
										Total (1999 $K):	144

MMA Cost Estimation Data Input Table

WBS Number 7.1 *e.g., 1.1.4.45*

Title Prototype Optical Fiber Systems *e.g., Project Management and Tracking*

Estimator D.M. Edmans *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	32%	*(See defintions)*

Task Description (ext for the WBS dictionary)

Purchase components and build field prototype optical fiber systems for integration in the 2 antenna test interferomete This will include only a SINGLE IF Data transmission system as the cost of a complete 8 channel implementation is prohibitive. Test and release for production phase.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	18	18	7					3.6
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	24	24	14					5.2
			Ops.								
		Chile	Constr.								
			Ops.								

Engineer total: 3.6
Technician Total: 5.2

WBS Number 7.1
Title Prototype Optical Fiber Systems

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Optical Fiber Protoype system (2 per antenna)										
*7.2 IF Tx and Rx pair	antenna	$35.88	2							71.8
**7.3.1 LO Ref. Dist + Round-Trip Phase (See 7.3.1)	Array	$206.00	1							206.0
*7.5 Monitor and Control Tx and Rx, LO, IF	antenna	$14.00	2							28.0
*7.6 Power Supply, Tx, Rx, LO, IF	antenna	$2.60	3							7.8
7.7 Bins, Tx, Rx, LO, IF	antenna	$3.50	3							10.5
* Note: Added 40% to production cost to cover 1 time charges, low quantity order pricing, etcetera. A reasonable estimate.										
** Note 2: Cost of 7.3.1 minus $20k usable hardware on hand										

Total (1999 $K): **$324**

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Included in above ...										

Total (1999 $K): 0

MMA Cost Estimation Data Input Table

WBS Number 7.2 *e.g., 1.1.4.45*

Title Digital IF Transmitters and Receivers *e.g., Project Management and Tracking*

Estimator Dan Edmans *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	4	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	40%	*(See defintions)*

Task Description (ext for the WBS dictionary)

Digital Transmitters, 8 optical signals per antenna, multiplexed onto a single fiber using DWDM technology, to transfer 16 GHz (64Gb/s + overhead) data to the central control building. The optical carriers are split using DWDM technology the receiver located at the central control building. The transmitters and receivers are commercial products procured u competitive bid. The Transmit and Receive units are assembled into standard mmA modules, integrated with the Mon and control system and tested by mmA staff.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		12	12	12	12	12	6	5.5
			Ops.								
		Chile	Constr.		3	6	6	6	6	6	2.8
			Ops.			3	3	3	3	3	1.3
Technician	months	US	Constr.			18	18	18	18	12	7.0
			Ops.								
		Chile	Constr.			9	9	9	6	6	3.3
			Ops.			3	6	6	9	9	2.8

Engineer total: 9.5
Technician Total: 13.0

WBS Number 7.2
Title Digital IF Transmitters and Receivers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
*Laser,	Antenna	$4.8	0	8	7	7	7	7	0	172.80
*Modulator, MZ LiNbO3, 1550 nm band	Antenna	$11.8	0	8	7	7	7	7	0	426.24
*Modulator Driver Amplifier	Antenna	$3.4	0	8	7	7	7	7	0	121.54
*photodiode with integrated Tz amp	Antenna	$4.7	0	8	7	7	7	7	0	169.92
*Limiting amp-output	Antenna	$5.8	0	8	7	7	7	7	0	207.36
*Pre-amp - Input	Antenna	$4.0	0	8	7	7	7	7	0	144.00
*Bessel Filter - 10GB/s Rx	Antenna	$0.8	0	8	7	7	7	7	0	28.80
Optical Components	Antenna									
*Fiber jumpers	Antenna	$1.6	0	8	7	7	7	7	0	57.60
*Fixed optical attenuator at Rx	Antenna	$1.0	0	8	7	7	7	7	0	36.00
*DWDM Gratings price /channel MUX	Antenna	$1.5	0	8	7	7	7	7	0	54.05
*DWDM Gratings price /channel DeMU	Antenna	$1.5	0	8	7	7	7	7	0	54.05
Electronic Components	Antenna									
*laser temperature control	Antenna	$0.4	0	8	7	7	7	7	0	13.44
*laser power output control	Antenna	$0.6	0	8	7	7	7	7	0	22.66
*Microprocessor and support	Antenna	$0.8	0	8	7	7	7	7	0	28.80
*Mux chip	Antenna	$2.7	0	8	7	7	7	7	0	96.67
*Demux chip	Antenna	$2.7	0	8	7	7	7	7	0	96.67
*Shift registers (8/) and other chips	Antenna	$0.3	0	8	7	7	7	7	0	9.60
*Xylinx chips	Antenna	$3.2	0	8	7	7	7	7	0	115.20
Optical power measurement circuit	Antenna	$0.3	0	8	7	7	7	7	0	9.60
Mechanical Hardware (x2 for Tx and Rx)	Antenna									
Connectors, RF and electrical	Antenna	$8.0	0	8	7	7	7	7	0	288.00
*Optical Connectors/ polishing material	Antenna	$4.0	0	8	7	7	7	7	0	144.00
Cooling equipment (TEC's etc.)	Antenna	$6.4	0	8	7	7	7	7	0	230.40
Power Regulatioin and Miscellaneous	Antenna	$8.0	0	8	7	7	7	7	0	288.00
RFI shielding and machining	Antenna	$16.0	0	8	7	7	7	7	0	576.00
*Optical Fiber Splicing Unit - Field	Unit	$12.5	0	2						25.00
Spares, 5%	Array	$94.2	0	1	1	0	0	0	0	188.41
* 1999 Cost Estimates adjusted to refle anticipated technology development in the commercial sector										

Total (1999 $K): **$3,605**

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
PC Boards, Fab, populate, Power test	antenna	2.4		8	7	7	7	7	0	86.4
*Module build to Print 8/antenna	antenna	5.3		8	7	7	7	7	0	192
Spares, PC Boards		2.4							2	4.8
*Spares, Modules		5.3							2	10.7
* 1999 Cost Estimates adjusted to refle										
anticipated technology development in										
the commercial sector										
								Total (1999 $K):		294
								Grand Total (without contingency) ($K)		**$3,899**

WBS Number 7.2

Title Digital IF Transmitters and Receivers

Supporting data for Materials and contracts:

Materials

Material Description	Quantity	Unit cost	Units per Antenna	Cost per antenna
Laser,	288	1.8	8	14.40
Modulator, MZ LiNbO3, 1550 nm band	288	4.44	8	35.52
Modulator Driver Amplifier	288	0.844	8	6.75
photodiode with integrated Tz amp	288	1.77	8	14.16
Limiting amp-output	288	1.44	8	11.52
Pre-amp - Input	288	1	8	8.00
Bessel Filter - 10GB/s Rx	288	0.3	8	2.40
Optical Components	288		0	0.00
Fiber jumpers	288	0.4	8	3.20
Fixed optical attenuator at Rx	288	0.25	8	2.00
DWDM Gratings price /channel MUX	288	0.563	8	4.50
DWDM Gratings price /channel DeMUX	288	0.563	8	4.50
Electronic Components	288		8	0.00
laser temperature control	288	0.14	8	1.12
laser power output control	288	0.236	8	1.89
Microprocessor and support	288	0.3	8	2.40
Mux chip	288	1.007	8	8.06
Demux chip	288	1.007	8	8.06
Shift registers (8/) and other chips	288	0.1	8	0.80
Xylinx chips	576	0.6	16	9.60
Optical power measurement circuit	288	0.1	8	0.80
Mechanical Hardware (x2 for Tx and Rx)				
Connectors, RF and electrical	576	0.5	16	8.00
Optical Connectors/ polishing materials	576	0.5	16	8.00
Cooling equipment (TEC's etc.)	576	0.4	16	6.40
Power Regulatioin and Miscellaneous	576	0.5	16	8.00
RFI shielding and machining	576	1	16	16.00
Optical Fiber Splicing Unit - Field				0.00
Spares, 5%	2	186.08	Total	**186.08**

Contracts

Contract Description	Quantity	Unit cost	Units per Antenna	Cost per antenna
PC Boards, Fab, populate, Power test	1,152	0.075	32	2.4
Module build to Print 8/antenna	576	1	16	16
			Total per Antenna	18.4

Grand Total per Antenna **$204**

MMA Cost Estimation Data Input Table

WBS Number 7.3.1 *e.g., 1.1.4.45*

Title 16 GHZ FO LO Ref Dist Prototype *e.g., Project Management and Tracking*

Estimator Ron Beresford *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	40%	*(See defintions)*

Task Description (text for the WBS dictionary)

This subsytem delivers the 16GHz RF Local Oscillator from the central master local oscillator to the antennas via fiber optics. A 16GHz return signal from the antennas provides round trip phase measurement . The scheme is limited to Direct Detection Intensity Modulation. No coherent photonics are involved .The design uses commercially available components but polarization requirements and wavelength selection will necessitate special procurement.
All aspects of construction will be in-house. The cost of unjacketed Polarization Maintaining fiber included.
Performance at 800GHz and 4.7km of fiber span is dubiuos and at best will require substantial experimentation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months 24	US	Constr.	18	18	9					3.8
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	36	36	18					7.5
			Ops.								
		Chile	Constr.								
			Ops.								

