System Integration (WBS 10)

Three main phases:

A. Planning

- Overall system specifications (Project Book)
- Design infrastructure:
  specifications of interfaces (ICD)
- Catchall: What's fallen through the cracks?

B. US Test Site

- Physical infrastructure (e.g. antenna foundations)
- Bringing antenna #1, then #2, on line
  - Holography
  - Checking out Single Dish systems
- Checking out interferometric systems

C. Chilean sites

- First at the OSF in San Pedro:
  (Lab outfitting and test equipment expenditure from WBS 2)
  - Receive first antennas.
  - Outfit antennas, install NRAO hardware
  - Measure (holography), adjust surface
  - Single dish tests only (not interferometry)

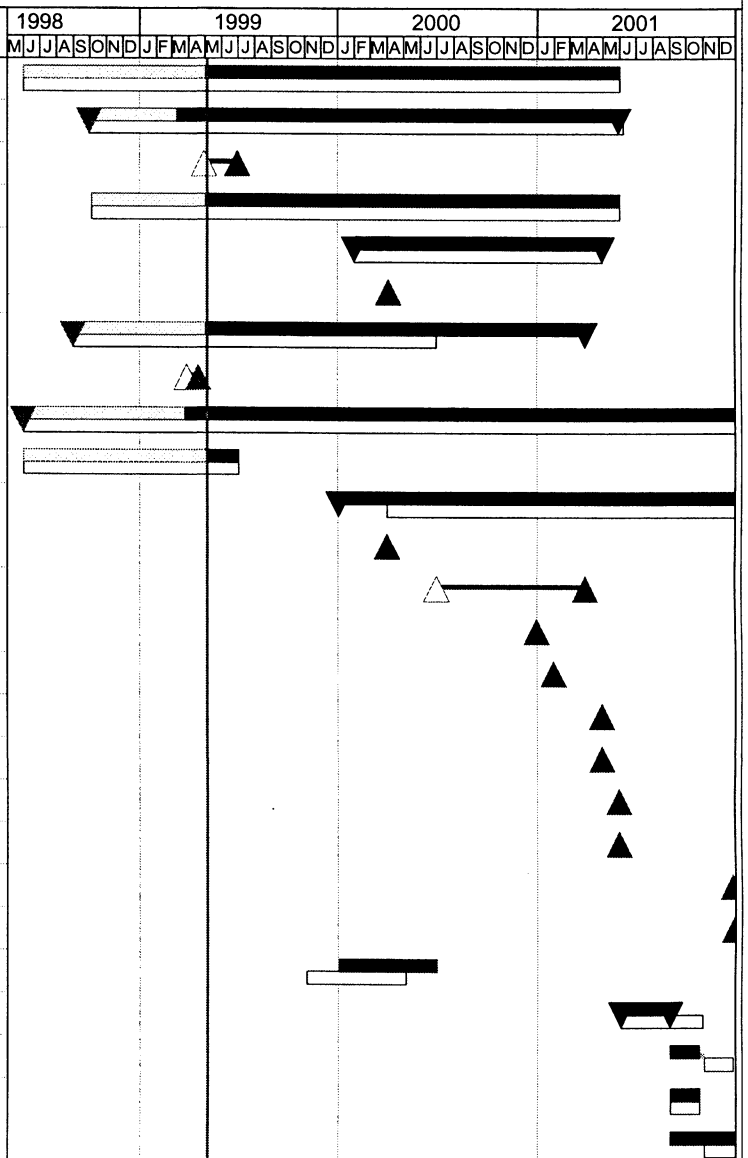
- Then at high site:
  - Transport antennas from OSF
  - Check out individually at high site
  - Interferometric checkout at high site

Filter:

10 System Integration Tasks

Summary Progress View
1 of 1

WBS (f)	Task	BaselineStart	Start	Finish
10.1	Overall Specifications for all systems	1998-06-01	1998-06-01	2001-06-01
10.2	**Specification of interfaces and standards**	**1998-10-01**	**1998-10-01**	**2001-05-30**
10.2.3	Deliver MMA Interfaces and Standards Document	1999-04-30	1999-06-30	1999-06-30
10.3	Monitor and Control Coordination	1998-10-05	1998-10-05	2001-06-01
10.4	**Test Interferometer Site Preparation**	**2000-02-01**	**2000-02-01**	**2001-04-30**
10.4.2	Design Review: Test Int. Site Preparation	2000-04-03	2000-04-03	2000-04-03
10.7	**Holography System**	**1998-09-01**	**1998-09-01**	**2001-03-30**
10.7.3	Design Review: Holography System	1999-03-29	1999-04-19	1999-04-19
10.10	**Prototype Antenna Integration and Testing**	**1998-06-01**	**1998-06-01**	**2003-03-28**
10.10.1	Antenna Testing Plan	1998-06-01	1998-06-01	1999-07-02
10.10.3	**Antenna Subsystem Deliveries**	**2000-03-31**	**2000-01-03**	**2002-08-23**
10.10.3.1	Test Correlator Delivered	2000-03-31	2000-03-31	2000-03-31
10.10.3.2	Holography System Delivered	2000-06-30	2001-03-30	2001-03-30
10.10.3.3	Photonic Phase Cal prototypes delivered	2000-12-31	2000-12-31	2000-12-31
10.10.3.4	Prot. Ant. Metrology Delivered	2001-01-31	2001-01-31	2001-01-31
10.10.3.5	Test Interferometer Site Complete	2001-04-30	2001-04-30	2001-04-30
10.10.3.6	Eval. Rcvr. #1 Delivered	2001-05-01	2001-05-01	2001-05-01
10.10.3.7	Antenna #1 Delivered	2001-06-01	2001-06-01	2001-06-01
10.10.3.13	Antenna Transporter #1 Delivered	2001-06-01	2001-06-01	2001-06-01
10.10.3.8	Antenna #2 Delivered	2001-12-28	2001-12-28	2001-12-28
10.10.3.9	Eval. Rcvr. #2 Delivered	2001-12-31	2001-12-31	2001-12-31
10.10.3.20	Antenna Engineering Mockup Facility	1999-11-05	2000-01-03	2000-06-30
10.10.4	**Prototype Antenna Outfitting**	**2001-06-04**	**2001-06-04**	**2001-09-03**
10.10.5	Integration Holography System/Antenna	2001-11-05	2001-09-03	2001-10-26
10.10.6	Integration Metrology/Antenna	2001-09-03	2001-09-03	2001-10-26
10.10.7	Antenna #1 Integration & Testing	2001-11-05	2001-09-03	2003-02-28



Legend: Open symbols and bars for baseline plan; Dark blue and black bars for currently planned tasks and summary tasks; Light green bars for progress to date

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System Integration

MMA Construction Phase

WBS 10.4

US Test Site Preparation

Finish preparations of test site from D&D phase.

2001-2002:

Expenditure:

48k$ Miscellaneous Office & Lab Equipment
125k$ Test equipment

Manpower:

0.25 man-year

System Integration

MMA Construction Phase

WBS 10.10 Antenna Outfitting at US Test Site

Perform outfitting of the first two antennas, and of other equipment needed to form the test interferometer at the U.S. test site.

WBS 10.10.4 Antenna #1 outfitting.

All NRAO-supplied equipment, including first evaluation receiver & cryogenics, holography, metrology etc.

2001:

Expenditure

25 k$ Miscellaneous

Manpower

1 man-year

WBS 10.10.7 Antenna #2 outfitting
As WBS 10.10.4

2002:

Expenditure
25 k$ Miscellaneous
Manpower
1 man-year

WBS 10.10.10 General Outfitting

Installation of non-antenna equipment, including tower-mounted holography transmitter, central lab electronics.

2002:

Expenditure
55 k$ cable, connectors etc.
Manpower
2 man-years

System Integration

MMA Construction Phase

WBS 10.11 Single Dish Tests

Detailed tests on each antenna, including holography, and observations of terrestrial transmitter and celestial sources, both in line and continuum.

1 man-year from Operations Budget

WBS 10.11.1 Antenna #1, holography and surface setting

2001:

Manpower

0.6 man-year

WBS 10.11.2 Antenna Evaluation

Detailed performance evaluation antenna #1

Primarily astronomical astronomical observations, with instrumentation tests. Gain, elevations effects, beam shapes, sidelobes, pointing, tracking, solar heating, servo performance, dynamics

2001 - 2002:

Manpower

1.3 man-year

WBS 10.11.6 Antenna #2 holography and surface setting
As WBS 10.11.1

2001:

Manpower
0.6 man-year

WBS 10.11.7 Antenna Evaluation

Detailed performance evaluation antenna #2
As WBS 10.11.2

2002:

Manpower
1.3 man-year

System Integration

MMA Construction Phase

WBS 10.12: Interferometric Tests on both antennas

WBS 10.12.1: Phase/gain stability tests

WBS 10.12.2: Sensitivity evaluation

WBS 10.12.3: Holography on astronomical sources. Antenna distortion as function of elevation

WBS 10.12.4: Modifications and Retrofits

2002 - 2004:

Manpower

- 1.3 man-yr scientist
- 0.7 man-yr programmer
- 0.8 man-yr engineer
- 0.3 man-yr technician

3.1 man-year

System Integration

MMA Construction Phase

WBS 10.13: Disassemble test system and ship to array site

Disassemble all components of test interferometer, including both antennas, and package for shipping. Restore test site facilities to former condition.

2005:

Expenditure

776 k$ antenna shipping (2*388 k$)

30 k$ Electronics shipping

Manpower

0.4 man-year

System Integration

MMA Construction Phase

WBS 10.14: On-site (Chile) System Integration

All outfitting and testing, both at the OSF in San Pedro and at the final array site. Antennas #3 through #36, over 2003-2007.

WBS 10.14.1 Set up assembly & test facilities at OSF

WBS 10.14.2.1, 10.14.2.2 Wiring, plumbing, electronics installation

2003 - 2007:

Expenditure

748 k$ Cable, connectors, hardware, cryogenic lines for 34 anennas

Manpower

5.6 man-year

System Integration

MMA Construction Phase

WBS 10.14.2.3: Check out completed antennas at OSF in San Pedro

Includes basic operational tests as well as single-dish holographic measurments of surface and fine alignment.

