The Nautilus Institute *for Security and Sustainability*

The Antennas of Pine Gap

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Summary

Antennas are the most readily available and visible evidence of the existence, character, and size of signals intelligence facilities that operate or monitor space systems. Coupled with data on the timing of developments in US geosynchronous satellite programs, the timing of antenna installation permits identification of almost all antennas at Pine Gap. Since 1967, at least 46 antenna systems have been installed at Pine Gap. Of the 33 antenna systems at the facility as of February 2016, 19 were in radomes and 14 were uncovered, including high frequency, helical, and multi-beam antenna systems. Most of Pine Gap's antennas are still concerned with the core functions relating to the geosynchronous signals intelligence (SIGINT) Orion satellites. Six belong to the Relay Ground Station for early warning and missile tracking data down-linked from Defense Support Program and Space Based Infrared System satellites, three most likely for the US Missile Defense Agency's Space Tracking and Surveillance System, and another three to the bases's foreign satellite/communication satellite (FORNSAT/COMSAT) interception mission, including a Torus multi-beam antenna.

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See *Kristian Laemmle-Ruff Photography* at http://www.kristianlaemmleruff.com/, and *Felicity Ruby – The Fourth Eye,* at http://FelicityRuby.com/.

Larger versions of all images will be available shortly on the main Pine Gap page on the Nautilus Institute *Australian Defence Facilities* website, at http://nautilus.org/publications/books/australian-forces-abroad/defence-facilities/, currently under reconstruction.

Very large file size versions of Laemmle-Ruff's images are available through his website. Media requests for reproduction rights should be directed to that website. Felicity Ruby's photographs are available through her website.

Note that the small spheres across the upper part of the cover image are lens flares, an artifact of the camera pointing directly at light sources at night.

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We acknowledge the traditional owners and elders of the land on which the Pine Gap facility is located, and wish to express our gratitude for the kind assistance given to this project at an important point. We also thank Rosalie Schultz for assistance in fieldwork. We are deeply grateful to Felicity Ruby and Kristian Laemmle-Ruff, who very generously gave us permission to reproduce their photographs of Pine Gap. Luke Hambly from the Coral Bell School of Asia Pacific Affairs at the Australian National University kindly prepared the Figure 2. Philip Dorling kindly provided a government photograph to us. We are grateful to Rebecca Pollack at Nautilus Institute in Berkeley for patient and expert help with the preparation of this and other publications in this series.

The views expressed in this report do not necessarily reflect the official policy or position of the Nautilus Institute. Readers should note that Nautilus seeks a diversity of views and opinions on significant topics in order to identify common ground.

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Abbreviations and Acronyms

AFB	Air Force Base
ASD	Australian Signals Directorate
bps	bits per second
CIA	Central Intelligence Agency
COMSAT	communications satellite
CSE	Communications Security Establishment
CSG	Combined Support Group
DSCS	Defense Satellite Communications System
DSD	Defence Signals Directorate
DSP	Defense Support Program
EIRP	effective isotropic radiated power
FORNSAT	foreign satellite
GCHQ	Government Communications Headquarters
GCSB	Government Communications Security Bureau
GED	Ground Enterprise Directorate
GHz	Gigahertz
HF	high frequency (3 – 30 MHz; 100 m – 10 m)
HQJOC	Headquarters Joint Operations Command
ITU	International Telecommunications Union
LPA	log periodic antenna

MASINT	measurement and signatures intelligence
MCS	Mission Control Station
MHz	Megahertz
MUOS	Mobile User Objective System
NGA	National Geospatial-Intelligence Agency
NRO	National Reconnaissance Office
NSA	National Security Agency
PMG	Postmaster-General's Department
RGS	Remote Ground Station
RGS	Relay Ground Station
SATCOM	satellite communications
SBIRS	Space Based Infrared System
SCA	Service Cryptologic Agency
SIGINT	signals intelligence
STSS	Space Tracking and Surveillance System
UKUSA	UKUSA Agreement(s)
VHF	very high frequency (30 – 300 MHz; 10 m – 1 m)
UHF	ultra high frequency (300 MHz – 3 GHz; 1 m – 100 mm)

1. Introduction

Antennas are the most readily available and visible evidence of the existence, character, and size of signals intelligence facilities that operate or monitor space systems. Coupled with data on the timing of developments in US geosynchronous satellite programs, the timing of antenna installation now permits, for the first time, identification of the role and function of almost all antennas at Pine Gap. Documenting the development of the antenna systems of Pine Gap provides visual evidence of the profound changes in the base's operations and its missions: a subject of political controversy in Australia for half a century. The antennas of Pine Gap are a powerful political symbol in Australia, representing either promise of enduring alliance protection or loss of national autonomy and nuclear threat to different audiences.

Since 1967, at least 46 antenna systems have been installed at Pine Gap, including 23 parabolic dish antennas covered by protective radomes and 23 uncovered antennas of assorted types. (See Table 1.) Four of those in radomes were subsequently dismantled (although three were replaced by other systems in radomes); nine without radomes also have been dismantled. Hence, of the 33 antenna systems at the facility as of February 2016, 19 were in radomes and 14 were uncovered (see Table 1 and Figures 1 and 2).

Most of these are still concerned with Pine Gap's core functions relating to geosynchronous SIGINT satellites – controlling the satellites, maintaining the boresights of the intercept antennas on the satellites, downlinking the intercepted data from the satellites, and sending both raw and processed data to an increasing number of users. (See Figure 3.)

Six of the satellite terminals now at Pine Gap (four in radomes and two unshielded) belong to the DSP/SBIRS Relay Ground Station (RGS), which relays early warning and missile tracking data down-linked from Defense Support Program (DSP) and Space Based Infrared System (SBIRS) satellites. Another three radomes are probably associated with the US Missile Defense Agency's Space Tracking and Surveillance System (STSS) developmental satellites.

Pine Gap evidently acquired a foreign satellite/communication satellite (FORNSAT/COMSAT) interception mission around 1999-2000, with the arrival of elements of the National Security Agency's (NSA's) Service Cryptologic Agencies (SCAs) at the end of the 1990s. Two very suitable 23-metre dishes were installed inside 30-metre radomes in 1999-2000. A Torus multi-beam antenna for interception of secondary satellite communications, and capable of receiving in the order of a thousand communications channels simultaneously was installed in 2008.[1]

Some of the antenna systems were installed to facilitate Australian participation in Pine Gap's activities, including two satellite dishes/radomes built in 1990-91 to provide the Defence Signals Directorate (DSD) with direct access to SIGINT collected at the station.

2. Antenna identification system

One aim of this research is to identify all antenna systems installed at Pine Gap since 1967, with a view to then understand their characteristics and likely roles. There is no publicly available information about the system by which the US government identifies antennas and other elements of Pine Gap infrastructure. Over a number of years, the authors have used different systems of antenna identification, each mainly based on the numerical order in which antennas were installed. As the number of antennas known to have been installed grew, and as more accurate information about the date of antenna installation was established (and on occasion revised more than once), it became clear that the identification of a particular antenna in a straightforward chronological system may need to be revised, sometimes more than once, leading to confusion. In Table 1, column 2, the authors introduce a year-based identification system.

The antennas are listed in chronological order, with some allowance for uncertainty in particular cases. The antenna identification number in column 2 is based on the year that the antenna was installed (see column 6), with a letter suffix further identifying it within the group installed that year. The first antenna listed, 67-A, was built in 1967, and it was the first (and only) antenna built that year. The second antenna listed, 68-A, was one of four installed in the following year. In cases of uncertainty, the best estimate is noted with a question mark. When an antennna is known to have been installed at some point during a specific period, the indentification number is derived from the earliest possible year of construction in that range – e.g. antenna 86-A is known to have been installed between 1986 and 1988.

[1] Duncan Campbell, '"Torus": has one word in a Snowden leak revealed a huge expansion in surveillance?', Wired.co.uk, 28 May 2015, at http://www.wired.co.uk/news/archive/2015-05/28/torus-duncan-campbell-report. On the Five Eyes Torus FORNSAT/COMSAT interception system see Desmond Ball, Duncan Campbell, Bill Robinson and Richard Tanter, *Expanded Communications Satellite Surveillance and Intelligence Activities utilising Multi-beam Antenna Systems*, Nautilus Institute Special Report, 28 May 2015, at http://nautilus.org/wp-content/uploads/2015/05/Torus-SATCOM.pdf.

Figure 1. Antenna systems at Pine Gap, Google Earth imagery, 6 November 2015

Table 1. Antennas at Pine Gap

	Authors' numbering system ID	Size (ft.) antenna/ radome	Size (m.) antenna/ radome	Coordinates	Built	Comments
1	67-A	?			1967	No radome. UHF Yagi antenna. Located on the roof of the Operations Building. Provided link to the Alice Springs Telecom tower. Dismantled.
2	68-A	85/125	26/38	-23.798403°, 133.736261°	1968	Radome replaced in 1977.
3	68-B	?/67	?/20	-23.799296°, 133.736276°	1968	Radome replaced in 1977.
4	68-C	?		-23.797437°, 133.738290°	1968	No radome. HF radio transmitting antenna. Located on the NE side of the Operations Building. Tower is about 53 metres high.
5	68-D	?		-23.796319°, 133.738033°	1968	No radome. HF radio receiving antenna. Tower is about 15 metres high.
6	69-A	?/60	?/18	-23.798040°, 133.737430°	1969	Radome. 'Research' dish. Dismantled in 1973. Site occupied by 73-A in 1973.

7	69-B	?/15	?/5	-23.798814°, 133.736224°	1969	Radome. Dismantled in 1980. Upgraded to 80-B in 1980.
8	69-C	?	?	?	1969	No radome. Dismantled.
9	71-A	?/50	?/15	-23.798849°, 133.736185°	1971	Radome.
10	73-A	35/60	11/18	-23.798040°, 133.737430°	1973	Radome. SCT-35 DSCS dish. Dismantled in 1991-1994. Located at site previously occupied by 69-A. Operations Building addition built on site c.1998.
11	77-A	?/50	?/15	-23.798071°, 133.736247°	1977	Radome.
12	80-A	8/15	2/5	-23.798773°, 133.737046°	1980	Radome. SCT-8 DSCS dish. Installed on roof of Operations Building.
13	80-B	?/25	?/8	-23.799051°, 133.736280°	1980	Radome. 'Upgrade' in size of 69-B.
14	84-A	?	?	?	1984	No radome. Large HF LPA. Dismantled by 1997.
15	85-A	95-100/125	29-31/38	-23.797614°, 133.736466°	1985	Radome. Reportedly associated with the Orion-1 (Magnum-1) satellite.
16	86-A	25/	8/	-23.797372°,	1986-1988	No radome.

				133.737366°		
17	87-A	18/	5/	-23.799438°, 133.739077°	1986-1988	No radome. South of tennis court. TV reception?
18	88-A	18/	5/	-23.799505°, 133.739129°	1986-1988	No radome. South of tennis court. TV reception?
19	88-B	?	?		1986-1988	No radome. Dismantled.
20	89-A	?/22	?/7	-23.799415°, 133.735998°	1989	Radome. Dismantled. Site later occupied by 11-A.
21	90-A	?/30	?/9	-23.796753°, 133.737278°	1990-1991	Radome. One of pair announced in August 1990. Communications.
22	90-B	?/100	?/30	-23.796316°, 133.737278°	1990-1991	Radome. One of pair announced in August 1990. Communications.
23	98-A	33/52	10/16	-23.800425°, 33.732769°	1998	Radome. DSP/SBIRS.
24	98-B	33/52	10/16	-23.800811°, 133.732769°	1998	Radome. DSP/SBIRS.
25	99-A	66/	20/	-23.795116°, 133.737281°	1999?	No radome. Communications re DSP/SBIRS.

26	99-B	66/	20/	-23.795576°, 133.737288°	1999?	No radome. Communications re DSP/SBIRS.
27	99-C	72/100	22/30.5	-23.797218°, 133.736466°	1999	Radome. One of pair built just N of 85-A. FORNSAT/COMSAT collection role.
28	99-D	72/100	22/30.5	-23.796774°, 133.736462°	1999	Radome. One of pair built just N of 85-A. FORNSAT/COMSAT collection role.
29	99-E		3/	-23.795257°, 133.737448°	Before 9.2004	No radome. Present in 1999 DoD photo. Dismantled between October 2014 and January 2016.
30	01-A		6/	-23.795250°, 133.737121°	Before 9.2004	No radome.
31	01-B		2.5/	-23.795135°, 133.736749°	Before 9.2004	No radome. Present ?/2004-2012/13. Dismantled in 2013.
32	01-C[2]					No radome. Dismantled. Not present in September 2004.
33	03-A	16/	5/	-23.799829°, 133.732699°	2003-2004?	No radome. RGS area. Dismantled in 2011-2012.
34	03-B	16/	5/	-23.800025°, 133.732712°	2003-2004?	No radome. RGS area.

[2] The existence of Antenna 01-C is implied in the May 2002 Ministerial Statement that three uncovered antennas were installed between the 1999 official photograph (Figure 31) and May 2002.

						Dismantled in 2011-2012.
35	04-A			western mast: -23.795454°, 133.737057° eastern mast: -23.795459°, 133.737176°	8.2005 - 10.2009	Helical antenna array. Located on southwest and southeast corners of the building between 99-A and 99-B. Two small single helical antennas installed by September 2004. Present in Google Earth imagery dated 8 September 2004.
36	05-A	?/17	?/5	-23.799853°, 133.733103°	2005-2008?	Radome. STSS-related?
37	05-B	?/17	?/5	-23.799856°, 133.733361°	2005-2008?	Radome. STSS-related?
38	05-C		4/	-23.796584°, 133.737283°	2005-2009	No radome. Built in 2005-2009.
39	05-D		4/	-23.796594°, 133.737190°	2005-2009	No radome. Built in 2005-2009.
40	05-E			-23.795813°, 133.737426°	2005-2009	Helical antenna array. Located south of 99-B. Four masts with twin helicals installed between 2005 and 2009. Not present in Google Earth imagery dated 11 August 2005. Present in TerraServer imagery in October 2009.
41	08-A	75?/	23?/	-23.803366°, 133.738043°	2008	Torus multiple-beam antenna. FORNSAT/COMSAT collection role.
42	10-A	95-100?/125	29-31?/38	-23.796265°, 133.736433°	2010	Radome. Probably associated with the Orion-7 satellite.

43	11-A	40/	12/	-23.799440°, 133.735973°	2011-2012	No radome. Installed on the site previously occupied by 89-A.
44	12-A	?/17	?/5	-23.799822°, 133.733232°	2012	Radome. STSS-related?
45	13-A	33?/52?	10/16	-23.800003°, 133.732771°	2013	Radome. DSP/SBIRS.
46	13-B	?/ca. 60?	?/18	-23.801743°, 133.732762°	2013	Radome. SBIRS-related?

