CHAPTER 12

NUCLEAR WEAPON ACCIDENT SCENARIOS

INTRODUCTION

12.1 In the previous chapter it was noted that submissions opposed to the current position presented to the Committee a range of accident possibilities, with little agreement on which should provide the basis for assessing the need for contingency planning. For the purposes of its inquiry, the Committee considered the risks in three groups: nuclear detonation; accidents which would produce particles of plutonium of a size able to be inhaled; and accidents involving dispersal of plutonium in larger pieces.

RISK OF NUCLEAR DETONATION

Views in Submissions

12.2 Few of the submissions which criticised the absence of planning for nuclear weapon accidents indicated that the risk of accidental nuclear detonation could be regarded as so small as not to justify specific contingency planning.[1] Other submissions focused on accidents less serious than nuclear detonation without

----

1. But see submissions from the Peace Squadron (Sydney), pp. 7-8 (plutonium dispersal by fire is the 'worst case' accident for planning purposes); Mr R. Bolt, p. 20 (Evidence, p. 970) (one-point detonation accident should be the basis of planning). See also Evidence, p. 921 (Mr M. Lynch): 'not that anybody is suggesting an accidental [nuclear] detonation'; pp. 597-98 (Prof W. J. Davis): nuclear detonation not considered possible.

expressly stating that nuclear detonation was not a credible event.[2]

12.3 Some submissions argued that, when nuclear weapons were involved, any possible accident, no matter how remote, should be taken into consideration:

> While naval authorities will tell us that the chance of...[an accidental nuclear detonation] occurring is very slim, they do not deny it is possible. Therefore, mathematical probability says it is likely to happen, given sufficient time. It is therefore this, the worst scenario, that must be addressed by any safety procedures.[3]

12.4 The Committee, as discussed in chapter 3, has adopted the orthodox approach to risk assessment, which distinguishes credible from other physically possible events. Because arguments of the type quoted are inconsistent with this approach, the Committee does not accept them. In the Committee's view, planning is appropriate only for credible accidents, not for all physically possible accidents irrespective of their likelihood.[4]

12.5 Other submissions suggested that predictions by nuclear planners had proven false in the past:

> Chernobyl, Three Mile Island, and the recent sinking of a Soviet submarine and indeed, the US Navy's accident record all PROVE that no matter how remote the risk, nuclear accidents

----

2. e.g. see the submissions from the Victorian Association for Peace Studies, p. 3; Assoc Prof P. Jennings, p. 1; Dr B. Ewald, p. 3; Scientists Against Nuclear Arms (NSW), p. 2 (Evidence, p. 804); People for Nuclear Disarmament, p. 3 (Evidence, p. 1305); Senator J. Vallentine, p. 21 (Evidence, p. 1064).
3. Submission from Balmain People for Nuclear Disarmament, p. 3. See also for example the submissions from the Coalition Against Nuclear Armed & Powered Ships, pp. 6-7 (Evidence, pp. 1378-79); Derwent Valley Peace Group. p. 3.
4. See para. 3.14.

do happen.[5]

12.6 The claim was also made that the fact that a particular type of accident has not yet happened does not mean that it never will: there has to be a first time.[6] It was also put to the Committee that, as the consequences of a nuclear weapon accident would be so catastrophic, it would be prudent to eliminate the small probability that one would occur.[7] The Victorian Government submission suggested:

> There must always be a very small but real risk of nuclear detonation through either a sequence of technical faults or human error, or through an act of fanaticism by one or more of the ship's crew ...[8]

12.7 In contrast to these views, Eugene J. Carroll, formerly a rear admiral in the United States Navy and subsequently a strong critic of many aspects of nuclear weapons and strategy in his capacity as deputy director of the Center for Defense Information in Washington, considered that 'there is no credible possibility of accidental detonation of a nuclear weapon'.[9] The Australian former nuclear scientist, Sir Mark Oliphant, was quoted as having said recently that the probability of an accidental nuclear detonation 'is almost exactly zero'.[10]

Official Views

12.8 The view of the Department of Defence is that:

----

5. Australian Nuclear Free Zones Secretariat, p. 3 (emphasis in original). See also the submissions from Scientists Against Nuclear Arms (Townsville), p. 2 (Evidence, p. 776); Epping & District Peace Group, p. 2.
6. e.g. submission from Mrs M. J. Holmes, p. 1.
7. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 9 (Evidence, p. 795).
8. Submission from the Victorian Government, pp. 2-3.
9. E. J. Carroll, 'Nuclear Trojan Horse', New York Times, 8 August 1983, p. A17.
10. 'Sir Mark Oliphant says N-ships safe', Advertiser (Adelaide), 19 October 1988, p. 1.

> If we take into account the fact that any accidents to nuclear weapons are extremely unlikely to occur when those weapons are in secure storage, as would be the case during visits by US warships, the actual risk of a nuclear detonation during a visit to an Australian port by a US warship becomes infinitesimally small.[11]

12.9 On 24 September 1986, Senator Evans, as Minister representing the Minister for Defence, told the Senate:

> the Government is satisfied that the standards required by the North Atlantic Treaty Organisation countries, including France, in respect of nuclear weapons safety, coupled with the precautions taken on board visiting warships, effectively preclude the possibility of accidental nuclear detonation.[12]

12.10 The Australian Ionising Radiation Advisory Council (AIRAC) reviewed information on nuclear weapon safety features supplied to it by the Department of Defence. On the basis of this information it:

> concluded that the extensive safety precautions make identification of a likely cause of an accidental nuclear detonation difficult.[13]

AIRAC stated that it believed the possibility of a nuclear detonation occurring accidentally to be 'exceedingly small'.[14]

12.11 The position of the United States Navy with regard to planning for nuclear weapon accidents is:

----

11. Submission from the Department of Defence, p. 24 (Evidence, p. 29).
12. Senate, Hansard, 24 September 1986, p. 754. See similarly HR, Hansard, 30 May 1984, p. 2397; ibid., 23 August 1985, p. 458; Senate, Hansard, 2 May 1986, p. 2292.
13. Supplementary submission from AIRAC, p. 4 (Evidence, p. 704).
14. Evidence, p. 707 (AIRAC). See also p. 708 where the Chairman of AIRAC gave his personal view that the possibility of such a detonation was 'negligible' and 'almost impossible'.

