example, the CBU-72/B generates overpressures of 300 psi. Overpressures of 465 psi - equivalent to the blast wave effect of a 20 kiloton nuclear explosion at a distance of 500 feet from ground zero - are within the state of the art. See Steven J. Rosen and Desmond J. Ball, 'Fuel Air Explosives for Medium Powers', Pacific Defence Reporter (Vol.3, No.10), April 1977, pp.16-18; and S. Schaetzel, 'FAE Development Potential in Australia', Pacific Defence Reporter (Vol.3, No.11), May 1977, pp.50-51. A concrete aircraft shelter six feet thick can only resist 70 psi. See A.S. Fraser, 'Tactical Fighter Force Security', Defence Force Journal (No.18), September/October 1979, pp.24-31.

10. Gavin Long, The Six Years War: Australia in the 1939-1945 War (The Australian War Memorial and the Australian Government Publishing Service, Canberra, 1973), p.216.
11. Timothy Hall, Darwin 1942: Australia's Darkest Hour (Methuen Australia Pty Ltd, Sydney, 1981 reprint).
12. Australian Defence (White Paper presented to the Parliament by Hon. D.J. Killen, Minister for Defence, Government Printer of Australia, 4 November 1976).
13. The Age, 29 October 1981. Emphasis added.
14. See Hansard (Senate), 27 February 1980, p.325; 24 February 1981, p.61; 13 May 1981, pp.1879-1880; 18 August 1982, pp.246-247; Hansard (House of Representatives), 24 February 1981, p.63; and 21 September 1982, pp.1694-1696. See also Appendix 3 to this volume.
15. J.O. Langtry and Desmond J. Ball, Controlling Australia's Threat Environment: A Methodology for Planning Australian Defence Force Development (Strategic and Defence Studies Centre, Australian National University, Canberra, 1979), p.4.
16. Defence Report 1981 (Australian Government Publishing Service, Canberra, 1981), p.54.

9
Limiting Damage from Nuclear Attack

Desmond Ball

'In the event of a nuclear war there will be no chances, there will be no survivors - all will be obliterated.'
- Lord Louis Mountbatten,
former Chief of the UK Defence Staff and Chairman of the Chiefs of Staff Committee, speech at Strasbourg, 11 May 1979.

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'Should [a nuclear] conflict take place, we shall all die.'
- Hon. Lionel Bowen,
Deputy Leader of the Opposition, 'Disarmament: The World Needs Fewer Swords and More Ploughshares', (address to the Victorian Branch, Australian Institute of International Affairs, Melbourne, 12 February 1982), transcript, p.3.

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'There is no defence against [nuclear] weapons; ... nuclear warfare will destroy civilisation, and perhaps exterminate mankind. To hope for salvation from Civil Defence is a dangerous self-deluding pipe dream.'
- Lord Philip Noel-Baker,
Letter to the Editor, The Times (London), 25 January 1980.

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'For a large range of possible nuclear wars, damage-limiting (D/L) systems can be designed that would reduce ... estimates of fatalities by 90 per cent or more.'
- William M. Brown,
Limiting Damage From Nuclear War, (The RAND Corporation, Santa Monica, RM-6043-PR, October 1969), p.v.

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'Everybody's going to make it, ... if there are enough shovels to go around. Dig a hole, cover it with a couple of doors and then throw three feet of dirt on top. It's the dirt that does it.'

- T.K. Jones,

Deputy Undersecretary of Defense for Strategic and Theater Nuclear Forces, US Department of Defense, cited in Los Angeles Times, 15 January 1982, p.22.

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To the extent that there is a typical popular or lay view of nuclear war it is that the outcome would be nothing less than wholesale destruction, amounting to Doomsday either world-wide or at least for those countries subject to attack. According to this view, measures to limit damage are self-deluding and dangerous; not only will such measures inevitably fail to reduce casualties and urban-industrial damage should nuclear war occur, but by creating the illusion that damage can be reduced to 'acceptable' limits they actually increase the likelihood of nuclear war.

On the other hand, there is a group of strategic analysts who have become increasingly influential in the United States who argue that even relatively crude damage-limiting measures can reduce casualties and damage to extremely low levels. For example, Arthur A. Broyles and Eugene Wigner have argued that current Soviet planning for evacuation together with plans for the construction of 'expedient' shelters could reduce Soviet casualties from an all-out nuclear exchange to 2 per cent or 3 per cent of the Soviet population - i.e. 5-8 million people.[1] And T.K. Jones, the Deputy Undersecretary of Defense for Strategic and Theater Nuclear Forces in the Department of Defense has opined that if the US had a similar programme it would be able to recover fully from an all-out nuclear exchange in just two to four years.[2]

Such assertions have generally been received with incredulity. They depend on some quite particular assumptions regarding the warning time available, the docility and cooperativeness of the population being evacuated, the mildness of the weather, and the commitment of both sides to population targeting. Even where the assumptions are reasonably realistic, the logic of the overall argument is extended beyond the point where the conclusions might still bear some relation to what would actually happen.

These extreme claims have done much to discredit damage limitation studies, but it remains the case that damage limitation measures are likely to prove more effective than the popular view is ready to concede.

The damage that would attend a nuclear attack is not invariant. It depends on numerous variables, of which the most important are the

scale and nature of the attack, the meteorological conditions prevailing at the time of the attack, the warning time available, the geographical relationship between the target set and the population distribution, and the protective measures available to the population.

Some of these variables range over a wide magnitude, and others are subject to gross uncertainties, so that even for an attack of given size the damage estimates can vary by a factor of five or more.

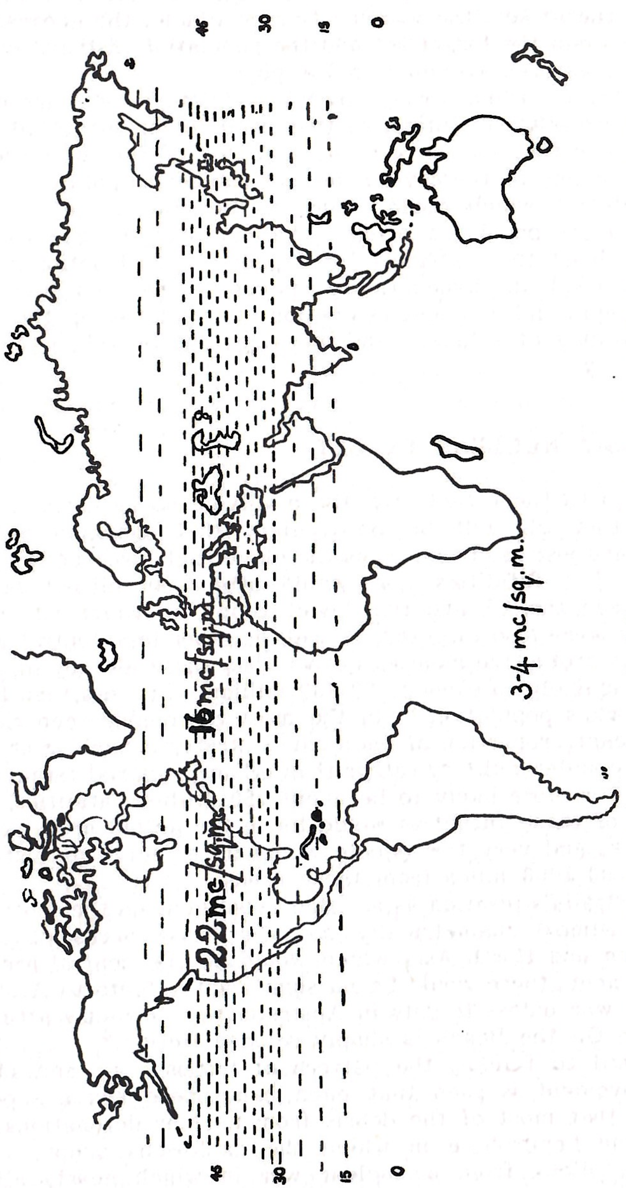
Moreover, many of these variables are subject to policy decision. Bases and facilities which could figure as possible targets can be located away from populated areas. Fallout shelters can be constructed, or at least the materials for expedient construction can be procured and stockpiled. Evacuation plans can be prepared in order to facilitate the rapid and efficient relocation of population in the event of crisis or warning of attack. And measures can be taken to assist post-war recovery.

AUSTRALIA AS A NUCLEAR TARGET

Statements to the effect that there will be no survivors from a nuclear war, that all will be obliterated, that mankind will be exterminated, are just as erroneous as the claim that 'everybody's going to make it'. The fatalities that would attend an all-out nuclear exchange between the US and the Soviet Union, in which China and Western Europe were also targeted, as well as other less central areas, and assuming no protective measures other than those already in place, would be most unlikely to exceed 400-450 million - i.e. less than 10 per cent of the world's population.[3] In the most reasonable scenarios, in which a significant proportion of each side's strategic nuclear arsenals is allocated to counter-military rather than urban-industrial targets, the maximum figure is more likely to be about 250 million fatalities. The great majority of these fatalities would lie in the actual areas subject to direct attack, and very few people would be affected at distances greater than 2000-3000 miles from these areas.

Given Australia's position as an island continent on the south-east of the globe, almost diametrically opposite those areas of North America, Europe and North Asia which would be the central areas of nuclear engagement, there would be no significant effects to Australia from a nuclear war unless targets in Australia were directly attacked. The scenario in On the Beach is simply science fiction.[4]

With regard to fallout, the pattern of tropospheric and stratospheric air movement is such that each hemisphere has a separate circulation, so that most of the debris from nuclear detonations falls out in the same hemisphere in which the explosions occur. Consequently, the fallout from a nuclear war in which nearly all the



World-wide distribution of Strontium 90 in fall out, 1956, showing band of highest concentration in Northern latitudes.

