The Winston Churchill Memorial Trust of Australia

Final Report by

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2003 Churchill Fellow

Project:

To study the technical infrastructure, management models
And educational programs at sites which operate
Radio and optical astronomy facilities

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Introduction

I was awarded a Churchill Fellowship to examine the technical infrastructure, management models and educational programs at sites which operate radio and optical astronomy facilities throughout the USA, Italy and the UK.

The purpose of this study was manifold. Its main purpose was to examine what is being done overseas in the area of space science education at the school level, specifically in the areas of practical radio astronomy and space communications; to examine how this is being done (from technical, management and educative perspectives), and to use this information to assist in the development of an appropriate model for the development of an Australian based radio astronomy and space communications educational facility accessible to all Australian school students.

Importantly, the opportunity to travel also enabled the initiation of personal links with staff from a variety of institutions. This has already resulted in a cooperative sharing of ideas and the development of initiatives which, if duly nurtured, will have marvellous potential to benefit Australian students, and indeed international students as well.

Australia has along list and a proud history of astronomical and space science achievements. However, our educational landscape presently does not offer students any sort of hands on exposure to the science at the high school and primary school level. Frequently, such radio astronomy and active participation in space science is perceived as technically exotic and generally beyond the capabilities of the regular classroom teacher and student, and almost certainly beyond the financial capabilities of a single comprehensive school.

I would like to see established a facility accessible to Australian students from primary level through secondary and right up to undergraduate university students, (either personally or via the internet), which will give them the opportunity to actively participate in cutting edge space science, motivate them toward science based tertiary study and possibly pursue a career in science. By its nature space science is very exciting and has traditionally been more than a passing interest for school students and offers exceptional opportunities for motivating students.

Although still technically challenging, active participation in radio astronomy and space communications at the school student level is now more feasible than ever and would serve as a wonderful engine to develop and drive the passion in youngsters to get to know and discover their world, to pursue hands-on science with vigour and to see value in pursuing science at tertiary level, and later, as adults, to contribute to the development of a safe, sustainable world as energetic and forward thinking scientists.

Executive Summary

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Project: To study the technical infrastructure, management models and educational programs at sites which operate radio and optical astronomy facilities for school students.

Detail: In 2002 I was awarded the inaugural University of Sydney Science Teacher Fellowship for a project of my own design entitled: A Radio Observatory & Space Communications Facility for school students.

The motivation for the project came from the realisation that no such facility exists in the Australian educational landscape; that Australia has a proud history of contribution to radio astronomy and space science (and that this history more often than not goes unrecognised), and that available technology and the support of the university of Sydney and the catholic education office, (my employer) made such a dream a real possibility.

This fellowship was taken throughout 2003 and during that year I worked at the School of Physics at Sydney University on the design and construction of a variety of components which contributed to the development of a pilot facility enabling school students to have access to so-called exotic science which they would otherwise never have had the opportunity of experiencing. Planned activities are many and diverse and include such things as Voice Contacts with the crew of the International Space Station, radio meteor counting, two-way satellite communications, weather satellite reception and picture decoding, satellite telemetry reception, detection of neutral hydrogen emissions, timing radio reflections from the moon, and a plethora of other unique and technically challenging demonstrations.

With the award of the Churchill Fellowship toward the end of 2003, I was given the opportunity of studying sites in the northern hemisphere which offered similar activities for school students that I had proposed in my University Fellowship project. The experience of these visits was invaluable on many fronts. I was able to see, first hand, the operation of such facilities and a variety of experiments and demonstrations I had not before considered. I was also able to share, by a number of Lectures, what I was doing in Australia. This served as an inspiration for many and has been instrumental in securing technical support and collaborative support from technical people across the US, Italy and the UK. I was able to meet directly with managers, scientists and technicians to learn from their own experiences of such ventures, to share ideas and to explore the possibilities for further international collaborative efforts and sharing of data.