> The possibility of a nuclear weapon accident affecting the civilian population is virtually nil, nonetheless we plan for the worst possible, though unlikely, case. Even in worst case there is no danger of nuclear explosion.[15]

12.12 The United States General Accounting Office has reported that according to United States Departments of Defense and Energy sources:

> the probability of an accidental detonation of a nuclear weapon warhead is virtually non-existent because extensive safety precautions have been taken in the design, handling, storage, and maintenance of weapons.[16]

The view of the British Government is similar.[17]

12.13 In 1979, a representative of the United States Department of Defense stated:

> we still require that under normal environmental situations that the probability for a nuclear weapon detonation to occur through an accident is less than 1 in 1 billion. In the most extreme cases, like a fire, we maintain a

----

15. US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Hearings on H. R. 1409 to Authorize Certain Construction at Military Installations for FY 1986, 27 March 1985, p. 432 ('Response to a Nuclear Weapon Accident on a Navy Ship').
16. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 16. See also US, General Accounting Office, Observations on Navy Nuclear Weapon Safeguards and Nuclear Weapon Accident Emergency Planning, (GAO/NSIAD-85-123, 29 July 1985), p. 5: 'Department of Energy studies indicate that the possibility of an accidental nuclear explosion while transporting or storing nuclear weapons is so remote as to be virtually nonexistent'.
17. UK, Parliamentary Debates (Lords), 5th series, vol. 466, 10 July 1985, cols. 190 and 191: 'there is no prospect of an atomic bomb-type explosion occurring by accident or mistake' and 'the prospect of an accidental discharge of a nuclear weapon is very remote indeed'.

probability of less than 1 in 1 million.[18]

12.14 The Committee has not had access to the methodology or the data used to produce these risk estimates or underlying the official assurances. Assuming that formal risk assessments have been made,[19] the input to the assessments would of necessity include highly classified details of weapon design. It follows, therefore, that assurances from the Australian Government are based to a considerable extent on assurances given to it by United States and British sources, not on its own independent assessment.[20]

Effect of Nuclear Reactor Accident

12.15 Some visiting warships may be both nuclear powered and nuclear armed. No plausible scenario has been put to the Committee whereby an accident involving the reactor could lead to a nuclear detonation of the weapon.[21]

----

18. US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 224. See also Evidence, p. 1261 (Department of Defence).
19. It may be that quantified assessments have only been made for the newer weapons: cf. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, p. 69 (Dr R. Barker, Department of Defense): for the probability of an older nuclear weapon's conventional explosive detonating by accident:

    > it is difficult, if not impossible, to assign a number of [sic] the probability in an accident environment. We still believe it is quite low, some place between one in ten to the third or one in ten to the sixth, but because of the nature of the design, we cannot quantify it, we cannot do the tests which make us feel comfortable in providing a number. The modern devices are such that we can tell you indeed it is at least as good as one in a million and maybe better.

    Since the nuclear detonation requires the prior detonation of the conventional explosive, it would seem to follow that where the latter cannot be quantified, neither can the former. The ambit of the category of weapons for which quantification is not possible was deleted from the published transcript on security grounds.
20. Second supplementary submission from the Department of Defence, pp. 22-23 (Evidence, pp. 238.277-78).
21. cf. Evidence, p. 425 (ANSTO).

Conclusions - Nuclear Detonation

12.16 The Committee found no reason to disagree with the official view that the risk of accidental nuclear detonation is so small that there is no need to have specific plans for this contingency. The Committee reached its conclusion on the basis of what is publicly known about the safety features in the design of nuclear weapons; the fact that warheads and explosives are officially stated to be held in safe storage during port visits; the integrity of that storage; the absence of any accident to date leading to nuclear detonation; and the absence in submissions made to it of any credible scenario which would result in nuclear detonation during a port visit.

12.17 Having reached this conclusion the Committee did not find it necessary to assess the effects of a nuclear detonation. Nor was it necessary to consider what sort of planning would be required in order to deal with these effects.

ACCIDENT CAUSING DISPERSAL OF PLUTONIUM PARTICLES

Introduction

12.18 The hazards from plutonium were discussed in the previous chapter, in particular the hazard from inhalation of plutonium particles. The Committee therefore examined the possibility of accidents leading to this result. It appeared to the Committee that the expert view was that the plutonium in a weapon could, in an accident, be rendered into particles capable of inhalation by one of two means. These were fire and/or conventional explosion.[22]

Effect of Fire

12.19 Even if a nuclear weapon is involved in an intense, prolonged fire, only a small proportion of the plutonium will be turned into a form in which it can be inhaled. The United States Departments of Defense and Energy reported in 1984:

> The experimental efforts of the Department of Energy study of plutonium dispersal under various fire scenarios have been completed. The conclusions of the study are that in a fuel fire approximately 0.1 percent of the plutonium mass is aerosolized and that nearly all of this aerosol is respirable. The worst-case fuel fire would aerosolize up to only one percent. The results of this joint study correlate quite well with other tests and studies on the aerosolization of plutonium.[23]

12.20 AIRAC told the Committee it accepted the accuracy of these conclusions.[24]

12.21 One purpose of the British nuclear 'Minor Trials' conducted at Maralinga, South Australia in the late 1950's and early 1960's was to assess the degree of plutonium dispersal from an accident involving a nuclear weapon. The Committee was told

----

22. e.g. see US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 16 (views of US Defense and Energy Department officials); UK, Parliamentary Debates (Commons), 6th series, vol. 149, Written Answers, 20 March 1989, col. 477. See also US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, Washington, 1984), p. 3: if the conventional explosive in a nuclear weapon

    explodes ... there may be extensive radiological contamination. A fire, while less serious than an explosion may also give rise to substantial contamination.

23. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. II-25.
24. Evidence, p. 725 (AIRAC). Contrast the submission from Prof W. J. Davis, p. 18 (Evidence, p. 465) and his Evidence, p. 591, where it is assumed that 100% of the plutonium is aerosolised in a shipboard fire. No scientific evidence or argument is provided by Prof Davis to support his assumption. Nor is the Committee aware of any.

that the dispersal from tests designed to simulate an intense petrochemical fire was limited to an area with a maximum dimension across the perimeter of 200 metres.[25] Only a very small percentage of the material was dispersed into the air.[26]

12.22 The Committee noted that it appears that the plutonium would have to remain subject to the intense fire for a considerable period in order to produce significant aerosolisation.[27] One accident scenario, that put to the Committee by Professor W. J. Davis, postulated significant aerosolisation by assuming that the weapon would remain in the fire for three hours.[28]

Effect of Conventional Explosion

12.23 The United States General Accounting Office found that officials of the United States Departments of Defense and Energy:

> believe the most probable health and safety hazards from a nuclear weapon accident are the detonation of conventional explosives and the

----

25. Evidence, p. 719 (AIRAC). See also Evidence, p. 418 (ANSTO); J. L. Symonds, A History of British Atomic Tests in Australia, (AGPS, Canberra, 1985), p. 502.
26. J. L. Symonds, A History of British Atomic Tests in Australia, (AGPS, Canberra, 1985), p. 501. Each of the two tests involved burning a 7.6 cm long rod of plutonium. The total plutonium present was 405.4 g, of which an estimated 395 g was returned to Britain after the tests: ibid., p. 556. See also Evidence, pp. 706.708 ff for a now declassified extract from the UK Atomic Weapons Research Establishment report on the Vixen A trials in 1959 from which Dr Symonds drew his information. In the first test, dispersal by fire was about 1%. In the second test, material was not collected for two days after the fire. About 3% was dispersed by the combined effects of the fire and then the wind during the two day period. It is important to note that the Maralinga tests were not designed to model an accident to a weapon in a warship magazine. The results do not reflect the extent to which plutonium dispersal might be reduced by deposition inside the magazine and inside the hull of the warship.
27. UK, Atomic Energy Authority, Atomic Weapons Research Establishment, AWRE Report No. T 15/60: Vixen A Trials, (AWRE, Aldemaston, 1961), pp. 11-12 (Evidence, pp. 706.711-12) indicates the temperatures (725-860 degrees Celsius) and times (20-30 minutes) involved.
28. Submission from Prof W. J. Davis, p. 18 (Evidence, p. 465). In giving an alternative scenario involving 100 warheds in a fire (Evidence, p. 593), no indication was given that the assumed duration of the fire was altered.

release of plutonium particles ...[29]

12.24 AIRAC also regarded a conventional explosion as a key factor:

> the dispersion to substantial distances involves a chemical explosion which disperses the plutonium. Fire may be the initiating event of a chemical explosion; collision may be the initiating event of the fire. But the essentiality of it is that you have to have a chemical explosion that disperses the plutonium, not only in order to get it dispersed, but in order to open up the magazine or whatever to the atmosphere. So the chemical explosion is a strong prerequisite right through the AIRAC submission.[30]

12.25 AIRAC described to the Committee the process by which a conventional explosion would convert some of the plutonium present into an aerosol:

> the casing fails - we are talking of a time sequence of nanoseconds or less - and what you really do is squirt out molten plutonium into the atmosphere. ... [This] will generate an awful lot of very small particles that are inhalable and that will travel quite large distances.[31]

12.26 A theoretical model used to predict plutonium dispersal

----

29. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 53. See also New York City, Department of Health, Bureau for Radiation Control, Radiation Aspects of Emergency Plan for Proposed Homeport, Navy Battleship Surface Action Group, Stapleton, Staten Island, (17 March 1988), p. 3, referring to naval nuclear weapon hazards:
    > Without specific information on the nuclear ordnance components, we view the principal accident in terms of possible health consequences as the result of unintended detonation of the conventional high explosive in the neighborhood of the fissionable capsule resulting in airborne dispersion of plutonium-239.
30. Evidence, p. 718 (AIRAC).
31. Evidence, p. 724 (AIRAC). It was experiments leading to this type of effect that resulted in the widespread contamination from the Maralinga trials: ibid., pp. 723-24.

following a nuclear weapon accident assumes that the detonation of the weapon's conventional explosive could result in twenty per cent of the plutonium being aerosolised in respirable sized particles.[32] Once in aerosol form, the assumptions and calculations used in the model indicate that this plutonium could be distributed over a significant area.[33]

12.27 However, the model uses very much worst case assumptions: the percentages of plutonium dispersed have been smaller in tests and actual accidents, and the statistical confidence level in the model is regarded as low.[34] In addition, the model, which is not directed specifically to shipboard accidents, makes no allowance for the percentage of plutonium particles that might be trapped within the ship.[35] Nonetheless, the plutonium dispersal achievable through the detonation of the weapon's conventional explosive poses a serious possible hazard.