Source: A. Pirie (ed.), Fallout: Radiation Hazards From Nuclear Explosions (MacGibbon & Kee, London, Second Edition, 1958), p.2.

detonations take place in the northern hemisphere should be deposited in that hemisphere, although some small proportion may cross the Equator through mixing of the stratospheric air between the two hemispheres.[5]

As Mr R.H. Mathams, the then Director of Scientific and Technical Intelligence in the Joint Intelligence Organisation (DSTI/JIO) stated in 1978,

> The immediate effect on Australia of a major nuclear exchange in the northern hemisphere would be negligible; in the longer term, levels of radioactivity in the southern hemisphere will increase as a result of fallout transferred from the northern hemisphere, but the effects of this could be relatively easily reduced by appropriate protective measures. In any event the amount of fallout would probably only be about twice that received in Australia from the combined atmospheric testing in the northern hemisphere during the early 1960s.[6]

Other conceivable effects, such as a diminution of the ozone layer in the stratosphere, in time may affect the entire globe, but current research indicates that these effects would be much less severe in the southern hemisphere than in the northern hemisphere.[7]

What, then, is the possibility of Australia being subject to direct nuclear attack? There is now a widespread acceptance within the defence community that in any general war between the superpowers there are a small number of targets in Australia which are likely to be attacked by the Soviet Union.[8]

Most analysts would attribute this possibility to Australia's hosting of US military communications, early-warning and intelligence facilities. For example, the Joint Parliamentary Committee on Foreign Affairs and Defence recently concluded that in the absence of the facilities it would be 'very unlikely' that Australia would be a nuclear target, whether or not it was a member of the Western Alliance.[9] However, the Minister for Defence has stated that the facilities do not draw attention to Australia:

> In the event of hostilities, risks of nuclear attack arise for Australia as an ally of the United States, whether or not it may be hosting particular United States facilities.[10]

The clearest statement on the possibility of nuclear threats to Australia is that of Mr R.H. Mathams in 1978:

> Although the likelihood of strategic nuclear attack against Australia is not great it is none-the-less finite ...
> The most significant trend for Australia in strategic forces development is the large number of nuclear warheads available to

the USSR, which now has sufficient warheads to adequately target the US and retain substantial reserves for use against secondary targets. We cannot determine the priorities the USSR attaches to targets in Australia, but joint US-Australian facilities would probably rank high, depending on Soviet perceptions of their strategic importance.

In descending order of probability, Australia might receive strategic nuclear attacks against: US facilities in Australia; Australian defence establishments; industrial complexes and urban centres.[11]

1. US Facilities in Australia

The US maintains a wide range of facilities in Australia - including ground stations for communications, early-warning, signals intelligence (SIGINT), navigation and geodetic satellites; several portable geodetic satellite observation posts; VLF communications and navigation stations; more than half a dozen seismic stations; and a solar observatory. Most of these facilities have quite marginal strategic significance.[12]

The three critical installations are the Naval Communications Station Harold E. Holt, North West Cape; the Joint Defence Space Research Facility (JDSRF), Alice Springs, commonly known as Pine Gap; and the Joint Defence Space Communications Station (JDSCS), Woomera, commonly known as Nurrungar.

North West Cape is presently one of the most important links in the US global defence communications network. According to official brochures, the base 'may serve several purposes. However, its main reason for existence is to maintain reliable communications with submarines of the US fleet servicing in this area of the world (i.e. the Indian and Western Pacific Oceans)' - and, in particular, 'to provide communication for the US Navy's most powerful deterrent force - the nuclear powered ballistic missile submarine'.[13] The US VLF system for communicating with the Fleet Ballistic Missile (FBM) submarine fleet consists of stations at Annapolis, Maryland; Cutler, Maine; Jim Creek, Washington; Luoluolei, Hawaii; Yosomi, Japan; and Harold E. Holt, North West Cape. The station at North West Cape is the largest and most powerful of all of these, and according to a recent report of the US General Accounting Office (GAO),

> Two of these stations - Cutler and Harold E. Holt - together provide VLF signals to virtually all ocean areas. In peacetime, the remaining VLF stations normally provide backup to the two main communications transmitters.[14]

North West Cape also has an array of high frequency (HF) transmitters which are extremely important to US military operations, as was dramatically illustrated during the American mining of Haiphong and other North Vietnamese harbours in 1972, when the high frequency site on the base was fully committed.[15]

This capability to support more general (i.e. non-FBM submarine) US military operations will be greatly enhanced with the installation of the AN/MSC-61 or AN/GSC-39(V)1 satellite ground station in 1983, which will tie North West Cape into the US Navy's Fleet Satellite Communications (FLTSATCOM) system as well as into Phase III of the US Defense Satellite Communications System (DSCS III).[16]

The Pine Gap facility, which became operational in 1969, is located 19 km (12 miles) south-west of Alice Springs. The 'business end' of the facility currently consists of seven large radomes and an enormous computer complex, currently being even further expanded.

Pine Gap is organisationally a facility of the US National Reconnaissance Office (NRO), although it is operationally controlled by the US Central Intelligence Agency (CIA). The station was originally established as part of Project Rhyolite, which involves a small number of signals intelligence (SIGINT) satellites in geostationary orbit capable of 'sucking up like a vacuum cleaner' a wide spectrum of Soviet and Chinese military communications and radar transmissions and beaming them back down to Pine Gap. The frequencies covered by these satellites embrace a number of very significant radio emanations. First, it includes most radar transmissions, allowing the mapping of the extensive Soviet early-warning and air defence networks. Second, it includes telemetry data transmitted during Soviet ballistic missile tests. Analysis of these signals has become one of the principal means by which the US has been able to monitor Soviet missile developments - and hence Soviet compliance with the Strategic Arms Limitation (SAL) agreements. And, third, these satellites have the capability for intercepting Soviet and Chinese telephonic and radio microwave communications.[17]

Nurrungar, which is located within the Woomera restricted area, about 480 km (300 miles) north-west of Adelaide, is one of two ground stations for the American satellite early warning system. Officially known as Detachment 2 of the USAFs Space Command, Nurrungar provides a real-time data link between the North American Air Defense Command (NORAD), the Strategic Air Command (SAC) and the National Military Command System on the one hand, and the satellite early-warning system on the other hand. (The other ground station for the system is at Buckley, Colorado.) Data are derived from infra-red, charged particle and radiation sensors aboard the geostationary satellites of the Code 647 or Defense Support Program, which detect missile firings shortly after lift-off.[18] Program 647 has been officially described as 'the most important' system which the US relies on for early warning of ballistic missile attack.[19]

These three facilities are significant enough to be targets in their own right. As Mr R.H. Mathams stated in testimony to the Joint Parliamentary Committee on Foreign Affairs and Defence on 9 February 1981,

> ... my view would be that the Soviet Union would certainly consider the North West Cape installation (which obviously is a communications facility and involved with the command of submarines) and probably the other two facilities to be in some way connected with American strategic nuclear forces. As a result, they would feature on the Soviet target list. But I have never been able to assess if they would be near the top or bottom of the list. One could argue quite cogently for either depending on what one believes to be Soviet perceptions.
> However, let us accept that there is a finite risk of their being attacked.[20]

And as the Joint Committee itself concluded,

> It would be prudent for Australian defence planners to assume that the joint facilities at North West Cape, Pine Gap or Nurrungar are on the Soviet target list and might be attacked in the course of a nuclear conflict between the two superpowers. In other words, there is a finite risk that one or all of the facilities would be attacked during a Soviet-United States war that involved their nuclear strategic forces.[21]

There are many situations in which the taking out of one (or more) of the North West Cape, Pine Gap and Nurrungar facilities would degrade the US strategic capability more than would an actual attack on the strategic forces themselves - and even more situations where some measures to reduce or limit damage from nuclear attack could be achieved by such action.

With regard to situations where the destruction of the installations would disproportionately degrade the American strategic forces, the most obvious is probably the destruction of the communications network for the American FBM submarines. The missile-launching submarines are undoubtedly the least vulnerable leg of the American strategic Triad; they also carry the bulk of the US strategic nuclear warheads - more than 5,000 out of some 10,000 warheads. American nuclear submarines in general are quieter and faster than their Soviet counterparts, and Soviet hunter-killer submarines are quite inferior to the US nuclear attack submarines protecting the American FBM submarine fleet. The Soviets could be confident of destroying only a very few of these submarines, even in an all-out search and destroy

mission. On the other hand, they could relatively easily immobilise the whole American sea-based force by destroying its communications. At the very least, they would prevent the use of SLBMs against high-priority time-urgent targets, and would allow Soviet missiles to be launched or their bombers to be dispersed while the American submarines were sorting themselves out. Time would also be bought for the evacuation of cities, thus greatly limiting casualties in the event of an American counter-city response.

The destruction of the communications system for the US FBM submarine force is now taken for granted by US officials. For example, Admiral R.Y. Kaufman, USN, testified with regard to this system that 'we have to assume that an attack will be made on our communications facilities'.[22] In 1963 the Director of the US Navy's Special Projects Office, Admiral Gallatin, described the VLF stations as constituting 'lucrative targets'.[23] And more recently the Assistant Secretary of Defense for Communications, Command, Control and Intelligence (C^3I), Dr Gerald P. Dinneen, testified that these stations 'are vulnerable. They are soft targets.'[24]

Attacks on navigation and geodetic facilities can also have disproportionate impact in terms of reducing the effectiveness of opposing strategic forces. The lethality of a nuclear force is determined primarily by the accuracy with which it can be delivered - which depends, in turn, on precise knowledge of the launch position (ICBM silo or FBM submarine) and the aim point for the intended target - missile silo, military base, or city. If accuracy is degraded, then many more warheads are needed for a given lethality or level of destruction - or, alternatively, a given number of weapons can do much less damage. Destruction of navigation and geodetic facilities can thus limit damage to Soviet military forces and value targets. Further, if accuracy is sufficiently degraded, some targets could no longer be destroyed at all. In the case of SLBMs, for example, as the elements which provide navigation for the submarines (such as the US Navy's Navigation Satellites) are removed, those missiles lose entirely whatever capacity they would normally have for destroying hardened targets.

