PLANNING FOR THE MMA DESIGN AND DEVELOPMENT PHASE

THE 1992 D&D PLAN

It is interesting to recall the 1992 planning for the D&D phase. Mike Balister put a lot of time into getting this into what we imagined at the time was good shape. Let me summarize its funding categories and costs just so we have a reference for what we may plan to do now. Costs in the table below are in k$. [I'll lump the first partial year of the previous plan into the first whole year so that what you see below is a 3-year plan; I'll also round numbers to make it simple for me]

Task	year 1	year 2	year 3	Sum
Administration	$433	$411	$411	1225
(includes rental space at $130k/yr)				
Site Eval & acquisition	823	183	332	1338
	(incl $700k EIS)	(incl $100k EIS)		
Antenna Development	865	725	360	1950
Prototype Antenna		2500		2500
Array Imaging Studies	194	151	152	497
SIS Mixer Development	1091	972	1003	3066
Contracts	613	460	460	1533
HFET Amplifiers	331	250	164	745
Contracts	125	125	125	375
Local Oscillator	563	438	557	1558
Ref Freq Transmission	156	212	182	550
IF Processing	172	212	213	597
Data Transmission	132	187	185	504
Monitor and Control	152	273	285	710
AIPS++	367	216	218	801
Correlator	256	180	208	644
Cryogenics	252	198	198	648
Prototype Receiver	191	403	73	667
System Testing	-	-	355	355
Test Equipment	1100	900	-	2000
TOTAL	7816	8996	5481	22,293

(Several things look strange here: We were thinking, apparently that AIPS++ would need more funding than Monitor and Control computing--I don't know how we reached that conclusion!)

The number of people needed in this plan is interesting also. We thought we'd need 52 people: 1-contracts; 24-engineers; 17-tech; 6-programmer; 2.5 scientists; 1.5 machinist.

Note that there is no test array in this plan, one prototype antenna is all. So much for history.

PRINCIPAL TECHNICAL GOALS OF THE MMA DESIGN AND DEVELOPMENT PROGRAM

1. Identification of THE MMA Site
   - Permission to use the site
   - Characterization of the site (soil samples etc)
   - Atmospheric tests (continue)
   - Array Configuration layout on the site

2. Design of the MMA Antenna and Optics
   - Produce a design that:
     - meets the MMA specs
     - is affordable
     - is reproducable in quantity
   - Design validity demonstration: Prototype antenna for tests

3. Identification of an Effective Phase Calibration Technique

4. Prototype Quantum-limited SIS Receivers
   - Tunerless design
   - balanced, image separating mixers
   - SIS mixer integrated with wideband HFET IF amplifier

5. Prototype Wideband Local Oscillator
   - Evaluate and choose between conventional multiplied Gunn local oscillator and a photonic local oscillator

6. Full Data Flow Based design and Prototype of Computing System
   - Monitor and Control of instrumentation
   - Pre-observation and realtime astronomer interface
   - post-observation interface to AIPS++

7. Completion of System Level Design Including:
   - Wideband optical fiber IF systems
   - Reference frequency transmission system
   - Correlator and chip block diagram

THE WHO, WHAT AND WHERE OF THE MMA DESIGN AND DEVELOPMENT PHASE

WHERE	WHAT	WHO
TUC/SOC	MMA Site Development	
	Chilean Representative	Contracts/business
	Atmospheric tests	Radford
	Array config on site	Holdaway
	Test data manager/organizer	Astronomer
		subtotal 4 people