12.28 In the aircraft accident which occurred in 1966 at Palomares, Spain the high explosive in two nuclear weapons

----

32. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 52, referring to studies using the US Department of Energy's Atmospheric Release Advisory Capability system. Respirable size is defined as being 10 microns or less.
33. ibid., p. 51 contains a diagram indicating that the downwind dispersal of quantities sufficient to require respirator protection or evacuation could extend for about 2 kilometres. See also Evidence, pp. 718, 720, 723-4 (AIRAC) on the extent of plutonium dispersion following detonation of the conventional explosive in a nuclear weapon.
34. ibid. In contrast to the model's assumption of 20%, a study done by Sandia National Laboratories suggested that the fraction aerosolized in respirable form might be in the range of 1 to 10%: cited in New York City, Department of Health, Bureau for Radiation Control, Radiation Aspects of Emergency Plan for Proposed Homeport, Navy Battleship Surface Action Group, Stapleton, Staten Island, (17 March 1988), p. 16.
35. US, H of R, Committee on Armed Services, Subcomittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 235 (Dr J. P. Wade, Department of Defense): in the scenario modelled

> the accident happens while the weapon is on a hard concrete surface and occurs under adverse meteorological conditions. In real life, such an accident could occur while a weapon was being moved from one location to another, within a military installation, or being loaded into an airplane.

detonated when they hit the ground, dispersing plutonium. The furthest point at which plutonium was detected above the level of natural background radiation was a about one and a half kilometres from the point of detonation.[36] Contaminated soil was removed from 2.3 hectares for shipment to the United States, with other areas less seriously contaminated being treated at the site.[37]

Committee's Focus on Accident Likelihood

12.29 The Committee was prepared to assume for the purpose of its inquiry that an intense fire of some duration involving a nuclear weapon on a visiting warship, or the detonation of the conventional explosion of that weapon, might have serious consequences.[38] The Committee focused its attention on the means by which such a fire or conventional explosion might occur, in order to determine its likelihood.

12.30 The Committee notes that in taking this approach it did not follow the approach taken by many of the submissions opposing

---

36. US, H of R, Committee on Armed Services, Subcomittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 236 (Maj Gen J. K. Bratton, Department of Energy).
37. US, Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975), p. 65. On the effectiveness of the clean-up and the limited extent to which contamination still gives rise to concern, see E. Iranzo and others, 'Air Concentrations of 239Pu and 240Pu and Potential Doses to Persons Living Near Pu-Contaminated Areas in Palomares, Spain', Health Physics, April 1987, vol. 52(4), p. 460; New York Times, 28 December 1985, p. 2, 'Where H-Bombs Fell, Spaniards Still Worry'. The official view is that no one received exposure in excess of international safety levels as a result of the accident: New York Times, ibid., citing the Spanish Nuclear Energy Board; US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 227 (Maj Gen R. Cody, Defense Nuclear Agency).
38. Submissions by Prof W. J. Davis and Scientists Against Nuclear Arms (NSW) provided calculations which, using different values, gave differing figures for the numbers of additional cancers which would be caused by a nuclear weapon accident on a ship in Sydney. The Committee did not consider it necessary to investigate the accuracy of the calculations or the assumptions underlying them.

the current position. These submissions tended to focus in some detail on the consequences of a nuclear weapon accident, without giving equally detailed consideration to how any such accident might occur. The Committee considered that it was more efficient to focus on how accidents having those consequences might occur. If it can be concluded that the likelihood of occurrence is very small, there is no need to explore further some of the difficult issues that relate to accident consequences.

Possible Scenarios

12.31 The reported safety characteristics of the insensitive high explosive used as a trigger in modern nuclear weapons are such that the Committee can find no accident scenario which takes account of these characteristics that would lead to its detonation. Therefore, in looking for a means by which a nuclear weapon's conventional high explosive might be detonated, the Committee was considering only those older weapons not fitted with insensitive high explosive.[39]

12.32 The view of the Department of Defence is that 'credible hypothetical nuclear weapon accident scenarios on visiting warships are really very hard to envisage'.[40] Compared to the reference accident relating to naval reactors, the Department's view is that 'the chance of a nuclear weapons accident would be very much less than the chance of an accident involving a dynamic system, like a reactor system' on a visiting warship.[41] Because the weapon is in a passive state, the Department did not regard it as plausible to regard the weapon as the source of the events leading to the weapon burning or its conventional explosive detonating.[42]

----

39. See paras. 11.33 and 11.55-11.56 on the types of weapons which may not use insensitive high explosive.
40. Evidence, p. 1258 (Department of Defence).
41. Evidence, p. 1262 (Department of Defence).
42. Evidence, p. 1259 (Department of Defence).

12.33 The Committee considered this view to be sound. Accordingly, as the weapons are on a warship, it looked at ways in which the warship rather than the nuclear weapon could become the victim of fire or explosion which might then affect the weapon. Ship collision is one initiating factor which obviously has to be considered.

Collision

12.34 A number of submissions referred in general terms to vessel collision as the initiator of a nuclear weapon accident.[43] The Department of Defence examined the possibility of a nuclear weapon accident resulting from a collision - a possibility it regarded as 'conceivable as distinct from credible'.[44]

12.35 AIRAC, on its own initiative and on the basis of information supplied by the Department of Defence,[45] attempted to define some hypothetical accidents.[46] It did so as an interim step towards defining the most probable accident involving a nuclear weapon. AIRAC came to the view that in order to produce an immediate and serious radiation hazard the accident would have to involve a collision followed by a fire and conventional