Engineer total: 3.8
Technician Total: 7.5

WBS Number 7.3.1
Title 16 GHZ FO LO Ref Dist Prototype

Materials

Material Description	Total Quantity	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
High power DFB laser	4	3.7	1							3.7
Low power DFB laser	2	2.2	2							4.4
Wavelength Locker I1	1	2	1							2
Wavelength Locker I2	1	2	2							4
Thermal Control Hybrid	2	0.15	2							0.3
Bias Control Module	2	0.25	2							0.5
MZ Modulator	2	7	2							14
Isolators PM	2	0.9	2							1.8
Directional Coupler PM	2	1.2	2							2.4
PM Power Divider	3	1.2	3							3.6
Dispersion Compensation	2	4	2							8
Optical BPF	2	0.8	2							1.6
Microwave PIN diode	2	3.5	2							7
16GHz 20dB Amplifier	4	0.9	4							3.6
Module Hardware	2	0.5	2							1
Optical Connectors	18	0.04	18							0.72
PCB's	2	1	2							2
50MHz Amp + Filter	2	0.4	2							0.8
RF splitter	2	0.2	2							0.4
PM Fiber	5km	0.01	5000							50
PM Fusion Splicer	1	90	1							90
Polarizer	2	0.8	2							1.6

Total (1999 $K): 203

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Module Fabrication etc	2	1.5	2	0	0	0	0			3

Total (1999 $K): 3

TOTAL **$206 k**

MMA Cost Estimation Data Input Table

WBS Number 7.3.2 *e.g., 1.1.4.45*

Title 16 GHz FO LO Ref Dist with Integrated R/T Phase Meas. *e.g., Project Management and Tracking*

Estimator Ron Beresford *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical 10 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost 6 *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule 2 *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical 2 *(2 or 4 are valid)*

Cost 1 *(1 or 2 are valid)*

Calculated Contingency: 28% *(See defintions)*

Task Description (ext for the WBS dictionary)

16 GHZ FIBER OPTIC LO REFERENCE DISTRIBUTION with Integrated Round-Trip Phase Measurement: This subsy delivers the 16GHz RF Local Oscillator from the central master local oscillator to the antennas via fiber optics. A 16GH return signal from the antennas provides round trip phase measurement. The scheme is limited to Direct Detection Inte Modulation. No coherent photonics are involved. The design uses commercially available components but polarization requirements and wavelength selection will necessitate special procurement. All aspects of construction will be in-hous The cost of unjacketed Polarization Maintaining fiber included.Performance at 800GHz and 4.7km of fiber span is dub and at best will require substantial experimentation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		12	12	12	12			4.0
			Ops.						12	12	2.0
		Chile	Constr.			12	12	12			3.0
			Ops.						12	12	2.0
Technician	months	US	Constr.		12	12	12	12	12	12	6.0
			Ops.								
		Chile	Constr.				24	24	12	12	6.0
			Ops.								

Engineer total: 11.0

Technician Total: 12.0

WBS Number 7.3.2

Title ERR

Materials

Material Description	Qty	Cost	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
	Qty	**Array**	**18.6**	0	1	0	0	0	0	0	18.6
Base Station											
*High power DFB laser	4	4.9	1.23								
*Wavelength Locker I1	4	2.7	0.67								
*Thermal Control Hybrid	4	0.2	0.05								
*Bias Control Module	4	0.3	0.08								
*MZ Modulator	4	5.9	1.47								
*Isolators PM	4	1.8	0.45								
*Directional Coupler PM	4	2.4	0.60								
PCB's	4	0.4	0.10								
BS Spares (1 of each item!			4.65		1						4.7
Antenna	Qty	**Antenna**	**15.74333**	0	8	7	7	7	7	0	566.8
*Low power DFB laser	1	0.7	0.73								
*Wavelength Locker I2	1	0.7	0.67								
*Thermal Control Hybrid	1	0.1	0.05								
*Bias Control Module	1	0.1	0.08								
*MZ Modulator	1	1.5	1.47								
*Isolators PM	1	0.5	0.45								
*Directional Coupler PM	2	1.2	0.60								
*PM Power Divider	1	0.6	0.60								
*Dispersion Compensation	2	2.7	1.33								
*Optical BPF	2	0.5	0.27								
*Microwave PIN diode	2	1.8	0.90								
16GHz 20dB Amplifier	4	3.6	0.90								
*Module Hardware	2	0.3	0.17								
*Optical Connectors PM	18	0.4	0.020								
PCB's	2	0.2	0.10								
50MHz Amp + Filter	1	0.4	0.40								
RF splitter	1	0.2	0.20								
*Polarizer PM	1	0.4	0.40								
Spares (5%, i.e. 2 Ant.)		**Array**	**15.74333**							2	31.5

Array		Array									
PM Fiber	125000	500	0.004		**(Included in WBS 2 Site Development)**						
*PM Fusion Splicer	2	90	**45**	0	2	0	0	0	0	0	90.0
* 1999 Cost Estimates adjusted to refle											
anticipated technology development in											
the commercial sector											

Total (1999 $K): 711.5

Contracts

Contract Description	Total Quantity	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Module Fabrication etc	76	1.5		19	19	19	19			114

Total (1999 $K): 114

Grand Total (no contingency, $K) **$825**

MMA Cost Estimation Data Input Table

WBS Number 7.4 *e.g., 1.1.4.45*

Title Production Test Equipment *e.g., Project Management and Tracking*

Estimator Dan Edmans *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (ext for the WBS dictionary) Electronic Test equipment and fabrication fixtures for assembly of the production MMA optical fiber implementation

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								

Engineer total: 0.2
Technician Total: 0.2

WBS Number 7.4
Title Production Test Equipment

Materials

Material Description		Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Optical Power Meter		1	5.6	1							6
Optical Power meter Head	#2	1	2	1							2
Laboratory Laser controller	4.2	1	4.2	1							4.2
OTDR Test	HP6004A	2	0.58	3							1.74
Optical Spectrum Analyzer	71451B	1	4.57	1							4.57
Lightwave converter	83440C	1	7.805	1							7.805
Ampl. Light Convertor	11982A	1	14.75	1							14.75
HP Logic Analysis system	Multi	1	60	1							60
RF spectrum Anayzer		1	40	1							40
CW source 1.55um	83424A	1	36.21	1							36.21
Digital com analyzer	83480A	1	16.32	1							16.32
Plug-in for 83480A	83485B	1	24.48	1							24.48
Software	opt 001	1	0.995	1							0.995

Total (1999 $K): **219**

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K): 0

MMA Cost Estimation Data Input Table

WBS Number 7.5 *e.g., 1.1.4.45*

Title Monitor and Control Transmitters and Receivers *e.g., Project Management and Tracking*

Estimator Dan Edmans *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (ext for the WBS dictionary)

Transmitters and receivers, one pair per antenna, for 1Mb/s commmunication on the monitor and control system via si mode optical fiber at 1550 nm, and receivers, one per antenna, located at the array control building to receive the transmission. The transmitters and receivers are commercial products procured under competitive bid. They are assembled into standard mmA modules, integrated and tested by mmA staff.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3	3	3	3	3	3	1.5
			Ops.								
		Chile	Constr.		1	2	2	2	2	2	0.9
			Ops.			1	1	1	1	1	0.4
Technician	months	US	Constr.		6	6	6	6	6	6	3.0
			Ops.								
		Chile	Constr.		4	6	6	6	6	6	2.8
			Ops.			1	2	2	2	4	0.9
										Engineer total:	2.8
										Technician Total:	6.8

WBS Number 7.5

Title Monitor and Control Transmitters and Receivers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Modules (2)	antenna	3		8	7	7	7	7	0	108
Tx	antenna	0.5		8	7	7	7	7	0	18
Rx	antenna	0.4		8	7	7	7	7	0	14.4
Optical jumpers	antenna	0.4		8	7	7	7	7	0	14.4
Support electronics	antenna	0.4		8	7	7	7	7	0	14.4
pc boards	antenna	0.025		8	7	7	7	7	0	0.9
local powersupplies and conditioning	antenna	0.1		8	7	7	7	7	0	3.6
RFI shielding	antenna	0.5		8	7	7	7	7	0	18
miscellaneous mech & elec	antenna	0.5		8	7	7	7	7	0	18
Spares	array	5.825							2	11.65
		5.825						Total (1999 $K):		221

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
PC Boards, Fab, populate, Power test		0.05	115	115	115	58	58	58	58	28.85
Spares		0.05							29	1.45
								Total (1999 $K):		30
		6.6	$k					Grand Total (no contingency, $K)		**$252**