Throughout my travels I was continually impressed at the level of professionalism, dedication and shear inventiveness that educators, scientists and technicians have in the area of radio astronomy and space science education; particularly, in their willingness to offer technical advice, and in the passion and energy which they bring to their work. Such energy is infectious and is naturally picked up by their eager and equally passionate students.

Highlights of my Churchill Fellowship were many. Significant highlights include, time spent with Physicist Dr David Fields (Roane Community College/ Nasa's Marshall Space Flight Centre/ Oakridge National Laboratory). Dr Fields has established the Tamke-Allen observatory where a variety of radio and space science activities are undertaken. One of his students, only days before my arrival, was credited with the discovery of a new radio star (called a maser) under a work experience sojourn with a professional radio astronomer.

Time spent with Dr Charles Osborne and staff from the Pisgah astronomical Research institute (PARI) in North Carolina, was also most beneficial. The PARI site, a decommissioned satellite spy station, now equipped with a variety of radio telescopes and internet controlled optical telescopes, was purchased outright by a generous benefactor who continues to support staffing and running costs of over $100 000 (usd) per month. The site offers many activities which could be set up and made available locally to students in Australia. Furthermore, a cooperative approach between a similar institute in Australia would have benefits for students from both countries, enabling southern hemisphere students to obtain optical and radio views of the northern hemisphere sky and visa-versa for northern hemisphere students.

Conclusions:

Australia is in a prime geographic position for the establishment of a student centred Radio Observatory & Space Communications Centre. Such a centre would fulfil a long overdue gap in the school based education landscape. From the experience of similar sites overseas, the success of such a venture rests on several factors: a team approach at the technical, support and educational program development level; the availability of significant establishment capital; the good-will and generosity of community volunteers with technical or educative expertise in science; a source of on-going funding or sponsorship for maintenance, development and day to day salaries and running costs, and the recruitment of people with well developed technical skills in software development, and the design of control systems that can operate via the internet. Our own CSIRO/ATNF (Australia Telescope National Facility) staff has the expertise to fulfil all of the technical demands of such an enterprise. The most significant obstacle to establishing such a national educative facility is one of funding; start-up and on-going. This is the overseas experience as well, though less evident in the US where NASA directly supports a similar project in California (the GAVRT), and a larger population base seems to bring with it a wider group of generous benefactors.

Programme of Study

Following is the programme of study and activities undertaken during the course of my Churchill Fellowship. It was stimulating and fast-moving. In some places visited, where time permitted, I was able to include visits to additional organizations and institutions related to the project.

Place	Institution/ Organisation to be Visited & Purpose
Los Angeles -	Lewis Education Research Centre (Administrators of Goldstone Apple Valley Radio Telescope remote observatory – examine management model)
San Francisco	Lawrence Hall of Science – UCLA (Berkeley) (Hands-on-Universe Project/ activities & management)
	Stanford University (Gravity B Probe development project)
	Vandenberg Air Force Base (Witness launch of Gravity B Probe & participate in NASA educators' seminar)
	Goldstone Apple Valley Radio Telescope site visit (View operations & educational programs 2-3 days)
Denver CO*	Remote sensing laboratory NOAA (National Oceanic & Atmospheric Association) – study of techniques in receiving & displaying images from weather satellites
Knoxville TN	Pisgah Astronomical Research Institute - Rosmore NC (Operation of remote radio observatory, internet control techniques, management & teacher training programs) Roane Community College/Tamke-Allen Observatory (Two presentations to local educators and students on
Orlando FL	Kennedy Space Centre – Cape Canaveral (Implementation of education programs & hands-on activities for school students)
Washington DC	Smithsonian Institution – Museum of Air & Space (Planetarium & space related exhibits)
New York NY	Thomas Edison Memorial & Menlo Park Museum – Edison NJ New York Hall of Science NY (Technical evaluation: remote control via internet) Princeton University NJ – Radio Astronomy Department (Meeting & interview with Nobel laureate Dr Joe Taylor)
London*	British Museum Royal Institution British Science Museum University of Surrey – Surrey Space Centre (Inspection satellite construction & tracking technology) Greenwich Observatory
Manchester	University of Manchester – Dept of Physics & Astronomy Jodrell Bank Radio Telescope (Education outreach programs & radio telescope observing)
Paris*	University of Gent – Belgium (Examination of meteor counting system) l'Observatoire de Paris – Paris, Meudon & Nançay (Photograph historical observing equipment) Nançay Radio Observatory (Inspect radio & optical solar observatory)
Rome	Vatican Observatory (Participate in optical observation program & study early historical links between Christianity and astronomy)
Bologna	Guglielmo Marconi Home & Museum Participation in Radio workshop with Italian amateur radio operators
Rome/Florence	Vatican Observatory (Participate in optical observation program – cont.) Museum of the History of Science (Galileo Museum) (Museum contents & management, attend conference on science teaching at the museum)