---

43. e.g. submissions from Scientists Against Nuclear Arms (Townsville), p. 1 (Evidence, p. 775); Scientist Against Nuclear Arms (Tas), pp. 3-4 (Evidence, pp. 822-23); Balmain People for Nuclear Disarmament, p. 3; Port Adelaide Environmental Protection Group, p. 2; Mr R. Addison, pp. 1 and 2.
44. Evidence, p. 1259 (Department of Defence). In P. Hayes and others, 'Nuclear Weapons: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 26 it is incorrectly stated that Defence regarded the collision scenario as one of 'only two credible scenarios' involving a nuclear weapon in Australia.
45. Evidence, pp. 737-38 (AIRAC).
46. It is evident that some of those following the course of the inquiry have not appreciated the distinction between hypothetical accidents and a reference accident used as a basis for planning: see, for example, the submission from Mr P. Gilding, p. 5 (Evidence, p. 1338). Hypothetical accidents are the input to the risk evaluation process: a reference accident is one possible outcome of that process. The assumption that the Department of Defence has not evaluated hypothetical accidents does not follow from the fact that it has not arrived at a reference accident for nuclear weapons.

explosion.[47]

12.36 The Committee notes that AIRAC's scenario requires that three separate events occur in sequence. In order to evaluate the scenario, it has to be asked how likely is a collision, how likely is that collision to cause a fire, and how likely is the fire to cause the conventional explosive to detonate. If each of these events is unlikely, the probability of their all occurring together is even less likely.

12.37 The difficulty of accurately establishing the likelihood of a warship being involved in a collision in an Australian port was noted in relation to nuclear powered warships in chapter 7. In the present context, the Committee noted that, while special navigational controls apply in relation to the port movements of nuclear powered warships, no specific controls apply to the movements of nuclear weapons capable vessels.

12.38 The Victorian Government suggested that controls similar to those applicable to nuclear powered warships ought to be applied to nuclear weapons capable vessels.[48] But it provided no supporting argument based on collision probability. Nor did it explain how it considered that a collision would lead to a radiation hazard from a nuclear weapon that was in safe storage on board, or how likely it considered this in comparison to a collision-induced reactor accident.

12.39 The Department of Defence has taken the view that there

----

47. Supplementary submission from AIRAC, pp. 4-5 (Evidence, pp. 704-05); Evidence, pp. 708-09 (AIRAC). Although AIRAC set out this scenario in a measure of detail, it did not rule out other accident scenarios that might be developed: Evidence, pp. 709 and 713.
48. Submission from the Victorian Government, p. 4.

is no need to impose special speed limits on visiting warships.[49] It has preferred to leave the matter of appropriate limits to the individual port authorities and relies on warships observing these limits.[50] For Sydney for example, the limits are 12 knots (22 km/h) from the Heads to Bradley's Head and 10 knots (18.5 km/h) from there to the Harbour Bridge.[51]

12.40 A collision occurring at the relatively low speeds maintained in ports and port approaches is unlikely to affect weapons stored in the vessel's magazines, which for safety reasons are located away from the more vulnerable parts of the ship. The Committee received no information suggesting that a United States warship has been in a serious collision while entering or leaving an Australian port.[52] As noted in the previous chapter, none of the United States Navy's 630 reported nuclear weapon accidents or incidents in the period 1965-1985 resulted from ship collision.

12.41 As part of its collision-fire-conventional-explosion scenario, AIRAC canvassed the possibility that the firefighting capability of a warship could be rendered inoperative due to the vessel being involved in a collision which also caused a fire in

----

49. A surface warship would need to be the struck rather than striking ship for the maximum weapon accident likelihood to arise. If it was the striking ship the impact would probably be on its bow, well away from magazines and in a place where the prospect of localising a fire would be good. Thus the speed of other vessels in the vicinity is more important than the speed of the surface warship. This is less true for submarines, whose weapons may be stored near the bow.
50. cf. Evidence, pp. 1291-93 (Department of Defence) relating primarily to nuclear powered warships.
51. Evidence, p. 1292 (Department of Defence).
52. The attention of the Committee was drawn to collisions such as that of the USS Texas with a wharf in Brisbane in 1983: see, for example, the submissions from Friends of the Earth, p. 1; Mr P. Gilding, p. 7 (Evidence, p. 1340). But in the context of the scenarios under consideration this type of accident can fairly be regarded as insignificant: see Evidence, pp. 1393-94. Mr Peter Hayes, in a letter to Senator McIntosh, 10 February 1987, p. 1 stated that there had been a collision between a US aircraft carrier and a RAN destroyer in Sydney Harbour in the 1960's. The Department of Defence informed the Committee that they had no record of this.

the magazine.[53] The possibility of the collision and fire occurring as independent events at the same time is logically far less probable.

12.42 Collision might cause flooding rather than fire.[54] This would be particularly likely if the warship was a submarine. Even a collision that started either a magazine fire or a fire capable of spreading to a magazine might well not detract from the fire-fighting capability on the vessel.[55] This is especially true in that the magazine can be flooded or smothered even though the vessel has lost all power.[56]

12.43 The Committee was told by the Department of Defence that, given magazine safety systems, 'the risk of a major sustained fire in as well protected part of a warship as its magazine does stretch credibility very far'.[57] Thus, even if the AIRAC scenario proceeds from a collision to ship fire, it is difficult to find a mechanism by which the fire could affect the magazine so as to cause the nuclear weapon's conventional explosive to detonate.

12.44 As an alternative to the AIRAC scenario, the collision may impact directly on the magazine without causing a fire, but with sufficient force to trigger the conventional explosive of a nuclear weapon. The need to ensure that the weapons can withstand the shock of routine handling, stormy seas, launching or, for bombs, aircraft take-off and landing, indicates that they must be robustly designed. The location of magazines in well-protected parts of ships also reduces the likelihood of this scenario eventuating. The absence of collision-induced nuclear weapon accidents is as relevant to this scenario as to other collision scenarios.