There is also great strategic value to be gained from the destruction of the command, control and real-time surveillance facilities of an adversary. This is particularly so in the case of contingencies involving 'controlled responses', especially situations involving limited, sequential nuclear exchanges. At present the United States has a greater capability for these operations than does the USSR, but much of the American capability is dependent upon the maintenance of its military satellite systems. The destruction of these systems would not only remove the US advantage in these contingencies but might even effectively prevent US participation in controlled, sequential exchanges.

There are also some conceivable situations short of an attack against the United States in which the Soviet Union might attack the US facilities in Australia. Most Australian observers are prone to dismiss this possibility, but it is one which has engaged the attention of US strategic planners. For example, the Pentagon's recent Satellite Mission Survivability Study has a section on the vulnerability of the two Code 647-DSP ground stations, in which consideration is given to a Soviet attack on Nurrungar intended to demonstrate Soviet resolve and capability and at the same time degrade the US ICBM early-warning system, while avoiding the political and strategic consequences of a similar attack on the station in Colorado.

Some commentators have argued that the Soviets would not want to target US C^3I facilities since to destroy an opponent's information, command and communications systems could lead to the loss of any restraints in a nuclear exchange. Moreover, to launch missiles at a facility concerned with monitoring the Soviet ICBM fields for missile launches (i.e. the DSP facility at Nurrungar) would itself provide early-warning of attack. However, such arguments can only be made given ignorance about either the disproportionate strategic impact of modern command, control, communications, navigation and intelligence systems, or about the current strategic nuclear war-fighting doctrines of the US and the Soviet Union.

Soviet policy is to attack C^3I systems at the outset of any strategic nuclear exchange, in an effort to disrupt and degrade the enemy's military forces, political and administrative control, and industrial support capacity. As Major-General Van C. Doubleday testified in 1979, 'Soviet strategic doctrine indicates Soviet strategic targeting specifically includes US C^3'.[25] Uri Ra'anan has recently noted that

> the publications of Soviet military theoreticians and planners stress the need for paralyzing the adversary's C^3 system in the opening stage, obviously not sharing the preoccupation of Western analysts with the thought that functioning C^3 systems would be required to enable both sides to negotiate a halt in an escalatory process.[26]

And Joseph D. Douglass and Amoretta M. Hoeber concluded from their recent study of Soviet Strategy for Nuclear War that 'there would likely be an intensive, overt, active attack on reconnaissance, command and control, and communications assets at the very beginning of the war.'[27] The destruction of US national command and control facilities would disrupt US attacks and would allow the Soviet Union to control the progress of the conflict and to conduct military and political reconstitution more effectively. Attacks on strategic and tactical command

and control systems would be an integral part of the missions against the strategic nuclear and other military forces. As Col. Shirŏkov wrote in 1966:

> Under conditions of a nuclear war, the system for controlling forces and weapons, especially strategic weapons, acquires exceptionally great significance. A disruption of the control over a country and its troops in a theater of military operations can seriously affect the course of events, and in difficult circumstances, can even lead to defeat in a war. Thus, areas deserving special attention are the following: knowing the co-ordinates of stationary operations control centres and the extent of their ability to survive; the presence of mobile command posts and automatic information processing centres; the communication lines' level of development and, first of all, that of underground and underwater cable, radio-relay, ionospheric and tropospheric communication lines; field communication networks and duplicate communication lines; communication centers and the extent of their facilities, dispersion and vulnerability.[28]

Attacks on early-warning and signals monitoring facilities would of course alert the US to the fact of a Soviet strike, but without these eyes and ears the US would have difficulty ascertaining the scale and nature of the attack and hence the US response could well be far less effective than otherwise.[29]

2. Australian Defence Establishments

The only Australian defence establishments which are of sufficient importance to warrant consideration as possible nuclear targets in the event of a US-Soviet conflict are HMAS Stirling at Cockburn Sound, WA, and the RAAF Base at Darwin, NT. These are both Australian facilities under full Australian control, but their periodic use by nuclear-related US forces must invite Soviet interest.

Cockburn Sound: On 30 January 1980, during a visit to Washington to discuss the Soviet invasion of Afghanistan, Prime Minister Fraser offered the US the use of the new naval base at Cockburn Sound as either a 'home port' or a 'base port' for US nuclear-powered aircraft carriers and other warships involved in Indian Ocean deployments. A team of US Navy officials visited Cockburn Sound in April 1980 to make a technical survey of the base, but in April 1981 the Navy decided to proceed no further with consideration of the Prime Minister's offer.[30]

However, the US Navy has increasingly used Cockburn Sound as a transit point for its ships patrolling the Indian Ocean over the past two

VISITS BY US NUCLEAR ATTACK SUBMARINES TO HMAS STIRLING, WA 1976 - MARCH 1982

Dates of Visit	Name of Submarine
14-18 August 1976	USS Snook
19-27 April 1979	USS Tunny
20-25 October 1979	USS Pintado
24-29 October 1979	USS Gurnard
26 March - 1 April 1980	USS Haddock
1-7 April 1980	USS Los Angeles
19-26 May 1980	USS Guardfish
18-25 July 1980	USS Puffer
25-30 July 1980	USS Baton Rouge
13-19 August 1980	USS Tautog
6-11 September 1980	USS Groton
11-16 September 1980	USS Permit
10-17 November 1980	USS Omaha
16-22 December 1980	USS Haddo
23-29 December 1980	USS Philadelphia
6-11 February 1981	USS Memphis
27 February - 6 March 1981	USS Gurnard
15-22 April 1981	USS Cavalla
22-27 May 1981	USS Pintado
29 May - 3 June 1981	USS Bluefish
6-13 July 1981	USS Los Angeles
8-13 July 1981	USS Cincinnati
11-17 August 1981	USS Haddock
23-30 September 1981	USS New York City
5-12 October 1981	USS Bremerton
22-28 October 1981	USS Flasher
30 November - 7 December 1981	USS Aspro
29 January - 5 February 1982	USS Tautog
10-17 February 1982	USS Puffer
19-26 March 1982	USS Sea Horse.

Sources: Hansard (House of Representatives, 26 March 1981, p.1080; 5 May 1981, p.2004; 10 June 1981, p.3596; 19 August 1981, p.459; and 4 May 1982, p.2226.

to three years. For example, at least 35 warships stopped over at Cockburn Sound during the first eight months of 1981, including four aircraft carriers, eight nuclear-powered attack submarines, and several missile cruisers and destroyers.[31] The nuclear-powered attack or hunter-killer submarines are now visiting Cockburn Sound at an average of about one a month, with each stop-over averaging 6-7 days, so that there is one tied up at the base some 20-25 per cent of the time.

Nuclear-powered submarines, including hunter-killer as well as FBM submarines, together with the bases which support them, must rank very high on Soviet nuclear target lists.

RAAF Base, Darwin: In February 1980, the US Air Force began low-level navigation flights by B-52 aircraft over northern Queensland. During 1980, these flights were conducted on an average of twice a month; in 1981, the frequency increased to an average of 3.5 per month. These B-52s, based at Guam, did not land in Australia.[32]

On 11 March 1981, the Australian and United States Governments reached agreement on the terms and conditions governing US Air Force B-52 staging flights through RAAF Base Darwin. The Agreement provides that the B-52 flights shall be for sea surveillance in the Indian Ocean area and for navigation training; that the agreement of the Australian Government would need to be obtained before the facilities at Darwin can be used in support of any other category of operations; that the B-52 aircraft on surveillance flights will be supported by KC-135 tanker aircraft for aerial refuelling and the operations shall consist of periodic deployments of up to three B-52 and six KC-135 aircraft; and that about 100 US Air Force personnel and associated equipment will support the staging operations and some of these may be stationed at RAAF Base Darwin.[33]

The first B-52 in this operation arrived in Darwin on 5 May 1981, a day after the first KC-135 landed.[34]

The Australian Government has espoused a firm policy that aircraft carrying nuclear weapons will not be allowed to fly over or stage through Australia without its prior knowledge or agreement. The Exchange of Notes of 11 March 1981 provides that the facilities at RAAF Base Darwin cannot be used in support of operations other than sea surveillance and navigation training. There is also an unsigned record of conversation between the Minister for Foreign Affairs, Mr A.A. Street, and the then Secretary of State, Mr A.M. Haig, which states that all B-52s engaged in operations through or over Australia 'will be unarmed and carry no bombs'.[35] And the B-52s used to date have in fact had the bomb racks replaced with sophisticated monitoring equipment.

However, the Soviet Union could well consider that the agreements and the current B-52 configuration might not pertain in the event of a US-Soviet conflict. The bombers can readily be re-configured to

B-52 STAGING OPERATIONS RAAF BASE DARWIN 1981

1. 5 May
2. 19 June
3. 17 August
4. 14 September
5. 14 September
6. 28 September
7. 10 November

Separately, B-52 aircraft conducted navigation training over Australian territory on the following dates:

<u>1980</u>

1. 27 February
2. 12 March
3. 2 April
4. 16 April
5. 30 April
6. 13 May
7. 27 May
8. 10 June
9. 26 June
10. 8 July
11. 19 July
12. 22 July
13. 5 August
14. 19 August
15. 2 September
16. 9 September
17. 16 September
18. 7 October
19. 21 October
20. 4 November
21. 18 November
22. 2 December
23. 16 December

<u>1981</u>

1. 6 January
2. 13 January
3. 20 January
4. 27 January
5. 3 February
6. 10 February

<u>1981</u> (Cont'd)

7. 17 February
8. 24 February
9. 10 March
10. 17 March
11. 24 March
12. 31 March
13. 7 April
14. 14 April
15. 21 April
16. 28 April
17. 12 May
18. 19 May
19. 26 May
20. 2 June
21. 9 June
22. 23 June
23. 7 July
24. 14 July
25. 28 July
26. 4 August
27. 11 August
28. 25 August
29. 2 September
30. 8 September
31. 6 October
32. 13 October
33. 15 October
34. 20 October
35. 22 October
36. 27 October
37. 29 October
38. 3 November
39. 17 November
40. 24 November
41. 1 December
42. 8 December

Source: <u>House of Representatives</u>, Answer to Question No.2155, 16 February 1982.

carry nuclear weapons. The Street-Haig record of conversation has no standing in international law and is not binding as an agreement in any way. And the US has rarely been meticulous in observing more formal agreements of a similar nature. In any case, the support equipment and personnel at Darwin would enable the base to host other B-52s on a makeshift basis, and in the event of a nuclear exchange the Soviet Union would be likely to attempt to deny the US access to any facility which could provide succour for the B-52 force.

