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Systems Definition

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AT SYSTEMS DEFINITION

A. CONFIGURATION

A.1. Compact Array

a) Six antennas, each 22 m in diameter, alt/az mounted Cassegrain optics.

b) East-west grating array, maximum baselines 1.5, 3, 6 km.

c) Antennas relocatable on rail track between stations as follows:

(i) A 3 km section from 0 to 3 km containing 35 stations and 5 antennas.

(ii) 75 m section at 6 km containing 2 stations and 1 antenna. Provision for future third station.

d) Grating increment 15 m, shortest spacing 30 m.

e) Provision for a future spur track for a north-south extension of array.

f) Minimum redundancy solutions optimised for pseudo-regular coverage of the uv plane after 2, 4, 8, 12, 16, 24 observing periods of 12 hours.

g) All 4-period subsets of the 24-period solution optimised for pseudo-regular coverage of the uv plane.

h) All baselines with the 15 m increment in the 3 km array available after 27 observing periods.

i) Pseudo-zoom arrays available after 1, 2, 4, 8 observing periods.

j) Approximately scaled arrays available for 1.5/3 km and 3/6 km.

A.2. **Long Baseline Array**

a) The long baseline array includes:

(i) One or more compact array antennas in "tied" mode.

* (ii) A 22 m diameter antenna near Siding Spring Mountain in Coonabarabran Shire, NSW ('Mopra Site').

(iii) The Parkes 64 m telescope.

b) Tape recording capability at the three sites to enable data correlation.

c) Provision for inclusion into the array of an antenna at the NASA Deep Space Station, Tidbinbilla (with up to two 140 Mbits/s channels to Parkes on a real time radio link) and an antenna at Hobart.

d) Provision for future extensions of the array with:

(i) One or two additional antennas in the Culgoora/Siding Spring area.

(ii) An antenna at or near Epping.

B. <u>ANTENNA ELEMENTS</u>

* B.1. **New Antennas** (6 x 22 m dishes at Culgoora, 1 x 22 m dish at the Mopra Site.)

a) Alt. - Az mounted.

* b) At Culgoora the antennas will be self-propelled on rail track at a minimum speed of 3 km/hr; Mopra antenna fixed.

c) Subreflector to be provided with 50 mm axial motorised adjustments.

d) Access and space (a cube of side 0.3 m approximately) at Prime Focus provided for possible future use (maximum additional weight approximately 15 kg).

e) Full dish operable at 50 GHz with aperture efficiency

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* Denotes changes since last version

approximately 0.5. Central 15.3 m operational to 116 GHz with aperture efficiency approximately 0.3.

f) Optics: Cassegrain or Prime Focus.

B.2. **Existing Parkes 64 Metre Radiotelescope** (AT/15.7/013)

Optics: Prime focus all frequencies.

C. **FEEDS**

C.1. **Feeds for New 22 m Antennas**

C.1.1 All feeds (except at 327 MHz) designed for Cassegrain focus.

C.1.2 Feeds above 1 GHz are wideband (> octave) corrugated feed to cover:

(i) 20/13 cm (L/S): 1.25 - 2.70 GHz
(ii) 6/3 cm (C/X): 4.4 - 10.8 GHz
(iii) 12/7 mm (K/Q): 20.0 - 50.0 GHz
(iv) 3.5/2.6 mm (W/F): 84.0 - 116. GHz

C.1.3 Dichroic system for simultaneous observation at 13 & 3 (S & X) bands to be provided.

C.1.4 All feeds to operate on-axis, except 3 cm X band when simultaneous with 13 cm (S) band.

C.1.5 Wideband feeds and receivers to be mounted near vertex on rotating-turret (remotely controlled).

C.1.6 Low frequency (< 1 GHz) feeds will be dipoles or arrays of dipole at least covering the bands:-

(i) 90cm: 332-328.6 MHz (Prime focus)
(ii) 50cm: 582-603 MHz (Cassegrain focus)

C.1.7 The above feeds will be linearly polarised at 45 and 135 degrees.