Materials and Contracts Supporting Data

Material Description	Quantity	Unit cost	Units per Antenna	Cost per antenna
Modules	72	1.5	2	3
Tx	36	0.5	1	0.5
Rx	36	0.4	1	0.4
Optical jumpers	36	0.4	1	0.4
Support electronics	36	0.4	1	0.4
pc boards	36	0.025	1	0.025
local powersupplies and conditioning	36	0.1	1	0.1
RFI shielding	36	0.5	1	0.5
miscellaneous mech & elec	36	0.5	1	0.5
				5.825
Contracts				
PC Boards, Fab, populate, Power test				0.80
			Per Antenna	**$6.63** k

MMA Cost Estimation Data Input Table

WBS Number 7.6 *e.g., 1.1.4.45*

Title Fiber Optics Power Supply Modules *e.g., Project Management and Tracking*

Estimator Dan Edmans *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, and 15 are valid entries; see definition)*
Schedule	2	*(2, 4 or 8 are valid entries; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
	14%	*(See defintions)*

Task Description (ext for the WBS dictionary)

Power supplies built in-house for the optical fiber data (IF, LO, M&C) transmission and reception rack at each antenna and at the central control building. Produced from standard off-the shelf parts, procured by competitive bid. PC Boards populated, tested, Assembled into modules, integrated with the array Monitor and Control sytem, and system tested by mmA staff.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2	1	1	1	1	0	0.5
			Ops.								
		Chile	Constr.		2	1	1	1	1	1	0.6
			Ops.			1	1	1	1	1	0.4
Technician	months	US	Constr.		2	2	2	2	2	2	1.0
			Ops.								
		Chile	Constr.		2	2	2	2	2	2	1.0
			Ops.			1	1	1	1	1	0.4

Engineer total: 1.5
Technician Total: 2.4

WBS Number 7.6
Title Fiber Optics Power Supply Modules

Materials

Material Description		Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Kepco Switcher redundant	2x/ant	antenna	1.3		8	7	7	7	7		46.8
Rack Adapter		antenna	0.52		8	7	7	7	7		18.72
M&C interface, connectors		antenna	0.2		8	7	7	7	7		7.2
5% spares		array	2.02							2	4.04
			4.04							Total (1999 $K):	77

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
PC Boards, fab, populate, Power test		0.02	115	115	115	58	58	58	58	11.54
									Total (1999 $K):	12
									Grand Total (no contingency, $K)	**$88**

MMA Cost Estimation Data Input Table

WBS Number 7.7 *e.g., 1.1.4.45*

Title Bins / Racks (assemble and test) *e.g., Project Management and Tracking*

Estimator Dan Edmans *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, and 15 are valid entries; see definition)*
Schedule	2	*(2, 4 or 8 are valid entries; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
	14%	*(See defintions)*

Task Description (ext for the WBS dictionary)

All of the optical fiber hardware modules are assembled in standard mmA rack bins and installed in the mmA standard racks. The bins and racks are commercial procducts or will be built to mmA specifications in contract machine shops. The integrated modules will be assembled into the racks and tested by mmA staff.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		4	3	2	2	2	2	1.3
			Ops.								
		Chile	Constr.			2	2	2	2	2	0.8
			Ops.				1	1	1	1	0.3
Technician	months	US	Constr.	0	2	2	2	2	2	2	1.0
			Ops.								
		Chile	Constr.	0	4	6	6	6	6	6	2.8
			Ops.			2	2	2	2	2	0.8

Engineer total: 2.4
Technician Total: 4.7

WBS Number 7.7
Title Bins / Racks (assemble and test)

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Wire Bins 2 bins/ante	antenna	0.2		8	7	7	7	7	0	7
Build and install phase stable coax and connectors in bin		0.4		8	7	7	7	7	0	14.4
Wire and install coax in rack		0.2		8	7	7	7	7	0	7.2
spares		0.8							2	1.6
		1.6							Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Build Bin 3/ant	antenna	2		8	7	7	7	7	2	76
		2							Total (1999 $K):	76
		3.6								

Grand Total (no contingency, $K) **106**

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MMA Cost Estimation Data Input Table

WBS Number 8.1.1 *e.g., 1.1.4.45*

Title Refine digitizer design *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30.0%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The digitizer (sampler) design will be refined in preparation for production.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.1.1

Title Refine digitizer design

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lab supplies	each	5	1							5
									Total (1999 $K):	5

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.1.3 *e.g., 1.1.4.45*

Title Digitizer contract materials *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30.0%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The parts and materials required to assemble 320 digitizers will be procured.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3						0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		3						0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.1.3

Title Digitizer contract materials

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Custom digitizer chips	each	0.4		320						128
Circuit boards & components	each	1		320						320
Chassis	each	0.5		320						160
Cables & connectors	each	0.5		320						160
Misc. parts	each	0.5		320						160
									Total (1999 $K):	928

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.1.4 *e.g., 1.1.4.45*

Title Assembly of digitizers *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The required 320 digitizers will be assembled.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1						0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		23						1.9
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.1.4

Title Assembly of digitizers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 8.1.5 *e.g., 1.1.4.45*

Title Digitizer validation and delivery *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The 320 assembled digitzers will be tested and delivered.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	4					0.4
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		1	3					0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.1.5

Title Digitizer validation and delivery

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lab supplies	each	5		1	1					10

Total (1999 $K): 10

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 8.2.1 *e.g., 1.1.4.45*

Title Prototype FIR filter testing on interferometer *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	38%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The digital FIR filter will be tested with the test interferometer.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	4							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.2.1

Title Prototype FIR filter testing on interferometer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 8.2.2 *e.g., 1.1.4.45*

Title Design & test FIR filter refinement *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	32%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The final refinements to the design of the FIR filter will be determined and any final changes made.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.2.2
Title Design & test FIR filter refinement

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts	each	5	1							5
									Total (1999 $K):	5

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.2.4 *e.g., 1.1.4.45*

Title FIR filter chip & board fabrication *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	32%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

A custom FIR filter chip will be manufactured. The printed circuit boards needed for filter implementation will be fabricated.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.2.4

Title FIR filter chip & board fabrication

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
FIR filter chips	each	0.15	560	2000						384
Circuit boards & parts	each	0.5	100	220						160
Chassis	each	0.5	100	240						170
Cables & connectors	each	0.25	100	240						85
Misc. parts	each	0.25	100	240						85
									Total (1999 $K):	884

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.2.5 *e.g., 1.1.4.45*

Title FIR filter board assembly *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The FIR filter boards will be assembled.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1					0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		6	6					1.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.2.5

Title FIR filter board assembly

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Lab supplies	each	5		1	1					10
									Total (1999 $K):	10

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.2.6 *e.g., 1.1.4.45*

Title FIR filter board validation and delivery *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	32%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The FIR filter boards will be tested and delivered.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2	2					0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2	2					0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.2.6
Title FIR filter board validation and delivery

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 8.3.1 *e.g., 1.1.4.45*

Title Correlator boards *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The final versions of the control, memory, correlator, and accumulator board prototypes will be assembled and tested. Any needed design modifications will be made and tested. The production versions will be released.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	12							1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	30							2.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	8							0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.3.1

Title Correlator boards

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Circuit boards & parts	each	2	8							16
Lab supplies	each	5	1							5
Software maintenance	each	10	1							10
									Total (1999 $K):	31

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.4 *e.g., 1.1.4.45*

Title Correlator Chip *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The prototype correlator chips will be fabricated according to the design carried through the layout phase during design and development. The first wafer runs will be packaged and tested. Any design modifications needed in order to meet the specifications will be performed, and a new wafer run will be ordered if it is required. The new design will be verified and a production run for the prototype correlator will be procured.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6	12						1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	4	4						0.7
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.4
Title Correlator Chip

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Chip mask set	each	25	1	1						50
Correlator chips	each	0.15	1000	14000						2,250
									Total (1999 $K):	2,300

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Chip circuit design	each	50	1	1						100
Chip layout	each	50	1	1						100
									Total (1999 $K):	200

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MMA Cost Estimation Data Input Table

WBS Number 8.6 *e.g., 1.1.4.45*

Title Correlator software *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The software for the correlator will be written and tested. In addition, test software to aid the engineers in system integration will be written and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	12	12	12					3.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.6
Title Correlator software

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Computers	each	3		1						3
Software maintenance	each	2	1	1	1					6
									Total (1999 $K):	9

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.5 *e.g., 1.1.4.45*

Title Correlator Racks *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	20%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The prototype correlator racks will be designed, assembled, and tested.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	3							0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.5
Title Correlator Racks

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Racks & bins	each	10	1							10
Control computer	each	10	1							10
Power supplies	each	3	1							3
Cables & connectors	each	4	1							4
Fabricated parts	each	3	1							3
Misc. parts	each	1	1							1
									Total (1999 $K):	31

