History of Rocketry and Astronautics

Kerrie Dougherty and Donald C. Elder

Editors

AAS History Series, Volume 27

IAA History Symposia, Volume 18

American Astronautical Society

History of Rocketry and Astronautics

AAS History Series, Volume 27
International Academy of Astronautics Symposia

Front Cover Illustration:

Astronaut Alan Shepard (center right) and NASA Marshall Space Flight Center Deputy Director Eberhard Rees (center left) visit the Honeysuckle Creek MSFN Tracking Station near Canberra, Australia, in September 1968, prior to the Apollo 7 mission. The Australian personnel are Deputy Station Director Mike Dinn (right) and Australian Department of Supply representative Ian Homewood (left). (photo credit: H. Lindsay).

History of Rocketry and Astronautics

Proceedings of the Thirty-Second History Symposium of the International Academy of Astronautics

Melbourne, Australia, 1998

Kerrie Dougherty and Donald C. Elder
Volume Editors

Donald C. Elder, Series Editor

AAS History Series, Volume 27

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 18

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2007

ISSN 0730-3564

ISBN 978-0-87703-535-0 (Hard Cover)
ISBN 978-0-87703-536-7 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 9

Forty Years of NASA–Australian Cooperation*

Miriam Baltuck,† Dennis Cooper,‡
Peter Holland ** **and Graham Harris‡**

Introduction

NASA's fortieth anniversary (October 1, 1998), during the week of the 49th International Astronautical Congress (IAC) in Melbourne, offered an opportunity to review the history and diversity of cooperation with the 49th IAC's host country, Australia.

In this paper we look briefly at how NASA-Australia cooperation in tracking, satellite laser ranging, and environmental studies has evolved over the past several decades; at a number of more recent developments in additional technical fields; and then look ahead to the continuing evolution of the partnership. We make no pretense of providing an exhaustive catalog of the range of cooperative activities, but rather attempt to highlight some of the more prominent examples of long term cooperation.

---

* Presented at the Thirty-Second History Symposium of the International Academy of Astronautics, Melbourne, Australia, 1998.

† National Aeronautics and Space Administration.

‡ Commonwealth Scientific and Industrial Research Organization.

** Australian Surveying and Land Information Group.

‡ Commonwealth Scientific and Industrial Research Organization.

Space Tracking and Communications

The flagship of cooperation between Australia and NASA is the arrangement between the United States of America and Australia for space tracking and communications support. This relationship dates back to the 18 months of extraordinary international cooperation and accomplishment that constituted the International Geophysical Year (July 1957 – December 1958). The initial arrangement between Australia and the U.S.A. was established in June 1957 [1] to provide for radio tracking at Woomera, South Australia. Cooperation was subsequently broadened to include additional tracking facilities ceded to, or created by, the newly formed National Aeronautics and Space Agency in a government-to-government bilateral treaty put into effect in February 1960[2] which signaled the beginning of deep space tracking.

Figure 1: Island Lagoon tracking station near Woomera, the first Deep Space station established outside the U.S.

There have been some 13 major NASA space tracking and communication facilities in Australia operating at various times over the years since then[3] and numerous smaller facilities; the largest number of NASA tracking and communication facilities in any single country outside of the U.S.A. Today most of these facilities have been consolidated at the Tidbinbilla tracking station in the Australian Capital Territory (ACT). Formally designated the Canberra Deep Space Communication Complex (CDSCC), the Station is the southern hemisphere member of the three stations which together comprise the Deep Space Network.

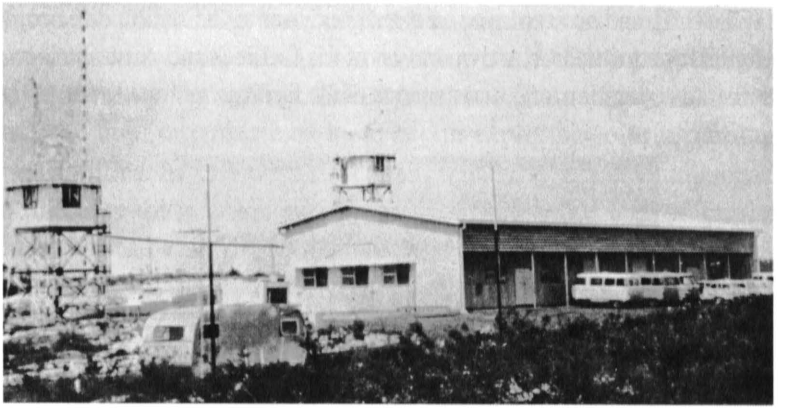

Figure 2: The NASA Mercury tracking station at Muchea, Western Australia, established in 1961.

