WBS	Name	Sci	Prog	Engin	Tech	Pers k$	M&S k$	Sum k$	Contg k$	Inf Sum k$	Inf Cont k$	Scope Cont	Ops Xfer	Net Const k$
1	Administration													
1.1	Project Management	72			24		600							
1.1.1	Management, Planning, and Oversight						50							
1.1.2	Business Operations						50							
1.1.3	Chilean Operations													
1.1.4	Safety and Health													
1.1.5	Personnel													
1.1.6	Project Science Office													
1.1.7	AUI Management						350							
1.2	Engineering			36	12		20							
1.2.1	System Engineering--Phase II													
1.2.2	Documentation System													
1.2.3	Production Engineering													
1.3	US Facilities													
1.3.1	CDL Permanent Facilities						600							
1.3.2	Manufacturing Facilities						100							
1.3.3	Common Infrastructure						200							
2	Site Development			12			50							
2.1	Review Legalities Regarding Array and OSF Sites													
2.2	Maintain Mining claims						25							
2.3	Contract A&E Studies													
2.4	Hire Construction Manager for Chile													
2.5	Array Site													
2.5.1	Prepare Site Development Bid Packages													
2.5.1.1	Prepare Package for Array Site													
2.5.1.2	Review Bid Packages													
2.5.1.3	Bid Civil Works Construction													
2.5.2	Evaluate Array Site Bid Response													
2.5.2.1	Review Bids													
2.5.2.2	Recommend Contractors													
2.5.2.3	Award Array Site Contracts													
2.5.3	Contract Array Site Civil Works						10925							
2.5.3.1	Array Site													
2.5.3.2	Inspect Completed Site Constr													
2.5.3.3	Accept Site Facility													
2.6	Operations Support Facility													
2.6.1	Prepare OSF Bid Packages													
2.6.1.1	Prepare Package for OSF													
2.6.1.2	Review Bid Packages													
2.6.1.3	Bid Civil Works Construction													
2.6.2	Evaluate OSF Bid Response													
2.6.2.1	Review Bids													
2.6.2.2	Recommend Contractors													
2.6.2.3	Award Contracts													
2.6.3	Contract OSF Civil Works						7320							
2.6.3.1	Operations Support Facility													
2.6.3.2	Inspect Completed OSF Constr													
2.6.3.3	Accept OSF Facility													
2.7	OSF/Array Link													
2.7.1	Prepare OSF/Array Link Bid Package													
2.7.1.1	Prepare Package for OSF/Array F/O Link													

2.7.1.2	Review Bid Package													
2.7.1.3	Bid OSF/Array Link Construction													
2.7.2	Evaluate Bid Response													
2.7.2.1	Review Bids													
2.7.2.2	Recommend Contractors													
2.7.2.3	Award Contracts													
2.7.3	Contract Civil Works						3890							
2.7.3.1	OSF/Array Link													
2.7.3.2	Inspect Completed OSF/Array Link Constr													
2.7.3.3	Accept OSF/Array Link													
2.8	Prepare for Instrument Assembly													
2.8.1	Equip Array Site													
2.8.2	Equip Operations Support Facility													
3	Antenna													
3.1	Antenna Engineering Support			48										
3.3.40	Acceptance Tests Antenna #1													
3.3.45	Delivery of Antenna #1													
3.8.10	Sign Transporter Contract													
3.8.15	Transporter Acceptance tests													
3.8.20	Deliver/Accept Transporter #1													
3.7	Procurement of Antenna #2													
3.7.1	Antenna #2 Contract Supervision													
3.7.2	Antenna #2 Acceptance tests													
3.8	Negotiate Production Antenna Contract													
3.9	Sign Contract for Production Antennas													
3.10	Antenna Contract Supervision													
3.11	Accept Antenna #3 at OSF													
3.12	Prepare Antenna #3													
3.12.1	Outfit & Verify Ant #3 at OSF													
3.12.2	Move, Install & Verify Ant #3 on Site													
3.13	Accept Antenna #4 at OSF													
3.14	Prepare Antenna #4													
3.14.1	Outfit & Verify Ant #4 at OSF													
3.14.2	Move, Install & Verify Ant #4 on Site													
3.15	Accept Antenna#5 at OSF													
3.16	Prepare Antenna #5													
3.16.1	Outfit & Verify Ant #5 at OSF													
3.16.2	Move, Install & Verify Ant #5 on Site													
3.17	Accept Antenna#6 at OSF													
3.18	Prepare Antenna #6													
3.18.1	Outfit & Verify Ant #6 at OSF													
3.18.2	Move, Install & Verify Ant #6 on Site													
3.19	Accept Antenna #7 at OSF													
3.20	Prepare Antenna #7													
3.20.1	Outfit & Verify Ant #7 at OSF													