TUC	Antenna and Optics		
	Antenna Engineers	Cheng, Lugten	
	Mechanical Engineer	Kingsley	
	Drafting/CAD	Draftsman	
		subtotal 4 people	
CDL	SIS Design		
	Design Balanced, image-separating mixer	Kerr, Pan, + 1 SIS engin	+1
		+1 test/setup engin.	+1
	SIS Fabricator	Tech to UVa	+1
	Integrated SIS/HFET	Engineer	
	SIS Techs	Tech (2)	
		subtotal 7 people	
CDL	HFET Design and Prototype	Pospieszalski & Tech	
		subtotal 2 people	
CDL	Local Oscillator: Conventional Design and prototype	Bradley + tech	+1
		subtotal 2 people	
TUC/CDL	Local Oscillator: Photonic Design and Prototype	Engineer + tech	
		subtotal 2 people	
TUC/CDL	Prototype Re~~c~~eiver (Sri)		
	Optical and Cryogenics design	Engineer (1)	
	Feed, Polarizer etc design	Engineer (1/2--CDL) Sri	
		Engineer (1/2 - Baldwin)	
		subtotal 1.5 people	
SOC	Phase Calibration		
	Evaluate Fast Switching	Astronomer	
	Build 2 183 GHz Shottky Rxs & Install on Chile site testing interferometer	Bagri, Tech	
		subtotal 3 people	
TUC	Computing		
	Control system for Prototype antenna	Emerson(1/2), Hagen, and Folkers	
		subtotal 2.5 people	
SOC	Computing		
	M/C, Full data flow analysis computing system for test array	Benson, Blachman, Sowinski(?)	
		subtotal 3 people	
	System Design		
CDL	Overall Engineering	Engineer +1	
SOC	IF Optical Fiber tests verif.	Engineer + Tech — maybe CB + CDL	
CDL/SOC	Correlator & Chip Design	Escoffier/Broadwell ?	
	Interim correlator ?		

		subtotal 4 people
SOC	Imaging Studies/ AIPS++	Astronomer
		subtotal 1 person
SOC	Test Array Preparation	Civil Engineer + Tech+ misc crafts workers
		subtotal 2+ people

Summary: Virtually all the tasks above should start as soon as there are funds to support them, and some before that. A couple things, like preparation of the test array site at the VLA can wait 18 months or so, but a good zero-order approximation is to assume that everything starts at once. In that case the personnel needed are:

CDL	13 people	actually 15 new
TUC	14	
SOC	11+	
TOTAL	38+	

To this number we may add administrative or management people, perhaps a machinist at the CDL. But we can also subtract from it opportunities here and there to use only parts of people. Let's say the total is 40 people.

Forty people making, say $60k on average brings a personnel cost of $40*1.3*60k = 3.120M per year. Forty people using say 300 sq.ft of space per person at $15 per square foot per year is 12,000sq.ft*$15=$180k.

Thinking about year 1 of the plan, our costs are $3M for people, $0.2M for space, $0.5M for test equipment (broadly defined), $0.5M for SIS contract work at least, and a fair amount for equipment to support the prototyping of the conventional and photonic LO development, say another $0.5 all told. That's a sum of $4.7M. Now add $3M for the first prototype antenna and we're at $7.7M the first year.

HOW THE D&D PLAN FITS TOGETHER AND SOME SUGGESTIONS

We would like to use the D&D phase to position ourselves to begin the construction phase. We don't want to spend money in the D&D phase that does not lead to equipment/software/techniques that end up on the MMA--the D&D funds are not incremental to the construction cost of the MMA, they ARE the construction funds of the MMA.

Receivers: The SIS devices are fabricated, mounted in mixer blocks and tested at the CDL. They are then shipped to Tucson for installation in the receiver assemblies. Tucson builds the cryogenic dewars and the mechanical and IF parts of the receivers. The finished products, in the long run are then shipped to Chile. In the short run, the first prototype receiver is installed by the people who built it on the first prototype antenna. If it doesn't fit or whatever the antenna engineers are also there to make changes/improvements. The D&D plan gets this process going both at the CDL and in Tucson, no overlap of responsibility.

Prototype Antennas: We'll need an interferometer of the prototype antennas, 2 or 3, to make a judgement regarding how well the antennas point, how stable the focus is and so forth. Since the antenna group, the single dish programmers and the receiver builders are in Tucson this will involve some extended work periods by this group at the VLA site.

Test Array: The 2-3 element test array is an instrument for bringing software to life and debugging it. In a perfect world this is best done at the VLA site because the test array will need all manner of support from the crafts, but no craftsmen full time, it will need lab, office and residence facilities. It will need heavy equipment. We have all that stuff at the VLA. Importantly, Albert Greve was telling me about an innovative scheme he has for precise antenna surface setting that needs a microwave "camera" mounted a few meters above the antenna to be measured. That would be easy to arrange in the VLA AAB. The test array software could be done by the best of our people in Socorro, Benson and Blachman, with a lot of advice from the groups in California.

We could also manage the test array in California if they also had a major role in the array software, but not otherwise. This has the advantage that they could get going now writing software that is used on their own instruments until the MMA prototype interferometer appears, something that won't happen until about 2001.