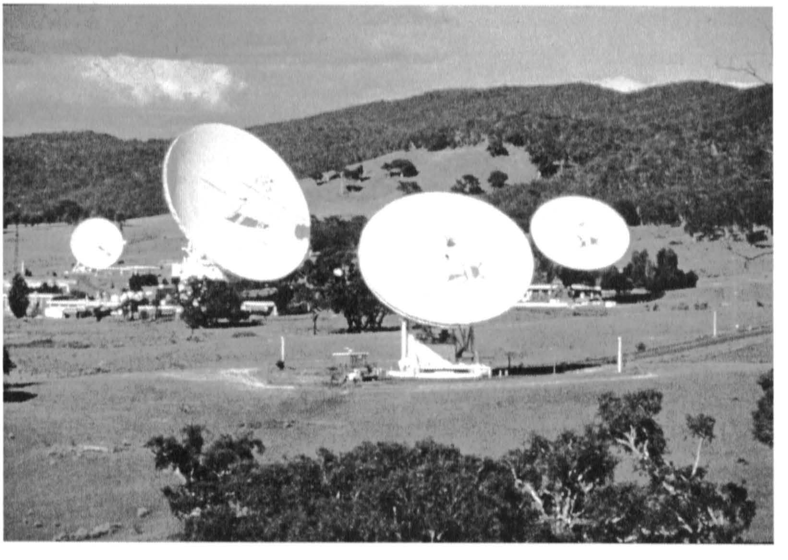

Figure 3: Canberra Deep Space Communication Complex at Tidbinbilla, near Canberra, in 1992.

O'Brien and Tuohy (1998)[4] provide a companion to this paper which traces the evolution of NASA Deep Space Network facilities in Australia. Greater detail on the circumstances leading to the establishment of initial arrangements can be found in Walters (1970)[5] and Waff (1993).[6]

Following the precedent set with the initial arrangement in 1957, the NASA stations in Australia have been staffed by Australian personnel and operated by private industry under contract to the Australian cooperating agency. The Australian Government designates this cooperating agency [currently the Commonwealth Scientific and Industrial Research

Organization (CSIRO)], and an employee of that agency serves as station director. NASA provides the funds for construction and operation of the facilities and Australia is responsible for the installation, operation, and maintenance of the facility.

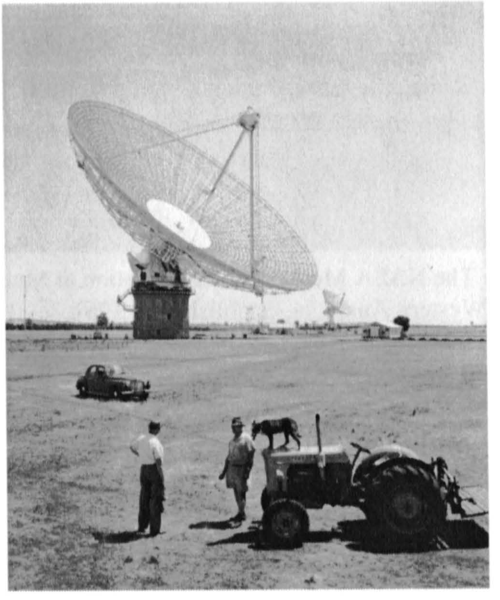

Figure 4: The Parkes Radio Telescope in the 1960s. This facility has frequently supported NASA space tracking programs and was the prototype for the Deep Space Network's 64 m antennas.

Australian facilities have also been brought to bear at critical junctures in the history of deep space tracking. In the I960s the CSIRO Radio Physics Laboratory at Parkes supported the Mariner missions: it was also called upon during the Apollo missions, particularly when Apollo 13 required extraordinary support. In the 1980s, NASA supported CSIRO studies of the structural performance of the Parkes telescope, which contributed directly to the design of the 64 m DSN antennas. Most recently, because of the configuration of the Solar System during the years of the Galileo mission to Jupiter, CDSCC had primary responsibility for tracking that mission. Thanks to the Australia Telescope National Facility (ATNF)'s agreement to hardware modification and observation schedule, post-launch difficulties with the spacecraft's communications data rate were largely transparent to the scientific community.