3.20.2	Move, Install & Verify Ant #7 on Site													
3.21	Accept Antenna #8 at OSF													
3.22	Prepare Antenna #8													
3.22.1	Outfit & Verify Ant #8 at OSF													
3.22.2	Move, Install & Verify Ant #8 on Site													
3.23	Accept Antenna #9 at OSF													
3.24	Prepare Antenna #9													
3.24.1	Outfit & Verify Ant #9 at OSF													
3.24.2	Move, Install & Verify Ant #9 on Site													

3.25	Accept Antenna #10 at OSF													
3.26	Prepare Antenna #10													
3.26.1	Outfit & Verify Ant #10 at OSF													
3.26.2	Move, Install and Verify Ant #10 on Site													
3.27	Accept Antenna #11 at OSF													
3.28	Prepare Antenna #11													
3.28.1	Outfit & Verify Ant #11 at OSF													
3.28.2	Move, Install & Verify Ant #11 on Site													
3.29	Accept Antenna #12 at OSF													
3.30	Prepare Antenna #12													
3.30.1	Outfit & Verify Ant #12 at OSF													
3.30.2	Move, Install & Verify Ant #12 on Site													
3.31	Accept Antenna #13 at OSF													
3.32	Prepare Antenna #13													
3.32.1	Outfit & Verify Ant #13 at OSF													
3.32.2	Move, Install & Verify Ant #13 on Site													
3.33	Accept Antenna #14 at OSF													
3.34	Prepare Antenna #14													
3.34.1	Outfit & Verify Ant #14 at OSF													
3.34.2	Move, Install & Verify Ant #14 on Site													
3.35	Accept Antenna #15 at OSF													
3.36	Prepare Antenna #15													
3.36.1	Outfit & Verify Ant #15 at OSF													
3.36.2	Move, Install & Verify Ant #15 on Site													
3.37	Accept Antenna #16 at OSF													
3.38	Prepare Antenna #16													
3.38.1	Outfit & Verify Ant #16 at OSF													
3.38.2	Move, Install & Verify Ant #16 on Site													
3.39	Accept Antenna #17 at OSF													
3.40	Prepare Antenna #17													
3.40.1	Outfit & Verify Ant #17 at OSF													
3.40.2	Move, Install & Verify Ant #17 on Site													
3.41	Accept Antenna #18 at OSF													
3.42	Prepare Antenna #18													
3.42.1	Outfit & Verify Ant #18 at OSF													
3.42.2	Move, Install & Verify Ant #18 on Site													
3.43	Accept Antenna #19 at OSF													
3.44	Prepare Antenna #19													
3.44.1	Outfit & Verify Ant #19 at OSF													
3.44.2	Move, Install & Verify Ant #19 on Site													
3.45	Accept Antenna #20 at OSF													
3.46	Prepare Antenna #20													
3.46.1	Outfit & Verify Ant #20 at OSF													
3.46.2	Move, Install & Verify Ant #20 on Site													
3.47	Accept Antenna #21 at OSF													
3.48	Prepare Antenna #21													
3.48.1	Outfit & Verify Ant #21 at OSF													
3.48.2	Move, Install & Verify Ant #21 on Site													
3.49	Accept Antenna #22 at OSF													
3.50	Prepare Antenna #22													
3.50.1	Outfit & Verify Ant #22 at OSF													
3.50.2	Move, Install & Verify Ant #22 on Site													
3.51	Accept Antenna #23 at OSF													
3.52	Prepare Antenna #23													

3.52.1	Outfit & Verify Ant #23 at OSF													
3.52.2	Move, Install & Verify Ant #23 on Site													
3.53	Accept Antenna #24 at OSF													
3.54	Prepare Antenna #24													
3.54.1	Outfit & Verify Ant #24 at OSF													
3.54.2	Move, Install & Verify Ant #24 on Site													
3.55	Accept Antenna #25 at OSF													
3.56	Prepare Antenna #25													
3.56.1	Outfit & Verify Ant #25 at OSF													
3.56.2	Move, Install & Verify Ant #25 on Site													
3.57	Accept Antenna #26 at OSF													
3.58	Prepare Antenna #26													
3.58.1	Outfit & Verify Ant #26 at OSF													
3.58.2	Move, Install & Verify Ant #26 on Site													
3.59	Accept Antenna #27 at OSF													
3.60	Prepare Antenna #27													
3.60.1	Outfit & Verify Ant #27 at OSF													
3.60.2	Move, Install & Verify Ant #27 on Site													
3.61	Accept Antenna #28 at OSF													
3.62	Prepare Antenna #28													
3.62.1	Outfit & Verify Ant #28 at OSF													
3.62.2	Move, Install & Verify Ant #28 on Site													
3.63	Accept Antenna #29 at OSF													
3.64	Prepare Antenna #29													
3.64.1	Outfit & Verify Ant #29 at OSF													
3.64.2	Move, Install & Verify Ant #29 on Site													
3.65	Accept Antenna #30 at OSF													
3.66	Prepare Antenna #30													