3. Industrial Complexes and Urban Centres

There are two arguments sometimes put forward which involve nuclear attacks against Australian urban-industrial areas. Neither of them is very persuasive.

One argument relates threats to urban-industrial areas to the presence of the US installations. For example, some commentators have suggested 'blackmail' scenarios in which an adversary (of the US, not necessarily of Australia) might issue an ultimatum to the Australian Government to dismantle the installations or suffer a nuclear attack on an Australian city. This 'linkage' scenario was addressed by the Joint Parliamentary Committee on Foreign Affairs and Defence in 1981 as follows:

> In a general war would the presence of the facilities attract hostile attention to other centres in Australia, particularly areas of high population density?
>
> The answer to this question is probably no. If for no other reason this unlikelihood can be attributed to the need of the Soviet Union (which like the United States has less nuclear warheads than potential 'counterforce' targets) to concentrate on targets which are of a higher priority than Australian cities.[36]

The second argument is that in a nuclear war the Soviet Union may have a motive to destroy Australia's capacity to support or succour the US (after the latter has been severely damaged in such a war) in order to impede the post-attack economic recovery of the US and ensure Soviet dominance in the post-war world.

It is true that Australia's major cities could be incapacitated by only a very small fraction of the Soviet nuclear arsenal. However, at the point in a nuclear exchange where large-scale attacks have already been undertaken against each side's urban-industrial areas this arsenal would be much depleted; it would be most unlikely to number more than a couple of hundred weapons. The Soviets would probably wish to retain the greater fraction of this number as a deterrent force, against any residual US capability as well as against any third countries, and, in any case, there would be many economic recovery targets in Europe and elsewhere far more lucrative than Sydney or Melbourne.

The probability of attacks on major Australian cities is thus of a different order to the likelihood of strikes against North West Cape, Pine Gap and Nurrungar, and perhaps Cockburn Sound and Darwin. However, the consequences of attacks against the major cities would be so horrendous that some consideration must be given to possible means of limiting damage in the event that this most remote contingency does nevertheless eventuate.

THE EFFECTS OF NUCLEAR ATTACKS ON AUSTRALIA

The Soviet Union has a number of alternative strategic nuclear delivery vehicles (SNDVs) which could be used to attack targets in Australia. These include the single-warhead SS-11 Sego ICBMs, the MIRVed SS-18 ICBMs, various SLBMs carried by FBM submarines operating out of Vladivostok or Petropavlovsk, or strategic bombers such as the Tu-95 Bear and Tu-22M Backfire if staging facilities were made available by Vietnam. The characteristics of these various SNDVs are described in the accompanying table.

All of the potential targets in Australia are 'soft' - i.e., they would be destroyed by the application of relatively low blast over-pressures. The VLF antenna at North West Cape and the radomes at Pine Gap and Nurrungar could probably withstand no more than about 5 pounds per square inch (psi) of peak blast overpressure and, indeed, perhaps only one or two psi of dynamic over-pressures. The facilities at Darwin and Cockburn Sound would be destroyed by 25 psi. In the case of urban-industrial areas, substantial damage would be rendered by one to three psi, and the area receiving blast damage at five psi or above would be essentially destroyed. Within the five psi blast area at Hiroshima, for example, two-thirds of all buildings were destroyed and casualties were approximately 50 per cent dead and 30 per cent injured.[37]

Attacks on targets such as these would not require the relatively high accuracy of the more modern Soviet ICBMs, such as the SS-18s, but could be undertaken almost as effectively with the obsolescent SS-11 ICBMs or some of the Soviet SLBMs, leaving the SS-18s for allocation against hard targets such as underground missile silos.[38] There are 120 SS-11 ICBMs within range of Australia, located in three fields at Drovyanaya, Olovyannaya and Svobodnyy[39], but a disadvantage of a single-warhead missile is that one missile must be allocated to each target; indeed, most planners would allocate two warheads - hence two missiles - to each target to compensate for potential reliability problems. On the other hand, a single SS-18 missile with eight or ten

SOVIET STRATEGIC NUCLEAR DELIVERY VEHICLES RELEVANT TO ATTACKS ON AUSTRALIA:

January 1982

	No. of Delivery Vehicles	Range (N.M.)	Throwweight (Thousand lbs.)	No. of Warheads (n).	Yield per Warhead (MT)	CEP (feet)
ICBMs:						
SS-11 Sego	518	5,700	2	1	1.0	5,000
SS-18 Mod 1)			16	1	24	1,400
SS-18 Mod 2)			16	8	.9	1,400
SS-18 Mod 3)	308	5,500	16	1	20	1,155
SS-18 Mod 4)			16	10	.5	900
SLBMs:						
SS-N-6 Mod 1)		1,300	1.6	1	.7	3,000
SS-N-6 Mod 2)	469	- 1,600	1.6	1	.65	3,000
SS-N-6 Mod 3)			1.6	3	.35	4,500
SS-N-8	302	4,300	1.8	1	.8	3,000
SS-N-18 Mod 1)	176	4,050	2.5	1	2	2,000
SS-N-18 Mod 2)			2.5	3	.5	2,000
BOMBERS:						
Tu-22M Backfire	90	3,075	4	2	1	3,000
Tu-95 Bear	113	4,000	8	4	1	3,000

warheads could cover all the interesting targets in Australia with two warheads each. The use of SLBMs is also a possibility. The FBM submarines in the Soviet Pacific Fleet between them carry some 312 SLBMs (176 SS-N-6, 72 SS-N-8 and 64 SS-N-18 missiles), the use of which would have the advantage of reducing the warning-time to 5-15 minutes; however, it is unlikely that Soviet planners would choose to send a submarine with 12 or 16 missiles (and perhaps 48 warheads) down to the southern hemisphere, which might take those missiles out of range of many interesting targets in the northern hemisphere, when no more than 10 warheads would be needed to cover the whole Australian target set.

Whatever the delivery vehicle chosen, the maximum damage to the sorts of equipment and buildings at each of the possible targets in Australia would be rendered by detonating the warheads in the air rather than at ground level. For a 1-Mt warhead, the optimum height of burst (HOB) for targets of 5 psi is about 9000 feet; for targets of 25 psi, it is about 3000 feet. At these altitudes, there would be very little fallout as compared to a weapon detonated at ground level.

The effects of long-term exposure (i.e. a week to a month) to radiation such as received from fallout is shown in the following table. The acute lethal dose (usually described as the dose from which 50 per cent of those exposed will die) is in the range from 450 to 500 REMs.[40]

Biological Effects of Radiation

Effect	Dose (REMS)	
	If delivered over 1 week	If delivered over 1 month
Threshold for radiation illness	150	200
5 per cent may die	250	350
50 per cent may die	450	600

For airbursts of weapons in the 0.5-1 Mt range, the area covered by 500 REM could extend for 2-3 kilometers downwind from the point of detonation.[41] For surface bursts, where radioactive material in particle form is drawn into the fireball from the earth, the 500 REM area could extend (assuming a constant average wind of 30 mph) about 100 miles downwind and nine miles across.

The general pattern of fallout distribution from nuclear detonations in some particular areas of Australia can be derived from the records of some of the nuclear tests that took place in Australia in 1952-57. The three test areas were Monte Bello, WA (115.5 deg.E, 20.5 deg.S), Emu Field, SA (132 deg.E, 28 deg.S), and Maralinga (131.5 deg.E, 30.5 deg.S).[42]

The following figure shows the cloud trajectories of radioactive fallout from the four tests of Operation Buffalo, which took place at Maralinga on 27 September 1956, 4 October 1956, 11 October 1956 and 22 October 1956. All were relatively low yields. Rounds one and four were detonated on tall towers; Round two was exploded on the surface; and Round three was dropped from a Valiant bomber and detonated above the surface.[43]

ATOMIC BOMB EXPLOSIONS IN AUSTRALIA 1952-1957

DATE	LOCATION	OPERATION CODE NAME		PLATFORM	YIELD
3 October 1952	Monte Bello	•			Kiloton Range
15 October 1953	Emu	Totem I			Kiloton Range
27 October 1953	Emu	Totem II			Kiloton Range
16 May 1956	Monte Bello	•	Mosaic		Kiloton Range
19 June 1956	Monte Bello	•	Mosaic		Kiloton Range
27 September 1956	Maralinga	One Tree	Buffalo	Tower	Kiloton Range
4 October 1956	Maralinga	Marcoo	Buffalo	Surface	Low yield
11 October 1956	Maralinga	Kite	Buffalo	Air Drop (Valiant Bomber)	Low yield
22 October 1956	Maralinga	Breakaway	Buffalo	Tower	Kiloton Range
14 September 1957	Maralinga	Tadje	Antler	Tower	Low yield
25 September 1957	Maralinga	Biak	Antler	Tower	Kiloton Range
9 October 1957	Maralinga	Taranaki	Antler	Balloon	Kiloton Range

Sources: Hansard (House of Representatives), 31 March 1977, p.880; and Adrian Tame and F.P.J. Robotham, Maralinga: British A-Bomb, Australian Legacy (Fontana Books, London, 1982), pp.111,179.