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.7 *e.g., 1.1.4.45*

Title Prototype Correlator Production *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	28%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The parts for the prototype correlator capable of handling one baseline with 16 GHz bandwidth will be ordered. The prototype correlator will be assembled, tested, and delivered to the test interferometer site.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		24	18					3.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		32	18					4.2
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.7

Title Prototype Correlator Production

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Circuit boards & parts	each	2		32	32					128
Racks, bins, power supplies	each	5		2	2					20
Cables & connectors	each	10		1	1					20
Misc. parts	each	10		1	1					20
Software maintenance	each	10		1	1					20
								Total (1999 $K):		208

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
								Total (1999 $K):		

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MMA Cost Estimation Data Input Table

WBS Number 8.8.1 *e.g., 1.1.4.45*

Title First 1/4 Correlator *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	28%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

The final configuration for the correlator will be determined. The parts, including correlator chips, will be ordered for the first 1/4 of the correlator (enough to handle the first 1/2 of the antennas). This first 1/4 of the correlator will be assembled, tested, and delivered to the site in Chile.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			18	18				3.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			18	18				3.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.8.1
Title First 1/4 Correlator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Racks & power supplies	each	67			1					67
PC boards & components	each	197			1					197
Bins, cables, connectors	each	46			1					46
Fabricated parts	each	26			1					26
Misc. parts	each	53			1					53
Software maintenance	each	10				1				10
									Total (1999 $K):	399

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.8.2 *e.g., 1.1.4.45*

Title Second 1/4 Correlator *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The parts, including correlator chips, will be ordered for the second 1/4 of the correlator. This second 1/4 of the correlator will be assembled, tested, and delivered to the site in Chile.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				18	18			3.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				18	18			3.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.8.2

Title Second 1/4 Correlator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Racks & power supplies	each	67			1					67
PC boards & components	each	197			1					197
Bins, cables, connectors	each	46			1					46
Fabricated parts	each	26			1					26
Misc. parts	each	53			1					53
Software maintenance	each	10					1			10
Computers	each	3					7			21
									Total (1999 $K):	420

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.8.3 *e.g., 1.1.4.45*

Title Third 1/4 Correlator *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The parts, including correlator chips, will be ordered for the third 1/4 of the correlator. This third 1/4 of the correlator will be assembled, tested, and delivered to the site in Chile.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.					18			1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					18			1.5
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.8.3

Title Third 1/4 Correlator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Racks & power supplies	each	67				1				67
PC boards & components	each	197				1				197
Bins, cables, connectors	each	46				1				46
Fabricated parts	each	26				1				26
Misc. parts	each	53				1				53
Software maintenance	each	10						1		10
									Total (1999 $K):	399

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.8.4 *e.g., 1.1.4.45*

Title Fourth 1/4 Correlator *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	24%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

The parts, including correlator chips, will be ordered for the fourth 1/4 of the correlator. This last 1/4 of the correlator will be assembled, tested, and delivered to the site in Chile.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.						36		3.0
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.						36		3.0
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.8.4
Title Fourth 1/4 Correlator

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Racks & power supplies	each	67					1			67
PC boards & components	each	197					1			197
Bins, cables, connectors	each	46					1			46
Fabricated parts	each	26					1			26
Misc. parts	each	53					1			53
									Total (1999 $K):	389

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 8.9 *e.g., 1.1.4.45*

Title Correlator test equipment *e.g., Project Management and Tracking*

Estimator Webber *Name*

Basis of Estimate VQ **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Standard test equipment to be dedicated to the correlator production task will be procured.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 8.9

Title Correlator test equipment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Digital oscilloscopes HP54616B	each	6.7	3							20
Logic analyzers HP1660ES	each	20	1							20
Carts	each	0.25	6							2
Multimeters	each	0.2	6							1
Pulse generators HP8110A	each	6	1							6
									Total (1999 $K):	49

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9 *e.g., 1.1.4.45*

Title Computing

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

Computing systems for the MMA. Includes real-time control, observing systems, data production (image and UV-plane). Does not generally include development of post-processing items, other than those which are specific for the MMA.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9

Title Computing

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.1 *e.g., 1.1.4.45*

Title Control Software

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Real-time and near-real-time control software for the MMA. Includes monitor, control, and communication with all devices, and production of primary science data (e.g., UV-data but not image data). Does not include embedded software within particular devices.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1

Title Control Software

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.1.1 *e.g., 1.1.4.45*

Title Test Interferometer Control and Analysis

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Additional software required to operate the first two antennas as an interferometer. Includes items such as fringe rotation and modifications required for the test correlator. Includes required analysis capabilities which might not be directly available in the post-processing software, such as baseline determination.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	36	12						4.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1.1

Title Test Interferometer Control and Analysis

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.1.2 *e.g., 1.1.4.45*

Title MMA Correlator Software

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

This consists of the following items. Station control - the most important task here is loading the delay coefficients. Also control of FFT engines is done here. Baseline control - this includes control of the LTA, filter, and writing the output files. Pulsar gate control - minor in comparison to the first two. Includes integration with the larger control system, flagging, sub-array control, online calibrations, and data formatting.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	3	3	3					0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	36	36	36	36	12	12	12	15.0
			Ops.								
		Chile	Constr.								
			Ops.					6	6	6	1.5
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1.2
Title MMA Correlator Software

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.1.3 *e.g., 1.1.4.45*

Title Multi-antenna & sub-array control

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Software to implement control and synchronization of multiple antennas, including full sub-arraying capabilities. Includes provisions for antennas coming into and out of service without disrupting operations.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.		12	24	24				5.0
			Ops.								
		Chile	Constr.					6	6	6	1.5
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1.3

Title Multi-antenna & sub-array control

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Per-antenna VME crate		10	3			5	9	11	10	380
Developer and test VME crates		10	3			3				60
Central network concentrator		60				1				60
(Cabletron SmartSwitch 6500, 40 ports										
									Total (1999 $K):	500

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.1.4 *e.g., 1.1.4.45*

Title Operators and Observers Interfaces

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Near real-time displays for operators and observers. Operators screens include current and historical monitor data with available trend analysys, summary displays of the system, integration with calibration catalogs and other astronomical information, and well as logging and warning systems. Observers screens report the state of observations required to carry out a project, access to any first-look data which has been collected, and archival information for projects which have already been observed. All displays shall be capable of remote operation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	18	18	18	18				6.0
			Ops.					6			0.5
		Chile	Constr.								
			Ops.					6	12	12	2.5
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1.4

Title Operators and Observers Interfaces

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Workstation	PC	5				1	1		4	30
									Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.1.5 *e.g., 1.1.4.45*

Title Deliver control software

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Deliver operational control software to the site.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1.5

Title Deliver control software

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.1.6 *e.g., 1.1.4.45*

Title Maintenance

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	18%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Correct defects and provide enhancements as required during interim operations.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.				12	12	6	6	3.0
		Chile	Constr.								
			Ops.					6	12	12	2.5
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.1.6

Title Maintenance

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.2 *e.g., 1.1.4.45*

Title Scheduling

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

Turn a high-level description of the observations required for a scientific or test project into detailed instructions to the control system. Queue scheduling, observing at fixed times (e.g., VLBI), interactive use, and dynamic scheduling must all be available.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.2

Title Scheduling

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.2.1 *e.g., 1.1.4.45*

Title Static Scheduling System

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform detailed control of the system from static files which contain general observational information required to observe projects. Time can be specified in either relative (LST+durations) or absolute time systems. Support for reordering during observations, and interactive usurpation of the queue will be provided.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.			9	9	6			2.0
			Ops.								
		Chile	Constr.					3	6		0.8
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.2.1

Title Static Scheduling System

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.2.2 *e.g., 1.1.4.45*

Title Dynamic scheduling simulations

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Simulations using weather and other site characteristics data to determing effective heuristics for dynamically scheduling the MMA.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.				12	12			2.0
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.2.2

Title Dynamic scheduling simulations

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.2.3 *e.g., 1.1.4.45*

Title Dynamic scheduling prototype

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Implement a prototype dynamic scheduling system using previously determined heuristics.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.					3			0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.					6			0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.2.3

Title Dynamic scheduling prototype

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.2.4 *e.g., 1.1.4.45*

Title Dynamic scheduling implementation

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	39%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Implement final dynamic scheduling system. Must also accomodate fixed time, queue, and interactive observing. This need not be an entirely automatic system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.						12	6	1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.						24	12	3.0
			Ops.								
		Chile	Constr.								
			Ops.							6	0.5
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.2.4

Title Dynamic scheduling implementation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.3 *e.g., 1.1.4.45*

Title Proposal preparation software

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description *(Text for the WBS dictionary)*

Tools for proposers and observers.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.3

Title Proposal preparation software

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.3.1 *e.g., 1.1.4.45*

Title Proposal assistance prototype

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Graphical tools to help proposers determine parameters required for initial proposals. Includes tools to estimate required observing time and calibration strategies.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.				3				0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.				6				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.3.1