Table 2.
Radomes and uncovered antennas at Pine Gap, 1970-2015

	Radomes	Uncovered	Total
1970	4	4	8
1979	6	4	10
1989	9	9	18
2002	14	12	26
2008	16	15	31
2015	19	15	34
2016	19	14	33

Figure 2.
Number of antenna systems at Pine Gap, 1970-2015

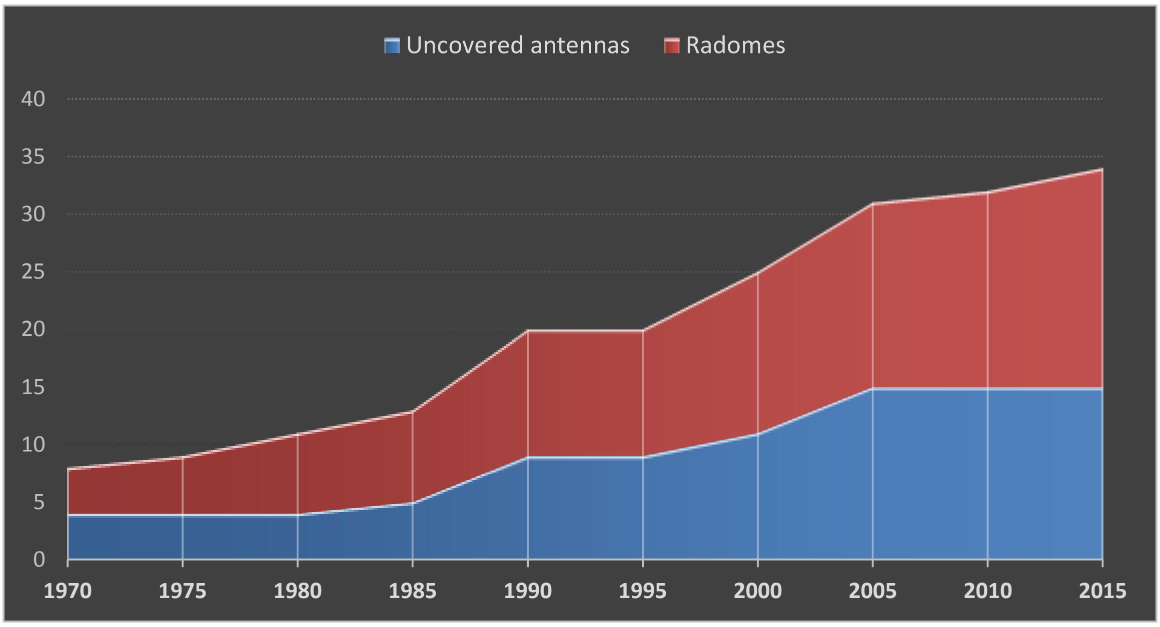

Figure 3. Pine Gap signals intelligence compound, Here.com imagery, 2012

Figure 4. Principal SIGINT and FORNSAT/COMSAT parabolic antennas in radomes
(Antennas 90-A, 10-A, 99-D, 99-C, 85-A, 77-A, 68-A, 71-A, 68-B)

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

3. The first communications systems

The communications systems that the US would require at Pine Gap were considered in detail at meetings between Australian officials and US 'project officers' in September 1966, during the final drafting of the Implementing Arrangements. At meetings at the Department of Defence in Canberra on 20 and 22 September 1966, both attended by Richard Stallings, the first Chief of Facility, six 'communication facilities' were identified as being 'required':

1. A telex service from Alice Springs, to be available in early 1967;
2. A 24-hour full duplex 75 baud (bps) telegraph/teletype circuit between Alice Springs and the office of Raymond Villimarette, the CIA Station Chief (1966-69), in Melbourne, to be available by September 1967;
3. A 24-hour full duplex 75 baud telegraph/teletype circuit between Alice Springs and Sydney, with connections via submarine cable to the US, to be available around June 1968;
4. A 3-KC Voice/Data fulltime circuit, able to operate at 2400 bps, between Alice Springs and Sydney with connections via submarine cable to the US, to be available around September 1968;
5. Another full duplex 75 baud telegraph/teletype circuit between Alice Springs and Sydney, with connections via submarine cable to the US, to be available around January 1969; and
6. A 28-pair land-line cable between the Pine Gap station and the PMG/Telecom facilities in Alice Springs.[3]

The Senior Assistant Director-General (Planning) in the Postmaster-General's (PMG) Department was advised (by Commander R.C. Swan from the Defence Department's Joint Services Communication Staff) of the 'likely requirements' on 21 September. He 'saw no insurmountable difficulties in providing these facilities'.[4]

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[3] 'Proposed Joint Defence/Space Research Project: Minutes of Meeting Held at 1530 Hours Tuesday 20th September 1966, Department of Defence, Canberra', National Archives of Australia (NAA), 'Joint Defence Space Research Facility: Policy 1965-1984', Series A1945, Item 227/1/131; and 'Proposed Joint Defence/Space Research Facility: Minutes of Informal Meeting at Department of Defence at 1415 Hours Thursday 22nd September 1966, Attachment "A"', National Archives of Australia (NAA), 'Joint Defence Space Research Facility: Policy 1965-1984', Series A1945, Item 227/1/131.

[4] Commander R. C. Swan, 'Proposed Defence/Space Research Project: Notes for Record of Discussions with Mr R. W. Turnbull, Senior Assistant Director-General (Planning) Postmaster-General's Department Melbourne 0845 Hours 21st September 1966', National Archives of Australia (NAA), 'Joint Defence Space Research Facility: Policy 1965-1984', Series A1945, Item 227/1/131.

A UHF Yagi antenna was mounted on the roof of the Operations Building in 1967 and provided a link with the Alice Springs Telecom tower. It was the first antenna to be installed at Pine Gap (67-A in Table 1).

The first satellite communications (Satcom) capability, an SCT-35 antenna designed for use with the Defence Satellite Communication System (DSCS) satellites, was installed in 1973 (73-A). Until then, as the Minister for Defence, Mr D.J. Killen, stated in November 1981, these 'surface communications links were used between the [Pine Gap] facility and the United States'.[5]

4. The first Rhyolite antennas and radomes

The Minister's announcement of the Pine Gap agreement on 11 December 1966 stated that only 'two radomes, each of which will enclose a large antenna', would be built at the facility.[6] These two radomes were installed in 1968[7] (and designated Antennas 68-A and 68-B in Table 1). On 22 March 1967, at a meeting with Alice Springs residents, Richard Lee Stallings, the first chief of the facility, stated that the largest dish would be '100 feet [30 metres] in diameter'.[8] The dish (68-A) is actually about 85 feet (26 metres) in diameter, and the radome about 125 feet (38 metres) in diameter. The second radome (68-B) is 20 metres (67 feet) in diameter. (See Figures 4-9.)

In 1977, the radome surrounding the largest dish was dismantled and replaced by a new radome, the panels for which were flown to Alice Springs by a C-5A Galaxy transport aircraft in May 1977. According to a newsletter of the Department of the Northern Territory:

> After about nine years some of the panels, there mainly to keep dust out of delicate equipment, have become grazed and cracked. Their replacement is part of a general refurbishing of the big radome. The original panels were brought out by sea and then trucked by road and rail to Alice Springs. It was an easier operation to bring the new panels out by air and some were so large they would not fit in [a C-141] Starlifter.[9]

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[5] Mr Killen, 'DSCS Terminals at Joint Defence Space Research Facility, Pine Gap, Northern Territory', *Hansard (House of Representatives)*, 18 November 1981, p. 3165.

[6] Department of Defence, 'Joint U.S.-Australian Defence Space Research', *Defence and Services Newsletter*, January 1967, p. 1. See also *Canberra Times*, 13 December 1966, p. 1.

[7] 'Pine Gap and Nurrungar', *Hansard (House of Representatives)*, 3 May 1979, p. 1892.

[8] 'Official Gives Facts on Space Base', *Centralian Advocate*, 23 March 1967, p. 1; 'Alice Space Centre to be "Unobtrusive"', *Northern Territory News*, 23 March 1967, p. 1. On Richard Stalling's CIA career see Desmond Ball, Bill Robinson, and Richard Tanter, *Management of Operations at Pine Gap*, Nautilus Institute Special Report, 24 November 2015, pp. 10-11, at http://nautilus.org/napsnet/napsnet-special-reports/management-of-operations-at-pine-gap.

[9] 'The World's Largest Plane in Alice', *Northern Territory Newsletter*, May 1977, pp. 2, 22.

Two more satellite dishes/radomes were installed in 1969. The third radome (69-A) (housing the sixth antenna) was about 18 metres (or 60 feet) in diameter, and was located some 60 metres northeast of the Operations Building (see Figure 7). The Minister for Defence said in 1981 that this terminal had been 'used for research'.[10] It was only used with Rhyolite-1, during its first few years when there was considerable experimentation with the capabilities of the system; it was dismantled in 1973, when Rhyolite-2 was launched.[11] (The site was used for an 18-metre-diameter SCT-35 X-band antenna for communication with the DSCS satellite system [Antenna 73-A].[12])

The fourth radome (housing the seventh antenna) was installed at the same time as the third radome; it was about five metres (15 feet) in diameter, and was located just north of the second radome. It was dismantled in 1980 and upgraded with a larger dish and radome.

These first four dishes/radomes were built to work, at least initially, with the first Rhyolite satellite, launched in June 1970. Presumably, the larger dish (68-A) was for receiving the down-linked stream of intercepted data, while the smaller dishes were for satellite station-keeping and orientation of the intercept antenna. One was likely to have been a back-up in case one of the others required maintenance or servicing.

The fifth satellite dish/radome (housing the ninth antenna; 71-A) was installed in 1971 and is about 15 metres (50 feet) in diameter. It is located just south of the first large radome. (See Figures 4, 6, 8, 9 and 10.) It was presumably constructed in anticipation of the launch of the second Rhyolite satellite in March 1973, which probably required augmentation of the ground systems previously installed for Rhyolite-1, although some terminals were undoubtedly used for both satellites.

Two other antennas, without radomes, were also installed in 1968 (68-C and 68-D), and another in 1969 (69-C).

A collimation tower used to ensure the precise alignment, or degree of error, between the boresight of an antenna and the data beam from a given satellite was installed 270 m west of 68-A (Figures 6, 8, 19 and 27).

Figure 5. Two radomes at Pine Gap, 1968-69
(Antennas 68-A and 68-B)

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[10] Mr Killen, 'DSCS Terminals at Joint Defence Space Research Facility, Pine Gap, Northern Territory', *Hansard (House of Representatives)*, 18 November 1981, p. 3165.
[11] For a listing of the SIGINT satellites controlled by Pine Gap since 1970, see Desmond Ball, Bill Robinson and Richard Tanter, *The SIGINT Satellites of Pine Gap: Conception, Development and in Orbit*, Nautilus Institute Special Report, 15 October 2015, Table 3, at http://nautilus.org/?p=46814.
[12] Mr Killen, 'DSCS Terminals at Joint Defence Space Research Facility, Pine Gap, Northern Territory', *Hansard (House of Representatives)*, 18 November 1981, p. 3165.

Figure 6. Five radomes at Pine Gap, 1973-77
(Antennas 68-B, 71-A, 68-A and 73-A; 69-B not visible;
collimation tower to left of 68-A)

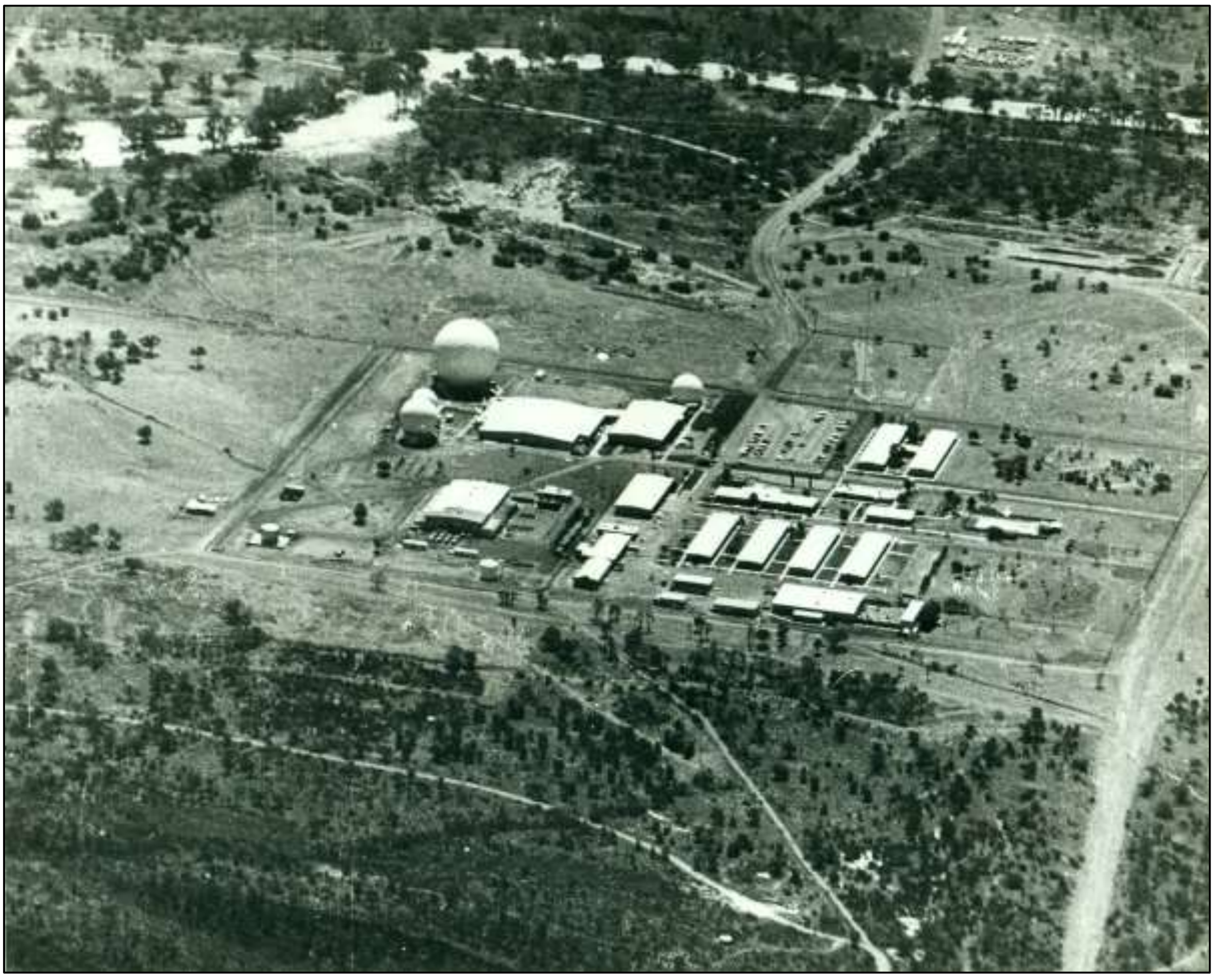

Figure 7. Four radomes at Pine Gap, 1969-71
(Antennas 69-A, 68-A, 69-B and 68-B)