Fellowship Description & Lessons Learned

The aims of my fellowship were to examine the technical infrastructure, the management models and the educational programs in place at sites which operate radio and optical astronomical facilities.

Many sites were visited around the world that offer student visitors various levels of access to radio and optical astronomy activities, as well as other space related ventures. None of the student/educator-based enterprises are entirely self-sustaining in a financial sense. Many sites make use of volunteer programs to reduce running costs.

Two US sites were studied in some depth, the Goldstone Apple Valley Radiotelescope in California, operated by the Lewis Centre for Educational Research and the Pisgah Astronomical Research Institute (PARI) in North Carolina. The former is predominantly funded by NASA and the Lewis Centre for Educational Research, and uses a decommissioned deep space tracking antenna previously operated by NASA. controllers point the antenna on behalf of school students.

There is a classroom environment at the base of the antenna and critical inservice time is made available for teacher instruction, jointly funded by school systems and the Lewis Centre. The system is capable of being controlled via the internet from remote classrooms. The site is located within a military base, which prevents a casual visit from students or teachers.

The PARI centre has been funded solely by a single benefactor. An outright purchase was made of the land and antennae once used for as a satellite 'spy' station in North Carolina (in the order of $20 million USD). Running costs for the centre average out at about $100 000 USD per month including staffing. These costs are currently met largely by the benefactor, and are supplemented in a small way by the reception of small grants and the use of 'unused' facilities on the site for (meagre) income generation. There is a full-time educator employed and the target audience includes students from kindergarten right through to post-graduate students.

Whilst employing a full-time staff of around 10, the centre survives on an extraordinarily large band of volunteers coordinated by the chief technician, Dr Charles Osborne. These people, mostly retired, give of their time and expertise in any way possible. Frequent working bees can see up to 100 volunteers onsite at any one time. The success of the PARI venture, claim the management, is a result of the dedicated band of volunteers. Without them the site would not work.

PARI is set up to perform a host of other practical field activities both locally and controllable via the internet. For example, optical telescopes with CCD cameras, as well as a small radio telescope can be controlled via the web. There are seismometers, cosmic ray detectors, radio meteor counting systems and some 10 other projects operating from the site. Many have been set up originally as the basis of undergraduate university projects.

A significant amount of computer programming is necessarily undertaken by employed staff and volunteers to make the various projects work as they should. Onsite maintenance time and costs are high. The site has its own accommodation and dining hall capable of serving the needs of large groups which may stay for a few days to an extended period. There are several large classrooms and meeting rooms available for lessons, and students are encouraged to learn about the systems on-site and to directly control equipment themselves.

Educational programs at the centre are diverse, continually evolving and designed to match the age of the students. Responsibility for the development of educational programs and activities onsite are left to a single staff member recruited as a young professor from a state university. Part of his job description is the time consuming task of grant preparation and submission. Despite the availability of grant monies in the US, grants won by PARI are really not significant in offsetting the recurring costs of running the facility.