----

53. Evidence, pp. 709-10 (AIRAC).
54. Evidence, p. 709 (AIRAC); p. 1259 (Department of Defence).
55. Evidence, p. 709 (AIRAC); p. 1259 (Department of Defence).
56. cf. Evidence, p. 1260 (Department of Defence).
57. Evidence, p. 1259 (Department of Defence).

Collision - Committee's Conclusion

12.45 The Committee is unable to find a credible scenario in the context of an Australian port visit in which a collision would lead to either a sustained fire in a warship magazine or to the detonation of a nuclear weapon's conventional explosive.

Fire

12.46 The Department of Defence canvassed the possibility of a nuclear weapon accident caused by fire because it had been raised by others, but did not itself consider the scenario credible.[58] The Department gave as reasons for its conclusion the safety features of magazines and the procedures governing weapons storage combined with the safety features in nuclear weapon design.[59]

12.47 As noted in the previous chapter, the Department of Defence considers and the Committee accepts that all weapons will be safely stored during a port visit. None of the submissions postulating an accident involving a fire provided any detail of how such a fire might occur in a magazine, or of how the plutonium might be directly exposed to the fire. Given the record of safety of warship magazines under combat conditions it difficult to postulate a credible cause in port in peacetime for a fire starting in a magazine, let alone burning for the three hours required by Professor Davis's accident scenario.[60]

12.48 The magazine safety record, together with the safety features of magazines is such that the Committee is unable to postulate a credible means by which a fire could start in a magazine without some external triggering event.

----

58. Second supplementary submission from the Department of Defence, p. 24 (Evidence, p. 238.279).
59. Submission from the Department of Defence, p. 26 (Evidence, p. 31).
60. Submission from Prof W. J. Davis, p. 18 (Evidence, p. 465).

12.49 The alternative is to consider the possibility of a fire which starts outside the magazine, and spreads to it. The cause may be external to the vessel. One cause, collision, has already been considered. The Department of Defence canvassed the scenario of a large aircraft crashing onto the warship and causing a fire. It was considered that this appeared 'to be an extremely remote possibility',[61] which the Department did not consider credible.[62]

12.50 The Committee agrees with this assessment. To be considered credible, a scenario of this type has to contend not only with the unlikelihood of the initiating event, but also with the ship's general firefighting capability and the fire protection built into magazines. In particular a credible means to overcome the ability to flood or smother magazines by passive means has to be found in order that the overall scenario be credible. Scenarios can be imagined in which the ship might be

----

61. Evidence, p. 1259 (Department of Defence). cf. submission from Mr R. Addison, p. 12, where it is assumed that a visiting aircraft carrier would have aircraft landing and taking off while berthed in Australian port and that one of the vertical takeoff aircraft crashes through the flight deck into the nuclear weapons magazine which is assumed to be directly underneath. This scenario gives no reason for assuming that the magazine is located in such an exposed place, nor that the flight deck is so thinly constructed as to be unable to survive such an obvious hazard as an aircraft crashing on to it.

62. Evidence, p. 1260 (Department of Defence). In assessing Brisbane's suitability for visits by nuclear powered warships the possibility of an aircraft crashing onto the warship was examined, due to the proximity of Brisbane Airport to the berths approved for visits: ANSTO, Assessment of Berths for Operational Use by Nuclear Powered Warships in Australian Ports: Supplement No. 6, The Container Terminal, Fisherman Islands, Brisbane, (March 1982), p. 3 (Evidence, p. 264). The assessment concluded:

> it is estimated that the probability of an accident of sufficient severity to penetrate the reactor compartment and cause damage to reactor safety systems is about 10^{-9} for an NPW visit of one week's duration. This accident therefore does not contribute significantly to the total risk of a reactor accident at an NPW berthed at the Container Terminal.

Because the risk of aircraft crashes are generally highest near busy airports, the likelihood of a crash onto a visiting warship would generally be lower at ports other than Brisbane as major airports are further away from the berths used. The new Brisbane Airport was formally opened in 1988. ANSTO considers that the move to the new airport does not alter the risk sufficiently to affect its conclusion on total risk made with respect to the old airport.

massively damaged, so as to impair all firefighting capability. But the likelihood of this happening without either sinking or extensively flooding the vessel appears small.

12.51 Other causes external to the vessel are physically possible but, when examined, no more credible. A fire starting on a wharf to which the vessel was moored, an explosion on shore throwing burning debris onto the warship, an oil spill on the water catching fire and drifting to the vessel, another vessel catching fire and drifting towards the warship, and many other scenarios can be imagined. But all both involve rare events and allow time for actions by the warship's crew to prevent the fire affecting any nuclear weapons on board. Even if the warship cannot be moved, there would be time to flood the magazines.

12.52 It is possible to imagine a fire starting on the warship but outside the magazine. The precautions taken on warships suggest that the possibility is limited. Fuel storage tanks and other inflammables are not located close to magazines. But the problem still remains of how the fire would overcome the ship's firefighting ability and magazine safety measures. Fires have occurred on warships of the relevant navies in peacetime, but they have not caused explosions in magazines.[63]

Fire - Committee's Conclusion

12.53 The Committee is unable to find a credible scenario in the context of an Australian port visit in which a fire could start and could continue in a warship magazine for the necessary time at the necessary intensity to cause the dispersal of respirable-sized plutonium outside the vessel.

Effect of a Reactor Accident

12.54 Most nuclear powered warships are also nuclear weapons

----

63. See paras. 11.73-11.74 on magazine safety records.

capable. The possibility of a reactor accident leading to a weapon accident has to be considered. The Committee was prepared to assume that any nuclear weapons that might be on board would not be stored immediately adjacent to the reactor(s). A reactor accident is itself an unlikely event for the reasons discussed earlier in the report. There is no obvious mechanism by which even a meltdown in the reactor compartment should have any impact on weapons located in magazines some distance away.