Figure 8. Five radomes at Pine Gap, 1973-77
(Antennas 68-B, 69-B, 71-A, 73-A and 68-A, and collimation tower)

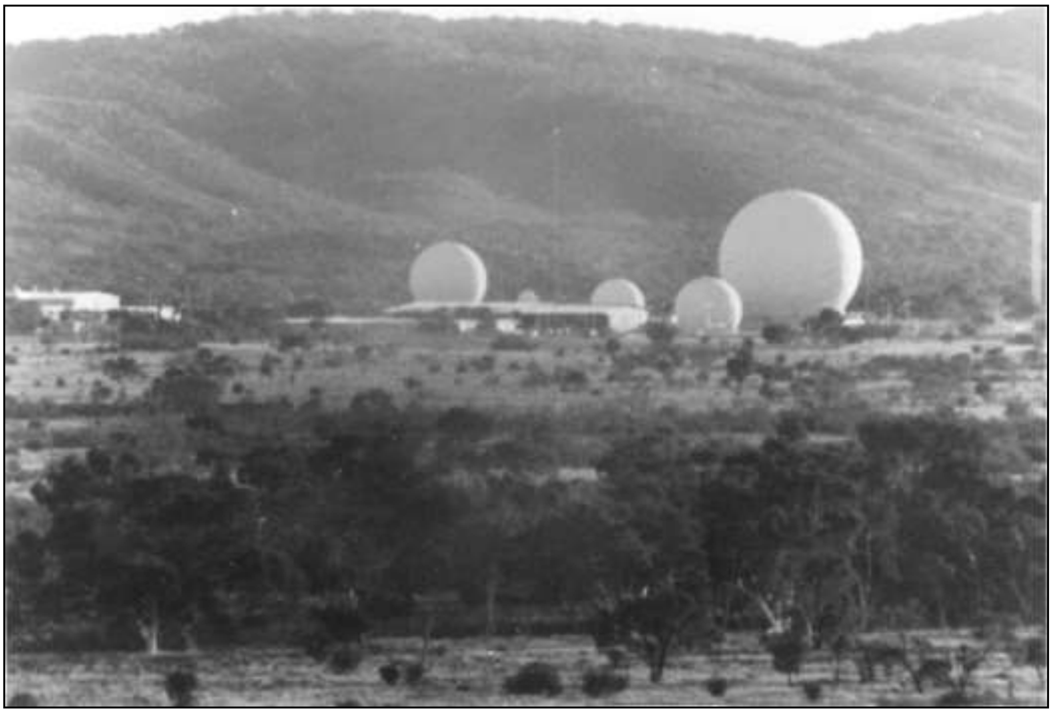

Figure 9. Antennas 77-A, 68-A, 71-A, 68-B

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

5. High frequency (HF) radio communications

The two antennas installed at Pine Gap in 1968 and not covered by radomes were for high frequency (HF) radio communications with the US. At the meeting held on 20 September 1966, chaired by Gordon Blakers, Deputy Secretary B in the Defence Department, and with Richard Stallings also present, one of the attendees stated that 'HF radio circuits would be required for "back-up" of line/cable circuits'.[13] At an 'informal meeting' two days later, it was stated that 'the HF back-up facilities will be installed in the 9/68 [i.e., September 1968] time frame'.[14] A draft of the Pine Gap Implementing Arrangement in October 1966 stated that: 'As a contingency measure, the United States Government may install and maintain in a state of readiness at the facility a high frequency radio communications capability'.[15]

The HF system, still extant today, is located on the northeastern side of the Pine Gap complex. The transmitting antenna tower (68-C) is 53 metres high and is located on the northern side of the car-park, directly east of 85-A. (Figures 10 and 11.) At least until the early 1990s, a Marconi HF wire antenna was strung between this tower and a similar one located about 200 metres further east, but this has not been discernible in more recent imagery. The system was registered with the International Telecommunications Union (ITU) with the call-sign VL5TY, assigned on 25 February 1969, and provided a direct link with the US base at Clark Field in the Philippines. In March 1987, it operated on 16 frequencies from 4.048 MHz up to 23.69 MHz.[16] The associated HF receiving antenna (68-D) is located about 100 metres north of the transmitter, directly east of 90-A. It is about 15 metres high (see Figure 11).

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[13] 'Proposed Joint Defence/Space Research Project: Minutes of Meeting Held at 1530 Hours Tuesday 20th September 1966, Department of Defence, Canberra', National Archives of Australia (NAA), 'Joint Defence Space Research Facility: Policy 1965-1984', Series A1945, Item 227/1/131.

[14] 'Proposed Joint Defence/Space Research Facility: Minutes of Informal Meeting at Department of Defence at 1415 Hours Thursday 22nd September 1966', National Archives of Australia (NAA), 'Joint Defence Space Research Facility: Policy 1965-1984', Series A1945, Item 227/1/131.

[15] 'Implementing Arrangement(s) Between the Department of Defence of the Commonwealth of Australia and the Advanced Research Projects Agency of the Department of Defense of the United States of America Relating to the Establishment of a Joint Defence Space Research Facility: Second Draft', October 1966, National Archives of Australia (NAA), 'Joint Defence Space Research Facility: Policy 1965-1984', Series A1945, Item 227/1/131.

[16] International Telecommunications Union, *List of Fixed Stations Operating International Circuits drawn up by the International Frequency Registration Board*, (International Telecommunications Union, Geneva, Tenth edition, 1 February 1977), p. A-19; and information for 24 March 1987 provided by Department of Communications, Canberra.

Figure 10. Antennas 68-B, 80-A (on Operations Building roof), 80-B, 71-A, 68-C (HF transmitter), 68-B, 77-A and 86-A, 23 January 2016

Source: Felicity Ruby, (Attribution - NonCommercial CC BY-NC).

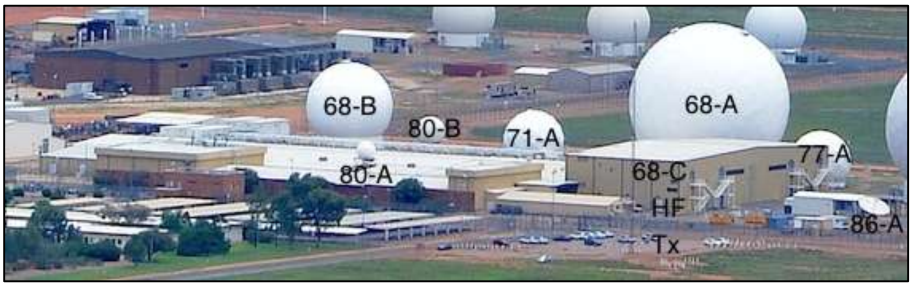

Table 3. Pine Gap (VL5TY) assigned frequencies (MHz)
for communication with Clark Air Force Base, the Philippines, 24 March 1987

4.048	8.093	10.587	17.523
5.92	8.17	12.21	17.623
6.766	9.224	14.782	23.355
6.866	9.915	15.895	23.69

Source: International Telecommunications Union, *List of Fixed Stations Operating International Circuits drawn up by the International Frequency Registration Board*, (International Telecommunications Union, Geneva, Tenth edition, 1 February 1977), p. A-19; and information for 24 March 1987 provided by Department of Communications, Canberra.

Figure 11. HF transmitter (68-C) and receiver (68-D) antennas at Pine Gap, Google Earth imagery, 6 November 2015

Another HF system, a large horizontally polarised log-periodic antenna (LPA) was later installed, probably in 1984 (84-A). It had a 29-metre-long boom, mounted on a steel mast about 34 metres high, and was located on the northern side of the administration complex. It is not apparent in photographs taken in the 1970s, but was there in the period around 1985-91 (see Figures 19 and 27); it had been dismantled by 1997.

6. The SCT-35 and SCT-8 DSCS antenna systems

An SCT-35 SATCOM terminal was installed at Pine Gap in 1973, on the site previously occupied by the third radome (69-A).[17] The SCT-35 was built by Ford Aerospace and Communications Corporation for operation with the DSCS Phase II and Phase III satellites. It was a customer-designed terminal designed to serve the satellite communication needs of the military and government. It was designed to provide more than 15 years service without any degradation in performance. The modular design incorporated redundant systems in critical component areas and allowed for expansion of the terminal when necessary. The terminal had four basic units: the 18-metre antenna; the pedestal and drive assembly; two-rack remote control and status equipment; and the high-power and low-noise amplifiers and up/down converters. The frequency range on the down-link was 7250-7750 MHz, and 7900-8400 MHZ on the up-link. A particular feature of the terminal was its ability to survive extremely high winds – up to 120 mph (193 km/h).[18] (See Figure 12.) It was dismantled between 1991 and 1994. The site is now covered by an Operations Building extension built around 1998.[19]

An SCT-8 DSCS satellite communications terminal was installed in 1980 (80-A). It is a 2.5-metre-diameter X-band antenna, and was also produced by Ford Aerospace and Communications Corporation. [20] As with the SCT-35, the SCT-8 receives in the frequency range from 7250 to 7750 MHz and transmits in the frequency range from 7900 to 8400 MHz. It has an effective isotropic radiated power (EIRP) of 98.5 dBm, a continuous data rate coverage from 45 baud to 19.2 kbaud, eight data channels and two voice channels, and can survive wind velocities up to 160 km/h. It was installed on the roof of the Operations Building, where it still sits (see Figures 10, 13, 16, and 20).

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[17] Mr Killen, 'DSCS Terminals at Joint Defence Space Research Facility, Pine Gap, Northern Territory', *Hansard (House of Representatives)*, 3 May 1979, p. 1892. See also Desmond Ball, *Code 777: Australia and the US Defense Satellite Communications System (DSCS)*, Strategic and Defence Studies Centre, Australian National University, Canberra, 1989), incl. pp. 161-3.

[18] Ford Aerospace and Communications Corporation, *SCT-35 X-Band Earth Terminal*, (Ford Aerospace and Communications Corporation, Western Development Laboratories Division, Palo Alto, California). See also R. J. Raggett (ed.), *Jane's Military Communications 1979-80*, (Jane's Publishing Company, London, First edition, 1979), p. 223.

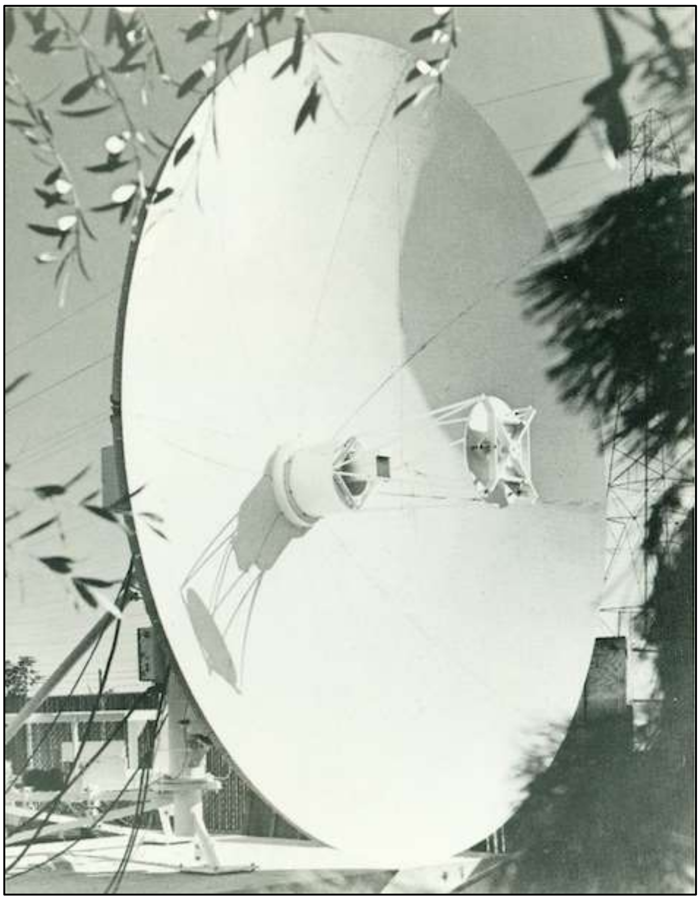
[19] The extension is labeled B-2 in Figure 22 and Table 5 in Desmond Ball, Bill Robinson, and Richard Tanter, *Management of Operations at Pine Gap*.

[20] Ford Aerospace and Communications Corporation, *SCT-8/18 X-Band Adaptive SATCOM Terminal*, (Ford Aerospace and Communications Corporation, Western Development Laboratories Division, Palo Alto, California).

Figure 12. Ford Aerospace SCT-35 DSCS antenna system

Source: Ford Aerospace

Figure 13. Ford Aerospace SCT-8 DSCS antenna system



Source: Ford Aerospace

7. The Aquacade satellites

In 1977, a new radome (Antenna 77-A; see Figures 4, 9 and 10), about 15 metres (50 feet) in diameter, or the same size as the fifth (71-A), was installed on the northern side of the first large radome. It was probably associated with Rhyolite-3, or Aquacade-1, launched in December 1977, and Rhyolite-4, or Aquacade-2, launched four months later, although these would have mainly used the terminals built in 1968-69 for Rhyolite-1.[21]

In 1980, 69-B, the fourth dish/radome installed at Pine Gap, was upgraded. The new radome, 80-B, is 8 metres (25 feet) in diameter, substantially larger than its predecessor. It was presumably being used with the Aquacade satellites (see Figures 16, 24 and 27).

[21] Rhyolite, the US government identifying code word for the first of the Pine Gap signals intelligence satellites was changed to Aquacade after the Rhyolite program was made known to the Soviet Union by Christopher Boyce. See Ball, Robinson and Tanter, *The SIGINT Satellites of Pine Gap*, p. 9 and Table 2.