3.66.1	Outfit & Verify Ant #30 at OSF													
3.66.2	Move, Install & Verify Ant #30 on Site													
3.67	Accept Antenna #31 at OSF													
3.68	Prepare Antenna #31													
3.68.1	Outfit & Verify Ant #31 at OSF													
3.68.2	Move, Install and Verify Ant #31 on Site													
3.69	Accept Antenna #32 at OSF													
3.70	Prepare Antenna #32													
3.70.1	Outfit & Verify Ant #32 at OSF													
3.70.2	Move, Install & Verify Ant #32 on Site													
3.71	Accept Antenna #33 at OSF													
3.72	Prepare Antenna #33													
3.72.1	Outfit & Verify Ant #33 at OSF													
3.72.2	Move, Install and Verify Ant #33 on Site													
3.73	Accept Antenna #34 at OSF													
3.74	Prepare Antenna #34													
3.74.1	Outfit & Verify Ant #34 at OSF													
3.74.2	Move, Install and Verify Ant #34 on Site													
3.75	Accept Antenna #35 at OSF													
3.76	Prepare Antenna #35													
3.76.1	Outfit & Verify Ant #35 at OSF													
3.76.2	Move, Install & Verify Ant #35 on Site													
3.77	Accept Antenna #36 at OSF													
3.78	Prepare Antenna #36													
3.78.1	Outfit & Verify Ant #36 at OSF													
3.78.2	Move, Install & Verify Ant #36 on Site													

3.79	Prepare Antenna #1													
3.79.1	Antenna #1 Reassembled at OSF													
3.79.2	Outfit & Verify Ant #1 at OSF													
3.79.3	Move, Install & Verify Ant #1 on Site													
3.80	Prepare Antenna #2													
3.80.1	Antenna #2 Reassembled at OSF													
3.80.2	Outfit & Verify Ant #2 at OSF													
3.80.3	Move, Install & Verify Ant #2 on Site													
3.81	Antenna Transporter													
3.81.1	Contract for Transporters #2, #3													
3.81.2	Accept Transporters #2, #3 at OSF													
4	Receivers													
4.1	Receiver Package													
4.1.1	Prototype Production Receiver Cryogenics													
4.1.1.1	CDR: Cryogenics Development													
4.1.1.2	Construct & test prototype cryogenics													
4.1.1.3	Deliver Prototype Cryogenics Subsystem													
4.1.2	Prototype Production Receiver Package			12	12		100							
4.1.2.1	Prototype Receiver Package Integration													
4.1.2.2	Prot. Rcvr. Pckg Lab Test & Evaluation													
4.1.2.3	Complete Prototype MMA Receiver Package													
4.1.3	MMA Rcvr Pckg Design Refinement													
4.1.4	Documentation													
4.1.5	Release MMA Receiver Pckg for manufacture													
4.1.6	Contract for Receiver Pckg Subassemblies													
4.1.6.1	Machine Dewars				30		50							
4.1.6.2	Fabricate Cryogenics subsystems			6	24		240							
4.1.6.3	Fabricate windows, IR filters, etc			6	30		100							
4.1.7	Accept Receiver Pckg Subassemblies													
4.1.7.1	Subassemblies #1-6													
4.1.7.2	Subassemblies #7-16													
4.1.7.3	Subassemblies #17-26													
4.1.7.4	Subassemblies #27-36													
4.1.7.5	Subassemblies #37-40													
4.1.8	Fab Rcvr Pckg Instrumentation & Electronics		12	12	12		100							
4.1.9	Fabricate Receiver Inserts			24	24		100							
4.1.10	Assemble Receiver Package													
4.1.10.1	Integrate Rcvr Instrumentation & subass'y			24	36		80							
4.1.10.2	Deliver Receiver Package #1-6													
4.1.10.3	Deliver Receiver Package #7-16													
4.1.10.4	Deliver Receiver Package #17-26													
4.1.10.5	Deliver Receiver Package #27-36													
4.1.10.6	Deliver Receiver Package #37-40													
4.2	SIS Receiver Modules			144	193		2873							
4.2.1	211-275 GHz Module													
4.2.1.1	SIS Mixer													
4.2.1.1.1	Design, Fab and Test Mixer Design													
4.2.1.1.2	Deliver Production Design													
4.2.1.1.3	Fabricate Production Mixers													
4.2.1.2	Design & Verify Optics													
4.2.1.3	Design Module													
4.2.1.4	Contract Fabrication													
4.2.1.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.1.4.2	Assemble Modules													

4.2.1.5	Install SIS Mixer & Test Modules													
4.2.1.6	Deliver 211-275 GHz Receiver Modules													
4.2.1.6.1	Deliver Modules #1-7													
4.2.1.6.2	Deliver Modules #8-26													
4.2.1.6.3	Deliver Modules #27-40													
4.2.2	602-720 GHz Module													
4.2.2.1	SIS Mixer													
4.2.2.1.1	Design, Fabricate and Test Mixer Design													
4.2.2.1.2	Deliver Production Design													