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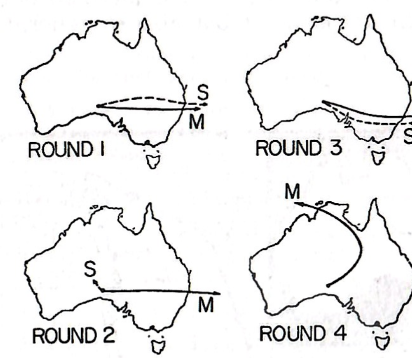


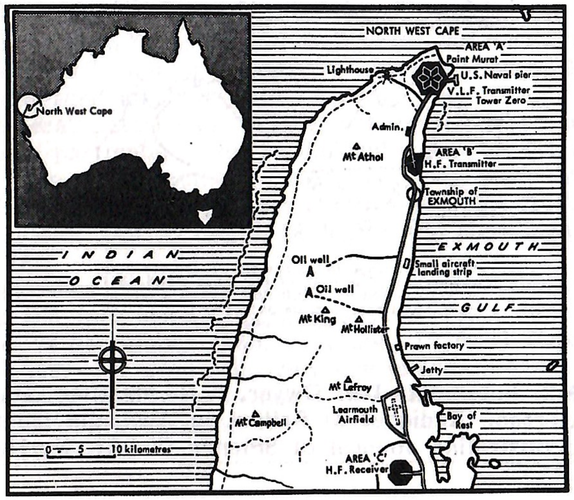
The cloud trajectories are shown for the four explosions. The path of the main cloud (M) is represented by a full line. When a secondary cloud occurred, its path (S) is indicated by a broken line.

Source: W.A.S. Butement, L.J. Dwyer, K.H. Martime, D.J. Stevens and E.W. Titterton, 'Radioactive Fallout in Australia from Operation Buffalo', The Australian Jounral of Science (Vol.21, No.1), July 1958, p.65.

Great care was taken to ensure that the meteorological conditions were favourable at the time of the firings. Nevertheless, the secondary cloud from Round three on 11 October 'passed close to Adelaide and contaminated the city and surrounding countryside with radioactive fission products'. Minor contamination occurred as far as 1500-2000 miles from the Maralinga test site, with some significant concentrations of radioactivity found on the north-eastern coast and in central western Queensland. There was also some 'clearly discernible' contamination in the Alice Springs area.[44]

The three most likely targets in Australia - North West Cape, Pine Gap and Nurrungar - are fortunately located in relatively unpopulated areas far from Australia's major urban-industrial areas. Indeed, in terms of nuclear effects, the locations of these facilities are similar to those of the nuclear test sites of the 1950s - with an important caveat in each case: whereas none of the test sites were located close to any built-up areas, the VLF antenna at North West Cape is 20 km and the HF transmitter 5 km from the township of Exmouth (which has a population of just on 3,000); the Pine Gap facility is 20 km from Alice Springs (which has a population of over 16,000); and Nurrungar is 10 km from Woomera Village (which has a population of 3,000).

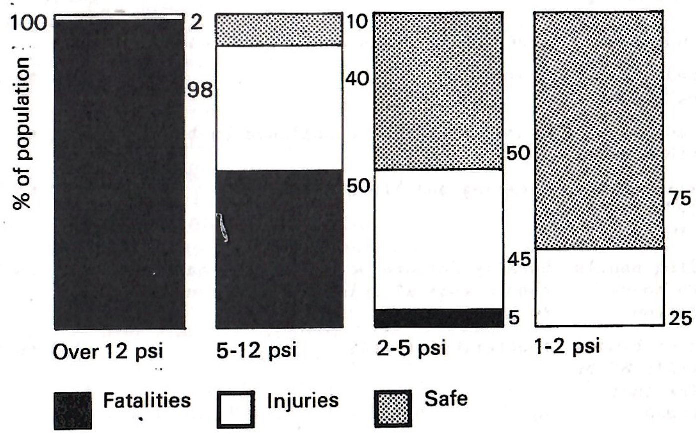
In the case of North West Cape, the desired ground zero (DGZ) would likely lie south of Tower Zero, calculated to not only ensure the destruction of the VLF transmitter but also to generate 1 or 2 psi over the HF transmitter.



RELATIONS BETWEEN PEAK OVERPRESSURES AND STRUCTURAL FAILURE

Structure or structural element	Damage	Approx overpressure p.s.i.
Glass windows	Shattering; occasional frame failures	0.5 to 1
Corrugated asbestos siding	Shattering	1 to 2
Corrugated steel or aluminum panel	Connection failure followed by buckling	1 to 2
Brick wall panel 8" or 12" thick (not reinforced)	Shearing and flexure failures	3 to 10
Wood siding panels standard house construction	Usually failure occurs at the main connections allowing a whole panel to be blown in	1 to 2
Concrete or cinder block walls 8" or 12" thick (not reinforced)	Shattering of wall	1.5 to 5.5
Wood frame building, residential type	Moderate: Wall framing cracked; roof badly damaged; interior partitions blown down	2 to 3
	Severe: Frame shattered so that for the most part collapsed	3 to 4
Wall-bearing masonry building apartment house type	Moderate: Exterior walls badly cracked, interior partitions badly cracked or blown down	3 to 4
	Severe: Total collapse of structure	5 to 6
Multistorey wall bearing building monumental type	Moderate: Exterior walls facing blast badly cracked, interior partitions badly cracked	6 to 7
	Severe: Some of bearing walls collapse	8 to 11
Reinforced concrete building, concrete walls, small window area	Moderate: Exterior walls badly cracked, interior partitions badly cracked or blown down, frame distorted, spalling of concrete	8 to 10
	Severe: Walls shattered, incipient collapse	11 to 15

VULNERABILITY OF POPULATION IN VARIOUS OVERPRESSURE ZONES



Source: Office of Technology Assessment, Congress of the United States, *The Effects of Nuclear War* (Croom Helm, London, 1980), p. 19.

For a 1-Mt weapon, this would generate 1 psi over the township of Exmouth - sufficient to shatter windows and cause occasional failures at the joints of panels in standard house constructions, but not sufficient to cause the collapse of standard residential houses.[45]

In the case of Nurrungar, a 1-Mt weapon detonated over the facility would generate about 2 psi over Woomera Village - sufficient to cause the wooden frames of residential-type buildings to shatter so that the buildings collapse and to cause the ignition of some local fires.

In the case of Pine Gap, the blast effect at Alice Springs would be less than 1 psi. Some windows would break and there would be occasional frame failures, but most houses would be undamaged. The casualties from blast effects should be nil.

Concern has sometimes been expressed to the effect that a warhead aimed at Pine Gap could miss the target and hit Alice Springs, or at least impact such that the built-up area of Alice Springs lies within its lethal radius. However, the probability of such an impact is infinitessimal.

Assume that the distribution of warhead impact points is circular normal about the target point or DGZ. This means that errors in any two directions at right angles through the target point are independent of one another, but their extents are determined by the same probability distribution, i.e. the normal distribution:

$$P(x_0 < x < x_1) \propto \int_{x_0}^{x_1} \exp(-x^2/\sigma^2)\, dx$$

The parameter δ is directly related to the accuracy of the missile; the smaller δ, the more accurate the missile, that is, the less likely large errors are. In strategic literature, reference is usually made not to δ, but to the quantity 1.1774δ, since this distance, the CEP, is such that the probability of the distance between target and impact being less than the CEP is the same as the probability of its being more, i.e., each 0.5. Thus a disk of radius CEP with centre at the target will contain the impact point of, on average, one shot in two.

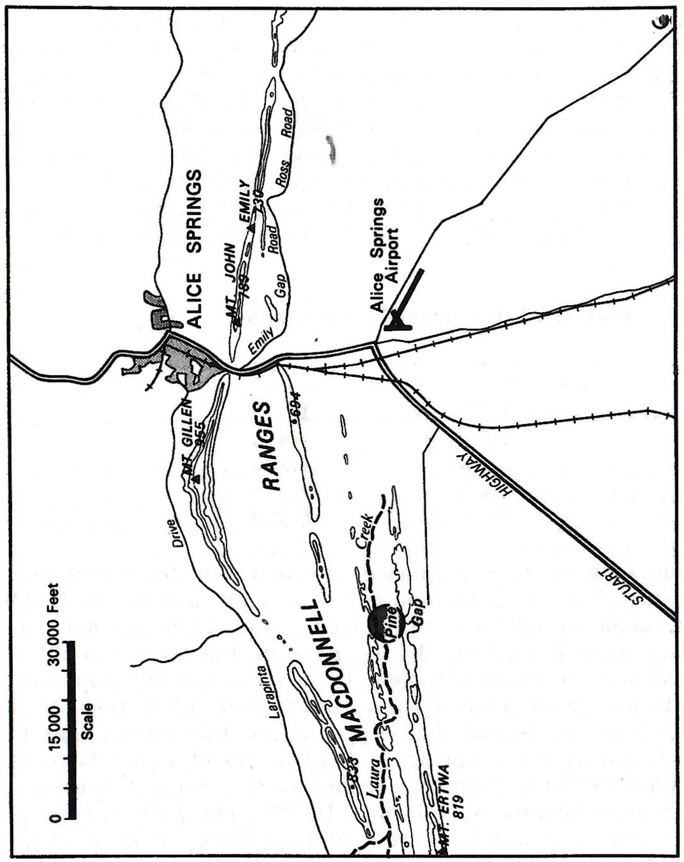
It follows from the normal distribution that 99 per cent of impacts will lie within a circle of radius $3.035 \times \delta$, which is $2.578 \times$ CEP ($\delta = 0.8493 \times$CEP and CEP$=1.1774\times\delta$). Thus the chance of an impact more than 3 CEP from the target point is negligible ($<<1$ per cent).[46]

Radius of P% Probability Circles

P	δ	CEP
50	1.77	1
75	1.665	1.414
90	2.146	1.823
95	2.448	2.079
99	3.035	2.578

The built-up area of Alice Springs is about 10 nm from Pine Gap at its closest point. For the 5 psi contour of a 1-Mt weapon to touch this area the weapon would have to impact closer than 2.5 nm, i.e. more than 7.5 nm from Pine Gap. In the case of the 25 psi contour, the impact would have to be closer than 1 nm from the built-up area, or more than 9 nm from Pine Gap. Given that 1200 feet is a representative CEP of the Soviet delivery vehicles, this means that to generate 5 and 25 psi at Alice Springs a 1-Mt warhead would have to impact 38 and 45 CEP from Pine Gap respectively. From the normal distribution, the probabilities of this are 10^{-400} and 10^{-600} respectively! And, of course, if a missile was to land some 38 or 45 CEP from Pine Gap, it is just as likely to be to the south or west of the facility rather than the north-east, so that the probability of its lethal radius actually intersecting Alice Springs would be several factors smaller than these probabilities.

