VLB ARRAY MEMO No. 225

Canadian Long Baseline Array

Réseau Interférométrique Canadien

Current Activity

1983 April 16

The REPORT to NSERC and NRC was submitted late in 1982 and considered by both councils early in 1983. Although individual council members were enthusiastic, the Council of NRC postponed its decision. Immediately after the Council's meeting the report was widely distributed to industrial firms, universities, provincial research councils, the press and other interested individuals and organizations. The report has already drawn many enthusiastic comments and generated widespread support for the project.

The WINNIPEG INITIATIVE

The University of Manitoba and the Winnipeg Business Development Corporation are sponsoring a meeting on May 16 to explore and publicize the array's scientific and industrial benefits to Canada. About sixty people have been invited. One third of those invited are senior officers of industrial firms, one third are university presidents or vice-presidents and the remainder are scientists, some of whom are directly involved with the array design. The meeting will explore methods of implementing the array and, hopefully, will produce a document recommending a course of action. Although the sponsors of the meeting, no doubt, favour Winnipeg as the headquarters of the array, the principal objective of the meeting is to assess the array, not to promote the City.

The LETHBRIDGE INITIATIVE

Both the University and the City are making a strong case for the array to be built with headquarters in Lethbridge. The University has offered to donate serviced land on the campus. The City has offered to finance construction of the headquarters building so that it could be started without delay. (It would later be leased to the array organization.)

The University has recently acquired both a new president and a new academic vice-president. The university is maturing and is now developing an ambitious plan to upgrade the physics department and to provide both a small teaching observatory and astronomical laboratories. They intend to hire several new staff and to introduce a graduate program in astronomy in cooperation with other Alberta universities.

The CALGARY INITIATIVE The Calgary Research and Development Authority has prepared a brief for the Executive Committee of the Calgary Chamber of Commerce. The Chamber is planning to lobby the Provincial Government and expects to meet soon with both the Priorities Committee and the Science and Research Committee of the Provincial Cabinet.

INDUSTRIAL RESPONSE

The report and follow-up letters have been sent to many companies who may want to participate in production and operation of the array. We have had numerous constructive and encouraging replies. One computer manufacturer has offered to donate a large array processor to the organization as soon as we are able to house it and begin software development. Several companies have already begun to lobby provincial and federal governments and some are preparing unsolicited briefs for implementation of the array.

RESEARCH and DEVELOPMENT

As a result of an NSERC collaborative grant, FET Amplifier research at the University of Alberta is well under way. Several successful amplifiers have been built and new methods of fabrication and testing are being investigated. At the University of Toronto the NSERC grant has been used to develop a system which records a 24 MHz bandwidth on two video cassette recorders. The Americans are adopting the Toronto design as a basis for further study in their own array design.

Single-sideband mixers for use with these recorders have been built at Penticton and a new multi-station correlator, designed around the new recording system, is being developed in the Earth Physics Branch of the Dept. of Energy, Mines and Resources. Software for the control of receivers, recorders and correlators is being developed in Penticton, Ottawa and York University.

An ARRAY in the UNITED STATES

When the Canadian Astronomical Society first proposed an array there was no corresponding plan for one in the United States. Since then, and particularly since our own design study began, there has been a flurry of activity in the States. Their array has suddenly risen to top priority and it is almost certain that several million dollars will be available for a design study by the end of this year.

In the light of these developments two questions have arisen: (1) If the Americans build an array should we build one in Canada also? (2) Should we join forces to produce a North American array? Such questions prompted NRC to ask that a delegation go to the States to find out whether a joint array might be possible. A meeting has finally been arranged for April 21 at which Canada will be represented by Locke, Seaquist, Andrew, Routledge and Galt. Preliminary conversations with our American colleagues, however, suggest that Canadian participation is not viewed with much enthusiasm. Their own planning is now well advanced and inclusion of a significant Canadian contribution at this stage would seriously delay their project.

If we were to become a partner in a North American array the benefits to Canada would be minimal compared to those for a Canadian array. In particular most of the high-technology development and manufacturing would occur in the U.S. It would be unrealistic to expect that the headquarters would be in Canada.