4.2.2.1.3	Fabricate Production Mixers													
4.2.2.2	Design & Verify Optics													
4.2.2.3	Design Module													
4.2.2.4	Contract Fabrication													
4.2.2.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.2.4.2	Assemble Modules													
4.2.2.5	Install SIS Mixer and Test Modules													
4.2.2.6	Deliver 602-720 GHz Receiver Modules													
4.2.2.6.1	Deliver Modules #1-7													
4.2.2.6.2	Deliver Modules #8-26													
4.2.2.6.3	Deliver Modules #27-40													
4.2.3	275-370 GHz Receiver Module													
4.2.3.1	SIS Mixer													
4.2.3.1.1	Design, Fabricate and Test Mixer Design													
4.2.3.1.2	Deliver Production Design													
4.2.3.1.3	Fabricate Production Mixers													
4.2.3.2	Design & Verify Optics													
4.2.3.3	Design Module													
4.2.3.4	Contract Fabrication													
4.2.3.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.3.4.2	Assemble Modules													
4.2.3.5	Install SIS Mixer and Test Modules													
4.2.3.6	Deliver 275-370 GHz Receiver Module													
4.2.3.6.1	Deliver Modules #1-5													
4.2.3.6.2	Deliver Modules #6-30													
4.2.3.6.3	Deliver Modules #30-40													
4.2.4	91-119 GHz Receiver Module													
4.2.4.1	SIS Mixer													
4.2.4.1.1	Design, Fabricate & Test Mixer Design													
4.2.4.1.2	Deliver Production Design													
4.2.4.1.3	Fabricate Production Mixers													
4.2.4.2	Design & Verify Optics													
4.2.4.3	Design Module													
4.2.4.4	Contract Fabrication													
4.2.4.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.4.4.2	Assemble Modules													
4.2.4.5	Install SIS Mixer and Test Modules													
4.2.4.6	Deliver 91-119 GHz Receiver Modules													
4.2.4.6.1	Deliver Modules #1-5													
4.2.4.6.2	Deliver Modules #6-30													
4.2.4.6.3	Deliver Modules # 31-40													
4.2.5	163-211 GHz Receiver Module													
4.2.5.1	SIS Mixer													
4.2.5.1.1	Design, Fabricate & Test Mixer Design													
4.2.5.1.2	Deliver Production Design													

4.2.5.1.3	Fabricate Production Mixers													
4.2.5.2	Design & Verify Optics													
4.2.5.3	Design Module													
4.2.5.4	Contract Fabrication													
4.2.5.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.5.4.2	Assemble Modules													
4.2.5.5	Install SIS Mixer and Test													
4.2.5.6	Deliver 163-211 GHz Receiver Modules													
4.2.5.6.1	Deliver Modules #1-5													
4.2.5.6.2	Deliver Modules #6-30													
4.2.5.6.3	Deliver Modules #31-40													
4.2.6	385-500 GHz Receiver Module													
4.2.6.1	SIS Mixer													
4.2.6.1.1	Design, Fabricate & Test Mixer Design													
4.2.6.1.2	Deliver Production Design													
4.2.6.1.3	Fabricate Production Mixers													
4.2.6.2	Design and Verify Optics													
4.2.6.3	Design Module													
4.2.6.4	Contract Fabrication													
4.2.6.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.6.4.2	Assemble Modules													
4.2.6.5	Install SIS Mixer and Test													
4.2.6.6	Deliver 385-500 GHz Receiver Modules													
4.2.6.6.1	Deliver Modules #1-5													
4.2.6.6.2	Deliver Modules #6-30													
4.2.6.6.3	Deliver Modules #31-40													
4.2.7	125-163 GHz Receiver Module													
4.2.7.1	SIS Mixer													
4.2.7.1.1	Design, Fabricate & Test Mixer Design													
4.2.7.1.2	Deliver Production Design													
4.2.7.1.3	Fabricate Production Mixers													
4.2.7.2	Design & Verify Optics													
4.2.7.3	Design Module													
4.2.7.4	Contract Fabrication													
4.2.7.4.1	Machine Mixer Blocks, Feed, WG, Lenses													
4.2.7.4.2	Assemble Modules													
4.2.7.5	Install SIS Mixer and Test													
4.2.7.6	Deliver 125-163 GHz Receiver Modules													
4.2.7.6.1	Deliver 125-163 GHz Modules #1-5													
4.2.7.6.2	Deliver 125-163 GHz Modules #6-30													
4.2.7.6.3	Deliver 125-163 GHz Modules #31-40													
4.3	HFET Receiver Modules			7	15		70							
4.3.1	Contract for HFET Wafer													
4.3.2	Receive Diced HFET Wafer													
4.3.3	33-45 GHz Module													
4.3.3.1	Design Module													
4.3.3.2	Design & Verify Optics													
4.3.3.3	Contract Fabrication													