Title Proposal assistance prototype

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.3.2 *e.g., 1.1.4.45*

Title Proposal assistance implementation

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Final proposal assistance implementation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.					3	3	3	0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.					6	12	6	2.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.3.2

Title Proposal assistance implementation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.3.3 *e.g., 1.1.4.45*

Title Observe program prototype

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Prototype graphical tool to enable observers to enter the information required by the scheduling system to observe the project.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			3	3				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.			3	6				0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.3.3

Title Observe program prototype

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.3.4 *e.g., 1.1.4.45*

Title Observe program

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Final observe program.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.					3	3	3	0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.					6	6		1.0
			Ops.							6	0.5
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.3.4

Title Observe program

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.4 *e.g., 1.1.4.45*

Title Image pipeline

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** - *Engineering/Bottom Up/ Parametric;* **VQ** - *Vendor Quote;* **PO** - *Place Order; or* **AC** - *Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

For routine observations create nearly automatically images that are at least of first-look quality, and will often suffice as the final image. Uses information from the observers proposal, and calibrations obtained by the system, to automatically calibrate and image the raw data. Archives generated images for later retrieval.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.4

Title Image pipeline

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.4.1 *e.g., 1.1.4.45*

Title Automated calibration & imaging heuristics

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	39%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Determine calibration heuristics which, when combined with proposal information and system-determined calibrations can be applied to routine mm observations to obtain images of at least first-look quality.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			6	6				1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.4.1

Title Automated calibration & imaging heuristics

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.4.2 *e.g., 1.1.4.45*

Title Prototype image pipeline

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Produce a prototype image pipeline using previously determined heuristics.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.				3	3			0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.				6	6			1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.4.2

Title Prototype image pipeline

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 9.4.3 *e.g., 1.1.4.45*

Title Parallelization studies and implementation

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Evaluate performance of post-processing system for routine observations, and parallelize hot-spots to aid in keeping up with the average data rate of the MMA (1MB/s).

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.				12	12			2.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.4.3

Title Parallelization studies and implementation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parallel computer	4CPU SG	55				1				55
									Total (1999 $K):	55

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.4.4 *e.g., 1.1.4.45*

Title Initial image pipeline operations

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	26%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Evaluate the prototype pipeline on real data obtained from interim operations.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.					1	1	1	0.3
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.4.4

Title Initial image pipeline operations

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.4.5 *e.g., 1.1.4.45*

Title Production image pipeline

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Final image pipeline. Must interact with the archive system, both to obtain raw (UV) data, and to store final and intermediate images. The pipeline should produce intermediate images as observations progress so the observer can steer further observations.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.					6	6	6	1.5
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.					12	12	12	3.0
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.4.5

Title Production image pipeline

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Large parallel system (64 node)	Beowulf	250							1	250
									Total (1999 $K):	250

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.5 *e.g., 1.1.4.45*

Title Archiving

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description (*Text for the WBS dictionary*)

Provide access to both humans (observers, operators) and software (image pipeline) to both raw (UV and total power) data, and data processed by the image pipeline. Must allow remote access to data, meta-data searches. It must also enforce proprietary data rights.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.5

Title Archiving

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.5.1 *e.g., 1.1.4.45*

Title Prototype distributed archive

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Prototype archive, emphasizing remote access and searching capabilities.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			6	3				0.8
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.			6	6				1.0
			Ops.								
		Chile	Constr.								
			Ops.					1	1	1	0.3
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.5.1

Title Prototype distributed archive

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Small jukebox		15			1					15
Tape/DVD writer		6			1					6
									Total (1999 $K):	21

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.5.2 *e.g., 1.1.4.45*

Title Evaluate storage hardware

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	11%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Evaluate the technology which should be purchased for the final archive. Longevity, reliability, and total storage capacity are all concerns. Volume access time is not critical, but streaming performance should be faster than the average data rate of the instrument.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.						3		0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.						3		0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.5.2

Title Evaluate storage hardware

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.5.3 *e.g., 1.1.4.45*

Title Production archive

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	30%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Final production archive.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.					6	3	3	1.0
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.					12	12	6	2.5
			Ops.								
		Chile	Constr.							6	0.5
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.5.3

Title Production archive

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Big jukebox		200							1	200
Tape/DVD writer		6							3	18
Disk server		50							1	50
									Total (1999 $K):	268

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 9.6 *e.g., 1.1.4.45*

Title Post processing

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description
(Text for the WBS dictionary)

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.6

Title Post processing

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.6.1 *e.g., 1.1.4.45*

Title Define data formats

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	18%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Define the science data formats the MMA will produce for UV, single dish, and final images. These are anticipated to be in FITS and based on existing standards.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.		6						0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.6.1

Title Define data formats

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.6.2 *e.g., 1.1.4.45*

Title Filler and format conversions

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	22%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Software to write data in the determined formats from the array, and the corresponding software to import it into a post-processing package.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.				6	6			1.0
			Ops.						1	1	0.2
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.6.2

Title Filler and format conversions

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.6.3 *e.g., 1.1.4.45*

Title ALMA specific calibrations

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	39%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

In the post-processing system or control system implement changes required for calibrations which are unique to this instrument.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			3	6				0.8
			Ops.					6	6	6	1.5
		Chile	Constr.								
			Ops.					6	6	6	1.5
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.6.3

Title ALMA specific calibrations

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.6.4 *e.g., 1.1.4.45*

Title MMA Post-processing begins

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description
(*Text for the WBS dictionary*)

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.6.4

Title MMA Post-processing begins

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.6.5 *e.g., 1.1.4.45*

Title Maintenance

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	22%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Make MMA specific post-processing changes determined to be necessary during interim science operations.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.						6	6	1.0
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.						6	6	1.0
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.6.5

Title Maintenance

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.7 *e.g., 1.1.4.45*

Title Software support

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Cost *(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*

Schedule *(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical *(2 or 4 are valid)*

Cost *(1 or 2 are valid)*

Calculated Contingency: 0% *(See defintions)*

Task Description
(*Text for the WBS dictionary*)

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.7

Title Software support

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 9.7.1 *e.g., 1.1.4.45*

Title Tool support

Estimator Brian Glendenning *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Support tools not otherwise supported by the observatory. Includes items such as the make system, the CVS repository, software testbeds, and a maintenance database.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	9	9	6	6	6			3.0
			Ops.						6	6	1.0
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.7.1

Title Tool support

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.7.2 *e.g., 1.1.4.45*

Title Quality assurance

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	10	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	34%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Define and implement procedures related to documentation, code acceptance, and test procedures.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	6	6	12	12	12	12	12	6.0
			Ops.								
		Chile	Constr.						6	6	1.0
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.7.2

Title Quality assurance

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 9.7.3 *e.g., 1.1.4.45*

Title Chile system administration

Estimator Brian Glendenning *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	22%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Maintain computer and networking equipment required by MMA staff in Chile during interim operations.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.				3	6	12	12	2.8
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 9.7.3

Title Chile system administration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10 *e.g., 1.1.4.45*

Title System Integration *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule		*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Coordinate assembly and testing at US test site, specify and verify all inter-subsystem interfaces.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10

Title System Integration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Special test equipment	lot	125		1						125
									Total (1999 $K):	125

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.4 *e.g., 1.1.4.45*

Title Test Interferometer Site Preparation *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Finish preparation of the test site that was begun during the D&D phase. Note that antenna foundations and utilities were put in place during D&D. Purchase and install office equipment and furniture, lab benches, and small general purpose test equipment.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	3							0.3
	3		Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.4

Title Test Interferometer Site Preparation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Office furniture		13	1							13
Office equipment		6	1							6
Lab benches		3	3							9
Small test instruments		3	5							15
Tool boxes and hand tools	set	2.5	2							5
									Total (1999 $K):	48

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.10 *e.g., 1.1.4.45*

Title Oufitting at U.S. test site *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	8	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform outfitting of the first two antennas and of other equipment needed to form the test interferometer at the U.S. test site. [See subtasks for details and costs]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.10

Title Oufitting at U.S. test site

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.10.4 *e.g., 1.1.4.45*

Title Antenna #1 Outfitting *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Install, integrate, and verify operation of all NRAO-supplied equipment on Antenna #1. This includes the first evaluation receiver and its cryogenics, the LO/IF rack, any special antenna metrology not supplied by the antenna manufacturer, and the holography front end. It also includes later removal of the holography front end and installation of subreflector with nutator. All required interconecting wiring is also included. [3 months duration, crew of 2 engineers and 2 technicians]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	6							0.5
	6	6	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	6							0.5
	6	6	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.10.4

Title Antenna #1 Outfitting

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Wire, cable, opt fiber, connectors, misc	lot	20	1							20
Expendible materials	lot	5	1							5
									Total (1999 $K):	25