Figure 14. Six radomes, 1977

(Antennas 73-A, 68-B, 69-B, 71-A, 68-A and 77-A)

This photograph and Figure15 show the installation of a new radome around the largest antenna (68-A) in mid-1977

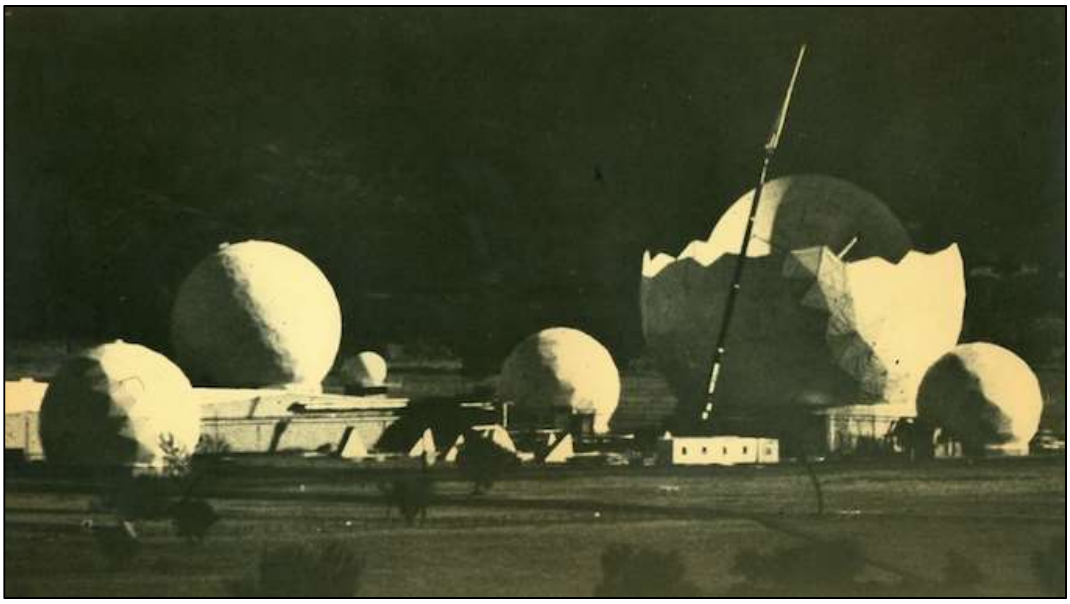


Figure 15. Six radomes, 1977

(Antennas 68-C [HF], 73-A, 68-B, 69-B, 71-A, 68-A and 77-A)

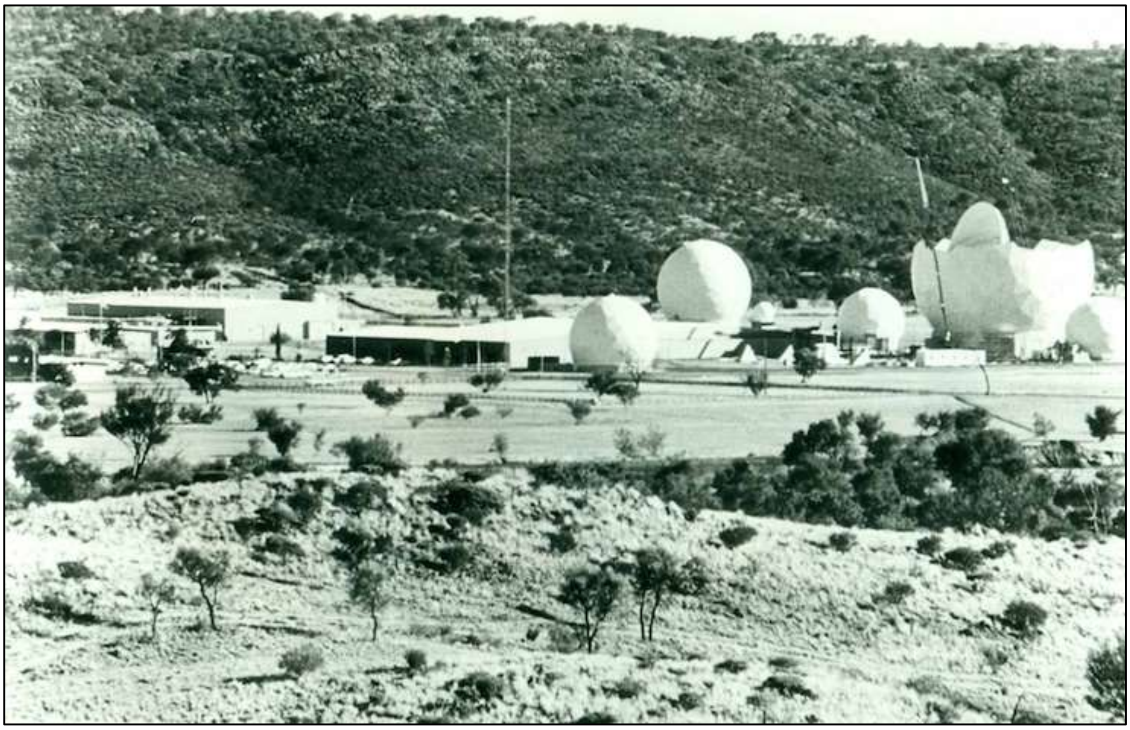
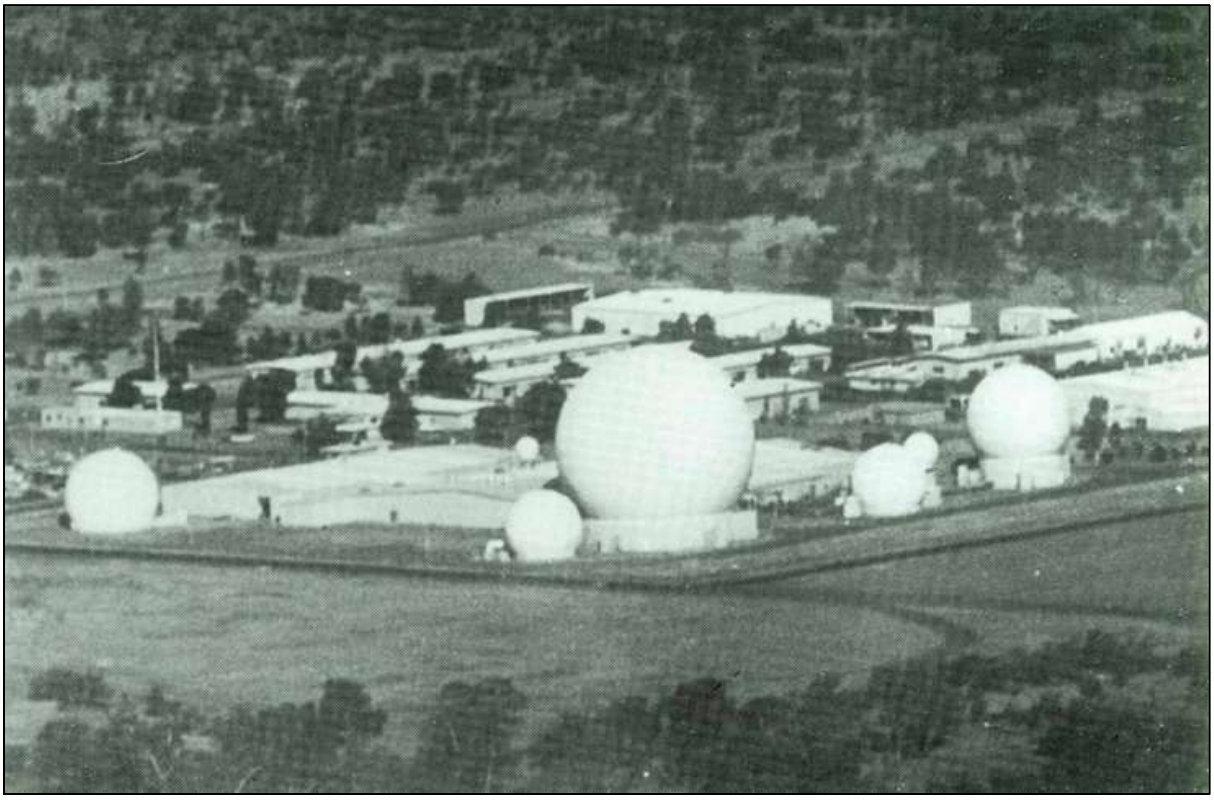


Figure 16. Seven radomes at Pine Gap, 1983
(Antennas 73-A, 77-A, 80-A [on the roof of the Operations Building], 68-A, 71-A, 80-B and 68-B)



Source: 'Concern Rises Over "Spy Role"', *Centralian Advocate,* 18 January 1985, (photograph taken January-July 1983).

8. The early Orion radomes

In July 1982, the Minister for Defence, Mr Ian Sinclair, announced that 'the construction of an additional antenna' was under consideration,[22] and in July 1983 his successor, Mr Gordon Scholes, announced the award of a contract for 'the construction of the foundations for the antenna pedestal and for the radome' for the new antenna.[23] The foundations were completed in late 1984,[24] and on 15 November 1984 the Minister for Defence announced that 'part of the new antenna for the Joint [Defence] Space Research Facility at Pine Gap will arrive in Alice Springs on Monday (November 19) in a US Air Force C5 Galaxy transport aircraft'.[25] Additional parts of

[22] 'Changes at Pine Gap Joint Facility', *Defence News Release No. 98/82*, 5 July 1982.
[23] 'New antenna at Pine Gap', *Defence News Release No. 118/83*, 8 July 1983.
[24] Photographs of the antenna foundation taken in December 1984 were published in *Centralian Advocate*, 18 January 1985, p. 1.
[25] 'Equipment to be Delivered to Pine Gap', *Defence News Release No. 205/84*, 15 November 1984.

the new antenna arrived in Alice Springs on 29 January 1985,[26] and further parts in April-May 1985.[27] (The project code-name for installation of this antenna was Credible Dove. See Figure 17.) Construction of this antenna was completed later in 1985. It is about 30 metres in diameter, housed inside a 38-metre-diameter radome (85-A), about the same size as the first large dish/radome (68-A) built in 1968, and was located at the northern end of the radome complex. According to several US press reports, the installation of this new antenna was associated with the launch of the first Orion geosynchronous SIGINT satellite (originally designated Magnum-1 before launch[28]) on 24 January 1985.[29] (The fact that the launch took place before the antenna was finished might seem to contradict this association, but it need not. The satellite was probably operated from the United States for several months after its launch in order to ensure that all systems were operating properly before it was handed over to Pine Gap for operational control.)

An antenna without a radome (86-A) was installed in 1986, another in 1987 and two in 1988. Two of these, 86-A and 88-B, probably related to the Magnum satellite which would have required additional terminals for some of its secondary down-links. (The other two, both dish antennas about 5 metres in diameter, are located south of the tennis court outside the inner secure area, identified as 87-A and 88-A in Table 1, and could be for television reception. [See Figure 18.] CNN cable television was available in January 1991, when its coverage of Operation *Desert Storm* was streamed live into the Operations Room).[30]

Another radome (89-A), which measured 7 metres (22 feet) in diameter, was installed in 1989 (see Figures 40 and 41). The timing suggests a connection with Orion-2 (Magnum-2), launched in November 1989. It was located at the southern end of the radome complex. It was later dismantled and, in 2011, a larger, 12-metre dish, 11-A, was installed on the site (see Figures 50 and 53).

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[26] 'Equipment for Pine Gap', *Defence News Release No. 11/85*, 25 January 1985. See also Richard Macey, 'US Flies in Star Wars Technology to its Pine Gap Base', *Sydney Morning Herald*, 30 January 1985, p. 5.

[27] 'Equipment for Pine Gap', *Defence News Release No. 11/85*, 25 January 1985.

[28] The first satellite of what became the Orion series was initially officially called Magnum-1, but by the time that satellite was launched from the Space Shuttle on 24 January 1985, the name had been changed to Orion-1. All subsequent NRO Orion-class geosynchronous SIGINT satellites have been officially designated numerically, from Orion-1 to Orion-8. See Ball, Robinson and Tanter, *The SIGINT Satellites of Pine Gap*, p. 9 and Table 2.

[29] See, for example, Jeffrey T. Richelson and William H. Arkin, 'Spy Satellites: "Secret", But Much is Known', *Washington Post*, 6 January 1985, pp. C1-C2. See also 'Pine Gap's Spy Role? Link with "Listening Satellite"', *Centralian Advocate*, 11 January 1985, p. 1; and 'Concern Rises Over "Spy Role"', *Centralian Advocate*, 18 January 1985, p. 3.

[30] David Rosenberg, *Inside Pine Gap: The Spy Who Came in From the Desert*, (Hardie Grant Books, Melbourne, 2011), p. 68.

Figure 17. Credible Dove, early 1985

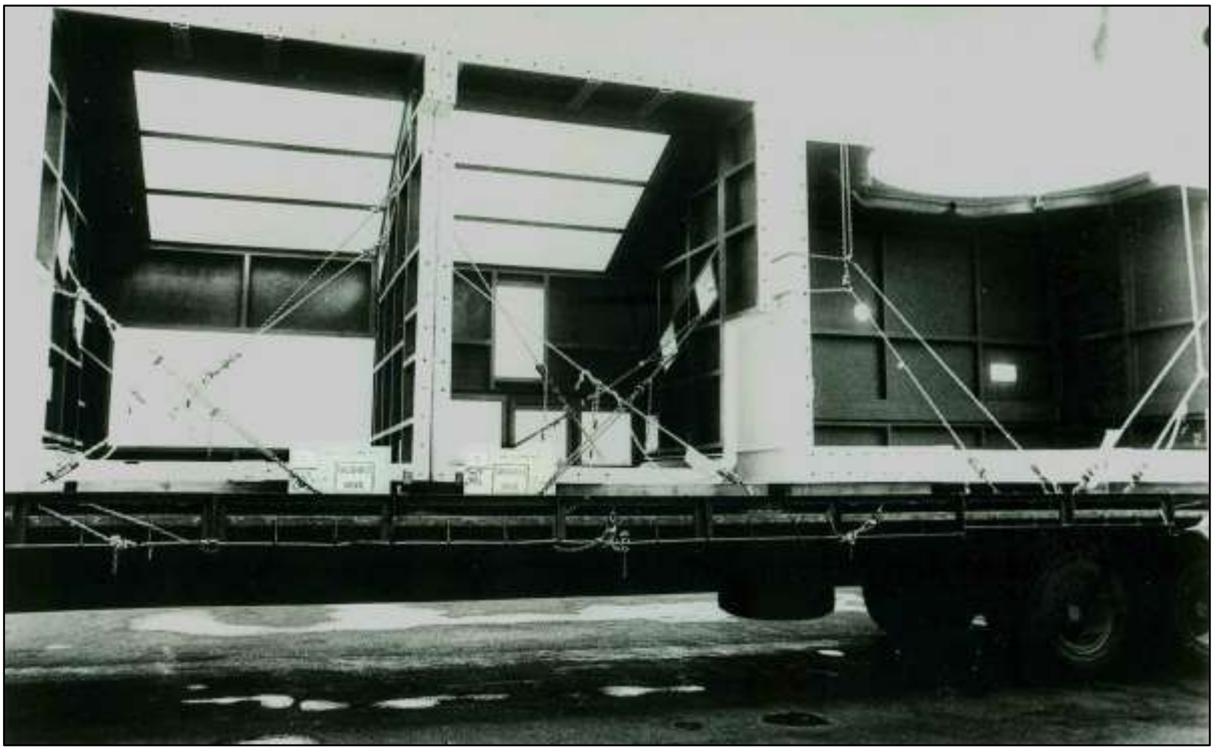


Figure 18. Antennas 87-A and 88-A, 23 January 2016

Source: Felicity Ruby, (Attribution - NonCommercial CC BY-NC).