To a growing extent, cooperation in space tracking between NASA and Australia transcends reimbursable arrangements. In 1996, under the auspices of the U.S.-Australian Agreement for Space Vehicle Tracking and Communications, the Australian Government assigned responsibility for agency-to-agency interaction to the CSIRO Division of Telecommunications and Industrial Physics (TIP), an organization with much in common with NASA's telecommunications and mission operations programs. This has proved an auspicious development, as engineers from both organizations have begun exploring joint technology development possibilities. In an era when space science flight project launches are projected to increase by more than an order of magnitude over current DSN-supported activities, while operations budgets are static at best, NASA welcomes the additional perspective that CSIRO TIP can bring to bear on these challenges.

Space Geodesy

The term "space geodesy" refers to the use of space-based techniques to derive precision geodetic information. Space geodetic techniques include: the use of ground-based high resolution Global Positioning System (GPS) receivers; the correlation of quasar signals acquired simultaneously at more than a single location on Earth (very long baseline interferometry, or VLBI); and the use of satellite laser ranging (SLR), a technique which measures the two-way travel time of a laser pulse from ground station to satellite to provide precision orbit determination and, conversely, precise geodetic location of the laser station. Over 60 countries participate in the International Geodetic Network through hosting or operating a space geodetic facility, and dozens more participate in the analysis of data.

All of these space geodetic techniques are capable of sub-centimeter spatial precision, and all involve multinational network coordination. Geodetic information of this level of precision has applications in characterizing: global tectonic plate motion; regional crustal deformation near plate boundaries; Earth's gravity field and center of gravity; polar motion; and its rate of spin. Additionally the satellite precision orbit determination is used to support numerous Earth observation missions such as ERS-1 and TOPEX/Poseidon.

In 1964, NASA first successfully demonstrated laser ranging to satellites equipped with retroreflectors, and subsequently to a lunar retroreflector erected during the Apollo missions. Beginning in the 1970s, NASA began developing an international network of sites and partners to characterize global plate motion. In 1975 in cooperation between the Australian Government and the Smithsonian Astronomical Observatory (SAO), the Orroral Geodetic Observatory (a facility of the Australian Surveying and Land Information Group (AUSLIG)), in the Australian Capital Territory, first operated as a lunar laser ranging station. In 1979 the NASA Mobile Satellite Laser Ranging Station (MOBLAS) 5 was established in Western Australia as part of the growing international network. Because of the excellent capabilities of the Australian operations staff, the continued improvements to observation hardware, and the favorable weather conditions, these two sites have consistently been among the best performers out of the over 40 SLR sites world wide. The two stations are critical geodetic reference sites in the global SLR network. Both are also equipped with high resolution GPS receivers and are reference sites in the International GPS Network.

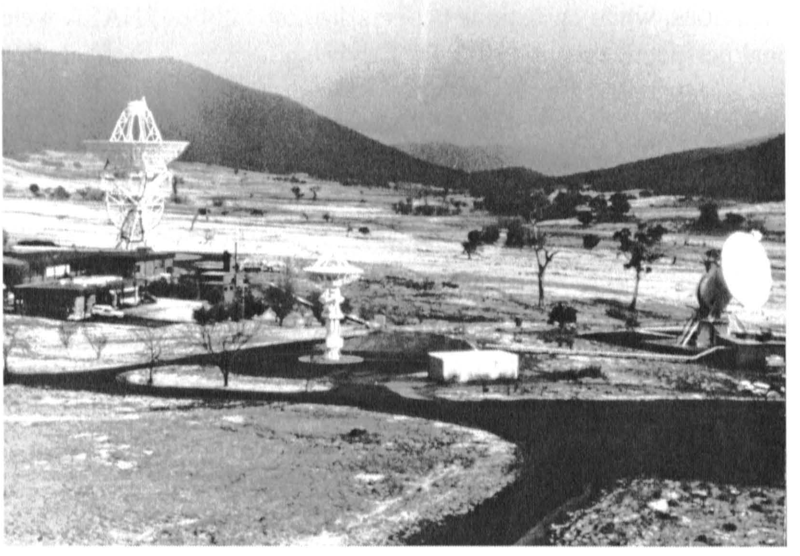

Figure 5: NASA's Orroral Valley STADAN station also became a site for laser-ranging in the 1970s.

Recent developments in Australia signal a new era of SLR cooperation with NASA. During 1995, NASA commissioned an international study[7] team to review its satellite laser ranging efforts and to provide recommendations in terms of scientific priorities and critical site locations. In consequence of the recommendations of this study, NASA and AUSLIG began negotiating for the transfer of responsibility for the operation of the MOBLAS 5 facility in Western Australia to AUSLIG. March 1998 saw the beginning of a one year transition during which AUSLIG assumes responsibility for SLR in Western Australia. Also in 1998, AUSLIG is closing its Orroral Observatory to establish SLR operations at a new facility on Mt. Stromlo in the Australian Capital Territory.* The Mt. Stromlo SLR Observatory will use innovative new techniques in satellite laser ranging developed by Australian industry.