4.3.3.3.1	Machine Blocks, Feed, WG, Lenses													
4.3.3.3.2	Assemble Modules													
4.3.3.3.3	Flip-in Mirror													
4.3.4	Install HFET & Test Modules													
4.3.5	Deliver 33-45 GHz Receiver Modules													
4.3.5.1	Deliver Modules #1-20													

4.3.5.2	Deliver Modules #21-40													
4.3.6	67-95 GHz Module													
4.3.6.1	Design Amplifer													
4.3.6.2	Design Module													
4.3.6.3	Design & Verify Optics													
4.3.6.4	Contract Fabrication													
4.3.6.4.1	Machine Blocks, Feed, WG, Lenses													
4.3.6.4.2	Assemble Modules													
4.3.6.5	Install HFET & Test Modules													
4.3.6.6	Deliver 67-95 GHz Receiver Modules													
4.3.6.6.1	Deliver Modules 67-95GHz #1-20													
4.3.6.6.2	Deliver Modules 67-95GHz #21-40													
5	LO System													
5.1	LO Reference: Prototype Systems			12	12									
5.1.1	Deliver: Bench Prototype													
5.1.2	Testing and Design Refinement													
5.1.3	Procure/Fab Field Prototypes													
5.1.4	Deliver: LO Ref Field Prototypes													
5.1.5	Field Prototype testing and Design Refinement													
5.1.6	Preproduction Review													
5.1.7	Final Documentation and Design Modifications													
5.1.8	Release for Manufacture													
5.2	LO Reference: Production System													
5.1.1	Production test and lab equipment													
5.1.2	H-maser Frequency Standard (& Rb)													
5.1.3	8 GHz PL Oscillator & Distributor						3							
5.1.4	10 GHz PL Oscillator & Distributor						5							
5.1.5	12 GHz PL Oscillator & Distributor						5							
5.1.6	14 GHz PL Oscillator & Distributor						5							
5.1.7	3.2-5.2 GHz Synthesizer						40							
5.1.8	3.2 -5.2 GHz PLO and Fringe Generator						800							
5.1.9	Sampler Clock 4 GHz PL Osc & Distributor						3							
5.1.10	LO Ref Generator						8							
5.1.11	LO Ref Distributor - Control Bldg						3							
5.1.12	Microwave Round-trip Phase Measurement						300							
5.1.13	10-15 GHz Frequency Synthesizer						500							
5.1.14	First LO Fringe Generator						100							
5.1.15	16 GHz PL Oscillator						200							
5.1.16	26 GHz PL Oscillator						200							
5.1.17	LO Ref Distributor - Antenna						100							
5.1.18	VXCO Clean-up Loop						100							
5.1.19	Power supply module						300							
5.1.20	Bins / Racks (assemble and test)						80							
5.3	Millimeter LO Drivers			12	18		150							
5.3.1	Design and System Integration													
5.3.2	72-95 GHz Source													
5.3.2.1	Contract Procurement and Fabrication													
5.3.2.1.1	YIG-tuned Oscillator													
5.3.2.1.2	18.00 - 23.75 GHz 10 db Amplifier													
5.3.2.1.3	18.00 - 23.75 GHz x2 Multiplier													
5.3.2.1.4	36.0 - 47.5 GHz 10 db Amplifier													
5.3.2.1.5	36.0 - 47.5 GHz x2 Multiplier													
5.3.2.1.6	Mount and Tuning circuitry													
5.3.2.2	Assembly and Test													

5.3.2.3	Deliver 72 - 95 GHz LO Sources													
5.3.2.3.1	Deliver Modules #1-6													
5.3.2.3.2	Deliver Modules #7-24													
5.3.2.3.3	Deliver Modules #25-40													
5.3.3	100-120 GHz Source													
5.3.3.1	Contract Procurement and Fabrication													
5.3.3.1.1	YIG-tuned Oscillator													
5.3.3.1.2	25.00 - 30.00 GHz 10 db Amplifier													
5.3.3.1.3	15.00 - 30.00 GHz x2 Multiplier													
5.3.3.1.4	50.0 - 60.0 GHz 10 db Amplifier													
5.3.3.1.5	50-60 GHz x2 Multiplier													
5.3.3.1.6	Mount and Tuning circuitry													
5.3.3.2	Assembly and Test													
5.3.3.3	Deliver 100 - 120 GHz LO Sources													
5.3.3.3.1	Deliver Modules #1-3													
5.3.3.3.2	Deliver Modules #4-21													
5.3.3.3.3	Deliver Modules #22-40													
5.3.4	87 - 108 GHz Source													
5.3.4.1	Contract Procurement and Fabrication													
5.3.4.1.1	YIG-tuned Oscillator													
5.3.4.1.2	21.75-27.00 GHz 10 db Amplifier													
5.3.4.1.3	21.75-27.00 GHz x2 Multiplier													
5.3.4.1.4	43.5-54.0 GHz 10 db Amplifier													
5.3.4.1.5	43.5-54.0 GHz x2 Multiplier													
5.3.4.1.6	Mount and Tuning Circuitry													
5.3.4.2	Assembly and Test													
5.3.4.3	Deliver 87 - 108 GHz LO Sources													
5.3.4.3.1	Deliver Modules #1-6													
5.3.4.3.2	Deliver Modules #7-20													
5.3.4.3.3	Deliver Modules #21-35													