Figure 19. Foundation for new radome (85-A, at right) constructed in late 1984

(Antennas 68-B, 80-B, 71-A, 84-A [HF LPA], 73-A, 68-A, 77-A, foundation for 85-A, and collimation tower behind 85-A)

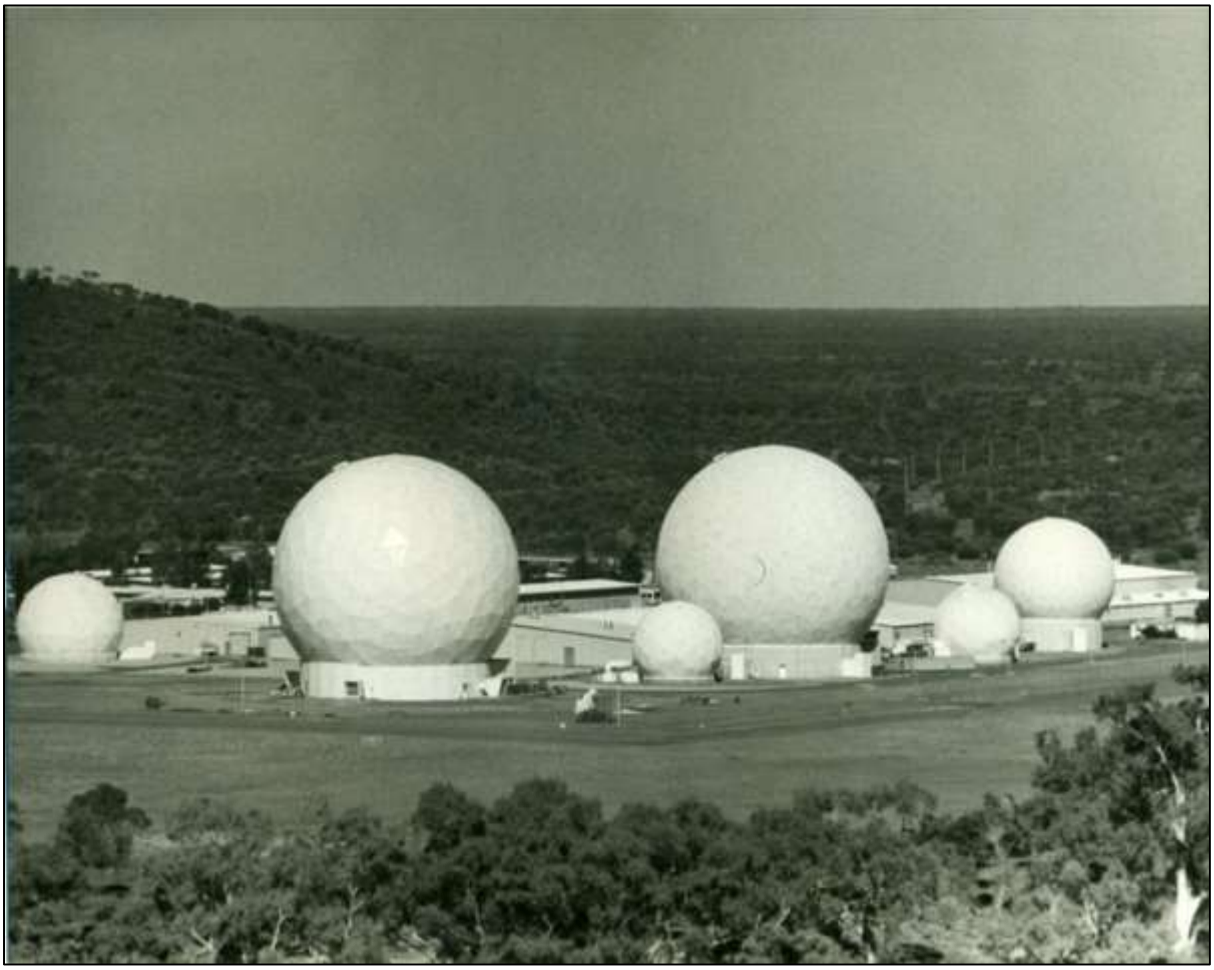
Source: 'Concern Rises Over "Spy Role"', *Centralian Advocate,* 18 January 1985.

Figure 20. Pine Gap, mid-1985, with seven radomes and new large dish under construction
(Antennas 73-A, 85-A under construction, 80-A, 77-A, 68-A, 71-A, 80-B and 68-B)

Figure 21. Eight radomes at Pine Gap, 1986

(Antennas 68-B, 80-B, 71-A, 80-A, 68-A, 77-A, 73-A and 85-A).

Figure 22. Radomes at Pine Gap, c 1986
(Antennas 73-A, 85-A, 77-A, 68-A, 71-A and 68-B)



Source: Department of Defence Public Relations, Canberra, Ref. No. CANA/85 / 315/17.

Figure 23. Radomes at Pine Gap, c 1986

(Antennas 85-A, 80-A [half hidden on roof of the Operations Building], 77-A, 68-A, 71-A and 68-B)

Figure 24. Radomes at Pine Gap in 1986

(Antennas 68-A, 71-A, 80-B, top of 73-A and 68-B)

Source: Department of Defence Public Relations, Canberra,
Ref. No. CANA/85 / 315/24.

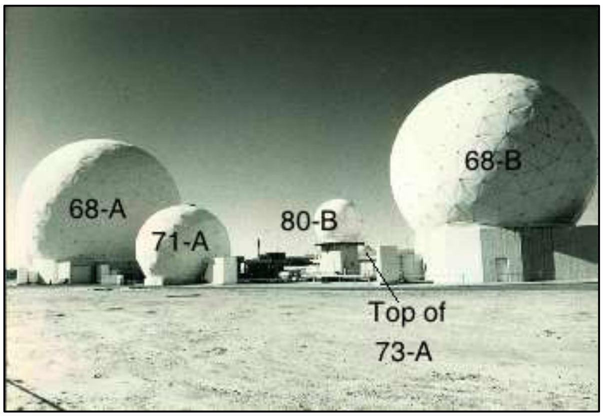


Figure 25. Radomes at Pine Gap in 1986
(Antennas 68-B, 80-B, 71-A, 68-A 77-A and 85-A)

Source: Department of Defence.

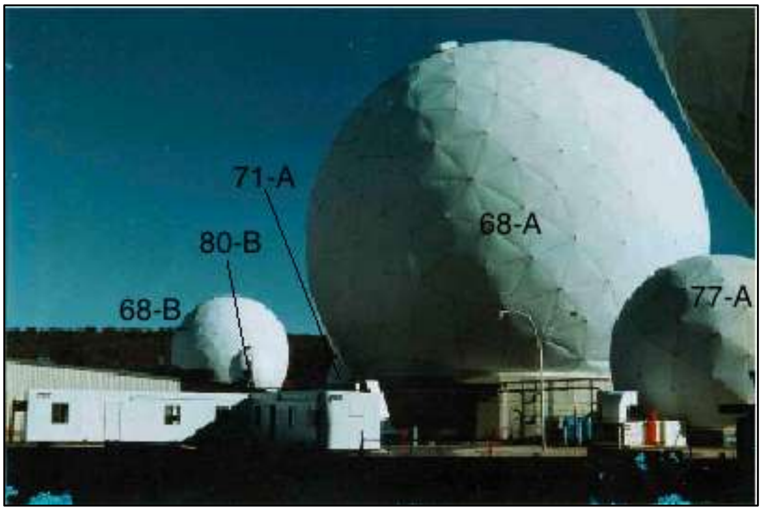
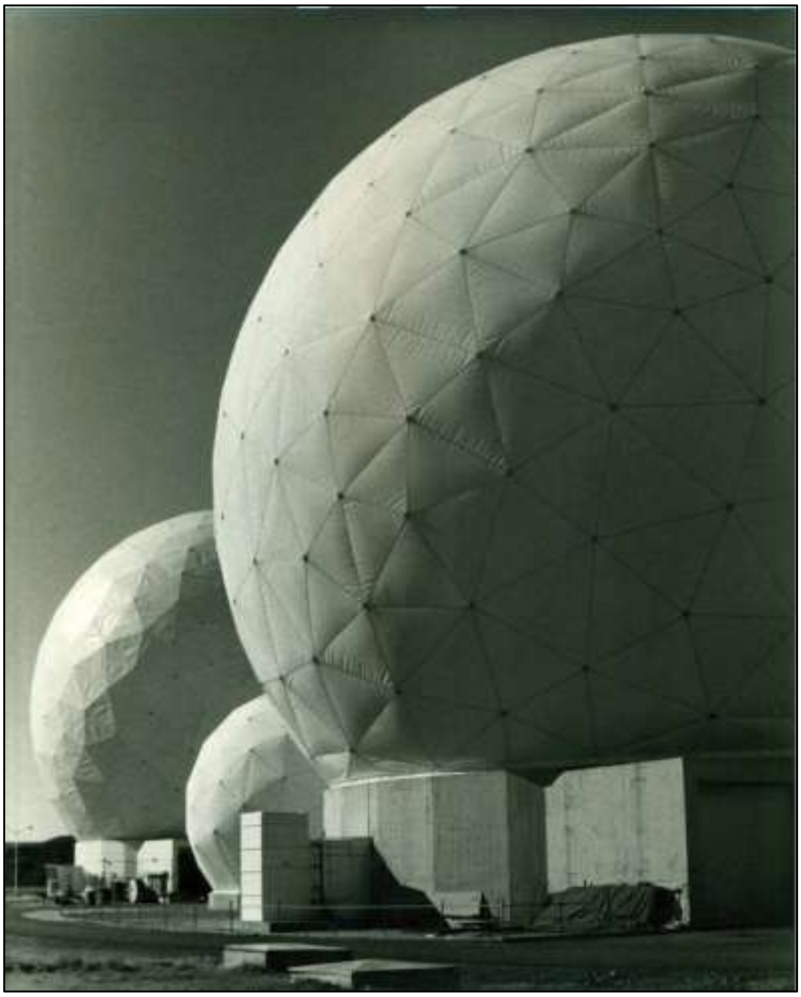


Figure 26. Radomes at Pine Gap in 1986

(Antennas 85-A, 77-A and 68-A)



Source: Department of Defence Public Relations, Canberra,
Ref. No. CANA/85 / 315/21.

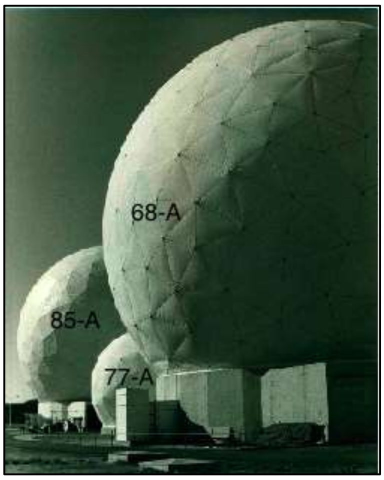


Figure 27. Radomes at Pine Gap, c 1991

(Antennas 68-B, 80-B, 71-A, 84-A HF LPA, 73-A, 68-A, 77-A, collimation tower behind 85-A, 85-A, 86-A without radome in front of 85-A, and 90-A)

Source: Erwin Chlanda, 'Spy base and Kindergarten: Are they above the law?' *Alice Springs News Online*, 12 December 2012, at http://www.alicespringsnews.com.au/2012/12/12/spy-base-and-kindergarten-are-they-above-the-law/.

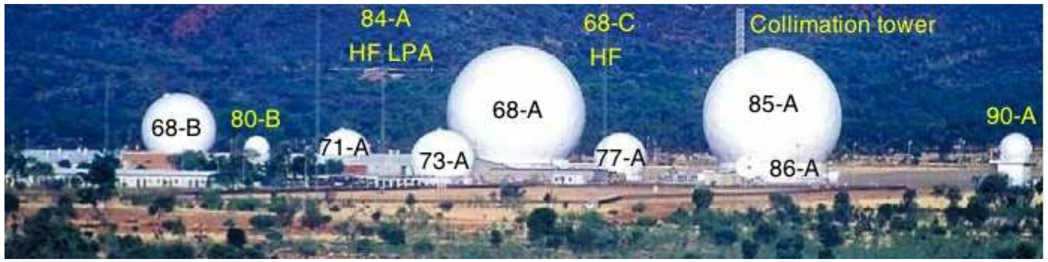


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Figure 28. Pine Gap, c 1997

(Antennas 68-B, 80-B, 80-A on the roof of the Operations Building, 71-A, 68-A, 77-A, 85-A and 86-A, with 87-A and 88-A in Administration/Recreation area)

Source: Stan and Holly Deyo, 'Pine Gap: America's Tribute to Nikola Tesla', at http://millennium-ark.net/News_Files/Newsletters/News000722/News000722.html.

9. Two new Australian radomes in 1990-91

In August 1990, the Minister for Defence, Senator Robert Ray, stated that there were then nine radomes at Pine Gap and that two more were 'to be constructed in the next 12-16 months'.[31] The contract for the new radomes (the tenth and eleventh) was awarded to TMC Constructions, an Alice Springs company, by the Australian government in 1989, and they were constructed in 1990-91. The first of them was completed in October 1990.[32] These are 9 metres and 30 metres in diameter, and are located at what was then the northeast corner of the radome complex (90-A and 90-B; see Figure 29 and 30). The enclosed antennas were designed to communicate via the new DEFAUSSAT SATCOM system with HMAS Harman in Canberra, where DEFAUSSAT antennas were also installed around this time, and from which the SIGINT data is relayed by cable to Russell Hill.[33] The new capability coincided with the move of DSD into Building M at Russell Hill in Canberra in 1991-92.

Figure 29. Antennas 90-A and 90-B, TerraServer imagery, 7 October 2014

[31] Senator Robert Ray, Minister for Defence, 'Pine Gap: Joint Facility', *Hansard (Senate)*, 21 August 1990, p. 1877, at http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=CHAMBER;id=chamber%2Fhansards%2F1990-08-21%2F0113;query=Id%3A%22chamber%2Fhansards%2F1990-08-21%2F0010%22.