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.10.7 *e.g., 1.1.4.45*

Title Antenna #2 Outfitting *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Install, integrate, and verify operation of all NRAO-supplied equipment on Antenna #2. This includes the first evaluation receiver and its cryogenics, the LO/IF rack, any special antenna metrology not supplied by the antenna manufacturer, and the holography front end. It also includes later removal of the holography front end and installation of subreflector with nutator. All required interconecting wiring is also included. [3 months duration, crew of 2 engineers and 2 technicians]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		6						0.5
	6	6	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		6						0.5
	6	6	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.10.7
Title Antenna #2 Outfitting

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Wire, cable, opt fiber, connectors, misc	lot	20		1						20
Expendible materials	lot	5		1						5
									Total (1999 $K):	25

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.10.10 *e.g., 1.1.4.45*

Title General Outfitting *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Intstall, connect, and verify operation of NRAO-supplied equipment other than that at the antennas. This includes the tower-mounted transmitter to support single-dish holography and equipment needed to support interferometry. At the test control building, the LO reference distribution electronics, IF receiving electronics, and test correlator must be installed. This task also includes running optical and electrical cables from each antenna to the test control building. [Task duration 6 months, crew of 2 engineers and 2 technicians]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		12						1.0
	12	12	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		12						1.0
	12	12	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.10.10

Title General Outfitting

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Wire, cable, opt fiber, connectors, misc	lot	45		1						45
Expendible materials	lot	10		1						10

Total (1999 $K): 55

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

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MMA Cost Estimation Data Input Table

WBS Number 10.11 *e.g., 1.1.4.45*

Title Single Dish Tests *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	11%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform detailed tests on each antenna as a single dish, including holography using a terrestrial transmitter and observation of celestial sources (continuum and line). See sub-tasks for cost.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
	12	12	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.11
Title Single Dish Tests

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.11.1 *e.g., 1.1.4.45*

Title Ant #1 holography and surface readjustment *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform holographic measurement of antenna #1 using tower-mounted transmitter. Analyze results and re-set surface accordingly. Repeat the process for several iterations if necessary. [Duration 4 months, crew of 2 sci, 1 engr, 1 prog, 1 tech (all part time)]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	2							0.2
	2	2	Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	1							0.1
	1	1	Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
	2	2	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2							0.2
	2	2	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.11.1

Title Ant #1 holography and surface readjustment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.11.2 *e.g., 1.1.4.45*

Title Ant #1 Antenna Evaluation *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Perform detailed performance evaluation of ant #1 and ant #2 in single-dish mode. This includes primarily astronomical observations, although some engineering tests using ground-based instrumentation may also be done. Measurements include gain and noise temperature vs. elevation, beam shape and sidelobes, pointing absolute accuracy, pointing tracking stability, effects of the Sun in and near the beam, servo characteristics, and structural dynamics. [Duration 4 months, part time participation by 3 scientists, 1 engineer, 1 programmer, and 1 technician.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	3	3						0.5
	3	3	Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.	1	1						0.2
	1	1	Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2	2						0.3
	2	2	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	2	2						0.3
	2	2	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.11.2

Title Ant #1 Antenna Evaluation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.11.6 *e.g., 1.1.4.45*

Title Ant #2 holography and surface readjustment *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform holographic measurement of antenna #2 using tower-mounted transmitter. Analyze results and re-set surface accordingly. Repeat the process for several iterations if necessary. [Duration 4 months, crew of 2 sci, 1 engr, 1 prog, 1 tech (all part time)]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.		2						0.2
	2	2	Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.		1						0.1
	1	1	Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		2						0.2
	2	2	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		2						0.2
	2	2	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.11.6

Title Ant #2 holography and surface readjustment

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.11.7 *e.g., 1.1.4.45*

Title Ant #2 Antenna Evaluation *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform detailed performance evaluation of ant #2 in single-dish mode. This includes primarily astronomical observations, although some engineering tests using ground-based instrumentation may also be done. Measurements include gain and noise temperature vs. elevation, beam shape and sidelobes, pointing absolute accuracy, pointing tracking stability, effects of the Sun in and near the beam, servo characteristics, and structural dynamics. [Duration 4 months, part time participation by 3 scientists, 1 engineer, 1 programmer, and 1 technician.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.		6						0.5
	3	3	Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.		2						0.2
	1	1	Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		4						0.3
	2	2	Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		4						0.3
	2	2	Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.11.7
Title Ant #2 Antenna Evaluation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.12 *e.g., 1.1.4.45*

Title Interferometric Tests *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	11%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform interferometric tests on 2-antenna system. [See subtasks for further details and costs]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.12

Title Interferometric Tests

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.12.1 *e.g., 1.1.4.45*

Title Phase/gain stability tests *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Measure gain and phase stability of interferometer using astronomical sources and internal test signals. Verify overall system operation, including correlator. [Duration 4 months; part time 2 sci, 1 eng, 1 prog, 1 tech]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			4					0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.12.1

Title Phase/gain stability tests

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.12.2 *e.g., 1.1.4.45*

Title Sensitivity verification *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Check sensitivity of interferometer using known astronomical sources on all bands supported by the evaluation receivers, as a function of bandwidth, integrating time, and other instrumental parameters. Verify that results are consistent with single dish test results. [Duration 2 months; part time 1 sci, 1 engr, 1 prog]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			2					0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.12.2

Title Sensitivity verification

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.12.3 *e.g., 1.1.4.45*

Title Holography with astronomical sources *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform holographic measurement of each antenna's surface using interferometer and natural sources. Verify that results are consistent with single-dish holography. Determine surface distortion as a funtion of elevation and under varied environmental conditions (day/night, cold/warm, etc.) [Duration 4 months; full time 1 sci, part time 1 engr, 1 prog, 1 tech]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.			4					0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.			2					0.2
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			1					0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.12.3

Title Holography with astronomical sources

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.12.4 *e.g., 1.1.4.45*

Title Modifications and Retrofits *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	35%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Modify and retrofit hardware in response to test results, as required. Repeat tests as indicated. [This task is very open ended and cost is not accurately predictible. Duration of 6 months is allowed, with half-time participation from 2 scientists, 2 engineers, 1 tech and 1 prog] [Automatic contingency calculation overridden by engineering judgment.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.				6				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.				3				0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.				6				0.5
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				3				0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.12.4

Title Modifications and Retrofits

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.13 *e.g., 1.1.4.45*

Title Dissassemble test system and ship to array site *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	35%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Disassemble all components of test interferometer, including antennas #1 and #2, and package for shipping. Deliver to common carrier for transport. Restore test site facilities to former condition. Includes disassembly, shipping, and reassembly of the two antennas by contract to the antenna manufacturer. Other work performed by NRAO personnel.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.					4			0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.13

Title Dissassemble test system and ship to array site

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14 *e.g., 1.1.4.45*

Title On-site System Integration *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	6	
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	50%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Perform all outfitting and testing in Chile, both at the OSF and at the array site. [See subtasks for details and costs.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.14

Title On-site System Integration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Consumables	lot									

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MMA Cost Estimation Data Input Table

WBS Number 10.14.1 *e.g., 1.1.4.45*

Title Set up assembly and test facilities at OSF *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

Intstallation of special test equipment, computers, and wiring to support testing of antennas and electronics during outfitting at the OSF. Installation of holography transmitter tower. [Basic infrastructure, including buildings, power, and furniture are accounted for under Site Development. General test equipment and tools are covered under Site Development and Operations.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.			1					0.1
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.			2					0.2
			Ops.								

WBS Number 10.14.1

Title Set up assembly and test facilities at OSF

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.2 *e.g., 1.1.4.45*

Title Outfit antennas 3 through 36 *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

For each new antenna, includes installation of NRAO supplied equipment; testing; delivery to array site.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.14.2

Title Outfit antennas 3 through 36

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Consumables	lot	10			1	1	1	1	1	50
									Total (1999 $K):	50

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.14.2.1 *e.g., 1.1.4.45*

Title Wiring and plumbing *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

2 techs; 3 weeks/ant for first two, then 2 weeks/ant.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.			7.4	6.5	6.5	6.5	5.6	2.7
			Ops.								

WBS Number 10.14.2.1

Title Wiring and plumbing

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Cable, connectors, hardware	lot/antenn	11			7	7	7	7	6	374
									Total (1999 $K):	374

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.14.2.2 *e.g., 1.1.4.45*

Title Install electronics in receiver cabin *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

2 techs; 2 weeks/ant.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.			6.5	6.5	6.5	6.5	5.6	2.6
			Ops.								

WBS Number 10.14.2.2

Title Install electronics in receiver cabin

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Cable, connectors, hardware	lot/antenn	11			7	7	7	7	6	374
									Total (1999 $K):	374

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

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MMA Cost Estimation Data Input Table

WBS Number 10.14.2.3 *e.g., 1.1.4.45*

Title Check out completed antenna at OSF *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Includes basic operational tests as well as single-dish holographic measurement of surface and fine alignment. [1 engr, 1 tech; 4 weeks/ant. 1 sci, 1 week/ant]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.			1.6	1.6	2.6	1.6	1.4	0.7
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.			6.5	6.5	6.5	6.5	5.5	2.6
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.			6.5	6.5	6.5	6.5	5.5	2.6
			Ops.								