* C.1.8 Feeds for stand alone operation of the Mopra antenna, dual opposite circularly polarised feeds, may be interchanged with the normal single feeds at 12, 7, 3.5 and 2.6 mm. In this mode beam subtraction will be performed in a correlation receiver.

C.2. **Feeds for Parkes 64 Metre Radiotelescope**

C.2.1 All feeds to be for prime focus operation.

C.2.2 Feeds currently under development: single frequency feeds covering receiver bands as defined in D1.1(a) and dual frequency feeds covering parts of 20/13 cm, 6/3 cm, 13/3 cm (L/S, C/X, S/X) bands will be provided.

C.2.3 The above feeds will be linearly polarised at 45 and 135 degrees.

C.2.4 For some parts of the receiver bands circularly polarised feeds will be available.

C.2.5 For stand alone operation dual oppositely circularly polarised feeds will be provided at 6 cm (C) and 3 cm (X) bands. Beam subtraction will be performed in a correlation receiver.

C.3. **Feed Priorities**

C.3.1 First priority - design and construction of 20/13 cm (L/S) and 6/3 cm (C/X) feeds for 22 m antennas.

C.3.2 Second priority - feeds for Parkes and provision for dual beam operation.

* C.3.3 Third priority - 13/3 cm (S/X) feeds on the compact array antenna at the 6 km site, and on the Mopra Site antenna.

* C.3.4 Fourth priority - provision for dual beam operation above 3 cm (X) band on Mopra antenna.

* C.3.5 Fifth priority - low frequency feeds for all compact array antennas.

D. **RECEIVERS**

D.1 **Receivers for New Antennas**

D.1.1 (a) High Frequency Systems (greater than 1 GHz)

Optics: Cassegrain.

Frequency: Each dual frequency, dual polarisation receiver system will be housed in a common cryogenic package and operate from a single wide-band feed.

The following bands will be covered:

20 cm (L): 1.25 - 1.78 GHz Common cryogenic

13 cm (S):	2.2 - 2.5 GHz	package
6 cm (C):	4.4 - 6.1 GHz	Common cryogenic
3 cm (X):	8.0 - 9.2 GHz	package
3 cm (X):	8.0 - 10.7 GHz	Off axis
12 mm (K):	20.0 - 25.5 GHz	Common cryogenic
7 mm (Q):	42.0 - 50.0 GHz	package
3.5 mm (W):	84.0 - 98.5 GHz	Common cryogenic
2.6 mm (F):	105.0 - 116.0 GHz	package

NOTE: (a) These are design goals. Present technology would restrict us to approximately 15% bandwidth.

(b) These frequency bands are "clear" bandwidths, i.e. system performance should not deteriorate significantly up to the band edges, particularly where spectral lines are involved.

(c) Within the budget a minimum of 20/13 cm, 6/3 cm (L/S, C/X) systems will be provided.

D.1.1 (b) Low Frequency Systems (less than 1 GHz)

Optics: Cassegrain or Prime focus.

Frequencies: (i) 90 cm: 322-328.6 MHz (Prime focus)
(ii) 50 cm: 582-603 MHz (Cassegrain)

Receiver bandwidths greater than these should be provided initially. Suitable filters to be inserted later when interference becomes a problem.

D.1.2 Environment -

(i) LNA's above 1 GHz will be cooled together with as much of the polarisation, bandsplitting and feed waveguide as practicable.

(ii) Low frequency LNA's will operate at room temperature.

D.1.3 The four on axis receiver systems (8 frequency bands) in D.1.1 (a) will be operational at all times as far as practicable.

D.1.4 Space to be provided on turret for all 4 on axis feeds mentioned in C.1.2 and the associated dual channel receivers.

D.2 **Receivers for Parkes 64 Metre Radiotelescope**

D.2.1 (a) High Frequency Systems (greater than 1 GHz)

Optics: Prime focus.

Frequency: Multi-frequency systems will be provided.