[32] Greg Thomson, '$2.7 m Base Home Boost: Radomes Will be Built by Alice Firm', *Centralian Advocate*, 5 September 1990, p. 2.

[33] Desmond Ball, *Defence Aspects of Australia's Space Activities*, Canberra Papers on Strategy and Defence, 91, Strategic and Defence Studies Centre, Australian National University, 1992.

Figure 30. Antennas 90-B, 05-C, 05-D and 90-A

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

10. May 1989, September 1994 and May 2002 stock-takes

On 3 May 1989, Senator Graham Richardson, representing the Minister for Defence, in response to a Question on Notice, stated that '9 radomes and associated antennae are operating at Pine Gap along with 9 other antennae/dishes'. He added that 'antennae with radomes were constructed in 1968 (2 antennae, both radomes being replaced in 1977), 1969 (2 antennae, 1 being upgraded in size in 1980), 1971, 1977, 1980, 1985 and 1989. The other antennae or satellite dishes without radomes were constructed in 1967, 1968 (2), 1969, 1984, 1986, 1987 and 1988 (2)'. He also said that 'No radomes or antennae are under construction at Pine Gap' as of that date.[34]

On 19 September 1994, the Minister for Defence, Senator Robert Ray, stated that 'there are ten radomes and associated antennae, as well as three additional satellite antennae, at the facility'.[35] The three satellite antennas without radomes presumably were 69-C, 86-A and 88-B. The non-satellite antennas at the facility (presumably 67-A, the original UHF Yagi antenna, 68-C and 68-D, the HF transmitting and receiving antennas, and 84-A, the HF LPA), and the two satellite dishes in the administration/recreation area, 87-A and 88-A, were not discussed in the exchange.

On 28 May 2002, the Minister for Defence, Senator Robert Hill, provided a response to another Question on Notice, in which he said that 'there are 26 satellite antennas located at the Joint Defence Facility, 14 of which have environmental covers', and that four of these were 'associated with the Defence Support Program Relay Ground Station, 2 of which have environmental covers'. The Minister also provided the questioner, Ms Tanya Plibersek, a 'panoramic' photograph of the facility, taken in 1999 (Figure 31), and said that 'three new satellite antennas [had] been installed since that

[34] Senator Richardson, 'Joint Defence Facilities: Radomes and Antennae', *Hansard (Senate)*, 3 May 1989, p. 1742, at http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=CHAMBER;id=chamber%2Fhansards%2F1989-05-03%2F0116;query=Id%3A%22chamber%2Fhansards%2F1989-05-03%2F0118%22.

[35] Senator Robert Ray, 'Defence: Pine Gap Facility', *Hansard (Senate)*, 19 September 1994, p. 957, at http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=CHAMBER;id=chamber%2Fhansards%2F1994-09-19%2F0126;query=%28Dataset%3Aweblastweek,hansardr,noticer,webthisweek,dailyp,votes,journals,orderofbusiness,hansards,notices,websds%29%20ParliamentNumber%3A%2237%22%20Responder_Phrase%3A%22senator%20faulkner%22%20Electorate_Phrase%3A%22sa%22%20Party%3A%22ad%22%20ChamberSource_Phrase%3A%22senate%22;rec=13.

Figure 31. Pine Gap, 1999

Source: Department of Defence, supplied to Ms Tanya Plibersek, MHR, accompanying 'Defence: Pine Gap', *Hansard (House of Representatives)*, 28 May 2002, p. 2555.

time'.[36] These three new antennas were evidently without radomes (as no new dishes with radomes were installed between the 14 shown in the 1999 photograph and the small STSS-related antennas installed after 2005). Further, they do not include the two uncovered DSP RGS antennas (98-A and 98-B), already shown in the 1999 photograph.

In sum, according to these official figures, there was a net increase of eight antennas in the 13-year period between 1989 and 2002, five with radomes and only three without, including the two uncovered DSP RGS antennas installed in 1999. These figures are reconcilable if two uncovered antennas were dismantled sometime between 1989 and 1999. (One of these was presumably 84-A, the HF LPA).

11. DSP/SBIRS antenna systems

Six antennas, four of them with radomes, are now at Pine Gap in connection with the DSP/SBIRS infrared missile early warning and tracking system. Four of these, two with radomes and two without, were installed in 1998-99; the fifth and sixth, with radomes, were installed in 2013 (see Table 4 and Figures 32-37).

The two dish antennas with radomes installed in 1998-99 (98-A and 98-B) comprised the DSP/SBIRS Relay Ground Station (RGS). It is located in the southwest corner of the Pine Gap facility, some 250 metres from the main complex.

It was reported from Los Angeles Air Force Base on 27 March 1998 that:

> Construction is in full swing on the Relay Ground Station at the Joint Defence Facility Pine Gap, Alice Springs, Australia, since pouring both antenna foundations, along with the ring walls that anchor the air-supported radomes. The foundations are for the 10-meter antennas that are destined to control the DSP and SBIRS High satellites and receive mission data from the satellites.[37]

[36] Mrs Vale, 'Defence: Pine Gap', *Hansard (House of Representatives)*, 28 May 2002, p. 2555, at http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=CHAMBER;id=chamber%2Fhansardr%2F2002-05-28%2F0139;query=Id%3A%22chamber%2Fhansardr%2F2002-05-28%2F0000%22.
[37] 'Joint Defence Facility Pine Gap, Alice Springs', *Astro News*, Los Angeles Air Force Base, Calif., 27 March 1998, at http://www.globalsecurity.org/intell/library/news/1998/03/980327-astro-alice.htm.

Figure 32. The Relay Ground Station compound, Pine Gap

(Antennas 05-B, 12-A, 05-A, 13-A, 98-A, 98-B and 13-B)

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

The 16-metre-diameter radomes covering these two antennas were installed in 1999. Bardavcol Pty Ltd, a major South Australian civil engineering and construction company, under sub-contract from Boeing, assisted with the construction of these radomes.[38]

Also in 1998-99, two dishes were installed for DSP/SBIRS communications (99-A and 99-B). They are both about 20 metres (66 feet) in diameter. They are located at each end of an associated support building, which is about 12 metres wide and 16 metres long, in the northeastern corner of the main complex (see Figures 42-46). They normally both point to the northeast, sometimes with the same azimuths. However, an aerial photo taken in July 2011 shows 99-A pointing to the northwest, while in TerraServer imagery dated 20 September 2012, 99-A is pointing acutely to the northeast and 99-B is only slightly east of north. They are both pointing to the northeast in TerraServer imagery dated 8 October 2013. In Google Earth imagery dated 6 November 2015, they are both pointing up to slightly north of east.

They provide a link to the SBIRS Mission Control Station (MCS) at Buckley Air Force Base (AFB), near Denver, Colorado, and the Mission Control Station Backup at Schriever AFB near Colorado Springs. (The processed data is then relayed to HMAS Harman in Canberra, and then sent to the Defence Department at Russell Hill and the Headquarters Joint Operations Command [HQJOC] at Bungendore.)

Two small (5-metre) dishes without radomes were installed in the RGS area, just north of the first two DSP/SBIRS radomes, in 2003-04 (03-A and 03-B; see Figure 33). They were dismantled in 2011-12.

Two new large antennas with radomes (13-A and 13-B) were built in the RGS area between late 2012 and mid-2013, and are presumably related to prospective SBIRS satellite launches (see Figures 35-37). Antenna 13-A, with a 16-metre radome, is the same size as the previous two. It was built immediately to the north of 98-A and 98-B, close to the site of one of the dismantled small dishes (03-B). It is shown nearly completed in Google Earth imagery dated 9 January 2013.

[38] James Crisera, *LinkedIn*, at https://au.linkedin.com/pub/james-crisera/a8/472/a32.

Table 4.
DSP/SBIRS/STSS-related satellite antennas and radomes at Pine Gap

(a) DSP/SBIRS Relay Ground Station

No.	Authors' ID system	Size (ft.) antenna/ radome	Size (m.) antenna/ radome	Coordinates	Built	Comments
23	98-A	33/52	10/16	23.800425°, 133.732769°	1998	Radome. DSP/SBIRS.
24	98-B	33/52	10/16	23.800811°, 133.732769°	1998	Radome. DSP/SBIRS.
33	03-A	16/	5/	23.799829°, 133.732699°	2003-2004?	No radome. RGS area. Dismantled in 2011-2012.
34	03-B	16/	5/	23.800025°, 133.732712°	2003-2004?	No radome. RGS area. Dismantled in 2011-2012.
36	05-A	?/17	?/5	23.799853°, 133.733103°	2005-2008?	Radome. STSS-related?
37	05-B	?/17	?/5	23.799856°, 133.733361°	2005-2008?	Radome. STSS-related?
44	12-A	?/17	?/5	23.799822°, 133.733232°	2012	Radome. STSS-related?
45	13-A	33?/52?	10/16	23.800003°, 133.732771°	2013	Radome. DSP/SBIRS.
46	13-B	?/52?	?/16?	23.801743°, 133.732762°	2013	Radome. SBIRS-related?

(b) Northern section of SIGINT compound

No.	Authors' ID system	Size (ft.) antenna/ radome	Size (m.) antenna/ radome	Coordinates	Built	Comments

25	99-A	66/	20/	23.795116°, 133.737281°	1999?	No radome. Communications re DSP/SBIRS.
26	99-B	66/	20/	- 23.795576°, 133.737288°	1999?	No radome. Communications re DSP/SBIRS.

The fourth radome (13-B), which appears to be about the same size as the others but has a different design, was installed in early to mid-2013. Unusually, it was located outside the main compound. It is almost in a straight line with 98-A, 98-B and 13-A, but it was 50 metres south of the compound fence (latitude 23.801661° S, longitude 133.732888° E). The fence was subsequently re-routed to include 13-B within the compound.

Figure 33. DSP/SBIRS RGS compoundGoogle Earth imagery, 11 August 2005

Figure 34. DSP/SBIRS RGS compound, 2012
Here.com imagery

Figure 35. DSP/SBIRS RGS compound
Google Earth imagery, 9 January 2013

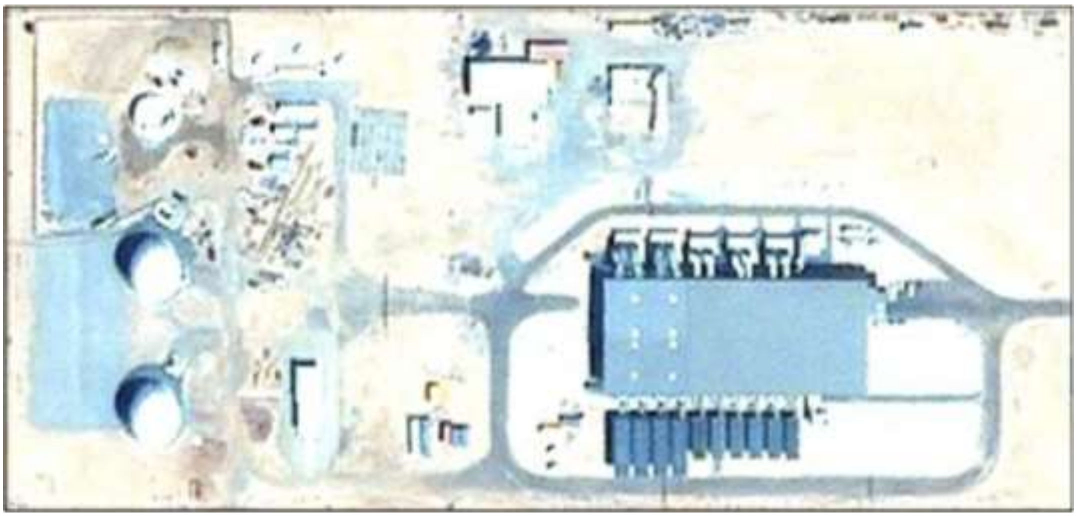

Figure 36. DSP/SBIRS RGS compound
Google Earth imagery, 2 October 2014

Figure 37. DSP/SBIRS overhead persistent infrared antennas, Pine Gap

(Antennas 13-A, 98-A, 98-B and 13-B)

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

12. The Space Tracking and Surveillance System (STSS) antenna systems

There are three 5.3-metre radomes, 05-A, 05-B and 12-A, probably associated with the Space Tracking and Surveillance System (STSS), located in a west-east line at the northern side of the DSP/SBIRS RGS (see Figures 38 and 39).

The first two of these were installed between 2005 and 2008, and the third in 2012. (Three identical radomes were installed at Buckley, Colorado, in 2009-10). The first two STSS satellites had originally been scheduled for launch in 2006-07, but were delayed until 2009.

Figure 38. Three 5.5-metre STSS radomes, 2012
(Antennas 05-A, 12-A and 05-B)

Source: Here.com, 2012.

Figure 39.
Antennas 05-B, 12-A and 05-A

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

13. Foreign satellite/communications satellite (FORNSAT/COMSAT) interception antenna systems

Two 22-metre dishes covered with 30.5-metre radomes were built in 1999 (99-C and 99-D). They are located just north of 85-A, the large dish/radome established in connection with Magnum-1 (see Figures 4, 40 and 41). The radome elements were installed by Bardavcol Pty Ltd under sub-contract from Boeing.[39]

Figure 40. FORNSAT radomes under construction, early 1999
(Antennas 98-B, 98-A, 89-A, 68-B, 80-B, 71-A, 80-A, 68-A, 77-A, 85-A, 99-C and 99-D under construction, 90-A and 90-B)

Source: Philip Dorling, 'Pine Gap drives US drone kills', *Sydney Morning Herald,* 21 July 2013 (photograph supplied), at http://www.smh.com.au/national/pine-gap-drives-us-drone-kills-20130720-2qbsa.html.

[39] James Crisera, *LinkedIn*, at https://au.linkedin.com/pub/james-crisera/a8/472/a32.

Figure 41. FORNSAT radomes (99-C and 99-D) under construction, early 1999 (Antennas 98-B, 98-A, 89-A, 68-B, 80-B, 71-A, 80-A, 68-A, 77-A, 85-A, 99-C, 86-A in front of 99-C, 99-D, 90-A, 90-B, 99-B, 99-E, 99-A.)

Source: '"Pine Gap", Australian Map - Military Communications, Spy Bases and Nuclear Ship Ports', at http://australianmap.net/pine-gap/.