WBS Number 10.14.2.3

Title Check out completed antenna at OSF

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.2.4 *e.g., 1.1.4.45*

Title Install antenna at array site. *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Includes transporting antenna to site, installing it at assigned station, and basic initial checkout. [Further work on commissioning is part of Operations phase.] [3 techs; 1.5 weeks/ant]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.			7.3	7.3	7.3	7.3	6.3	3.0
			Ops.								

WBS Number 10.14.2.4

Title Install antenna at array site.

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.3 *e.g., 1.1.4.45*

Title Refurbish antennas 1 and 2 *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Upon arrival from test site, re-install electronics (including upgrades) and re-test. [Antenna reassembly is part of contract under WBS 10.13]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.14.3

Title Refurbish antennas 1 and 2

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.3.1 *e.g., 1.1.4.45*

Title Re-install electronics and upgrade as needed *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description *(Text for the WBS dictionary)*

[2 techs, 1 wk/ant]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.					1			0.1
			Ops.								

WBS Number 10.14.3.1

Title Re-install electronics and upgrade as needed

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.3.2 *e.g., 1.1.4.45*

Title Check out at OSF *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Includes single-dish holography and fine alignment. [1 engr, 1 tech, 4 weeks/ant; 1 sci, 1 week/ant]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.					0.5			0.0
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.					2			0.2
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.					2			0.2
			Ops.								

WBS Number 10.14.3.2
Title Check out at OSF

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.3.3 *e.g., 1.1.4.45*

Title Install antenna at array site *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Includes transporting antenna to site, installing it at assigned station, and basic initial checkout. [Further work on commissioning is part of Operations phase.] [3 techs; 1.5 weeks/ant][Similar to production antennas.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.					2			0.2
			Ops.								

WBS Number 10.14.3.3

Title Install antenna at array site

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.4 *e.g., 1.1.4.45*

Title Install central building electronics *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	25%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Install local oscillator and signal transmission electroincs [2 techs, 4 weeks]. Install correlator [1 engr, 1 tech, 2 weeks]. Install monitor and control computers [1 tech, 2 weeks].

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.				2	1			0.3
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.				0.5				0.0
			Ops.								

WBS Number 10.14.4

Title Install central building electronics

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.14.5 *e.g., 1.1.4.45*

Title Support debugging and repair *e.g., Project Management and Tracking*

Estimator LRD *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	15	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	8	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:		*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Provide continuing support for repair of breakdowns, for debugging, and for unanticipated (but expected) problems. [0.5 engr, 1 tech for 5 years. Rather open ended, hence high contingency.]

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.			6	6				1
			Ops.					6	6	6	1.5
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.			12	12				2.0
			Ops.					12	12	12	3.0

WBS Number 10.14.5

Title Support debugging and repair

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

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MMA Cost Estimation Data Input Table

WBS Number 10.20 *e.g., 1.1.4.45*

Title Prototype Testing Support *e.g., Project Management and Tracking*

Estimator R. Simon *Name*

Basis of Estimate EN **EN** *-Engineering/Bottom Up/ Parametric;* **VQ** *- Vendor Quote;* **PO** *- Place Order; or* **AC** *- Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (*Text for the WBS dictionary*)

Additional effort and materials to support testing of prototypoe and pre-production systems on antennas #1 and #2. Specific items, such as the Prototype Production Receiver, will need some testing with antennas #1 and #2, even though such tests are not directly related to evaluating the antennas.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		1	1	1				0.3
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		1	1	1				0.3
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 10.20
Title Prototype Testing Support

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Miscellaneous materials	each	10		1	1	1				30
									Total (1999 $K):	30

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

MMA Cost Estimation Data Input Table

WBS Number 11.1.1 *e.g., 1.1.4.45*

Title Completion of 183 GHz Water Vapor Radiometer *e.g., Project Management and Tracking*

Estimator Al Wootten, Darrel Emerson, John Webber *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	11%	*(See defintions)*

Task Description (Text for the WBS dictionar

Design of cooled Schottky power stable radiometer operating over ~30 GHz bandwidth centered at the 183 GHz water line for estimating atmospheric path delay.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	1							0.083333
(5 mos. D&D plus 1 mo. co			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.1.1

Title Completion of 183 GHz Water Vapor Radiometer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.1.2 *e.g., 1.1.4.45*

Title Demonstrate 183 GHz Water Vapor Radiometer *e.g., Project Management and Tracking*

Estimator Al Wootten, Darrel Emerson, John Webber *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	12%	*(See defintions)*

Task Description (Text for the WBS dictionar

Demonstration of 183 GHz Water Vapor Radiometer Prototype

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician (11 mos D&D phase 1 mo	months	US	Constr.	11	1						1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.1.2

Title Demonstrate 183 GHz Water Vapor Radiometer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Radiometer Parts	Each	20	1							20
									Total (1999 $K):	20

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

MMA Cost Estimation Data Input Table

WBS Number 11.1.3 *e.g., 1.1.4.45*

Title Refinement of 183 GHz Water Vapor Radiometer *e.g., Project Management and Tracking*

Estimator Al Wootten, Darrel Emerson *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	3	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	6	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	16%	*(See defintions)*

Task Description (Text for the WBS dictionar

Refinement of 183 GHz Water Vapor Radiometer based upon demonstration on prototype antenna

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.		3						0.25
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		3						0.25
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.1.3

Title Refinement of 183 GHz Water Vapor Radiometer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.1.4 *e.g., 1.1.4.45*

Title Release WVR for manufacture *e.g., Project Management and Tracking*

Estimator Al Wootten, Darrel Emerson *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (Text for the WBS dictionar

Release of phase monitoring water vapor radiometer for manufacture

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.1.4

Title Release WVR for manufacture

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.2.1.1 *e.g., 1.1.4.45*

Title Contract Phase Monitor Radiometer Subassembly *e.g., Project Management and Tracking*

Estimator Al Wootten, D. Emerson *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (Text for the WBS dictionar

Contact fabrication of prototyped water vapor radiometer monitor and local oscillator

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.2.1.1

Title Contract Phase Monitor Radiometer Subassembly

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Radiometer and LO	Each	30		7	3	0	0	0	0	300

Total (1999 $K): 300

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

MMA Cost Estimation Data Input Table

WBS Number 11.2.1.2 *e.g., 1.1.4.45*

Title WVR Spectrometer *e.g., Project Management and Tracking*

Estimator Al Wootten, Darrel Emerson *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (Text for the WBS dictionar

Spectrometer for Water Vapor Radiometer--16 channels over 30 GHz based on BIMA design.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.	1							0.1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.2.1.2
Title WVR Spectrometer

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Spectrometer No. 1 for WVR Demo	Each	7	1							7
									Total (1999 $K):	7

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Spectrometer for WVR	Each	7.5		8	10	10	10			285
									Total (1999 $K):	285

MMA Cost Estimation Data Input Table

WBS Number 11.2.1.3 *e.g., 1.1.4.45*

Title WVR Feed, Window, Lens, Instrumentation *e.g., Project Management and Tracking*

Estimator Al Wootten, Darrel Emerson *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	10%	*(See defintions)*

Task Description (Text for the WBS dictionar

Auxiliary parts for 183 GHz water vapor radiometer. Includes Feed, Window, Lens, and instrumentation.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.2.1.3

Title WVR Feed, Window, Lens, Instrumentation

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.2.1.4 *e.g., 1.1.4.45*

Title Monitor and Control WVR Interface *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate DN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	4	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	14%	*(See defintions)*

Task Description (Text for the WBS dictionar

Monitor and Control interface for water vapor radiometers.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.2.1.4

Title Monitor and Control WVR Interface

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.2.3 *e.g., 1.1.4.45*

Title Deliver Production Radiometers *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	9%	*(See defintions)*

Task Description (Text for the WBS dictionar

Deliver production radiometer

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			6	6				1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.2.3
Title Deliver Production Radiometers

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Misc material	Each	5			0.5	0.5				5
									Total (1999 $K):	5

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
M/C Hardware	Each	1.5		7	3					15
									Total (1999 $K):	15

MMA Cost Estimation Data Input Table

WBS Number 11.2.4 *e.g., 1.1.4.45*

Title Integration of WVR into Receiver Package *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate DN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Integration of 183 GHz water vapor radiometer into receiver package.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			6	12	6			
			Ops.						6	6	4
		Chile	Constr.								
			Ops.								

WBS Number 11.2.4

Title Integration of WVR into Receiver Package

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.2.5 *e.g., 1.1.4.45*

Title Verification on Site of WVR *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate DN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	9%	*(See defintions)*

Task Description (Text for the WBS dictionar

Verification of WVR System on site

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.				3				0.25
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				3	3			0.5
			Ops.					6	9	9	2
		Chile	Constr.								
			Ops.								

