ALMA Development

ASAC 9/10 March 2010

•NAASC Strawman plan

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Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

ALMA Phases

- Construction now declining, Operations continuing rampup.
- Continued Development was featured in the Ops Plan, reviewed by Intl Committee and by NSF Committee then adopted by Board.
- No funding agency funds a 'pig in a poke', the character of development must be defined. This is up to the ALMA Board, now pondering.

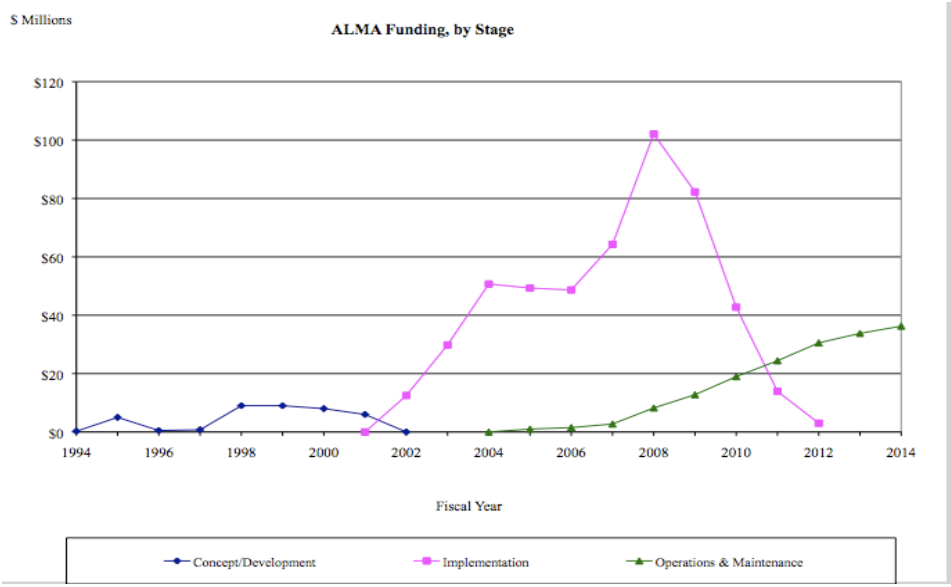


Table 3. Summary of ALMA Development Federal Funding Profile From the operations plan, NSF share, escalated to then-year USD

Fiscal Year	Proposed Development Funding
FY2010:	$ 30k
FY2011:	$ 476k
FY2012:	$1124k
FY2013:	$1995k
FY2014:	$3533k
FY2015:	$5129k

Development Items for ALMA 2010-2020

- Science clearly benefits from improving
  - Throughput (~~collecting area~~, instantaneous bandwidth, uv coverage)
  - Bandwidth (all accessible frequencies)
  - Resolution
- Proposal: First implement unfunded construction scope
  - ~~Unbuilt antennas (while production line remains open)~~
  - Unbuilt receivers (and consider bands not contemplated prior)
  - Unimplemented VLB capability
- Many other possibilities
  - ASAC Report
  - Correlator upgrade
  - Longer connected baselines
  - Are any science goals endangered to whose realization development could contribute?