ARE TWO (or more) ARRAYS USEFUL? ... NECESSARY?

Yes. There are thousands of sources to be studied, each requiring at least twelve hours observations. More than half of the galaxies and quasars which have already been studied are found to be variable and thus will require repeated observations. We expect the arrays to produce results with far-reaching consequences for cosmology and physics. Critical observations in this category should, for the integrity of science, be repeated with different instruments. (All arrays produce spurious responses; their understanding and elimination is one of the challenges of the game.)

DIFFERENCES between CANADIAN and AMERICAN ARRAY PLANS

In many respects the arrays would be "competitive" ... a healthy situation. There are, however, several important aspects in which the arrays would complement each other: (1) The Canadian array will be designed and used for geophysics as well as for astronomy. The American array is intended only for astronomy. We have a unique opportunity (or obligation) to use the geologically stable Canadian Shield as a base from which to observe changes in the earth's rotation with unprecedented accuracy. (2) At most frequencies, the Canadian array with its larger antennas will be more sensitive and able to study fainter sources. The Americans have chosen instead to go to higher frequencies where technical difficulties become more severe. (3) Over most of the northern sky the linear array proposed for Canada provides a more efficient use of the antennas than the array spread out in both latitude and longitude as proposed for the American configuration. A linear array produces a larger dynamic range and a larger field of fidelity for a given number of antennas. (4) Our array will be designed and produced by Canadian industries who will thereby acquire skills and technology which will be of great value in commercial fields. Most of the American array, on the other hand, will be designed "in-house" by the various collaborating universities.

We must realize that our American colleagues are expecting only design study money this year. They have no assurance that their array will actually be built. Remember that the American mm-wave telescope project received design funding for two consecutive years and was then abandoned. We cannot allow our own planning to be influenced by the ups and downs of similar projects south of the border.

WHAT NEXT?

NRC is awaiting the outcome of the meeting between Canadian and American radio astronomers before acting. Although NRC's Council may be enthusiastic about the all-Canadian array it still needs support at higher levels of government.

CAS CONTINUED SUPPORT

The newly constituted radio astronomy subcommittee of the Canadian Astronomical Society met in Penticton on April 14 and unanimously reaffirmed the Canadian Long Baseline Array as its top priority. It recommended several initiatives to the CAS Council for speeding up planning and obtaining funding. It expressed concern over what appeared to be slow progress in Ottawa since the report was completed and stressed a sense of urgency with regard to the project.

John Galt, Associate Chairman
CLBA Planning Committee
Penticton, B.C.

INDUSTRIAL "SPIN-OFF" and OTHER BENEFITS of the CANADIAN LONG-BASELINE ARRAY

It should be understood that the array's principal purpose is to increase our knowledge of the universe. The array is therefore similar to instruments found in laboratories where scientists study atoms, molecules and the forces which control them. In this context astronomy may be considered a branch of physics in which matter and energy are examined under extreme conditions unattainable on earth.

Nevertheless the production and use of a specialized instrument such as the Canadian Long-Baseline Array will require research and development which will result in new manufacturing capabilities for the industries involved. Much of the hardware and software needed for the array will be very specialized but its design and production will allow Canadian companies to gain experience in new areas of high technology and thus be more competitive in developing related commercial products. It is intended that all design and manufacture be done by Canadian industry with university or NRC scientists acting as consultants when appropriate.

Some of the areas in which the array will contribute new technology are discussed below.

Low-Noise Receivers

Because astronomical sources are so weak, radio astronomy has always pioneered the development of low-noise microwave receivers. Similar receivers were later adopted by the communications industry. In the design of a commercial communication channel a trade-off can usually be made between antenna diameter and receiver sensitivity. Thus a low-noise receiver will allow use of a smaller antenna with considerable reduction in cost, real estate and weather problems.

With the help of the radio astronomy observatory at Penticton, a research group has recently been established at the University of Alberta (Dept. of Electrical Engineering) to study, design and perfect amplifiers suitable for radio astronomy and communications. The group is developing amplifiers to operate at only a few degrees above absolute zero. Such amplifiers - which offer the ultimate in sensitivity - are not yet available commercially.