One of the interesting benefits about the United States educational landscape is that, with such a large population base and taxation base, there is an ever-increasing number of both government and non-government sources for grants and funding. This is much smaller in Australia, naturally, and because our population base is smaller funding opportunities will never be on par with the US. This forces Australians to be a little more creative in doing more with less.

The PARI model is quite the ideal for an educational centre. Though the ideal could hardly be reached without the initial and continued support of a generous benefactor. Such a site is long overdue in Australia. However, the viability of any such venture as a self-sustaining enterprise is indeed slim. And the prospect of finding a visionary benefactor is probably slight.

The largest radiotelescope in the UK, Jodrell Bank, which is managed by the University of Manchester, has, sadly, a rather neglected approach to school education. The UK has had quite a reputation for active space science education the school level. However such ventures are limited to those schools only which have a teacher with the necessary drive, competence and interest, and a school administration that is prepared to offer funding for such endeavours.

The situation is somewhat similar to Australia, in that there is local interest in student involvement in space science but either the funding or the competence is lacking. The solution is obvious: fund a centre that can be used as a focus for many schools – even a national centre. The possibilities of using public museum such as Sydney's Powerhouse or Canberra's National Science Centre (Questacon) come to mind.

Not far from Stonehenge, the oldest recognised astronomical observatory in the world, is Surrey Satellite Technology Ltd, set up by Professor Sir Martin Sweeting from the University of Surrey. The company is one of the fastest growing businesses in the UK. It is 90%owned by the university and 10 owned by its employees. The company designs and builds satellites for a variety of applications – mostly imaging- and a variety of customers, many from third world nations, using common off-the-shelf technology. They arrange launch vehicles, which invariably use decommissioned Russian intercontinental ballistic missiles, replacing the warhead with the satellite.

The costs of design, launch and commissioning can be as little as one-tenth the cost of a similar operation by NASA. Furthermore, with the University of Surrey as the principle shareholder in the company, application to use the Surrey satellites for educational applications is streamlined.

I was able to look over the design and manufacturing centre as well as the control room through the courtesy of Ms Audrey Nice, Public Relations officer at the Surrey Space Centre, and the UK AMSAT (Amateur Radio Satellite) group. Immediately I saw the potential for student access to the data these satellites were relaying to earth. In particular I continue to explore the possibility of having student access to the DMC (Disaster Monitoring Constellation) satellites recently launched by the company.

These satellites are capable of photographing the earth many times during an orbit, and when interrogated by a ground station, can transmit images that have previously been stored from another part of the globe. They are principally used for disaster monitoring such as flooding, bushfires and the like. The ground resolution is excellent at some 30 metres per pixel, though according to optical scientist, Dr Hugh Newell, "There is always room for improvement".

Student/teacher access directly to such satellites could have fantastic educational consequences from physics to geography. Students would need to learn basics in the art of satellite position finding and tracking. They would learn how to download an image direct from space, and then use software to decode the image and interpret it. Skills developed would enhance subjects studied from physics to geography and beyond. Such activities not only impress upon students valuable lessons in the physical sciences, but imbue in them also a sense of responsibility for the earth and an awareness of the fragility and inter-connectedness of earth systems.

The radio observatory and receivers at Nançay was inspected. As well as the large radio telescope, it features a solar interferometer and a Jovian (21 MHz) receiver for studying radio emissions from Jupiter. The data received from the interferometer and the Jovian receiver are posted on internet as they are received and offer an excellent source of correlation for students receiving such signals locally. The observatory is operated by L'Observatoire de Paris, which has sites also at Meudon and Paris. I was able to visit, inspect current equipment at these sites and photograph some very early astronomical apparatus kept there. The photographs in themselves provide an excellent educational resource.

In Italy I had the opportunity of participating in an international conference for secondary school teachers at the Museum of the History of Science in Florence, (also known as the Galileo Museum). This proved most interesting. Valuable contacts were made internationally, and there was much interest in the proposals of The Schools in Space Project.