Both the timing and the size of these two antennas suggest that they are used for Foreign satellite/communications satellite (FORNSAT/COMSAT) interception, a function which Pine Gap acquired around 1999-2000.[40] Their size corresponds closely to that commonly used for the ground terminals of international telecommunications satellites. More than 100 US military personnel moved to Pine Gap around 1999-2000, members of the Service Cryptologic Agencies (SCAs) who comprised the new Combined Support Group (CSG). Most of these were engaged in FORNSAT/COMSAT collection. The Air Force component, Detachment 2 of the 544th Intelligence Group (IOG), had previously been stationed at Sabana Seca in Puerto Rico, where they had worked for a FORNSAT program code-named Coraline, which was equipped with two 32-metre dishes and had intercepted satellite communications as part of the Echelon program.[41]

The Pine Gap operation is part of a global network of UKUSA FORNSAT/COMSAT collection stations, which includes NSA stations at Misawa in Japan (*Ladylove*) and Menwith Hill in the UK (*Moonpenny*), as well as GCHQ stations at Bude in Cornwall (*Carboy*), Ayios Nikolaos in Cyprus (*Sounder*), and Seeb in Oman (*Snick*), the CSE station at Leitrim, Ontario (*Candleglow*),

[40] The terms FORNSAT and COMSAT have the same meaning in this report, but are used to reflect different usage as between NSA (FORNSAT) and some of its Second Party partners (COMSAT).
[41] See Desmond Ball, Bill Robinson and Richard Tanter, *The militarisation of Pine Gap: Organisations and Personnel*, Nautilus Institute, Special Report, 14 August 2015, at http://nautilus.org/wp-content/uploads/2015/08/The-militarisation-of-Pine-Gap.pdf.

ASD stations at Geraldton in Western Australia (*Stellar*) and Shoal Bay in the Northern Territory, and New Zealand's GCSB station at Waihopai (*Ironsand*) (see Map 1 below).[42]

14. Antennas without radomes, 1999-2005

Four antennas not covered by radomes were installed from 1999 to around 2005 (not counting the two uncovered DSP/SBIRS dishes installed in 1999, 99-A and 99-B, or the two 5-metre dishes installed at the RGS site in 2003-04, 03-A and 03-B). There are two inter-related explanations for this flurry of activity. First, it coincides with the deployment of the US military elements to Pine Gap, who may have needed additional Satcom capabilities for their communications with NSA HQ at Fort Meade or their parent Service intelligence agencies.

Second, it coincides with the beginnings of active involvement by the US National Geospatial-Intelligence Agency (NGA) at Pine Gap. In May 1999, the NRO promulgated a Memorandum of Understanding on a 'Quadripartite Imagery and Measurement and Signatures Intelligence (MASINT) Research and Development Program', which may have required facilities at Pine Gap. In any case, imagery and geospatial data were being increasingly accessed by Pine Gap personnel, including both the NSA's civilian and military contingents, from around 1999-2000, which likely required some Satcom capability.

One antenna, 99-E, was installed in 1999 (it is present in the 1999 Department of Defence photograph). It was a 3-metre-diameter Satcom dish, near the northeast corner of the support building between 99-A and 99-B (see Figures 1 and 42-46). It was pointing up to the northeast in TerraServer imagery dated 17 October 2009. Antenna 99-E was present in Terraserver imagery dated 7 October 2014, and may be present in Google Earth imagery dated 6 November 2015, but had been removed by 6 January 2016.[43]

Another antenna without a radome (01-A) was installed around 2001. It was present in Google Earth imagery dated 8 September 2004. It is a 6-metre-diameter Satcom dish, located near the northwest side of the support building between 99-A and 99-B. It was pointing almost directly north in TerraServer imagery dated 20 September 2012, but it is usually oriented to the northeast.

A 2.5-metre-diameter dish (01-B) was also installed just west of 01-A, near the other Satcom antennas in the northeast part of the facility. It is also shown in Google Earth imagery

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[42] See Desmond Ball, Duncan Campbell, Bill Robinson and Richard Tanter, *Expanded Communications Satellite Surveillance and Intelligence Activities utilising Multi-beam Antenna Systems*. On the UKUSA Agreements and Five Eyes see Fn 2 therein.

[43] See Terraserver imagery for 7 October 2014 at http://bit.ly/1KeFhTu; and for1 January 2016, at http://bit.ly/23P6pPy.

dated 8 September 2004, as well as TerraServer images dated 17 October 2009 and 20 September 2012, but it was no longer there in TerraServer imagery dated 8 October 2013. It was pointed to the northeast in TerraServer imagery dated 20 September 2012.

The fourth antenna system without a radome installed in the early 2000s was a 2-element UHF helical array, which was in place by September 2004.

Figure 42. Antennas 99-A, 01-B, 01-A, 99-E, 04-A and 99-B
Google Earth imagery, 8 September 2004

Figure 43.
Antennas 99-A, 01-B, 01-A, 99-E, 04-A, 99-B and 05-E
TerraServer imagery,
17 October 2009

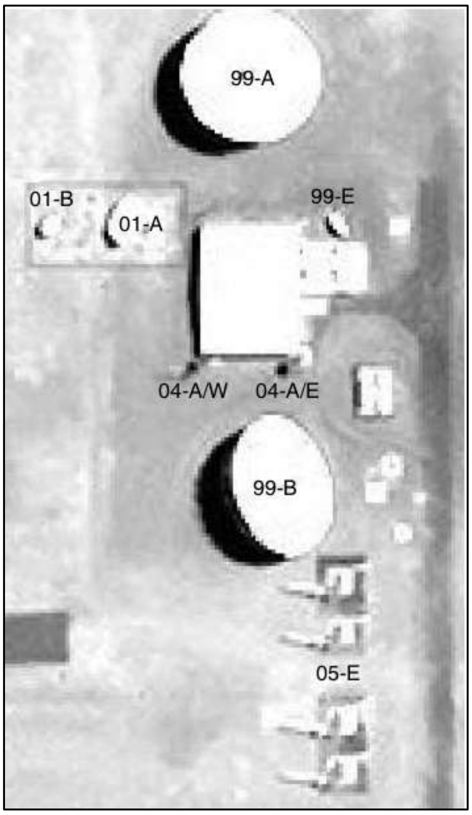


Figure 44.
. Antennas 99-A, 01-B, 01-A, 99-E, 99-B, 04-A and 05-E
TerraServer imagery,
20 September 2012

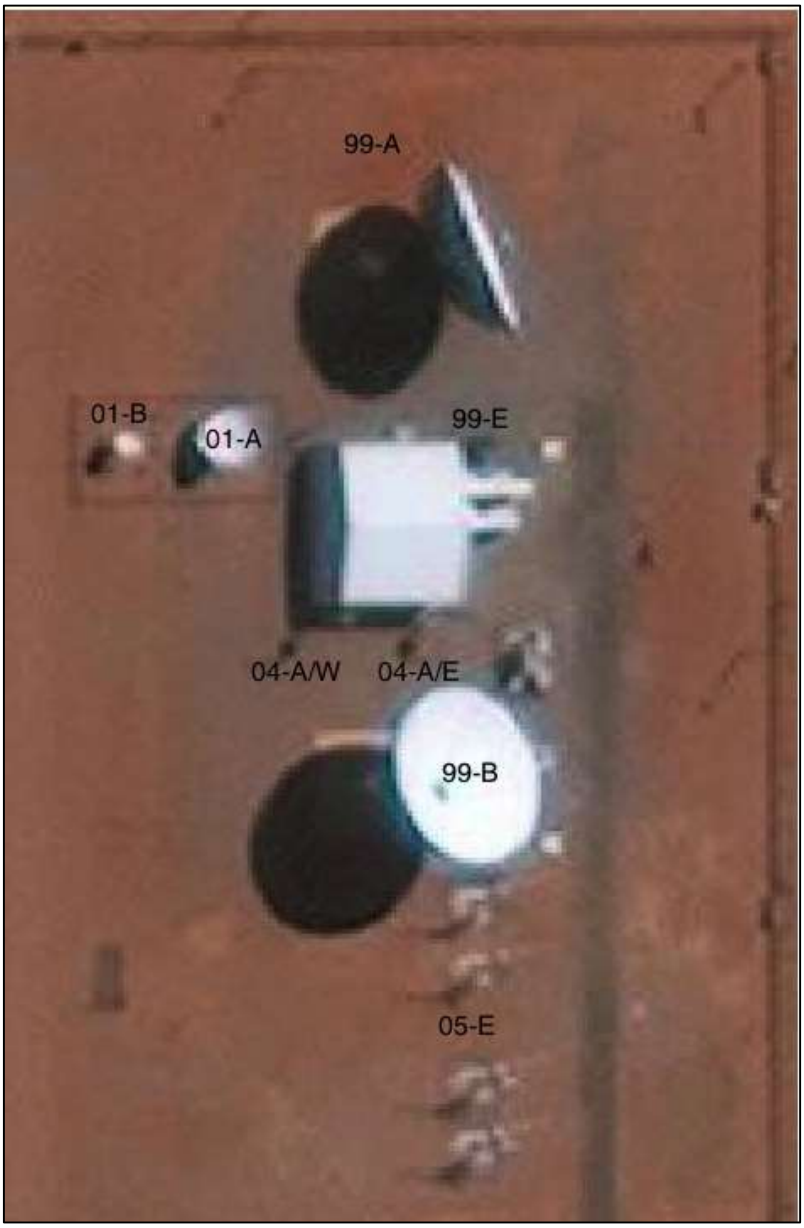


Figure 45. Antennas 99-A, 01-A, 99-E and 99-B
TerraServer imagery, 8 October 2013

Figure 46. DSP/SBIRS communications antennas

Antennas 99-A, 99-E, 01-A, 99-B, 04-A (helical array), 99-B and 05-E (helical array)

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

15. The UHF Helical antenna systems

Two sets of helical antennas were installed between 2004 and 2009 (04-A and 05-E in Table 1; see Figures 42-47). They are located in the northeast corner of the main complex, where they seem to be associated with other satellite communications dishes (including 99-A and 99-B). The first set (04-A) consists of two masts holding single helicals, about 4 metres long, and is located near the southwest (04-A/W) and southeast (04-A/E) corners of the building between 99-A and 99-B; they were present in Google Earth imagery dated 8 September 2004. The second set (05-E) consists of four masts, each with twin helixes about 5.5 metres long fixed at right angles to each other; they were not present in Google Earth imagery dated 11 August 2005, but are shown in TerraServer imagery dated 17 October 2009 (see Figure 32).

Helical Satcom antennas operate in the upper part of the UHF frequency range, usually around 1.8 to 2.4 GHz. They are circularly-polarised, which is advantageous for satellite communications, but are unable to achieve the higher gains obtained with larger dishes. They are unidirectional along the axis of the helix.

Figure 47. Helical array
(Antenna 05-E in two sets of two to right of 99-B)

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

A similar helical array is at HMAS Harman in Canberra. It is located on the roof of a building in the Satcom area on the southern side of the base, and consists of nine sets of twin helixes. A single helical antenna has also been installed on the roof of ASD's Building N at Russell Hill.

Another similar array is at the US Army's Transmitter Facility at Egelsbach, near Frankfurt, in Germany. It has 16 helixes, including four sets of twins. An array at the MUOS [Mobile User Objective System] at Wahiawa in Hawaii has five single helixes.[44]

16. Antennas without radomes, 2005-2015

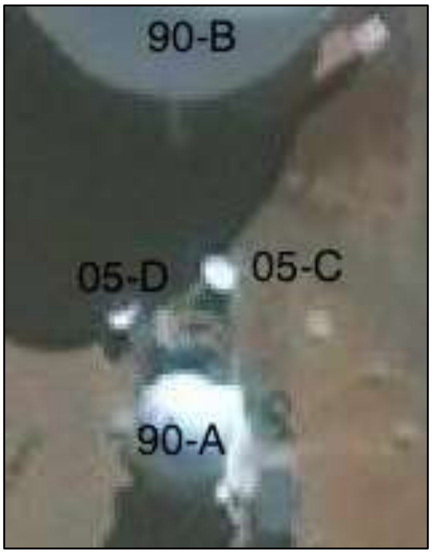
Two 4-metre-diameter dishes (05-C and 05-D), built between 2005 and 2009, are located between 90-A and 90-B (see Figures 30, 48 and 49). Neither was present in Google Earth imagery dated 11 August 2005, but they are both there in TerraServer imagery dated 17 October 2009. They both frequently change their azimuths. (05-C was pointing just slightly east of north in TerraServer imagery dated 10 February 2010; it was pointing much more sharply to the northeast in TerraServer imagery dated 20 September 2012; and it was pointing just slightly to the northeast in Google Earth imagery dated 6 November 2015. 05-D was almost vertical in TerraServer imagery dated 20 September 2012, but was pointing to the northwest in Google Earth imagery dated 6 November 2015.

It is likely that one of these provided connectivity with the NGA. In 2007-08, the NRO arranged for Pine Gap to have real-time access to all NGA products, to be fused with the SIGINT collected at the site. At the same time, NRO's Ground Enterprise Directorate (GED) and Mission Integration Directorate (MID) established mechanisms for the fused intelligence to be accessed by an increasing number of users.[45]

[44] 'MUOS Images', at http://thesoldiersnetwork.com/muos-images/.
[45] See Desmond Ball, Bill Robinson, and Richard Tanter, *The Higher Management of Pine Gap*, Nautilus Institute Special Report, 18 August 2015, p. 22 ff., at http://nautilus.org/?p=46660.

Figure 48. Two 4-metre dishes, Antennas 05-C and 05-D
TerraServer imagery
(Note changing azimuths.)

10 February 2010



20 September 2012

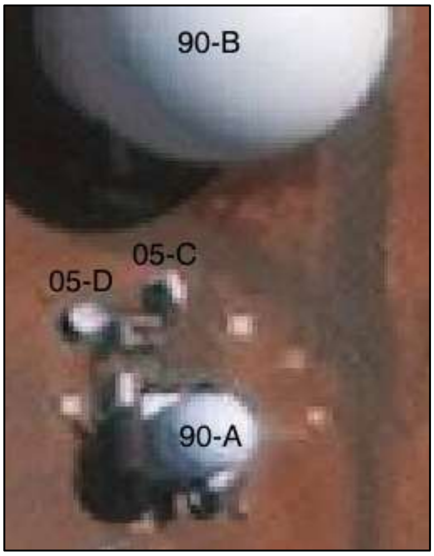


Figure 49. Two 4-metre dishes, Antennas 05-C and 05-D

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

17. The Torus multi-beam antenna system

A large Torus multi-beam antenna was installed at Pine Gap in 2008 (08-A in Table 1). It is located a little more than 200 metres south of the main compound in an entirely separate fenced compound measuring 55 m x 50 m, and was the first operations-related satellite antenna at Pine Gap located outside the principal antenna compound. The antenna is installed on top of a concrete pad approximately 17 metres wide, and is fixed on top of a steel frame, next to a small building (see Figures 50, 51, and 53).