5.3.4.3.4	Deliver Modules #36-40													
5.3.5	65 - 85 GHz Source													
5.3.5.1	Contract Procurement and Fabrication													
5.3.5.1.1	YIG-tuned Oscillator													
5.3.5.1.2	16.25-21.25 GHz 10 db Amplifier													
5.3.5.1.3	16.25-21.25 GHz x2 Multiplier													
5.3.5.1.4	32.5-42.5 GHz 10 db Amplifier													
5.3.5.1.5	32..5-42.5 GHz x2 Multiplier													
5.3.5.1.6	Mount and Tuning Circuitry													
5.3.5.2	Assembly and Test													
5.3.5.3	Deliver 65 - 85 GHz LO Sources													
5.3.5.3.1	Deliver Modules #1-6													
5.3.5.3.2	Deliver Modules #7-20													
5.3.5.3.3	Deliver Modules #21-35													
5.3.5.3.4	Deliver Modules #36-40													
5.4	Millimeter LO Multiplier Chains			24	90		635							
5.4.1	Design and System Integration													
5.4.2	211 - 275 GHz Receiver LO													
5.4.2.1	Contract Fabrication													
5.4.2.1.1	X3 Diode for 72-95 GHz Source													
5.4.2.1.2	Machine Mount													
5.4.2.1.3	Bias and Control circuits													
5.4.2.2	Assemble Multiplier and Test													
5.4.2.3	Integrate Source and Multiplier; test													

5.4.2.4	Deliver 211-275 GHz Rcvr LO Modules													
5.4.2.4.1	Deliver Modules #1-3													
5.4.2.4.2	Deliver Modules #4-21													
5.4.2.4.3	Deliver Modules #22-40													
5.4.3	602 - 720 GHz Receiver LO													
5.4.3.1	Contract Fabrication													
5.4.3.1.1	X2 Diode for 100-120 GHz Source													
5.4.3.1.2	X3 Diode for 200-240 GHz Input													
5.4.3.1.3	Machine Mount													
5.4.3.1.4	Bias and Control circuits													
5.4.3.2	Assemble Multipliers and Test													
5.4.3.3	Integrate Source and Multipliers; test													
5.4.3.4	Deliver 602-720 GHz Rcvr LO Modules													
5.4.3.4.1	Deliver Modules #1-6													
5.4.3.4.2	Deliver Modules #7-18													
5.4.3.4.3	Deliver Modules #19-34													
5.4.3.4.4	Deliver Modules #35-40													
5.4.4	275 - 370 GHz Receiver LO													
5.4.4.1	Contract Fabrication													
5.4.4.1.1	X2 Diode for 72-95 GHz Source													
5.4.4.1.2	X2 Diode for 144-190 GHz Input													
5.4.4.1.3	Machine Mount													
5.4.4.1.4	Bias and Control Circuits													
5.4.4.2	Assemble Multipliers and Test													
5.4.4.3	Integrate Source and Multipliers; test													
5.4.4.4	Deliver 275-370 GHz Rcvr LO Modules													
5.4.4.4.1	Deliver Modules #1-6													
5.4.4.4.2	Deliver Modules #7-27													
5.4.4.4.3	Deliver Modules #28-40													
5.4.5	163 - 211 GHz Receiver LO													
5.4.5.1	Contract Fabrication													
5.4.5.1.1	X2 Diode for 87-108 GHz Source													
5.4.5.1.2	Machine Mount													
5.4.5.1.3	Bias and Control Circuits													
5.4.5.2	Assemble Multiplier and Test													
5.4.5.3	Integrate Source and Mulitplier; test													
5.4.5.4	Deliver 163 - 211 GHz Rcvr LO Modules													
5.4.5.4.1	Deliver Modules #1-6													
5.4.5.4.2	Deliver Modules #7-24													
5.4.5.4.3	Deliver Modules #25-40													
5.4.6	385 - 500 GHz Receiver LO													
5.4.6.1	Contract Fabrication													
5.4.6.1.1	X3 Diode for 65-85 GHz Source													
5.4.6.1.2	X2 Diode for 130-170 GHz Input													
5.4.6.1.3	Machine Mount													
5.4.6.1.4	Bias and Control Circuits													
5.4.6.2	Assemble Multiplier and test													
5.4.6.3	Integrate source and Multiplier; test													
5.4.6.4	Deliver 385-500 GHz Rcvr LO Modules													
5.4.6.4.1	Deliver Modules #1-6													
5.4.6.4.2	Deliver Modules #7-24													
5.4.6.4.3	Deliver Modules #25-40													
5.4.7	125 - 163 GHz Receiver LO													
5.4.7.1	Contract Fabrication													

5.4.7.1.1	X2 Diode for 65 - 85 GHz Source													
5.4.7.1.2	Machine Mount													
5.4.7.1.3	Bias and Control Circuits													
5.4.7.2	Assemble Multiplier and test													
5.4.7.3	Integrate Source and Multiplier; test													
5.4.7.4	Deliver 125-163 GHz Rcvr LO Modules													
5.4.7.4.1	Deliver Modules #1-6													
5.4.7.4.2	Deliver Modules #7-18													
5.4.7.4.3	Deliver Modules #19-34													
5.4.7.4.4	Deliver Modules #35-40													
5.4.8	33-45 GHz Receiver LO													
5.4.8.1	Design & Fab Selection & Coupling from Sources													