Imaging Techniques

Petroleum geology, medical tomography, x-ray crystallography and radio astronomy all rely on the formation of images of objects which can only be observed indirectly. Computer imaging techniques developed for one discipline are often applicable in other areas. Radio astronomers have introduced techniques for phaseless image construction which have later been adopted by seismologists. Already several international conferences have been held and books have been published to compare the methods used by these otherwise unrelated disciplines.

Software Development

Apart from specialized imaging techniques, new software will always be required for telescope control, data handling and scientific interpretation. Some of this could be written by Canadian software companies in consultation with the array staff.

Tape-Recording Technology

Wide-band tape recorders were first developed for the television industry and subsequently used by radio astronomers as integral parts of long-baseline interferometers. Not satisfied with the performance of commercial video-cassette recorders, a group at the University of Toronto has developed a method of recording digital data on television cassette recorders. Although primarily designed for radio astronomy, the techniques will also be useful for Landsat image storage and other forms of data archiving. Several Canadian companies have already expressed an interest in extending this technology.

Fibre-Optics Technology

Although the array is designed around the use of tape-recorders it would be possible (though presently very costly) to join the antennas by a network of fibre-optics and thereby obtain almost "real-time" images. We have considered, as a first experiment along these lines, linking the closest pair of antennas in the Prairies with fibre-optics.

Precise Time Comparison

As mentioned in the report, virtually "perfect" time and frequency synchronization between antenna sites can be achieved via satellite. A prototype system has operated for two years between the Penticton and Algonquin observatories but the cost of commercial satellite channels, as presently allocated, would be prohibitive. As these techniques use very narrow bandwidth and are compatible with television and other services it will be relatively easy to develop a reliable and inexpensive method of time synchronization using commercial satellites. This technique, developed for astronomical and geophysical experiments, could have a wider application wherever precise time transfer is required (eg. high speed data transfer).

Precise Geodetic Surveying

Long-baseline interferometry has proved to be the most suitable technique for maintaining the fundamental geodetic reference frame. Portable receiving terminals used in conjunction with the array would extend this capability to all parts of Canada. Receiving terminals could be produced by a Canadian manufacturer.

Electronics Manufacturing

Large quantities of electronic hardware will have to be designed and built for the array. Much of this could be produced by small-to-medium sized companies located near the array headquarters so that frequent consultation and testing would be facilitated. There will be a continuous demand for similar manufacturing services throughout the lifetime of the array as new techniques and updated apparatus are introduced to keep the array at the forefront of technology.

Machine-Shop Fabrication

There will be a continuing need for the production of specialized apparatus to support development of new receivers, new feed horns, modifications to the antennas, etc. Many pieces of microwave hardware require sophisticated fabrication methods. If local machine-shops have suitable tools this apparatus could be produced in the same city as the array headquarters.

Antenna Structures

Although the world's largest antennas are used almost exclusively for radio astronomy, many smaller antennas are employed commercially for satellite communications. Both radio astronomers and communications engineers are moving to higher frequencies where increased accuracy of the antenna surface and of the control system are required. One Canadian antenna manufacturer is developing reflector panels of high precision under a contract with NRC. That company has already sold several radio telescopes in Europe.

Cultural and Educational Factors

Although less tangible than some of the previous items, the community which hosts the headquarters would benefit from the influx of a large number of scientists and engineers with a diversity of specialized skills. It may be noted that Okanagan College has frequently called upon the staff of the radio observatory in Penticton to give lectures and courses while radio astronomers from the Herzberg Institute of Astrophysics in Ottawa have taught courses at Carleton University.

A project of this sort will help retain scientific and technical manpower which might otherwise go elsewhere. The retention of skilled people is necessary to maintain the scientific and industrial infrastructure of the country.

Tourist Attraction

Astronomical observatories are centres of interest for tourists; for example, the observatory at Penticton is visited by several thousand members of the general public each year despite its relative isolation. Although most antenna sites for the array would be in remote locations, one or two of the more accessible ones could be constructed with public viewing in mind. The headquarters will certainly be of interest to tourists and, with some care taken to make the control room and other areas of activity available for public viewing, it could well be a major tourist attraction for the area in which it is located.

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