---

* The Mt. Stromlo facility was destroyed by wildfire in January 2003. It was rebuilt and reopened in April 2004. (ed.)

Environmental Remote Sensing

Being of comparable size and facing a range of common and similar environmental issues, Australia and the United States share an interest and expertise in environmental remote sensing applications. Motivation ranges from simple and pragmatic to global international policy, leading to applications from crop assessment and mineral exploration to Kyoto Greenhouse Gas Convention-driven carbon assessment.

NASA Aircraft to Australia

NASA and CSIRO have enjoyed a mutual interest in remote sensing in the visible, infrared and microwave portions of the electromagnetic spectrum since the 1980s. Discussions between individual scientists led to the development of an international agreement to deploy NASA's C-130 aircraft to Australia in 1985, carrying the then state-of-the-art hyperspectral Airborne Imaging Spectrometer.[8] Continued joint interest in studies of this part of the spectrum led to NASA's shipment to Australia in 1993 of the airborne Thermal Infrared Multispectral Scanner (TIMS),[9] which was mounted in an Australian F-27 and subsequently flown over sites of mutual interest in Australia. The CSIRO airborne CO_2 laser spectrometer overflew some of the same sites for sensor intercalibration and validation.

During 1993 NASA, the CSIRO Office of Space Science and Applications (COSSA), and the University of New South Wales (UNSW) coordinated the flight of the NASA DC-8 carrying NASA's airborne multiparameter synthetic aperture radar instruments (AIRSAR), which also operate in SAR Interferometry mode to acquire digital elevation. The 1993 AIRSAR flights were initially designed to support the NASA-Germany-Italian Shuttle Imaging Radar (SIR)-C/X-SAR remote sensing missions, which flew on the Shuttle in April and October, 1994. With multiple polarization, multiple frequency, and dual C-band receive antenna enabling acquisition of digital elevation data, the instruments represented the most sophisticated civilian SAR technology in existence.

However, the interest in the Australian science community went far beyond that of the Australian SIR-C science team members. COSSA and UNSW coordinated Australian academic and development interests with NASA such that, in November 1993, the aircraft acquired SAR data over 55 Australian sites for some 35 U.S. and Australian investigators.[10]

The enthusiasm with which this exercise was received led to a second AIRSAR deployment designed in close coordination between NASA, COSSA, and UNSW. In 1996, the AIRSAR was deployed to the western Pacific to overfly some 14 Pacific Rim countries (PACRIM I) pursuing studies in geology, ecology, archeology, natural disasters, and urban planning. Post-PACRIM I deployment activities have included a series of workshops in participating Pacific Rim countries, where NASA and CSIRO experts in SAR data processing and analysis have tutored local scientists in the applications of SAR data to their environmental studies.[11] A UN/IAF companion paper to one by Baltuck in 1998[12] outlines highlights of the PACRIM I AIRSAR deployment and current plans for PACRIM II in early 2000. PACRIM II will also support the Shuttle Radar Topography Mission (SRTM) currently manifested for launch in September 1999 and designed to use SAR interferometry to acquire a digital topographic data set for the entire land surface exposed between 60° north and south. From the selection in 1988 of a few Australian scientists to participate in the SIR-C/X-SAR, a multi-national Asia Pacific SAR environmental science program has blossomed under the leadership of NASA and Australia.

Cooperation in Hyperspectral Remote Sensing

With hundreds of channels of some 9-10 nanometers width in the visible-infrared portion of the electromagnetic spectrum, hyperspectral remote sensing can be used to observe the details of reflectance spectra that lead to diagnostic identification of mineral types and plant features.

Since the early 1980s, NASA and CSIRO scientists have shared an interest in hyperspectral remote sensing, with collegial cooperation and personnel exchanges leading to the 1985 deployment of the NASA AIS to Australia. Subsequently, joint analysis of data from AIS' successor, the Airborne Visible-Infrared Imaging Spectrometer (AVIRIS),[13] has maintained mutuality of interest. After the failure of NASA's hyperspectral satellite project, LEWIS, mere days after its launch in December 1997, NASA considered several avenues for attaining access to the hyperspectral remote sensing data required for enviromental studies. Recently, NASA has decided to restore hyperspectral capability to the NASA Earth Orbitor-1 (EO-1) flight project, scheduled to launch in 1999.[14]

In the same timeframe of the last several years, the Australian science community has developed the concept of ARIES[15] (the Australian Resource Information and Environment Satellite). The ARIES project aims to design, build and launch a Low Earth Orbit satellite and to provide its data commercially to an international remote sensing market place. ARIES is supported by a consortium of Australian government and commercial entities.