6	IF System			12	12									
6.1	IF System: Prototype Systems													
6.1.1	Deliver (Bench) Prototype IF System													
6.1.2	Testing and Design Refinement													
6.1.3	Procure/Fab Field Prototypes													
6.1.4	Deliver IF Field Prototypes to Test Interfeometer													
6.1.5	Field Prototype testing and Design Refinement													
6.1.6	Preproduction Review													
6.1.7	Final Documentation and Design Modifications													
6.1.8	Release for Manufacture													
6.2	Production test and lab equipment													
6.3	IF Multiplexer						800							
6.4	IF Demultiplexer						400							
6.5	IF Matrix Switch						320							
6.6	Baseband Converter						800							
6.7	Power supply module						200							
6.8	Bins / Racks (assemble and test)						80							
7	Optical Fiber System			12	12									
7.1	Optical Fiber System: Prototype Systems													
7.1.1	Deliver (Bench) Prototype FO System													
7.1.2	Testing and Design Refinement													
7.1.3	Procure/Fab Field Prototypes													
7.1.4	Deliver FO Field Prototypes to Test Interfeometer													
7.1.5	Field Prototype testing and Design Refinement													
7.1.6	Preproduction Review													
7.1.7	Final Documentation and Design Modifications													
7.1.8	Release for Manufacture													
7.1	Production test and lab equipment													
7.2	IF TX / RX						1200							
7.3	LO Reference TX / RX						200							
7.4	Microwave Round-trip Phase TX / RX						200							
7.5	Monitor / Control TX / RX						100							
7.6	Power supply module						200							
7.7	Bins / Racks (assemble and test)						80							
8	Correlator			36	36		2000							
8.1	Digital Sampler, 4 GHz			6	12		428							
8.1.1	Refine Design													
8.1.2	Release Digital Sampler for Manufacture													
8.1.3	Contract Materials													
8.1.4	Assembly													
8.1.5	Validation and Delivery													

8.2	Digital FIR Filter			2	2		533							
8.2.1	Prototype testing on Test Interferometer													
8.2.2	Design Refinement													
8.2.3	Release FIR Filter for manufacture													
8.2.4	Chip Fabrication													
8.2.5	Assembly													
8.2.6	Validation and Delivery													
8.3	Custom Boards													
8.3.1	Correlator Board													
8.3.1.1	Prototype assembly													
8.3.1.2	Prototype test													
8.3.1.3	Design modifications													
8.3.1.4	Fab, assemble and test with design mods													
8.4	Correlator Chip													
8.4.1	Prototype chip fabrication													
8.4.2	Prototype chip test													
8.4.3	Design modifications													
8.4.4	Fabricate and test design mods													
8.4.5	Fabricate production run													
8.5	Racks													
8.5.1	Design control wiring													
8.5.2	Design signal wiring													
8.5.3	Order parts													
8.5.4	Assemble prototypes													
8.6	Software													
8.7	Prototype Correlator Production													
8.7.1	Order parts													
8.7.2	Assemble													
8.7.3	Test													
8.7.4	Deliver Prototype Correlator to VLA site													
8.8	Site Correlator Production													
8.8.1	First 1/4 correlator													
8.8.1.1	Determine configuration													
8.8.1.2	Order parts													
8.8.1.3	Assemble													
8.8.1.4	Test													
8.8.1.5	Deliver 1/4 Correlator to MMA site													
8.8.2	Second 1/4 correlator													
8.8.2.1	Order parts													
8.8.2.2	Assemble													
8.8.2.3	Test													
8.8.2.4	Deliver 1/4 Correlator to MMA site													
8.8.3	Third 1/4 correlator													
8.8.3.1	Order parts													
8.8.3.2	Assemble													
8.8.3.3	Test													
8.8.3.4	Deliver 1/4 Correlator to MMA site													
8.8.4	Fourth 1/4 correlator													
8.8.4.1	Order parts													
8.8.4.2	Assemble													

8.8.4.3	Test													
8.8.4.4	Deliver 1/4 Correlator to MMA site													
8.9	Continued Support													
9	Computing						50							
9.1	Control Software													
9.1.1	Test Interferometer Control & Analysis													
9.1.2	MMA correlator software		52											
9.1.3	Multi-antenna & sub-array control													
9.1.4	Operators & Observers interfaces		26											
9.1.5	Deliver Control Software													
9.1.6	Maintenance													
9.2	Scheduling													