The following bands will be covered:

20 cm (L): 1.25 - 1.78 GHz
13 cm (S): 2.2 - 2.7 GHz

6 cm (C): 4.4 - 6.1 GHz
3 cm (X): 8.0 - 9.2 GHz

NOTE: These are design goals. Present technology would restrict us to approximately 15% bandwidths.

Initially a single dewar containing dual receivers at each of 20, 13, 6 and 3 cm (L, S, C and X) bands will be constructed. This will be followed by a second dewar providing more optimum operation in 20 and 13 cm (L and S) bands.

D.2.1 (b) Low Frequency Systems (less than 1 GHz)

Optics: Prime focus.

Frequencies: (i) 90 cm: 322-328.6 MHz (Prime focus)
(ii) 50 cm: 582-603 MHz (Cassegrain)

Receiver bandwidths greater than these should be provided initially. Suitable filters to be inserted later when interference becomes a problem.

D.2.2 Environment -

(i) LNA's above 1 GHz will be cooled together with as much of the polarisation, bandsplitting and feed waveguide as practicable.

(ii) Low frequency LNA's will operate at room temperature.

D.3 **Receiver Priorities**

D.3.1 First priority - provision of 6/3 and 20/13 cm (C/X, L/S) receivers for the 22 m antennas.

D.3.2 Second priority - provision of 6/3 and 20/13 cm (C/X, L/S) receivers at Parkes (including stand-alone operation).

* D.3.3 Third priority - provision for stand-alone operation of the Mopra antenna.

E. **SYSTEM**

E.1. **Compact Array** (Max R.F. frequency 116 GHz)

E.1.1 IF digitised antenna.

E.1.2 Two pairs of IF channels available from each antenna: selected from within the operating frequency bands. Each pair of IF's contains signals of the same frequency but of orthogonal linear polarisations.

E.1.3 For each antenna only two independent LO's will be provided. Provision will however be made to offset the phase between members of each pair of IF's. Circular polarisation can then be generated for the tied array.

E.1.4 Fringe stopping at antennas.

E.1.5 Signal transmission via optical fibres.

E.1.6 Each IF data stream (512 Mbits/sec capacity) shall be composed of one of the following:

a) 1 bit sampled, 256 MHz bandwidth.

b) 2 bit sampled, 128 MHz bandwidth.

c) 4 bit sampled, 64 MHz bandwidth.

E.1.7 The 4 bit sampled 64 MHz bandwidth signals will be processed at the centre as follows:

(1) 4 bit to 2 bit digital conversion to provide 64 MHz bandwidth inputs to the continuum correlator and/or to the line correlator.

(2) 4 bit to analogue conversion to provide:-
(a) an analogue signal for filtering in factors of 2 from 32 MHz down to 0.5 MHz. The filtered signal will be redigitised (2 bit) for input to the line correlator.

(b) analogue signals corrected in gain and phase that can be combined to give tied array signals in 2 linear and 2 circular polarisations with a maximum bandwidth of 16 MHz.

E.1.8 "Tied" array capability for 1 to 6 antennas. Providing up to 4 IF channels either linearly or circularly polarised.

E.2. **Long Baseline Array** (Max RF frequency 116 GHz where possible)

E.2.1 IF digitised at antenna.

E.2.2 4 IF channels available from each antenna.

E.2.3 Provision of 2 independent, simultaneous LO's per antenna.

E.2.4 Fringe stopping at antennna.

E.2.5 Signal data collection using tape recording.

E.2.6 Maximum IF data rate (to suit VLBA tape recorders)
256 Mbits/sec, i.e. for 2 bit sampling, 4 channels 16 MHz wide.

E.2.7 Narrowband filtering of IF will be available in factors of 2 down to 0.5 MHz in CA style receivers or to 62.5 kHz in VLBA tape recorders.

E.2.8 Where possible both linear and circular polarisations will be made available for recording.

E.3. **LO Switching**

All LO frequencies must be capable of being switched at rates of up to 0.2 Hz.