Additionally the museum holds the original telescopes, lenses and other apparatus used by Galileo (including his right index finger). It was an extraordinary educational experience. The museum has put together a very clever CD of their holdings, with some short video clips illustrating how early equipment was used and indeed how early astronomy was done. This was duly purchased.

At the Galileo Museum my visit coincided with a conference on introducing the history of astronomical science into secondary school science teaching. I attended the conference with the theme being the integration of science history into the teaching of modern astronomy. The museum was the ideal venue for such a conference, with actual historical instruments from Galileo, Kepler, Copernicus and some from ancient Egyptian and Babylonian astronomers on display. The conference was complemented by some very capable and knowledgeable presenters.

At Castel Gondolfo, in Italy, home to the Vatican Observatory, I had the opportunity of participating in an optical viewing program. Whilst one of the telescope domes was undergoing an unscheduled repair during my visit, the other dome and telescope were operating satisfactorily. However the weather was uncooperative and unsatisfactory for extended optical viewing. Nevertheless I made the most of the skies when they were clear and had an excellent tutorial on northern hemisphere astronomy. In passing, I had the opportunity of seeing original copies of some very old texts by Galileo, Kepler and Copernicus as well as historical equipment held at the Vatican Observatory.

Near Bologna I was able to visit Guglielmo Marconi's home where radio was first invented and demonstrated, and where, indirectly, the science of radio astronomy had its original beginnings. In addition to inspecting all the equipment preserved there (and being able to personally handle it!), I participated in a one-day conference with a group of 15 Italian scientists.

Demonstrations using Marconi's original equipment were given, and I had the opportunity of presenting to the assembled group the 'anticoincidence detector' which I designed last year to improve the accuracy of radio meteor detection. I was made feel most welcome by this group, and after many hours together during the day and into the evening it was difficult to leave.

Conclusions

The opportunity to participate in a Churchill fellowship has been an extraordinary, once-in-a-lifetime educational experience, both personally and professionally. The results of the study tour will undoubtedly have a positive effect on my working life for the rest of my career.

The findings related to the nature and status of overseas endeavours to expose school students to radio and optical astronomy and space communications technologies will be invaluable in constructing a strategic management proposal for the development of an Australian based radio observatory and space communications facility for school students. Such projects are only in the in their infancy even internationally, and only one site, the North American PARI facility, actually had a wide ranging curriculum which included radio astronomy, optical astronomy and space communications (and a myriad of other activities) all from one site.

The vision of PARI is an example for the science-education enterprises around the world to emulate. Not only does it have an extraordinary range of activities, and a flexible, diverse curriculum, but it has a management strategy that involves all employees and a philosophy that encourages and welcomes volunteer groups and individuals ensuring a kind of community ownership and a community responsibility for its success.

If there is a problem with bringing the PARI model to Australia, it is in the enormous financial cost of sustaining the venture. The very nature of the enterprise, with high establishment and maintenance costs, and the need to keep visiting student costs low, means that profitability of a stand-alone enterprise is out of the question.

In Australia, it is possible that an economic compromise could be managed by positioning such a centre under the auspices of a science museum. However, for acceptable results in radio astronomy, a radio quiet area, usually well outside a city, is favoured. There are few technological barriers to establishing an observatory in a radio quiet area and having control of the observatory placed within the galleries of a public museum or purpose built facility.

The results of my Churchill travel experience, (and the application and screening process for prospective Churchill fellows) have already been presented to my immediate colleagues and management and staff from the Catholic Education Office, Sydney and the School of Physics at the University of Sydney. Similarly, opportunities to speak and present findings at wider seminars outside the Sydney area have arisen. I have submitted a press release to the local (free) weekly community newspaper which will serve to promote, not only my own project, but the whole Churchill Fellowship concept. This newspaper has a weekly circulation of about 45 000 readers.