2003-2007:

Manpower

1 engineer, 1 technician: 4 weeks/antenna
1 scientist: 1 week/antenna
= 5.9 man-year

System Integration

MMA Construction Phase

WBS 10.14.2.4: Transport 34 antennas to high site, basic initial checkout. Installation of NRAO-supplied instrumentation. Further commissioning work is part of the Operations Phase.

2003 - 2007:

Manpower

3 man-years

WBS 10.14.3: Accept and outfit original 2 antennas, from US test site to Chile. First at OSF, then to final high site.

2005:

Manpower:

0.6 man-year

System Integration

MMA Construction Phase

WBS 10.14.4: Install central building electronics: correlator, monitor and control computers.

2004 - 2005:

Manpower

0.3 man-year

WBS 10.14.5: General support debugging and repair, fixing unanticipated problems.

2003-2007:

Manpower:

7.5 man-year

PROTOTYPE ANTENNA TESTS

1. **ON THE FIRST ANTENNA, BEFORE SECOND ANTENNA BECOMES AVAILABLE**

System Installation of:

- Thermistors
- Tilt meters
- Accelerometers, strain gauges, metrology
- Control interfaces
- Optical pointing system

General checks:

- General mechanical inspection, wiring checks
- Mechanical operation: brakes etc.
- Interface integrity
- Mechanical slew rate check
- Mechanical tracking check
- Surface setting check (theodolite?)
- Tiltmeter checks of azimuth rotation

Antenna dynamic (mechanical) response:

- Resonant frequencies, accelerations
- Check motor currents, bearing friction, power consumtion when slewing & tracking
- Weather-proof?

Monitoring:

- Start systematic monitoring of temperatures, tilt meters, motor currents, ambient conditions (wind, temperature ...)

First tracking and pointing tests:

- Optical pointing measurements
  - Needs CCD, interfaces, computer + software
  - Needs simple interface to telescope drive system (computer?)
- Simple servo tests:
  - Move to star, slew away, slew back:
  - Servo response, oscillation?
- Tracking tests:
  - Track edge of moon, stars ...
- Optical Pointing checks
  - Measure pointing offsets on > mag 5 stars
  - First astronomical pointing model
  - Consistency of pointing (night to night, temperature, wind ...)

Electromagnetic measurements:

- Prime Focus Holography.

  Initial Requirements:

  - Requires pointing and tracking understood,
  - Control system interface,
  - Holographic system, frontend and backend, tested out.
  - Holographic reference feed measured
  - Integrated holographic data acquisition, telescope pointing
  - Observing modes tried and tested
  - Holography data analysis system available

- Terrestrial holographic measurements
  - Beacon on a tower (or nearby mountain) at 92 GHz
  - { Repeat until no longer useful:
    First holography maps: 129*129, 10-cm resolution
    Repeat, check for repeatability
    ADJUST SURFACE.
    Derive efficiency
    End repeat }

- IF POSSIBLE:
  - Deformations as function of elevation.

- **Using 90 GHz/230 GHz, secondary focus receiver**
  - Needs nutating subreflector
  - Measure radio pointing (mainly planets).
  - Reconcile radio/optical pointing
  - Derive radio pointing model. Check for consistency, stability.
  - Check radiotracking (edge of moon, edge of Jupiter)
  - Measure efficiency at ~270 GHz:
    Radiometrically, planet
  - Measure error pattern (e.g. sensitive beam map on planet, moon scan).
  - Measure forward and rear spillover, variation with elevation? (Hot/cold calibration, sky tips)
  - Reconcile holographic measurements with radiometric, efficiencies and error pattern measurements
  - Using 230 GHz measurements, confirm fast switching characteristics
  - Surface deformation with elevation:
    Error pattern, Beam shape.

- Reproducibility after transportation
  Tilt meters. New pointing determination needed?
- Confirm that solar observations are possible
  (Heating, panel IR scattering, pointing)
- Subreflector.
  Is a nutating subreflector needed?
  Compare point source measurements, rapidly scanned OTF maps, with and without nutating S/R.
- Spectral purity:
  (Requires spectrometer.)
  Stability of baselines,
  Standing waves.
  Spectral purity - level and stability of spurious signals in passbands

2. WITH SECOND ANTENNA: INTERFEROMETER TESTS

(Can some of these be done before 2nd antenna available?)

- Are we SURE about close packing limitations?
- Phase stability (lateral displacements, wind, bearing slop)
- Phase stability while fast switching? (Structure oscillations?)
- More extensive radio pointing tests now possible

- **Interferometric Holography:**
  - Check out on terrestrial beacon
  - Using 86 GHz SiO maser (needs spectral correlator) and/or planets.
  - Needs complete interferometric, phase stable, fringe tracking, delay tracking electronics.
  - Measure surface (e.g. 48*48) deformations as function of elevation.
- General correlations:
  - Use archived weather (wind, temperature, gradients ...) data to look for correlated effects on antenna (surface deformation, pointing ...)