Accident during Weapon Transfer

12.55 One nuclear weapon accident scenario was canvassed in an article by Mr Peter Hayes and others in the September 1988 issue of Current Affairs Bulletin. The premise for the scenario was that nuclear weapon handling could occur between United States warships in an Australian port during a time of heightened tension between the super-powers.[64] Although the Committee did not accept this premise, it did consider the scenario. The accident postulated is one in which a helicopter being used to transfer a nuclear weapon crashes on land, explodes and burns with the result that the casing of the weapon is cracked and the

----

64. P. Hayes and others, 'Nuclear Weapon Accidents: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 27. Two apparently separate scenarios are presented. The one labeled 'A' involves no more than an increased number of ship visits to Australia following an increase in super-power tension in the Indian Ocean region. It is difficult to see how this increases the hazard markedly, unless an assumption is made that it is only in times of tension that visiting US vessels carry nuclear arms. While this assumption may be correct, the Committee adopted a 'worst case' assumption that nuclear weapons may be aboard during other visits (see para. 11.24). So, in terms of the Committee's approach, scenario 'A' adds nothing to what is assumed to be the risk. Another possibility is that the increased risk arises from the possibility of the vessels becoming targets. This is inconsistent with the focus of the article, which is on accidents. It may be that scenario 'A' is not intended to be a free-standing scenario, but is merely an element in scenario 'B'. This was the case in an earlier, draft, version of the article attached to the submission from Mr P. Hayes.

plutonium burns.[65]

12.56 The Committee considers that, in addition to its premise, this scenario contains many unlikely events. For example, it requires that two (or more) United States warships with compatible weapons systems be in an Australian port at the moment when the super-power tension increases.[66] Periods of the requisite degree of tension are very rare.[67] The chance of one coinciding with the warships' presence is even less likely, given the infrequency of multiple-ship visits to Australian ports.

12.57 The scenario requires a need to transfer nuclear depth

----

65. ibid. The relevant part of the scenario, premised on hightened super-power tension, reads (p. 27):

> The commanders of two US destroyers visiting Sydney consult with each other. They know that a Soviet submarine is waiting offshore for their departure. One destroyer has a full complement of nuclear anti-submarine depth bombs which it needs to share with the other so that it can fulfil its mission of protecting an American aircraft carrier steaming south from the North Pacific. It may also need them to destroy the Soviet submarine. The commanders are advised that there are no agreements with Australia forbidding them to ship these bombs from one ship to the other using helicopters - the fastest and easiest means of cross-decking the weapons. A helicopter makes the run across the wharves. On its third run, the motor sputters and stops. The chopper falls to the wharf and explodes. In the fire, the casing of a nuclear bomb is cracked and the plutonium burns. ...

66. If the period of tension had been running for any length of time, the the trans-shipment of weapons would presumably have taken place at sea or in a homeport.

67. In his submission, one of the authors of the article criticises the use by Australian authorities of the allegedly undefined concept of 'normal peacetime circumstances' ; submission from Mr P. Hayes, p. 3. Yet the article gives no definition of a 'crisis between the superpowers' which 'could result in non-routine crisishandling of nuclear weapons' (p. 27). Thus, it is not possible to say on how many days since nuclear weapons were first deployed such a state of crisis has existed. If only the core period of the 1962 Cuban missile crisis and the brief period of hightened super-power confrontation during the 1973 Arab-Israel war qualify as times of crisis in the relevant sense, then the number of days would average much less that one per year.

bombs.[68] This requirement is inconsistent with the virtually unanimous view of those opposing visits. On this view, vessels certified to carry nuclear weapons always do so. If this view is correct, there would never be a need to trans-ship weapons during port visits. Thus the scenario rests on the proposition that the view held by many commentators is incorrect.[69]

12.58 The weapons transfer envisaged by the scenario would seem likely to breach numerous United States Navy safety rules relating to the mechanics of transferring nuclear weapons,[70] unless there is provision to waive these rules in times of tension. The scenario requires that a helicopter be used as a transfer means, rather than placing the ships side-by-side and handling the weapons across. Further, the helicopter is required to experience an engine failure such that it is prevented from making a controlled descent or landing on water rather than a

----

68. It should be noted that according to a recent unofficial catalogue of what nuclear weapon-types are believed to be carried on board which US ship-types, destroyers do not carry the 'anti-submarine depth bombs' postulated (p. 27) by the scenario: see J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), pp. 14 and 48 (destroyers may carry Terrier missiles, ASROC's and Tomahawk missiles, depending on the class of destroyer). A vessel deploying depth bombs might be expected to also carry a helicopter capable of transporting them, as helicopter-delivery is one of the means of dropping the bombs. The scenario may be referring to ASROC's, whose warheads are sometimes called depth bombs. But ASROC's are not capable of being launched from helicopters, so a helicopter on an ASROC-carrying vessel could not be assumed to be routinely capable of transporting ASROC's.

69. More accurately, the position should be stated in terms of each visit. The scenario increases in plausibility (on this point) in proportion to the percentage of the total visits by nuclear-certified vessels which are visits with no nuclear weapons on board.

70. US, Department of the Navy, Loading and Underway Replenishment of Nuclear Weapons, (NWP 14-1, (Rev. C), August 1983) sets out the rules and conditions under which weapons transfers may occur between ships at sea or between a shore facility and a support ship. It seems reasonable to assume that similar conditions would apply to transfers between two combat vessels in a foreign port. For example, only specially approved equipment may be used to transfer nuclear weapons (pp. 1-3, 5-9); only certain helicopter types are to be used for transfers, and then only by specially trained crews (p. 5-1); and only explosives-loading anchorages may be used if the transfer takes place in a port that is not a US naval weapons station, etc. (p. 2-1).

wharf. There would, of course, be no need for it to fly over land at all in order to accomplish its mission.