The casualties induced by blast effects from attacks against North West Cape, Pine Gap and Nurrungar are therefore likely to be



Probable Area of Warhead Impacts in an Attack on Pine Gap

Assuming a CEP of 1200 feet, 99 per cent of impacts fall within a radius of 3093.6 feet.

extremely low indeed - exluding, of course, those employees working at the three facilities at the time, which would total about 500 people.[47] However, there could well be casualties resulting from fallout, depending on such factors as the number, size and fission fraction of the weapons used; whether they are detonated in the air or on the ground; the prevailing wind patterns and other meteorological conditions at the time of the attack; and the civil defence measures available (most particularly, the effectiveness of evacuation plans and the nominal protection factors [PFs]).

The direction and strength of the prevailing winds vary according to the season and the time of the day.[48] At North West Cape the winds are generally from the south, so that any fallout generated by an explosion at the VLF and/or HF transmitter sites would blow away from the township of Exmouth; in central Australia the winds are generally from the south-east, so that fallout from any attack on Pine Gap could well blow over Alice Springs; around Nurrungar, the winds are much more variable, with northerlies generally prevailing in the winter and southerlies in the summer. Adelaide's winds during the winter are frequently from the north and north-west, so that it could well receive fallout from explosions at Pine Gap or Nurrungar during that season. The worst case situation for Adelaide would be an attack against Nurrungar which involved a ground burst at a time when the winds were north-westerly and blowing at more than 30 kph (which is quite common in winter), in which case the radiation level in Adelaide would be about 50 to 100 REMs - sufficient to cause nausea and lower resistance to other diseases, and to cause some long-term damage, but medical treatment would probably not be required. Under the same conditions, however, (i.e. a 1-Mt ground burst at a time of north-westerly winds), the radiation level over such cities as Port Augusta (population 16,000), Whyalla (32,000), Port Pirie (15,000) and surrounding areas would be about 300 REMs, which would kill about 10 per cent of those exposed[49] - i.e. perhaps more than 10,000 people.

The second category of somewhat less likely targets consists of the bases at Cockburn Sound and Darwin. Although the probability of these being attacked is relatively low (say 20-25%, which in the case of Cockburn Sound is the likelihood of a US nuclear hunter-killer submarine being in port), the consequences of such attacks would be much greater than in the cases of North West Cape, Pine Gap and Nurrungar.

In the case of Cockburn Sound, a 1-Mt weapon detonated in the air above HMAS Stirling on Garden Island, WA, would generate blast overpressures of 5 psi out to about 22,500 feet or 6.86 km, 3 psi out to 30,000 feet or 9.14 km, and 1 psi out to 60,000 feet or 18.3 km. The 5 psi contour intersects the mainland only at Cape Peron, which is a non-residential area. The 3 psi contour, within which wooden houses would collapse and some small fires would be ignited, includes much of the residential areas of Peron, Rockingham and Kwinana. The 1 psi contour, within which there would be some slight damage to residential houses, extends up to South Fremantle. Fallout is likely to be a much more serious problem than blast damage, particularly if a ground burst is involved. The afternoon winds over Perth and Fremantle are predominantly south-westerlies throughout the year. A 1-Mt ground burst at a time of such winds would deposit a radiation level of more than 1000 REMs over a narrow but elongated area of Perth and Fremantle, which would kill everyone exposed to that dose. A larger area would receive several hundred REMs, sufficient to kill 50 per cent of the exposed population. The total fatalities in this worst case situation could well be as many as 100,000 people.

In the case of Darwin, a 1-Mt Weapon detonated in the air above the RAAF Base would envelope the whole of the built-up area within the 3 psi contour and large areas would receive much higher blast overpressures. The fatalities from blast effects alone could well be as many as half the population (i.e. 25,0000 people), with injuries suffered by a further 40 per cent (i.e. 20,000 people). Should a ground burst be used, which would more seriously damage the airfield runways while reducing the lethal radii of low blast overpressures against other buildings and equipment at the base, then much of Darwin would be covered with lethal levels of fallout.

The effects of attacks against the third category of possible targets - i.e. urban-industrial areas - are the most difficult to assess, precisely because of the relative implausibility of the relevant scenarios. For illustrative purposes, however, assume an attack on Sydney which involved a 1-Mt weapon detonated on the ground at the GPO. In this case, the immediate fatalities (i.e. blast and heat) would number about 180,000, the fatalities from fallout would number about 480,000, and there would be about 350,000 injured people. The great majority of the population would be unaffected.[50] Similar results would attend an equivalent attack on Melbourne.

WARNING TIMES

A critical consideration in any assessment of the effects of a nuclear attack and the effectiveness of measures designed to limit damage from such attack is the amount of warning time available. Measures designed to alleviate damage in situations where there is assumed to be no warning (i.e. a surprise attack out-of-the-blue) tend to be very costly, or relatively ineffective, or both.

In the United States in the 1950s and 1960s, it was assumed for planning purposes that if a nuclear attack occurred, the strike would be sudden and massive, leaving only the time after tactical warning for civilians to obtain protection.

For an attack against Australia, the tactical warning time could be anything from 5 to 45 minutes, depending on the locations of the specific targets and the type of delivery system used. The Code 647 DSP early-warning satellite controlled from Nurrungar is designed to detect the launch of an ICBM in the USSR from the infrared emitted by the rocket plume as the missile rises through the atmosphere. The Nurrungar facility would learn of any ICBM attack within 60-90 seconds of launch, which would provide some 40-45 minutes warning of any strike against Australia.[51] The warning time for an SLBM attack would be much less than this. In the case of the major Australian cities or installations located on or near the coast (e.g. North West Cape, HMAS Stirling, RAAF Base Darwin), the warning might only be 5-10 minutes. In the case of an SLBM attack against Pine Gap, the warning time would be about 15 minutes. This would provide sufficient time for any endangered populace to do no more than hurry to an existing shelter if one happened to be nearby. It is not surprising that analyses based on the assumption of tactical warning only suggest the relative ineffectiveness of civil defence measures. This assumption alone can prevent the development of potentially much more effective protective measures.[52]

In the early 1970s, the US came to accept that a nuclear attack would not be made from out-of-the-blue but would be preceded by an international crisis, which in turn would provide from several days to several months of 'strategic warning'; and in 1974 the Secretary of Defense issued SECDEF guidance to the effect that planners should assume that nuclear hostilities would be preceded by such a strategic warning period.[53]

The accompanying table shows a schematic nuclear crisis scenario.[54] The scenario is not intended to have any predictive validity, but only to illustrate a reasonable sequence of events in which a crisis takes more than a month to unfold and the first use of nuclear weapons takes place at least a week before there is any major strategic nuclear exchange.

The notion that warning may be given by a pre-attack crisis suggests the possibility, or even the likelihood, that before an attack there might be weeks or even months during which normal peacetime civilian behaviour would no longer be expected. Warning of this kind, ranging from a few days to several months, would enable the preparation and perhaps even practice of plans for orderly evacuation and the procurement of materials for the construction of expedient shelters should that seem necessary. Such measures could reduce the earlier estimates of fatalities by a factor of 10 or more.

A Schematic Nuclear Crisis Scenario

Date	
1 July	East German uprising
5 July	Violence increases - West Berlin absorbed by East Germany
7 July	Intervention by West German units
9 July	Soviet Union 'ultimatum' threatens escalation (mobilises)
12 July	Large-scale, conventional border clashes halted
15 July	Three-day cease-fire violated
18 July	Negotiations collapse, fighting resumes
22 July	Soviet Union troops advance deep into West Germany
28 July	Both sides use tactical nuclear weapons
1 August	United States - Soviet Union exchange of ultimatums
3 August	Soviet Union strikes soft counterforce targets in United States (with an attempt to avoid much collateral damage) - and uses hot line
4 August	United States responds partial counter-force (also with avoidance) -- and uses hot line
5 August	???

DAMAGE LIMITATION IN THE AUSTRALIAN CONTEXT

The principal means of limiting damage to the civilian population are the evacuation of that population from possible target areas, and the provision of blast shelters and/or fallout shelters in areas likely to experience nuclear effects.

Evacuation of the population from possible target areas is potentially the most effective means of limiting casualties. Indeed, if the whole population could be relocated away from high risk areas then the casualties could be reduced to zero. Moreover, evacuation is relatively a very inexpensive operation. The preparation of evacuation plans, the regular (though infrequent) exercise of those plans, the salaries of a few hundred professional personnel trained to give appropriate local guidance, and the stockpiling of selected host areas with food, shelter materials, clothing and other minor supplies, would cost perhaps $3-4 million annually - approximately 0.1 per cent of the current defence budget. This figure would include evacuation planning for all the major Australian cities as well as the high risk areas around and downwind from the US facilities and Australian bases used by US forces. The former Commonwealth Directorate of Civil Defence has stated that 'plans are being prepared which will enable strategic evacuations to be made should the Government decide such movements to be advisable'[55], but the scope and practicality of such plans has never been revealed.