WBS Number 11.2.5
Title Verification on Site of WVR

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.3.1 *e.g., 1.1.4.45*

Title Dual-Load Amp. Calibration Device Design Refinement *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Refine Design of Dual load amplitude calibration device as demonstrated on BIMA

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.	2							0.2
			Ops.								
		Chile	Constr.	5	2						0.6
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.1

Title Dual-Load Amp. Calibration Device Design Refinement

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.3.2 *e.g., 1.1.4.45*

Title Release Dual-Load Amp Cal for Mftr *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	2	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	8%	*(See defintions)*

Task Description (Text for the WBS dictionar

Release of Dual Load amplitude calibration device for manufacture.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.2

Title Release Dual-Load Amp Cal for Mftr

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.3.3 *e.g., 1.1.4.45*

Title Contract Subassembly Dual-Load Amp Cal *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Contract subassembly of existing design for dual load amplitude calibration system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.3

Title Contract Subassembly Dual-Load Amp Cal

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.3.3.1 *e.g., 1.1.4.45*

Title Dual-Load AmpCal Subassy Machining *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Machining of parts for Dual Load AmpCal Subassembly, from BIMA experience

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		1	1					0.17
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.3.1

Title Dual-Load AmpCal Subassy Machining

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Parts for machining	Each	1.333		24	14					50.7
									Total (1999 $K):	50.654

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
									Total (1999 $K):	

MMA Cost Estimation Data Input Table

WBS Number 11.3.3.2 *e.g., 1.1.4.45*

Title Load Fabrication for Dual Load Amp Cal *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Fabrication of Loads for Dual Load amplitude calibration device

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		4	4					0.666667
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.3.2

Title Load Fabrication for Dual Load Amp Cal

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Dual Load Materials	Each	1.333		20	18					50.654

Total (1999 $K): 50.654

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

MMA Cost Estimation Data Input Table

WBS Number 11.3.3.3 *e.g., 1.1.4.45*

Title Dual Load Amplitude Calibration Device Motors, Servo *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Motors and Servos for Dual Load amplitude calibration device.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		4	4					0.666667
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.3.3

Title Dual Load Amplitude Calibration Device Motors, Servo

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Motors, Servo	Each	1.333		20	18					50.654

Total (1999 $K): 50.654

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Total (1999 $K):

MMA Cost Estimation Data Input Table

WBS Number 11.3.3.4 *e.g., 1.1.4.45*

Title M/C Interface for Dual Load Amp Cal Device *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN✓ *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Monitor and Control system, electronics for dual load amplitude calibration system.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.		7	4					0.916667
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.3.4

Title M/C Interface for Dual Load Amp Cal Device

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
Temp reg circuit, VME card, Chassis, F	Each	2		24	14					76
								Total (1999 $K):		76

Contracts

Contract Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)
								Total (1999 $K):		

MMA Cost Estimation Data Input Table

WBS Number 11.3.4 *e.g., 1.1.4.45*

Title Assembly and Test of Dual Load Amplitude Calibration *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Assembly and test of dual load amplitude calibration device

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.			4					0.333333
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.4
Title Assembly and Test of Dual Load Amplitude Calibration

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.3.5 *e.g., 1.1.4.45*

Title Integration of AmpCal on Production Antennas *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Integration and test of Amplitude Calibration devices on production antennas

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.				3	3	3	3	1
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.3.5

Title Integration of AmpCal on Production Antennas

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.4 *e.g., 1.1.4.45*

Title Imaging Studies and Project Support *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	2	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	5%	*(See defintions)*

Task Description (Text for the WBS dictionar

Imaging Studies, Scientific evaluation of antennas and algorithms, turning antennas from engineering marvels into solid scientific production apparti.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	48							4
			Ops.		72	72	72	72	72	72	36
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.4

Title Imaging Studies and Project Support

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

MMA Cost Estimation Data Input Table

WBS Number 11.5 *e.g., 1.1.4.45*

Title Imaging Algorithm Development *e.g., Project Management and Tracking*

Estimator Al Wootten *Name*

Basis of Estimate EN *EN -Engineering/Bottom Up/ Parametric; VQ - Vendor Quote; PO - Place Order; or AC - Actual Cost*

Assigned Risk factors

Technical	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Cost	1	*(1, 2, 3, 4, 6, 8, 10, or 15; see definition)*
Schedule	4	*(2, 4 or 8; see definition)*

Multipliers for Contingency

Technical	2	*(2 or 4 are valid)*
Cost	1	*(1 or 2 are valid)*
Calculated Contingency:	7%	*(See defintions)*

Task Description (Text for the WBS dictionar

Development of algorithms for production of precision images from instrument.

Labor

Position Type	Effort in	Location	Constr. or Ops.	2001	2002	2003	2004	2005	2006	2007	Totals (person y)
Scientist	months	US	Constr.	12	12	12	12				4
			Ops.				12	24	24	24	7
		Chile	Constr.								
			Ops.								
Programmer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Engineer	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								
Technician	months	US	Constr.								
			Ops.								
		Chile	Constr.								
			Ops.								

WBS Number 11.5

Title Imaging Algorithm Development

Materials

Material Description	Unit of Measure	1999 Unit Cost ($K)	2001 Quantity	2002 Quantity	2003 Quantity	2004 Quantity	2005 Quantity	2006 Quantity	2007 Quantity	Totals (1999 $K)

Cost Summary Page

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Name of Sheet	Labor Pos'n?	WBS Number	Title	Contingency	Scientist 2001	2002	2003	2004	2005
11_1_1	ok	11.1.1	Completion of 183 GHz Water Vapor Radiometer	11%	0	0	0	0	0
11_1_2	ok	11.1.2	Demonstrate 183 GHz Water Vapor Radiometer	12%	0	0	0	0	0
11_1_3	ok	11.1.3	Refinement of 183 GHz Water Vapor Radiometer	16%	0	0	0	0	0
11_1_4	ok	11.1.4	Release WVR for manufacture	10%	0	0	0	0	0
11_2_1_1	ok	11.2.1.1	Contract Phase Monitor Radiometer Subassembly	10%	0	0	0	0	0
11_2_1_2	ok	11.2.1.2	WVR Spectrometer	10%	0	0	0	0	0
11_2_1_3	ok	11.2.1.3	WVR Feed, Window, Lens, Instrumentation	10%	0	0	0	0	0
11_2_1_4	ok	11.2.1.4	Monitor and Control WVR Interface	14%	0	0	0	0	0
11_2_3	ok	11.2.3	Deliver Production Radiometers	9%	0	0	0	0	0
11_2_4	ok	11.2.4	Integration of WVR into Receiver Package	7%	0	0	0	0	0
11_2_5	ok	11.2.5	Verification on Site of WVR	9%	0	0	0	0	0
11_3_1	ok	11.3.1	Dual-Load Amp. Calibration Device Design Refineme	7%	0	0	0	0	0
11_3_2	ok	11.3.2	Release Dual-Load Amp Cal for Mftr	8%	0	0	0	0	0
11_3_3	ok	11.3.3	Contract Subassembly Dual-Load Amp Cal	7%	0	0	0	0	0
11_3_3_1	ok	11.3.3.1	Dual-Load AmpCal Subassy Machining	7%	0	0	0	0	0
11_3_3_2	ok	11.3.3.2	Load Fabrication for Dual Load Amp Cal	7%	0	0	0	0	0
11_3_3_3	ok	11.3.3.3	Dual Load Amplitude Calibration Device Motors, Sen	7%	0	0	0	0	0
11_3_3_4	ok	11.3.3.4	M/C Interface for Dual Load Amp Cal Device	7%	0	0	0	0	0
11_3_4	ok	11.3.4	Assembly and Test of Dual Load Amplitude Calibratic	7%	0	0	0	0	0
11_3_5	ok	11.3.5	Integration of AmpCal on Production Antennas	7%	0	0	0	0	0
11_4	ok	11.4	Imaging Studies and Project Support	5%	48	0	0	0	0
11_5	ok	11.5	Imaging Algorithm Development	7%	12	12	12	12	0

		Programmer							Engineer							Technician						
2006	2007	2001	2002	2003	2004	2005	2006	2007	2001	2002	2003	2004	2005	2006	2007	2001	2002	2003	2004	2005	2006	2007
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	12	6	0	0
0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0
0	0	0	0	0	0	0	0	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reprocess 1 Page

Materials and Supplies								
2001	2002	2003	2004	2005	2006	2007	M&S tot	Check
0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	20	20
0	0	0	0	0	0	0	0	0
90	210	0	0	0	0	0	300	300
0	210	90	0	0	0	0	300	300
7	60	75	75	75	0	0	292	292
0	140	60	0	0	0	0	200	200
0	15	0	0	0	0	0	15	15
0	10.5	7	2.5	0	0	0	20	20
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	32	18.7	0	0	0	0	50.654	50.654
0	26.7	24	0	0	0	0	50.654	50.654
0	26.7	24	0	0	0	0	50.654	50.654
0	48	28	0	0	0	0	76	76
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0