Phase Calibration: This is a very important issue that we have not pursured nearly enough. We've concentrated on evaluating fast switching only. Jack's total power technique is ill suited to Hat Creek but may be useful in Chile. Woody's technique, or a variant of it at 183 GHz, actually holds the greatest promise because, if it works, we don't have to spend time off-source switching to a calibrator. We need to evaluate this possibility and this has to be done in Chile (or MK) where we are evaluating techniques on the actual sky for which they must be effective. In the plan below I propose to build two 183 GHz Schottky receivers and put them on a site testing interferometer. Then let's try and demonstrate that we can remove the phase variations seen by the 12 GHz interferometer with the radiometric measurements at 183 GHz. Richard Hills can be of some help here since he's designing a similar system for CSO/JCMT. It would also be useful to have the engineer doing the work (Bagri?) spend enough time with David Woody to understand what he is doing.

MMA DESIGN AND DEVELOPMENT TIMELINE

	1998	1999	2000	2001	2002
Project Management	x.................................				
Site Development	x.................................				
Antenna					
Design	x.................................				
Transporter Design	x........x				

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  Contract/Deliver #1             x............x
  Contract/Deliver Transporter               x.....x
  Contract/Deliver #2                     x.......x
  Contract/Deliver #3                             x.......x
  Verification process #1                      x.....................

Test Array
  Site Infrastructure                     x........
  Install/test #2                                  x.................
  Install/test #3                                         x..........
  First Fringes                                               x......

SIS Mixers
  230 GHz Tunerless               x.......
  230 GHz Bal, img-sep                    x.......
  Integrated SIS/HFET             x...............
  Integrated Bal, img-sep                     x...........
  Development other bands         x...................................

Local Oscillator
  Design/Proto Conventional       x.............
  Design/Proto Photonic           x.............
  Decision                                      X
  LO system design                              x....................

Prototype SIS Receiver
  Test receiver                   x.............
  230 GHz prototype #1                    x.......
  230 GHz prototype #2                    x...........
  230 GHz prototype #3                    x...............

Cryogenics
  Design/Prototype                x...................................

HFET Amplifiers
  30 GHz test/holography          x.............
  30 GHz Prototype #1                x.............
  30 GHz Prototype #2                    x............
  30 GHz Prototype #3                        x...........
  90 GHz Prototype #1                  x...........
  90 GHz Prototype #2                     x..........
  90 GHz Prototype #3                        x..........
  Production Design, Fab. Tech.                   x..................

Correlator
  Interim Test Correl             x...............
  MMA Design                      x...................................

IF and Signal Transmission
  Design F/O system               x.............
  Prototype and test                      x...........................

Computing
  Single Dish Test software       x...............
  Monitor & Control, Array        x...................................
  Astronomer Interface, Analysis x..................................