There are, of course, a number of major problems with reliance on evacuation. To begin with, there must be adequate warning time, which with regard to evacuation of the major cities such as Melbourne or Sydney would mean perhaps two to three days. Determination of the safest host areas is difficult because the direction the winds would blow after an explosion cannot be predicted with sufficient accuracy. The population must be either cooperative or at least non-resistant to the planned relocation - and this applies to the host population as much as to the evacuees. A capability for phasing smoothly into (and out of) an evacuation posture is essential: It could be managed with reduced costs (political, economic, and sociological), it could reduce uncertainty about its success, it could result in improved fallout protection, and it could help solve the problems of supplying the evacuees in the event of a protracted crisis.[56] The avoidance of false alarms would be critical to the success of the operation, since it would probably be most difficult to persuade people to evacuate on the third or fourth occasion. This means that the evacuation planners must possess extremely fine judgment as well as having timely access to all relevant intelligence and warning indicators.

Fallout shelters are generally the next most cost-effective means of limiting casualties. There are three broad types of programmes which could be considered: the provision of large public shelters in the major Australian cities and in the towns in the high risk areas; a programme of private shelters at places of work and residence; and preparation for the construction of expedient shelters as the circumstances warrant.

The radioactivity associated with heavy fallout diminishes steadily with time, starting immediately after the explosion, by a factor approximately of ten every seven-fold increase in time. If, for instance, the dose rate one hour after the explosion were 1,000 roentgens per hour it would be 100 roentgens per hour at seven hours, ten roentgens per hour at 49 hours (say two days), one roentgen per hour at two weeks and 1/10th roentgen per hour at fourteen weeks (three months).[57]

The degree of protection provided by a fallout shelter or other shielding is known as the Protection Factor (PF), which is the reciprocal of the fraction of radiation that penetrates a given protective structure. In other words, if a building occupant receives one-tenth (1/10) of the radiation which he would have received had he been standing on a smooth horizontal plane outside the building with fallout evenly distributed everywhere around him, then his PF is said to be 10. A PF of three, which is provided by a single-storey brick house, means that the radiation within the house is one-third of that outside. A house basement may have a PF of 20 to 40 (reducing radiation to two and a half to five per cent of that outside) if it is completely below ground level. A cover of approximately two feet of dirt or 16 inches of concrete can give a PF of 50-100.[58] In Australia, the recommended minimum PF for public fallout shelters is 40, and for hospitals and public utilities which are expected to function through an emergency it is 100.[59]

A nationwide private shelter programme, involving the construction of a small family fallout shelter at each occupied private dwelling in Australia, would be the most expensive approach to a fallout shelter programme; it would also be a most inefficient approach, since most dwellings would be outside likely areas of radioactive contamination.

The cost of a nationwide private shelter programme can be relatively low if the programme is undertaken at a steady rate over a long period, with construction of particular sheltered areas (such as modified basements) being done at the time the buildings themselves are constructed. For example, the residential shelter construction programme in Sweden is estimated to add approximately two percent to new residential building costs.[60]

The prices quoted for private backyard shelters manufactured in Australia range from $2,500 to $17,000, depending on their design and materials and on the amount of excavation required; $10,000 is perhaps an average price for both the shelter and its installation.[61] In 1976, there were some 4,140,500 occupied private dwellings in Australia - some 2,766,000 in the major urban areas, 856,000 in other urban areas, and 518,000 in the rural areas. A programme involving all private dwellings in Australia could thus cost more than $40 billion.

The areas where such shelters could well make a significant difference to casualties include Alice Springs, Woomera Village, and the area to the south-east of Nurrungar (including Port Augusta, Port Pirie, and Whyalla). The construction of some 30,000 shelters in these areas could cost $300 million.

There are two major problems with implementing a private shelter programme in Australia. First, since a nationwide system would obviously be both exorbitantly expensive and most inefficient, there is the problem of selecting the areas in which such shelters would be desirable. The process of identifying these areas could well have adverse political consequences. Second, there is the problem of enforcing any requirement for private shelters. Such shelters are compulsory in Sweden, Switzerland and Israel, but these countries have different political and strategic circumstances to those of Australia, and public compliance has not been readily forthcoming even in those countries. There is also a particular problem of enforcement in Australia in that any Australian programme would more likely be selective rather than national.

The other two types of fallout shelter programmes are expedient protective structures and large-scale public shelters. Expedient shelters are those which can be constructed from materials at hand within the likely period of strategic warning. Many expedient shelter designs capable of high PFs can be constructed with about 100-250 hours of labour.[62] These involve digging a hole some 350 cm (10-12 feet) deep, some 200 cm (6-7 feet) wide, and some 450 cm (15 feet) long, covering this hole with brushwood fascines, and covering these in turn with a layer of compacted clay and then 70-80 cm (2-3 feet) of soil on the top. Such structures can house 10 to 20 people and would provide a PF of about 40.

Even simpler expedient shelters are possible. One type of shelter recommended in an emergency is a trench, a metre wide and sufficiently long to accomodate the members of a family, and covered with boards or doors removed from the house, and then covered in turn with a waterproof membrane and 60 cm (2 feet) of soil.[63]

The definition of a public nuclear fallout shelter used by the NDO is a structure having a PF of 40 or higher which is accessable to the public and which is able to accomodate a minimum of 50 people. The National Fallout Shelter Survey has identified existing spaces in all suitable buildings in the capital cities, but neither the number of these shelters, their locations nor their capacity has ever been made public.[64]

Blast shelters are generally the least cost-effective of the range of possible damage-limiting measures, although they can be extremely valuable in certain specific situations. Most public blast shelters overseas are designed to withstand from 10 to 50 psi, although some Swedish shelters (e.g. the P-Klara shelter in Stockholm) can withstand as much as 150 psi, and to house from 500 to 5000 people. These shelters cost $4-6 per square foot, which includes the cost of the structure, earthworks, entranceway, environmental control system, and supplies for two weeks per person.[65] Assuming a constant space allocation of 10 square feet of gross floor area per occupant, a blast shelter designed for 5000 people would cost something like $250,000. On a normal work day, there are some 1.5 million people in Sydney within the 5 psi radius of the GPO (approximately 8 km, assuming a 1-Mt weapon) - i.e. an area of about 200 square kilometers.[66] The provision of 50 psi blast shelters throughout the central Sydney area would cut this risk area back to 6 square kilometers - and assuming a uniform population distribution would reduce the number of people at risk by perhaps 95 per cent. The cost of such a blast shelter system for these 1.5 million people would be approximately $75 million. A national blast shelter programme would cost perhaps $0.5-1 billion, depending upon how comprehensive it was intended to be.

The principal problem with such a programme is that much of this expenditure would be wasted. A 50 psi shelter would not survive if it was closer than 1.5 km from the DGZ (assuming a 1-Mt warhead), yet it would not be needed by people more than 8 km from the DGZ. In other words, it would be effective only within a narrow band around a given DGZ, but it would be impossible to predict a DGZ with any precision beforehand, and hence to properly locate the blast shelters within such a band.

However, there may be some particular centres or facilities which should be provided with some protection against blast effects because of their importance to the reconstitution of governmental authority in the aftermath of any attacks against Australia's urban-industrial areas. Many countries have implemented special measures for the protection of their National Command Authorities (NCA) and important elements of their leaderships. In Australia, an 1,800 square metre Executive Policy Direction Centre, sometimes referred to as a Crisis Command Centre, is being built two floors underground at the new Parliament House site, although this was not especially designed as a blast shelter.[67] It might well be sensible to have shelters capable of providing blast protection for several thousand key personnel and critical communications systems.

The most appropriate posture for limiting damage from nuclear attack against Australia would probably involve some combination of evacuation, fallout shelter and blast shelter programmes. The effectiveness of evacuation plans would be enhanced by the provision of some fallout protection for the evacuees, while some fallout and/or blast protection should be provided for those personnel responsible for city maintenance and high-priority activities.

CONCLUSION

The probability of nuclear attack against Australia must be assessed as being very low. Current developments in military technology and in the politico-strategic relationship between the United States and the Soviet Union are profoundly disturbing, but the prospect of large-scale urban-industrial destruction remains a powerful deterrent to any use of nuclear weapons by the superpowers.

However, while a strategic nuclear exchange is unlikely in the forseeable future, it must be accepted that there would be targets in Australia should such an exchange nevertheless occur. The US facilities at North West Cape, Pine Gap and Nurrungar would certainly be targeted by the Soviet Union; the RAAF Base at Darwin and the naval base at Cockburn Sound could be targeted in some circumstances; and there must be a finite although very small chance that Australia's major urban-industrial areas could be targeted.

The propositions that the US installations are the most likely targets in Australia, and that Australia would probably not be targeted in the absence of those installations, are frequently advanced in support of the argument that those installations should be removed. This would certainly effect a damage-limiting measure, but it is only one consideration in a very complex issue. It can be argued, for example, that insofar as the installations support surveillance and early-warning operations and communications for second-strike submarine forces then they are stabilising in that they reduce the probability of any Soviet first strike and hence of any strategic nuclear exchange.

In other words, although the presence of the installations greatly increases the probability of Australia being attacked in the event of a nuclear war, the operations of those installations could reduce the probability of war occurring in the first place. The actual likelihood of Australia suffering nuclear attack is a product of these probabilities. If Po is the probability of an attack on Australia in the absence of the installations and P1 its probability with the installations, and No the probability of nuclear war without them and N1 its probability with them, then the installations would be acceptable if Po.No > P1.N1, or

$$\frac{Po}{P1} > \frac{N1}{No},$$

where the decrease in the probability of nuclear war more than offsets the increased probability of Australia being attacked in the event of nuclear war.

Although some parts of Australia are likely to be attacked, the effects of this are not likely to be very great. It is a fortunate conclusion that the places which are the most likely to be attacked are located away from areas of significant population concentrations, while the probability of attack on the major urban-industrial areas must be reckoned as being very low indeed.