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I would like also to acknowledge the generous sponsorship of the Churchill Memorial Trust for giving me the opportunity to travel far and wide evaluating similar projects overseas and for the opportunity of sharing and gathering ideas from institutions and individuals around the world.

Most every door I knocked was opened, and I am most grateful for the way in which people were eager to share freely of their own educational endeavours, both their successes and failures in making space science accessible and the ways in which the ideas and spirit of the Schools in Space project has been collectively supported. In particular I would like to express my gratitude to the following people who were of great assistance:

Mr Edmond Burke	NASA Liason, Vandenberg Airforce Base, California
Dr David Fields	Physicist, Oak Ridge National Lab/Roane Community College/NASA
Dr Gerald Calia	Astronomer, Tamke-Allen Observatory
Dr Charles Osborne	Technical Operations Director, Pisgah Astronomical Research Institute & President, Society of Amateur Radio Astronomers
Mr J. Donald Kline	President, Pisgah Astronomical Research Institute
Dr Michael Castelez	Director of Astronomical Studies & Education, Pisgah Astronomical Research Institute
Dr Joseph Phillips	Technical & Software Development, Pisgah Astronomical Research Institute
Ms Audrey Nice	Public Relations, Surrey Satellite Technology Ltd, University of Surrey
Dr Hugh Newell	Research Scientist, Optics, Surrey Satellite Technology Ltd University of Surrey
Dr Irena McCabe	The Royal Institution of Great Britain, London
Dr Bertrand Flouret	Nançay Radio Observatory
Mr Stefano Casati	Museum of the History of Science, Florence
Dr Guy Consolmagno, S.J.	Vatican Observatory, Castel Gondolfo
Dianna Beretti	Marconi House Research Centre, Bologna
Jim Heck (G3WGM)	AMSAT UK

Recommendations

Excellent arguments can be made for the establishment of an Australian-based permanent radio observatory and space communications facility for school children where active demonstrations, student involvement and experimental proposals can be conducted.

School children have an almost natural and inbuilt fascination for space science. A dedicated centre for radio astronomy and space communications could harness such fascination and use it as a powerful motivational and educational tool.

All Australian school students should have some accessibility to active demonstrations of radio astronomy and satellite/space communications systems. Having inspected a variety of optical and radio observatories designed for education internationally I can make the following recommendations for Australia's educational landscape:

1. A well-rounded facility should have the capabilities for radio and optical astronomy, together with space communications experiments, on a single physical site, and a single virtual site for internet control

2. The facility should be equipped with a variety of static and dynamic displays, that engage students, with clear and accurate descriptions of principles used at the centre.

3. Ideally such a facility could be established, as in overseas models, in a decommissioned communications complex or similar. The advantage of such a site is that establishment costs are reduced with some infrastructure already being in place.

4. Such a facility could best be financially sustained by affiliation with sponsors and a public museum. This would enhance its accessibility and it could be readily appreciated by student audiences at such a science museum type location, such as the National Science Centre (Questacon) in Canberra for example. A microwave link could be established between a remote dark-sky site where the optical and radio astronomy components are placed.

5. High capacity internet linking could see remote (school or university) users accessing the activities and controlling radio and optical telescopes from around Australia or around the world. Internet accessibility would ensure that schools in remote areas could have access to technologies on equal footing with schools more local to the facility and able to visit in person.

6. International partnerships and technology sharing could see Northern Hemisphere students accessing optical and radio views of the southern hemisphere skies over the internet, and similarly, southern hemisphere students could use the internet availability at site such as PARI to access radio and optical views of skies in the northern hemisphere.

7. Such an enterprise would require maintenance and development staff with a variety of skills, but particularly in the areas of software and machine control interfacing.

8. Community participation in such a venture should be encouraged by a coordinated volunteer program. Volunteers could be drawn from retirees and community groups such as astronomy clubs and school or university science groups for example.