E.4. **Priorities**

E.4.1 First priority - Compact Array operation.

E.4.2 Second priority - Long Baseline Array.

* E.4.3 Third priority - Stand-alone operation for the Mopra antenna.

F. **CORRELATORS**

F.1. **Culgoora**

F.1.1 Provision for simultaneous operation in the following four modes:

a) Compact Array Line OR Wideband Continuum.

15 Baselines, with up to 8 products per baseline, providing a minimum of 16 frequency channels per product for 1 bit correlation at 256 MHz bandwidth or for 2 bit correlation at 128 MHz bandwidth. Recirculation up to a factor of 64 if possible.

Minimum bandwidth 0.5 MHz. For fewer products per baseline, proportionally more channels per product.

b) Compact Array Narrowband Continuum.

Operating at 64 MHz bandwidth, providing up to 8 products for each of the 15 baselines: with at least 8 frequency channels per product.

c) LBA Line OR Continuum.

Uses the same modules and blocks as in (a) above but with more flexible input arrangements so that if desired more baselines can be obtained with less products per baseline.

For 4 antennas, a maximum of 6 baselines and 8 products per baseline are possible.

For 5 antennas, a maximum of 10 baselines and 4 products per baseline are possible.

For 6 antennas, a maximum of 15 baselines and 2 products per baseline are possible.

For 7 antennas, a maximum of 21 baselines and 2 products per baseline are possible.

F.1.2 Compatible with future addition of FFT pre-processors at each antenna - to obtain more frequency channels.

F.1.3 Includes delay tracking systems for both arrays.

F.1.4 Includes FFT processing, Doppler tracking, Van Vleck correction, Hanning and output selection.

F.1.5 Tape playback system and interface to correlator for LBA correlations.

F.1.6 Provides phase differences between antennas and between polarised IF's to allow "typing of the array".

F.1.7 Provides sample statistics for level control at the digitizers.

* F.2. **Parkes and Mopra**

F.2.1 Provision of auto-correlators. Eight modules (1 Block) for Line and two Modules for continuum. This is identical to one baseline of the CA correlator.

F.3.3 Third priority - Long Baseline Array correlator.

* F.3.4 Fourth priority - Provision of a stand-alone correlator for the Mopra antenna.

G. CONTROL MONITOR AND VIDEO DATA

G.1. Compact Array: via Fibre Optics.

G.2. Long Baseline Array: Control and monitor data including digitised video data for semi-realtime fringe check, via Telecom links. Normal digitised video data via tape recorders (US VLB Array compatible).

H. LOCAL OSCILLATOR DISTRIBUTION

H.1. Compact Array: via coaxial cable.

H.2. Long Baseline Array: via AUSSAT.

I. COMPUTING

I.1. ON-LINE Computing

I.1.1 The ON-LINE computing system for the CA will be located at Culgoora and consist of:

a) At the control centre:

(i) A μ VAX II correlator control computer and associated SKY-WARRIOR 15 M flop array processor.

(ii) A VAX 8200 synchronous computer.

(iii) A VAX 8200 asynchronous computer.

(iv) Shared disk, tape and optical disk units.

(v) Control console.

b) At each antenna element:

(i) An LSI 11/73 antenna control computer to perform co-ordinate conversion and control/monitor functions.

(ii) A microprocessor antenna position computer which

I.1.2 ON-LINE computing for the LBA yet to be defined.

ordinate conversion and control/monitor functions.

(ii) A microprocessor antenna position computer which performs servo control and other antenna functions.

I.1.2 ON-LINE computing for the LBA yet to be defined.

I.2. **OFF-LINE Computing** (CA and LBA)

I.2.1 Off-line processing will utilize the NRAO AIPS software system.

I.2.2 Wide field mapping and the processing of large spectral line data cubes will require considerable computer power. At the same time provision must be made for simultaneous interactive processing of a number of smaller tasks.

* No decision regarding off-line computer has been made at this stage.