Although direct cooperation on these two flight projects may be precluded between Australia and NASA, discussions have begun in the area of joint applications development, calibration/validation studies, and possibly a jointly-organized deployment of NASA's AVIRIS to Australia.

Australia's FEDSAT Mission

In 2001, the first Australian scientific satellite mission in over thirty years will be launched. Federation Satellite-1 (FEDSAT-1) will be a low cost microsatellite, conducting communications, space science, remote sensing and engineering experiments.[16] FedSat will be built and operated by a group of research organizations, companies and universities comprising the Australian Cooperative Research Centre for Satellite Systems. Because of its interest in the remote sensing and space science aspects of FEDSAT, NASA intends to cooperate with Australia as a junior partner in this mission. NASA's major contribution will be the provision of a space-qualified, high resolution GPS receiver to the FEDSAT payload. A draft agreement to document this cooperation is currently under joint development.

Other Areas

This paper has highlighted some of the more highly visible areas of historical cooperation between NASA and Australia, but it should not be taken as an exhaustive catalog of past and present joint activities. Leaders in the fields of earth sciences, space sciences, aeronautics, life sciences, and enabling technologies in both countries have sought each other out and established cooperative arrangements, from collegial correspondence to formal memoranda of understanding. From sounding rockets and radioastronomy to deep ocean circulation and aeronautical scramjet technology, examples of joint activity abound.

Summary and a Look Ahead

A certain commonality appears in the various historical threads of cooperation between NASA and Australia. From initial pursuit of a NASA function to achieve NASA scientific objectives on Australian terrain to the joint planning of aircraft deployments and satellite projects in Australia, there has been an evolution towards real partnership in science planning and analysis and technology development. As our common interests continue to develop and bourgeoning information technology lessens the burden of remote communication, we look forward eagerly to another forty years of this partnership.

References

[1] Morton, P., *Fire Across the Desert: Woomera and the Anglo Australian Joint Project 1946-1980*, Australian Government Publishing Service, Canberra, 1989.

[2] Exchange of Notes constituting an Agreement between the Government of Australia and the Government of the United States of America relating to Space Vehicle Tracking and Communications, Australian Treaty Series 1960, No. 2 (1960).

[3] Dougherty, K., and James, M. J., *Space Australia: the Story of Australia's Involvement in Space*, Powerhouse Publishing, 1993.

[4] O'Brien, J, and Tuohy, I., *Operation and Maintenance Support of the Canberra Deep Space Communication Complex*, 49th International Astronautical Congress, Melbourne, 1998.

[5] Walter, E. M, *The "Partnership" Philosophy: Australian-American Space-Tracking Relations*, Unpublished doctoral thesis, 1970.

[6] Waff, C. B., *A History of the Deep Space Network*. Unpublished manuscript, 1993.

[7] Shapiro, I. (chair), *SLR Review Committee Report*. NASA Internal Publication, 1997 (available upon request).

[8] Goetz, A. F. H., "High Spectral Resolution Remote Sensing of the Land," *Society Photo-Optical Instrumentation Engineers Proceedings*, v. 475, 1984, pp.56-68.

[9] TIMS Description at NASA website: http://geo.arc.nasa.gov/sge/j skiles/top-down/OTTER/ OTTER_docs/TIMS.html.

[10] Milne, A. K. (editor), *Proceedings of the International Workshop on Radar Image Processing and Applications: Significant Results of the AIRSAR Australia 1993 Mission*, CSIRO Publication, 1995.

[11] Milne, A. K. (editor), *Proceedings of the International Workshop on the 1996 PACRIMI AIRSAR Deployment*, University of New South Wales, 1998.

[12] Baltuck, M. "NASA Earth Science in the Asia Pacific Region including Recent and Planned Airborne SAR Deployments," *Proceedings of the United National/International Astronautical Federation Workshop on Expanding the User Community of Space Technology Applications in Developing Countries*. September 24-27, 1998, Melbourne.

[13] AVIRIS description and instructions for requesting data can be found on its home page on the Internet: http://aviris.jpl.nasa.gov/.

[14] EO-1 "s hyperspectral instrument Hyperion is described on the Internet: http://eo1.usgs.gov/hyperion.php.

[15] AIRES is described on the Internet: http://www.cossa.csiro.au/ARIES/index.htm.

[16] FEDSAT status can be found at: http://www.crcss.csiro.au/.