The casualties from blast effects of attacks on North West Cape, Pine Gap and Nurrungar would be essentially limited to employees working at these installations, but in some circumstances there could be significant fallout casualties, depending principally on meteorological conditions and on whether the weapons are air or ground burst. The worst situation here would be a ground burst at Nurrungar with north-westerly winds prevailing. Attacks on the bases at Darwin and Cockburn Sound would be rather less likely, but the effects of these would be rather greater. Darwin could experience high casualties from both blast and fallout effects, and Perth and Fremantle could in some circumstances receive heavy doses of fallout. Australia's cities are most unlikely to be attacked, but in the event that they were the fatalities could well exceed 1-2 million people.

The most appropriate protective measures depend on both the location of the possible targets and their likelihood of being attacked. Highly expensive shelter programmes would be difficult to justify where the probability of attack is very low, as in the case of the major urban-industrial areas, or where the efficacy of such programmes is sensitive to the vagaries of the meteorological conditions. Protection for certain key points, such as the National Crisis Command Centre, may be the extent to which it is possible to justify shelter construction. In general, the appropriate response may involve no more than the preparation of evacuation plans and the stockpiling of materials for expedient shelter construction, coupled with a programme of public education on nuclear effects.

It is imperative, however, that there be some official acknowledgement of the facts that any nuclear war is likely to involve Australia, and that damage-limiting measures are by no means ineffective. Only then will it be possible for an informed debate to proceed on the most appropriate means of limiting damage to Australia in the event of a nuclear war.

NOTES

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The regional power of most concern to Australia as being a potential nuclear threat is Indonesia. The prospects for this were considered in the Strategic Basis of Australian Defence Policy of 3 October 1975:

> Indonesia has not ratified the non-proliferation treaty (NPT) but has no significant program of nuclear development. Without large-scale external support, Indonesia could not produce a nuclear weapon before 1990 at the earliest.

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Civil Defence and Australia's Security in the Nuclear Age

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Contents

Acronyms and Abbreviations

ACDC	Australian Counter Disaster College, Macedon, Victoria
AFCC	Australian Federation of Construction Contractors
AIF	Australian Imperial Force
ALP	Australian Labor Party
AN/GSC-39(V)1	Variant of AN/MSC-61 ground terminal for US DSCS III satellite, to become operational at North West Cape, WA, in 1983
AN/MSC-61	Ground terminal for the US DSCS III satellite
ANU	Australian National University
BBC	British Broadcasting Corporation
Be	Barrier Factor, a radiation reduction factor relating to the density and thickness of shelter materials
BISCOA	Building Industry Specialist Contractors Organisation of Australia
C^3	Command, Control and Communications
C^3I	Command, Control, Communications and Intelligence
CCC	Civil Constructional Corps of World War II
CCP	Chinese Communist Party, People's Republic of China
CDO	Counter Disaster Organisation
CEP	Circular Error Probability, the median miss distance of a missile given in feet; i.e., the radius

	of a circle centred on a target within which half the RVs are expected to fall
CIA	US Central Intelligence Agency
CIRC	Construction Industry Research Council
COMCOORD	Series of Australian counter-disaster command post coordination exercises
COMINT	Communications Intelligence component of signals intelligence (SIGINT)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCPA	US Defense Civil Preparedness Agency
DGNDO	Director-General, Natural Disasters Organisation, Department of Defence, Canberra
DGZ	Designated Ground Zero, aim point for nuclear strike
DoD	Department of Defence
DSCS	US Defense Satellite Communication System
DSP	US Defense Support Program, system of Program 647 geostationary satellites for ballistic missile early-warning and other intelligence purposes
DSTI	Directorate of Scientific and Technical Intelligence, JIO
ELINT	Electronic Intelligence component of signals intelligence (SIGINT)
EMP	Electro-magnetic Pulse
ERCA	Earthmovers and Road Contractors Association
ES	Emergency Service series of UK Home Office Circulars on Civil Defence
FBM	Fleet Ballistic Missile submarine, such as Polaris and Poseidon submarines
FEMA	US Federal Emergency Management Agency
FLTSATCOM	US Navy Fleet Satellite Communications System
FY	Fiscal Year
GAO	US Government Accounting Office

GPO	General Post Office
GZ	Ground Zero, the point on the surface of the earth vertically below or above the centre of a burst of a nuclear weapon
HE	High Explosive
HF	High Frequency radio transmission (3 to 30 MHz)
HIA	Housing Industry Association
HMAS	Her Majesty's Australian Ship
HOB	Height of Burst, the height above the earth's surface at which a bomb is detonated in the air
ICBM	Intercontinental Ballistic Missile, a ballistic missile having a range of 4,000 miles or more
JDSCS	Joint Defence Space Communications Station, Woomera, SA, commonly known as Nurrungar
JDSRF	Joint Defence Space Research Facility, near Alice Springs, NT, commonly known as Pine Gap
JIO	Joint Intelligence Organisation, Department of Defence, Canberra
kHz	Kilohertz, radio frequency of one thousand cycles per second. (The VLF band, for example, is 3-30 kHz)
kPa	Kilopascal, a metric measure of pressure (1kPa = 0.00987 atmospheres)
kph	Kilometers per hour
kt	Kiloton, measure of blast effect of nuclear weapons, equivalent to 1,000 tons of TNT
MAFF	UK Ministry of Agriculture, Fisheries and Food
MBA	Master Builders Association
MBFA	Master Builders Federation of Australia
MHz	Megahertz, radio frequency of one million cycles per second. (The VHF band, for example, is 30-300MHz)
MIRV	Multiple Individually-targeted Re-entry Vehicle
MPVO	Mestndya Protivovozdushnaya Oborona, Soviet Local Anti-Air Defence Oganisation

	of a circle centred on a target within which half the RVs are expected to fall
CIA	US Central Intelligence Agency
CIRC	Construction Industry Research Council
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CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCPA	US Defense Civil Preparedness Agency
DGNDO	Director-General, Natural Disasters Organisation, Department of Defence, Canberra
DGZ	Designated Ground Zero, aim point for nuclear strike
DoD	Department of Defence
DSCS	US Defense Satellite Communication System
DSP	US Defense Support Program, system of Program 647 geostationary satellites for ballistic missile early-warning and other intelligence purposes
DSTI	Directorate of Scientific and Technical Intelligence, JIO
ELINT	Electronic Intelligence component of signals intelligence (SIGINT)
EMP	Electro-magnetic Pulse
ERCA	Earthmovers and Road Contractors Association
ES	Emergency Service series of UK Home Office Circulars on Civil Defence
FBM	Fleet Ballistic Missile submarine, such as Polaris and Poseidon submarines
FEMA	US Federal Emergency Management Agency
FLTSATCOM	US Navy Fleet Satellite Communications System
FY	Fiscal Year
GAO	US Government Accounting Office

GPO	General Post Office
GZ	Ground Zero, the point on the surface of the earth vertically below or above the centre of a burst of a nuclear weapon
HE	High Explosive
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HMAS	Her Majesty's Australian Ship
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MBA	Master Builders Association
MBFA	Master Builders Federation of Australia
MHz	Megahertz, radio frequency of one million cycles per second. (The VHF band, for example, is 30-300MHz)
MIRV	Multiple Individually-targeted Re-entry Vehicle
MPVO	Mestndya Protivovozdushnaya Oborona, Soviet Local Anti-Air Defence Oganisation

mSv	Millisievert (= .1 REM)
Mt	Megaton, measure of blast effect of nuclear weapons, equivalent to one million tons of TNT
MTIA	Metal Trades Industry Association
NADISPLAN	Natural Disaster Plan
NATO	North Atlantic Treaty Organization
NBCC	National Building and Construction Council
NCA	National Command Authorities
NDO	Natural Disasters Organisation, Department of Defence, Canberra
NEOC	National Emergency Operations Centre, Canberra
NESC	National Emergency Services College
NIE	National Intelligence Estimate
NORAD	North American Air Defense Command, Colorado Springs
NPWC	National Public Works Conference
NRO	US National Reconnaissance Office
NSW	New South Wales
ONA	Office of National Assessments, Canberra
PF	Protection Factor, index of protective capacity against nuclear radiation
PLA	People's Liberation Army, People's Republic of China
psi	Pounds per square inch of blast overpressure
RAAF	Royal Australian Air Force
RAD	Radiation Absorbed Dose, a measurement of radiation dose which corresponds to the absorption of .01 joules per kilogram of tissue
RBE	Relative Biological Effectiveness, a measure of the varying biological effectiveness of different types of radiation (e.g., gamma, alpha, beta, x-rays)
REM	Roentgen Equivalent Man, a unit of biological dose of radiation

RF	Radiation Reduction Factor of a fallout shelter
RRS	Radiological Reporting Station
RSL	Returned Services League
SAC	US Strategic Air Command
SAL(T)	Strategic Arms Limitation (Talks)
SAMSO	US Air Force Space and Missile Systems Organization
SECDEF	US Secretary of Defense
SES	State Emergency Service
SI	International System of Units, based on the metre, the kilogram, the second, the ampere (electric current), the kelvin (temperature), and the candela (light intensity)
SIGINT	Signals intelligence, includes ELINT and COMINT
SLBM	Submarine-launched Ballistic Missile
SNDV	Strategic Nuclear Delivery Vehicle (ICBM, SLBM or strategic bomber)
STRAWS	Simple Technology Recovery Aids for Water Services
Sv	Sievert, a unit of radiation dose equivalent to 100 REM
UK	United Kingdom
UKWMO	UK Warning & Monitoring Organisation
US	United States of America
USGPO	United States Government Printing Office, Washington, DC
USN	United States Navy
USSR	Union of Soviet Socialist Republics
VDC	Australian Volunteer Defence Corps of World War II
VLF	Very Low Frequency radio transmissions (3-30 kHz)