Communication Links for the LBA

1.0 Introduction

The LBA consists of one or more of the six compact array antennas at Culgoora plus at least the Parkes 64 metre antenna and a new 22 metre on Siding Spring Mountain. In addition Tidbinbilla will be available for a small percentage of the time and it is hoped that other antennas can be added to give increased baseline.

The obvious communication need for the LBA is for the return of data to the central correlator at Culgoora. The specified minimum received bandwidth is 5 MHz x 2 channels. For one bit sampling this requires a minimum return bit rate of 20 MBit/sec per antenna. If more bandwidth can be achieved without undue cost this should obviously be considered.

There are also several other functions required of the link. Although of low bit rate, they can have a major impact on the link design.

Monitor signals to confirm the state of the antenna and to flag faults can be time multiplexed with the returning IF data.

Control signals for timing, tuning, pointing and fringe rotation must be sent from the central site to all antennas in a direction which is opposite to the foregoing signals.

To allow correlation of the returned data, all down conversions must be carried out using local oscillators with very low differential phase noise and drift rate. To ensure that the local oscillators at all antennas are coherent for up to an hour or more a reference signal is sent out to each site and from this signal all L.O's are generated.

Any method of transporting this signal over the distances involved will suffer drift rates at least an order of magnitude greater than that desired and a method of correcting for this is always used. A signal is sent to each antenna where it is suitably coded and returned to the central site. This allows the two way path to be measured and variations can be corrected for. Many different schemes for implementing this are known and all require two way propagation and rely on the out and return paths being reciprocal.

An alternative is to use very stable atomic oscillators at each site. Rubidium or cesium oscillators do not meet our requirements but Hydrogen masers can - but at very high cost.

2.0 Possible Systems

2.1 DATA. I.F. data can be transported from the remote antennas by microwave links, optical fibre or coaxial cables, satellite links or VLBI style tape recording.

Satellite links have very high rental rates for the bandwidth required (> $100/MHz per day per antenna) and this seems to rule out this option for data.

Microwave links are more economic than optical fibre or coaxial cables except for very high data rates (> 200 MBit/sec). Costs are roughly proportional to distance. A microwave link is therefore an option for the shorter distances and is worth considering for the unmanned Siding Spring site. For a microwave link through to Parkes, the cost approaches $1M. A microwave link already exists from Parkes to Tidbinbilla. None of these systems can be extended very far - interstate for example.

Wide bandwidth video or instrumentation tapes are clumsy, non-real time and manpower intensive. However they allow the addition of future telescopes at low incremental cost and they can be arranged to be compatible for international VLBI (and QUASAT). Cost appears reasonable (see AT/17.3.1/002) and does not depend on distance. However a considerable amount of development is likely.

The major contenders for data transmission are therefore microwave links or tape recorders.

2.2 L.O. Reference Signal

The reference signal from which the local oscillator is generated requires a real time two way link. This could be by microwave link, satellite link or optical fibre/coaxial cables.

Tests have shown that fibre optic cable systems have difficult non-reciprocal effects that may limit their use in the compact array to I.F. data return. These effects and cost rule out its use for the LBA. Coaxial cable is more expensive and no better.

A time multiplexed microwave link system can be designed to achieve stabilities of 2 picosec or better (i.e. 1 degree/GHz). This system is not inexpensive and data must share this system to be economic. It is also not easily expanded (to Tasmania or West Australia for example). Such expansion would required the development of a separate satellite system or purchase of masers at large incremental cost.

Satellite links are possible for the local oscillator reference, since only narrow bandwidths are needed. Both Canada and Netherlands have proved this system (but neither is operational) and a feasibility study has shown that a phase stability similar to that obtained with microwave links is achievable. A separate data path is needed however and operation depends on continued reliable satellite operation.

The options for L.O. signal distribution are therefore microwave links or satellite.

2.3 Other Signals

Control and monitor signals can be provided on any of these systems at little cost.

3.0 Conclusion

The most feasible options are microwave links for both reference and data or satellite for the reference and tapes for the data. Although exact costs are still ill defined both systems appear to be below the budgeted figure and have similar total cost.

Before final decisions can be made the scientific consequences should be considered.

For example, are fixed links from Parkes to Culgoora desirable over tape recording?

Should a fixed link from Siding Springs to Culgoora be considered separately since this site is essentially unmanned and will have a higher usage rate?

Will the use of tape recorders and non-real time correlation have any scientific impact?

What percentage of the time will Siding Spring and Parkes be used as part of the LBA?

Is say 10% loss of correlation acceptable at 22 GHz when the atmosphere is stable? This may not be a steady 10% loss but could vary continually from 0 to 10%.

Should 22 GHz be considered the upper frequency limit for the LBA? Will the Siding Spring-Culgoora baseline be used to 115 GHz?

Is 2 x 5 MHz a workable bandwidth.

Present plans call for any link tenders to be called during 1985 with the detailed design and construction of the LBA system following after that of the compact array.

Several AT technical reports are being prepared to detail the studies undertaken into the performance of microwave and satellite systems and into the cost of the various options. Draft copies or additional information can be obtained from the Author.

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