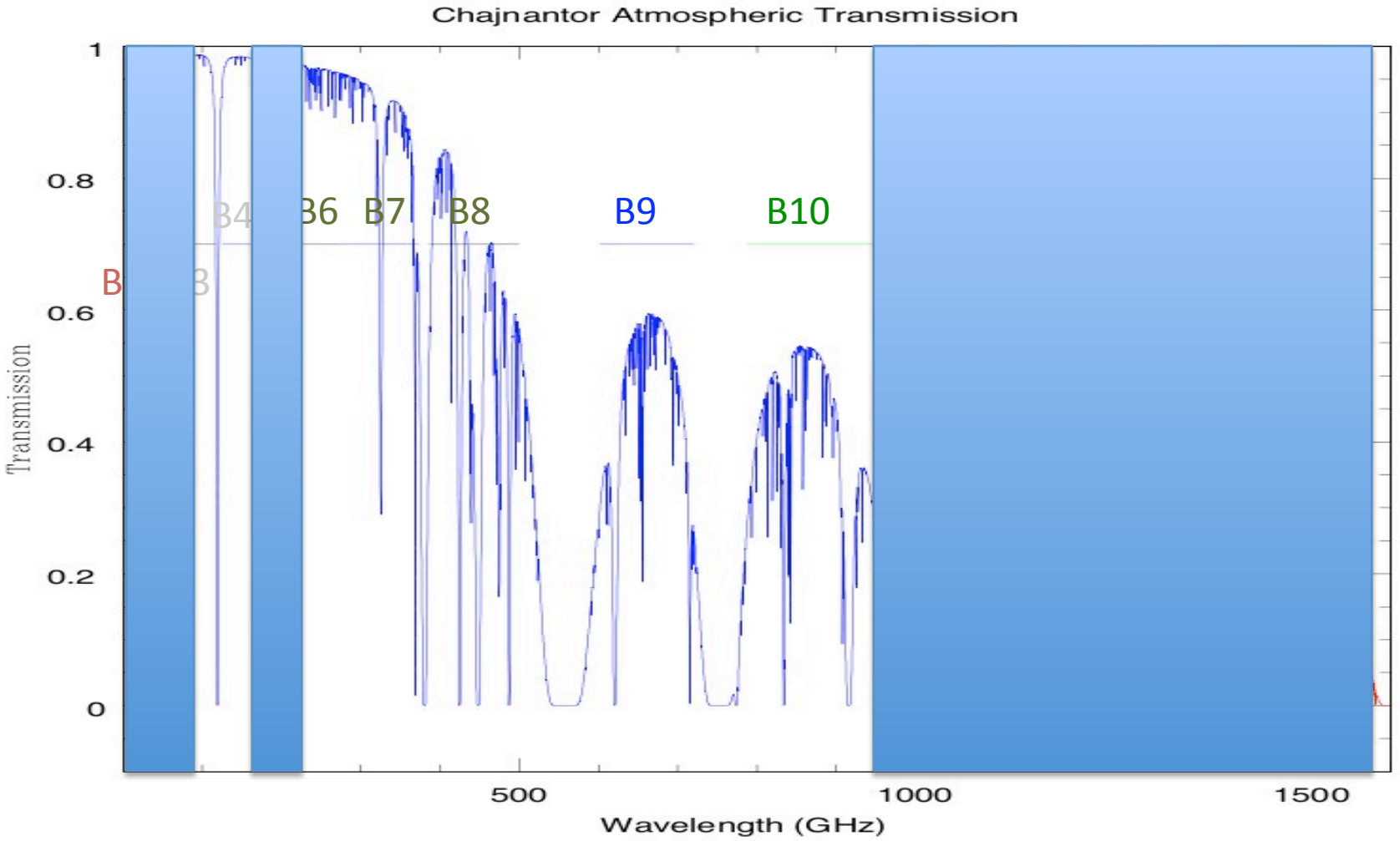
ASAC Recommendations

APPENDIX A: Interdependence of development issues

performance to be improved	development item	degree of improvement	speed/technical difficulti	cost	beneficial for
sensitivity	more antenna	add 5 antenna 10%	quick	expensive	all science
	new digital system/2GC	10%	moderate	expensive	all science
	receiver development (lower noise)	10 – 20%?	moderate?	moderate?	all science
angular resolution	longer baseline	a factor of a few	easy/quick but phase stability issues (including atmospheric and LO reference) should be improved as well	expensive?	limited brightest sources
	VLBI	orders of magnitude	easy/quick?	cheap	Sgr A* and very limited bright and compact sources
field of view	multi-beam receiver	a factor of a few?	long/tough? Enhance correlator power is also required?	expensive?	almost all science (but for compact sources)
	under-illuminated feed	a factor of a few	moderate?	moderate	Solar obs only
spectral coverage	band 1		medium-term	moderate	SZ, redshifted lines, protoplanetary disks, solar
	band 2		medium-term	moderate	SZ, redshifted lines, protoplanetary disks, solar
	band 5		medium-term	moderate	redshifted lines, planetary atmosphere
	band 11		long-term	moderate?	redshifted atomic lines, galaxies?
simultaneous frequency coverage	multi-frequency feed	a factor of a few	moderate? Enhance correlator power is also required (for narrow band observations BLC can accommodate?)	moderate?	almost all science?
	receiver development (wider frquency coverage)	a factor of a few?	moderate? Enhance correlator power is also required to cover whole wide freq. range?	moderate?	ISM, galaxies?
	new digital system/2GC	an order of magnitude? (at high spectral resolution mode)	moderate	expensive	ISM, galaxies?
imaging quality	more antenna	add 5 antennas ==> ~13% gain?	quick	expensive	targets with extended structures
	more 7m antenna	?	moderate?	expensive?	targets with extended structures
	software development	??	all	moderate?	all science
accuracy of amplitude	improved calibration device	???	difficult?	??	ISM?
accuracy of phase	improved atmospheric correction	???	difficult?	??	almost all science which requires high angular resolution
accuracy of polarization	improved calibration device	???	difficult?	??	star formation, ISM

ALMA Bands and Transparency

7 Bands in Construction Project—3 'descoped'



Tuna Lunch

0.5mm PWV v<950 GHz 0.2mm PWV v>950 GHz

Summary of Enhanced ALMA2020+

Table 2. Summary of ALMA Receivers

Band[a]	Frequency (GHz)	T^{b}_{SSB} (K)	Configuration of Receiver	Continuum[c] ΔS (mJy[c])	Spectral Line[d] ΔS (mJy)	Beam[e] (arcsec)
1	**31 - 45**	*17*	HEMT	0.03 (0.023)	8.5	0.12
2	**67 - 90**	*30*	HEMT	0.04 (0.032)	8.5	0.06
3	84 - 116	41	2SB	0.040 (0.03)	7.0	0.038
4	125 - 163	51	2SB	0.06 (.046)	7.1	0.030
5	**163 - 211**	*65*	2SB	0.075 (0.059)	4.9	0.021
6	211 - 275	83	2SB	0.10 (0.075)	10.2	0.018
7	275 - 373	147	2SB	0.18 (0.14)	16.3	0.012
8	385 - 500	196	2SB	0.28 (0.02)	22.6	0.010
9	602 - 720	175[f]	DSB	0.62 (0.49)	62.1	0.006
10	787 - 950	230[f]	DSB	1.1 (0.84)	56	0.005
11	**1255 - 1565**	*375*[f]	DSB	*11 (9)*	*450*	0.005

VLB Capability

- ALMA as a very sensitive node in a breakthrough array could enable:
  - Imaging of the Black Hole at the center of our Galaxy
  - Few 10 microarcsec resolution
  - Include with sensitive elements elsewhere:
    - GBT 3mm and below
    - LMT to 345 GHz
    - CARMA, SMA, JCMT, CSO
- Element of SA Array (~1 milliarcsec resolution)
  - ALMA Prototypes on high Argentine peaks (Brazil-Argentina proposal)
    - Several tens milliarcsec astrometry characterizes exosolar planets
    - Stellar photospheres resolved with beams much below 1 milliarcsec
    - Measure motions of galactic masers
    - High resolution observations of extragalactic megamasers (compare with VLBA project)
  - ~~Resited SMA (Sairecabur?)~~
  - CCAT (short baseline)

Strawman Development Ramp