9.2.1	Static scheduling system		10											
9.2.2	Dynamic scheduling simulations		12											
9.2.3	Dynamic scheduling prototype													
9.2.4	Dynamic scheduling implementation													
9.2.5	Initial Operations with Dynamic Scheduling													
9.3	Proposal Preparation Software													
9.3.1	Prototype		6											
9.3.2	Production version													
9.4	Image Pipeline													
9.4.1	Automated calibration & imaging heuristics		6											
9.4.2	Prototype image pipeline													
9.4.3	Parallelization studies and implementation													
9.4.4	Initial Image Pipeline Operations													
9.4.5	Production image pipeline													
9.5	Archiving													
9.5.1	Prototype distributed archive		10											
9.5.2	Evaluate storage hardware													
9.5.3	Production archive													
9.5.4	Data Archive operational													
9.6	Post-processing													
9.6.1	Define MMA Data formats		6											
9.6.2	MMA filler & format conversions													
9.6.3	MMA-specific calibrations		6											
9.6.4	MMA Post-processing begins													
9.6.5	Maintenance													
10	System Integration						50							
10.4	Test Interferometer Site Preparation													
10.4.1	Complete Office and Lab Space Preparation													
10.4.2	Cabling													
10.4.3	Test Interferometer Site Complete													
10.10.4	Prototype Antenna Outfitting													
10.10.4.1	Cabling													
10.10.4.2	Instrumentation													
10.10.4.3	Eval. Rcvr. #1 / Ant. #1 Integration													
10.10.4.4	Antenna #1 Outfitting Complete													
10.10.5	Integration Holography System/Antenna													
10.10.6	Integration Metrology/Antenna													
10.10.7	Antenna #1 Integration & Testing			24	12									
10.10.8	Prot. Rcvr. Test & Evaluation													
10.10.9	Antenna #2 Outfitting													
10.10.9.1	Cabling													

10.10.9.2	Instrumentation													
10.10.9.3	Eval. Rcvr. #2 / Ant. #2 Integration													
10.10.9.4	Antenna #2 Outfitting Complete													
10.11	Test Interferometer		6	24	12									
10.11.1	Antenna Evaluation & Characterization													
10.11.1.1	Antenna Verification													
10.11.1.4	Holography													
10.11.1.5	Beam and Sidelobes													
10.11.1.6	Gain vs. Elevation: Spillover Temp													
10.11.1.7	Effect of Sun in & Near the Beam													
10.11.2	Engineering Recommendations re Prod. Ant.													
10.11.3	Revise Interface Specifications													
10.11.5	Operations Personnel Training	5												
10.11.5.1	Recruit Initial Chile Ops Staff													
10.11.5.2	Array Operations													
10.11.5.3	Engineering Maintenance													
10.11.5.4	Scientific Support & Analysis													
10.12.2	Relocate Ops Staff to Chile													
10.8.4.6	Start On-site Operations													
10.12	Disassemble Test Interferometer													
10.12.1	Prepare & Ship Antenna #1, #2													
10.12.3	Restore Facilities at VLA Site													
10.13	On Site System Integration													
11	Calibration and Imaging	1												
11.1	Radiometric Phase Design & Prototype													
11.1.1	Complete 183GHz Phase Mon Prototype													
11.1.2	Demo 183 GHz Phase Monitor Radiometer on-Site													
11.1.3	Design Refinement													
11.1.4	Release Phase Mon Radiometer for manufacture													
11.2	Production Fab of Phase Monitor Radiometer						681							
11.2.1	Contract Subassembly Fabrication													
11.2.1.1	Radiometer & Local Oscillator													
11.2.1.2	Spectrometer													
11.2.1.3	Feed, Window, lens, instrumentation													
11.2.1.4	M/C Interface													
11.2.2	Assembly & Test													
11.2.3	Deliver Production Radiometers													
11.2.4	Integration in Receiver Package													
11.2.5	Verification on-Site													
11.3	Production Fabrication of Dual-load Amp Cal Sys						291							
11.3.1	Design Refinement													
11.3.2	Release Phase Mon Radiometer for manufacture													
11.3.3	Contract Subassembly													
11.3.3.1	Machining													
11.3.3.2	Load Fabrication													
11.3.3.3	Motors, Servo													
11.3.3.4	M/C Interface													
11.3.4	Assembly & Test													
11.3.5	Integration on Production Antennas													
11.4	Imaging Studies & Project Support	72												
11.5	Imaging Algorithm Development	8	4											