In multi-beam antennas, which are fixed in position and have no moving parts, the reflector, shaped spherically in its horizontal plane, reflects incoming radio waves back toward their source, to be captured at their particular focal points by feeds and attendant Low Noise Blocks (LNBs) slotted into the arc of the feed-box. The LNBs receive the very low level microwave signals from the satellite feeds, amplify them, change the signals to a lower frequency band and send them down the cable to the indoor receiver.

The virtue of a multi-beam antenna, compared to the more common parabolic dish type, is that it has an arc of view of between 70^o and 75^o, and is consequently able to receive satellite transmissions from 35 or more satellites simultaneously without degradation in performance (given a nominal separation between satellites of 2 degrees).[46] Moreover, a large number of transponders on all of these satellites can each be monitored simultaneously, meaning, for example, that even a smaller commercial Simulsat antenna of this type can receive almost 1,000 satellite channels simultaneously (compared with 24-32 simultaneously received channels for a comparable parabolic antenna).[47]

The antenna at Pine Gap faces north-northwest, bore-sighted at 329 degrees towards the equator, and corresponding to 120 degrees East on the geostationary belt. Its purview extends from about 85 degrees East to about 155 degrees East longitudes, capable of intercepting signals from communications satellites and other satellites in geostationary orbits over the equator from the mid-Indian Ocean region to the western Pacific Ocean.

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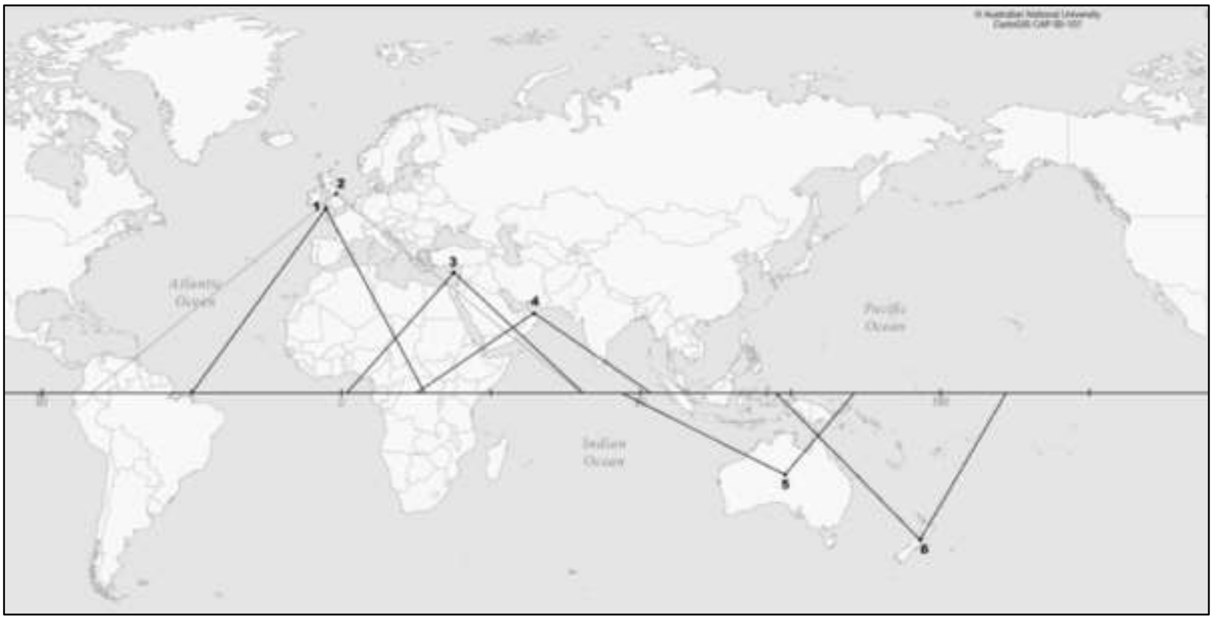
[46] "For the satellites that are reflected by the edges of the reflector, there is some spill-over and there is also more ground noise that the feeds are exposed to. However, the overall effect of this is minor and we have not seen a discernible difference in performance between edge feeds and middle feeds." *Simulsat Explained - Frequently Asked Questions*, ATCi, at http:// www.atci.com/assets/simulsat-faq.pdf.

[47] *Simulsat Multibeam Earth Station Product Family*, (ATCi, 2012), at http://www.atci.com/assets/simulsat_brochure2012.pdf. The CEO of ATCi boasted that "the ability to enable surveillance of 70 satellites simultaneously on approximately two parking spaces has created an incredible tool for the U.S. Department of Defense and other like agencies worldwide". Spotlight interview with Gary Hatch, ATCi CEO, at http://www.atci.com/assets/spotlight-interview.pdf.

Similar Torus antenna systems are located at the FORNSAT/COMSAT interception stations at Menwith Hill, Bude, Ayios Nikolaos, Seeb and Waihopai, providing global coverage (see Map 1).[48]

Map 1. Torus sites and coverage of the geostationary satellite belt



Note: Torus sites: 1 Bude, U.K.; 2 Menwith Hill, U.K.; 3 Ayios Nikolaos, Cyprus; 4 Seeb, Oman; 5 Pine Gap, Australia; 6 Waihopai, New Zealand. The grey lines extending from Menwith Hill show the entire section of the geostationary arc visible from that site. Like the antennas at the other Torus sites, the Torus at Menwith Hill is capable of monitoring only 70 degrees of the arc. Its orientation cannot be determined because the antenna, uniquely, is inside a radome.

[48] On primary and secondary FORNSAT/COMSAT interception missions see Desmond Ball, Duncan Campbell, Bill Robinson and Richard Tanter, *Expanded Communications Satellite Surveillance and Intelligence Activities utilising Multi-beam Antenna Systems*. See also Duncan Campbell, '"Torus": has one word in a Snowden leak revealed a huge expansion in surveillance?'.

Figure 50. Antenna 08-A, Torus multi-beam antenna
12 October 2013
(Antennas 68-A, 71-A, 68-B, 11-A, and 08-A at rear)

Source: Richard Tanter, (Attribution - NonCommercial CC BY-NC).

Figure 51. Antenna 08-A, Torus multi-beam antenna, 23 January 2016

Source: Felicity Ruby, (Attribution - NonCommercial CC BY-NC).

Figure 52. Torus multi-beam antenna compound, TerraServer imagery, January 2010

18. Orion-7 radome in 2010-11

The Australian Department of Defence announced in December 2009 that 'the antenna farm' at Pine Gap was to be upgraded, that the upgrades were 'expected to commence in May 2010', that 'these upgrades are intended to replace aging equipment and address technological change', and that 'the refurbishment [is] expected to be completed by 2014'.[49] A large radome, about 38 metres (125 feet) in diameter, was installed in 2010-11 (10-A; see Figures 4, 54, 55). It is the same size as the first large radome (68-A) installed for the Rhyolite satellites and 85-A installed in 1984-85 for Magnum-1 (Orion-1). It is undoubtedly associated with Orion-7, which was launched on 21 November 2010.

Construction of 10-A began in late 2010. TerraServer imagery dated 22 January 2011 shows that the foundation for the antenna/radome had been built, at the northern end of the radome complex (Figure 54). A photograph of Pine Gap taken on 18 October 2011 shows it fully constructed.[50]

In addition, as part of this 'refurbishment', a 12-metre-diameter satellite dish (11-A) was installed near the southern end of the radome complex (see Figure 53). It is on the site previously occupied by 89-A, which was a much smaller dish housed in a 7-metre radome.

Figure 53. Antenna 11-A, 23 January 2016

Source: Felicity Ruby, (Attribution - NonCommercial CC BY-NC).

[49] 'Australia to Upgrade Pine Gap Radar Antenna', *Defense-Aerospace.com*, 15 December 2009, at http://www.defense-aerospace.com/article-view/release/110674/australia-to-upgrade-pine-gap-radar-antenna.html.
[50] Angel PC and Susana SF, 'Base Militar de Pine Gap (Australia)', *Panoramio*, at http://www.panoramio.com/photo/64219611.

Figure 54. Antenna 10-A commencing construction, TerraServer imagery, 22 January 2011

Figure 55. Antenna 10-A

Source: Kristian Laemmle-Ruff, (Attribution - NonCommercial CC BY-NC).

19. Conclusion

The 46 antenna systems that have been installed at Pine Gap over the past five decades have mostly belonged to its core function: controlling the geosynchronous SIGINT satellites, maintaining the boresights of the intercept antennas on those satellites, downlinking the intercepted data from the satellites, and sending both raw and processed data to an increasing number of users. The increased number of SIGINT-related antenna systems mostly reflects the launching of new satellites, most recently the 5.2-tonne Orion-7 in 2010. But four original antennas installed in 1968, including two satellite terminals installed for the first Rhyolite satellite launched in June 1970, are still in place and operational.

Eleven antennas have been installed at the DSP/SBIRS Relay Ground Station since it was established at Pine Gap following the closure of the Joint Defence Space Communications Station at Nurrungar in 1999. The RGS now has six satellite terminals downlinking and relaying early warning and missile tracking data from Defense Support Program (DSP) and Space Based Infrared System (SBIRS) satellites. Another three radomes are probably associated with the US Missile Defense Agency's Space Tracking and Surveillance System (STSS) developmental satellites aimed at providing more reliable and accurate tracking and targetting of ballistic missiles after the DSP and SBIRS satellites have detected their launch.

The introduction of Pine Gap's third mission – the interception foreign communications satellite transmissions (FORNSAT/COMSAT) around the end of the last century resulted in the installation of two large new satellite terminals enclosed in radomes in 1999. This mission was amplified by the installation of a Torus multi-beam antenna installed in 2008, permitting the integration of Pine Gap into a new and increasingly comprehensive Five Eyes approach to SIGINT collection from communications satellites that emphasizes increased access to global Internet traffic carried by satellite.

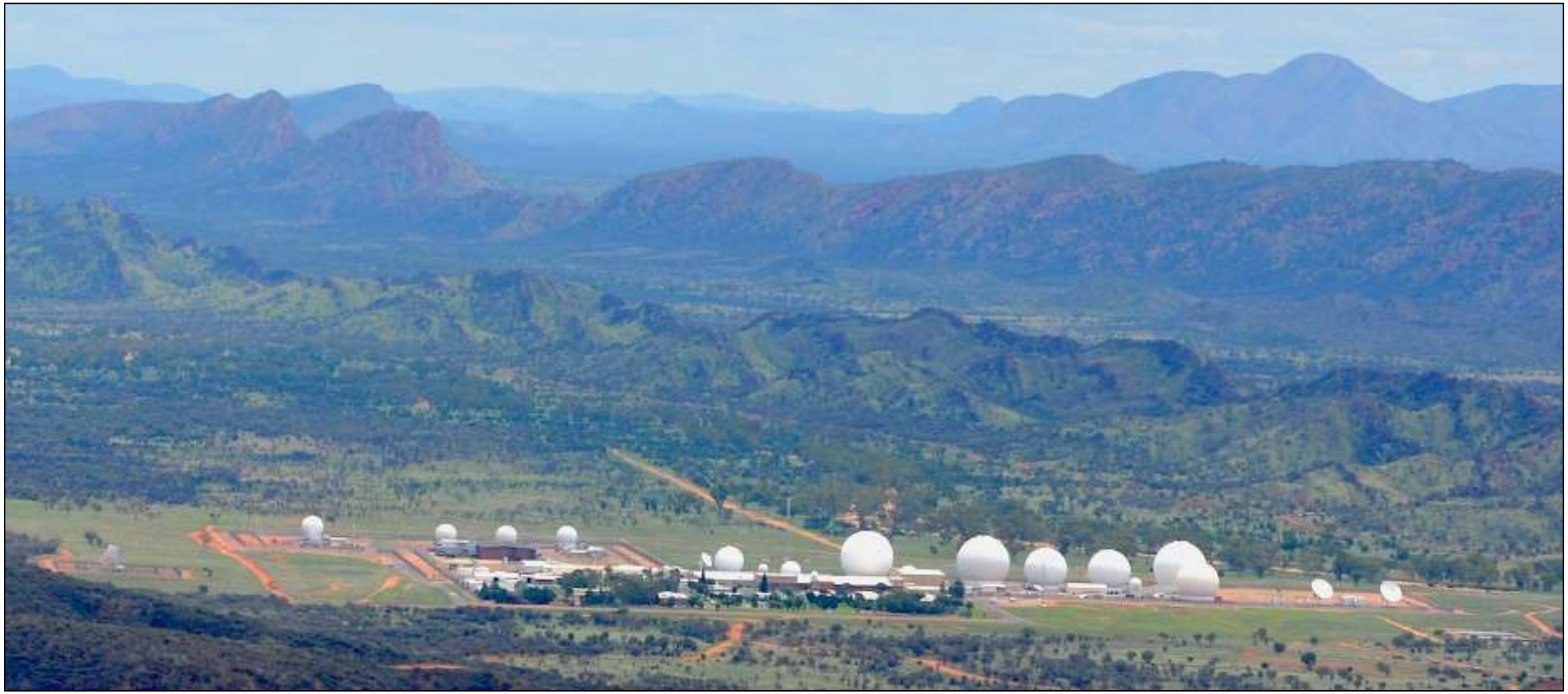
Two clusters of smaller antennas installed in between 1990 and 2005 reflected increasing needs for satellite connectivity of the US military elements that began to be deployed in that period, and the increased role of the US National Geospatial-Intelligence Agency in the facility and the integration of its products into 'fused' intelligence. Two large satellite antennas installed in 1990 enabled the transmission of SIGINT data by satellite to Canberra.

Beyond the reality of the base's US and Australian intelligence and military roles, it is important to understand that Pine Gap and its antennas are significant elements in Australian political culture, with the antennas occupying a literally iconic place in the Australian imaginary.

Located in Central Australia just a short way from Alice Springs, a town that most Australians never visit, Pine Gap vies with Uluru for primacy as the symbolic centre of the country. In countless media reproductions of a small number of images, the physiognomy of the base, with its faceless white domes jumping out of the browns and greens of the McDonnell Ranges, contributes much to associations of mystery and potency.

While the radomes themselves are quite prosaic – providing environmental protection and limiting adversary knowledge of the antennas' operations – their featureless white spherical shapes act as a container of powerful projections of promise and threat. Coupled with a deep history of official evasion and secrecy, an association with uncontrollable foreign powers, extraordinarily sophisticated technology, the necessarily fantasy-laden realms of space and war, nuclear threat, and most recently, the provision of targetting data for US drone assassinations, it is hardly surprising that the antennas of Pine Gap are powerful political symbols.

Figure 56. Pine Gap, from the southeast, 23 January 2016



Source: Felicity Ruby, (Attribution - NonCommercial CC BY-NC).