Phase Calibration
  Fast Sw. Analysis & Test        x...................................
  183 GHz radiometers (2)         x.............
  Radiom. Tests Chile Interf.                 x...........
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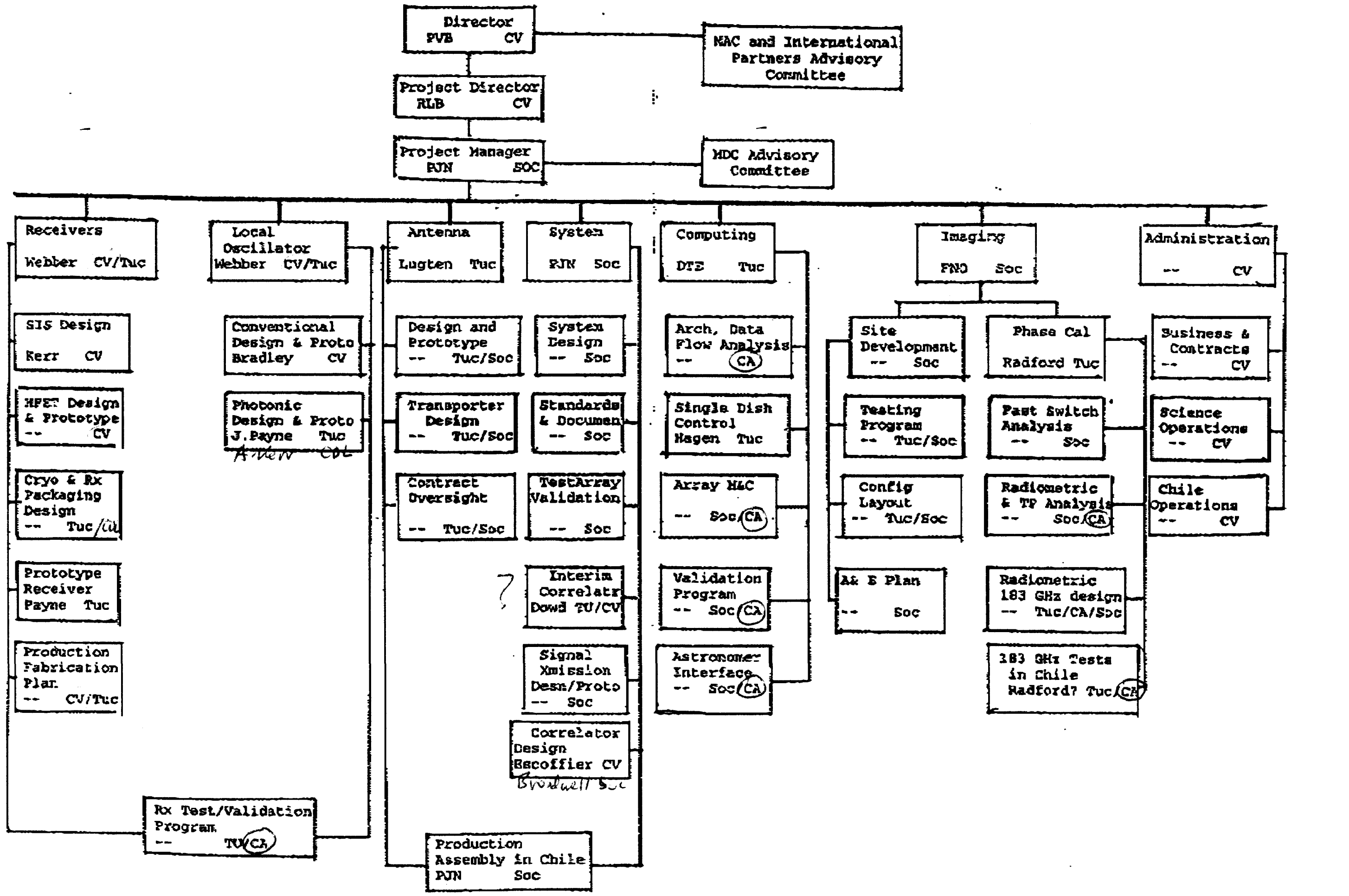

Director PVB CV
NAC and International Partners Advisory Committee
Project Director RLB CV
Project Manager PJN SOC
MDC Advisory Committee
Receivers Webber CV/Tuc
Local Oscillator Webber CV/Tuc
Antenna Lugten Tuc
System PJN Soc
Computing DTE Tuc
Imaging FNO Soc
Administration -- CV
SIS Design Kerr CV
HFET Design & Prototype -- CV
Cryo & Rx Packaging Design -- Tuc/CA
Prototype Receiver Payne Tuc
Production Fabrication Plan -- CV/Tuc
Rx Test/Validation Program -- TU/CA
Conventional Design & Proto Bradley CV
Photonic Design & Proto J.Payne Tuc
Design and Prototype -- Tuc/Soc
Transporter Design -- Tuc/Soc
Contract Oversight -- Tuc/Soc
Production Assembly in Chile PJN Soc
System Design -- Soc
Standards & Documen -- Soc
TestArray Validation -- Soc
Interim Correlatr Dowd TU/CV
Signal Xmission Desn/Proto -- Soc
Correlator Design Escoffier CV
Arch, Data Flow Analysis -- CA
Single Dish Control Hagen Tuc
Array M&C -- Soc/CA
Validation Program -- Soc/CA
Astronomer Interface -- Soc/CA
Site Development -- Soc
Testing Program -- Tuc/Soc
Config Layout -- Tuc/Soc
A& E Plan -- Soc
Phase Cal Radford Tuc
Fast Switch Analysis -- Soc
Radiometric & TP Analysis -- Soc/CA
Radiometric 183 GHz design -- Tuc/CA/Soc
183 GHz Tests in Chile Radford? Tuc/CA
Business & Contracts -- CV
Science Operations -- CV
Chile Operations -- CV