12.59 There has never been a United States nuclear weapon accident during helicopter trans-shipment. If the scenario is correct in saying that this mode of transfer is the fastest and easiest, the implication arises that it has been frequently done in the past. Therefore, the absence of any accident to date is statistically significant in terms of evaluating the likelihood of the scenario.

12.60 The scenario requires that the impact of the crash both crack the weapon casing and cause a fire. Given that the weapon is designed to be dropped from a plane or helicopter into the water, it cannot be assumed that the crash of the helicopter would crack the weapon casing. Nor can it be assumed that the fire will be of sufficient intensity or duration to aerosolise much, if any, plutonium.

12.61 This examination of the scenario does not purport to be exhaustive.[71] But the Committee considers that enough has been shown to establish three points. Firstly, although no step in the scenario is physically impossible, all the steps have a probability of occurrence that is less than one, in many cases vastly less. The second point derives from the mathematical rules for establishing the likelihood of a multi-step scenario. These require that the probability of each step or factor be multiplied together. Even the crudest calculation for the scenario in question indicates that multiplying the very unlikely by the

----

71. Comment on the likelihood of the super-powers reacting as set out in the scenario and preparing to start a nuclear war by using nuclear weapons off Sydney Heads would take the Committee well beyond its terms of reference. It should not be assumed, however, that the Committee would accept as valid these kinds of assumptions in the scenario.

unlikely gives an exceedingly small overall likelihood.[72]

12.62 The third point to emerge from consideration of the weapon transfer scenario is that, even if the fact that all weapons would be in safe storage during port visits is disregarded, credible accident scenarios do not become easy to sustain.

Conclusions - Plutonium Dispersal Accidents

12.63 The most serious accidents short of nuclear detonation are those involving fire and conventional explosion. The Committee does not consider that scenarios involving any of these accidents during a port visit in which weapons are held in safe storage are credible. Specific contingency planning and monitoring for such accidents are not, in the Committee's view, necessary.

12.64 In order to avoid misunderstanding, it should be noted that the accident scenarios considered in the previous sections do not represent all those that the Committee considered. Rather, in order to avoid an excessively lengthy report, the Committee

----

72. The authors of the scenario do not claim to have made any calculation of the the likelihood that it would eventuate, although they claim it is credible (p. 27). Without pretending to include all factors, or to be using anything other than very rough figures and rounding those used, the likelihood of particular elements of the scenario might be as follows: of a period of tension, 1 : 11,000 days (10 days during the last 30 years - ie. some days during the Cuban missile crisis and 1973 Arab-Israel War); of 2 US ships with compatible weapons-systems being in an Australian port together, 1 : 10 days; of one having excess nuclear weapons, the other lacking the weapons (ie. of a need to transfer), 1 : 3 times; of transfer being done by helicopter, 1 : 2 times; of the crash during transfer, 1 : 10,000 transfers; of the crash being onto land rather than water, 1 : 10 crashes; and of the crash causing an intense fire, cracked weapon casing, etc., 1 : 10 crashes. Multiplying these probabilities together gives a likelihood for the scenario of 1 : 660,000,000,000. If 6 transfers are assumed to occur on the one occasion, the overall figure must be divided by 6. Given the rough, often arbitrary, figures used, several zeros could be removed (or added) to the final figure through the selection of of different values. The aim in making the calculation is not produce any precise result, but rather to illustrate the sort of process that has to be gone through before any scenario can be said to be credible.

has only included in it those scenarios most often discussed in submissions, or which are commonly suggested as being worthy of serious consideration.

OTHER ACCIDENTS

12.65 In addition to the scenarios already considered, other accidents involving nuclear weapons can be postulated which would, if they occurred, have less serious consequences. If a collision leads to the loss of the weapon, either inside a sunken vessel or otherwise, no nuclear hazard will result provided the weapon is recovered intact. Recovery from the shallow water of a port or port approaches should present little difficulty. Other accidents to the vessel but not involving any break in the weapon casing will likewise produce no radiation release.

12.66 If a collision or some other event (however improbably) ruptures the weapon casing, the fissile material would be exposed, and perhaps broken into large pieces. There would be little or no dispersal off the vessel. More importantly, there would be no immediate danger of aerosolisation,[73] which is, as explained above, the most serious nuclear weapons hazard and the one most requiring immediate response.

12.67 In other words, accidents less serious than those involving aerosolisation are sufficiently akin to ordinary shipping accidents not to require specific nuclear weapon accident contingency planning.[74] The Committee considers, however, that the public interest would be assisted if knowledge of current plans to deal with shipping accidents in ports,

----

73. Evidence, p. 1261 (Department of Defence).
74. See also para. 11.44.

especially those relating to hazardous cargoes, was more widely available.[75]

12.68 Accordingly, the Committee RECOMMENDS that the Commonwealth Government confirm that the State and Northern Territory Governments have adequate plans to deal with shipping accidents involving hazardous cargoes in their ports. The Commonwealth should encourage the States and Northern Territory to make these plans public where this is not already the case.

GENERAL CONCLUSION

12.69 While accidents of the kind noted in paragraphs 12.65 and 12.66 may be more credible than those discussed earlier in the chapter, the consequences were they to occur are limited. Accidents of this kind are sufficiently similar to ordinary shipping accidents to be dealt with under the general port safety plans which currently exist.

12.70 Accidents involving plutonium dispersal in respirable form, and accidental nuclear detonation are, in the Committee's view, sufficiently unlikely as not to warrant specific contingency planning.

----

75. In para. 11.117 it was recommended that the Department of Defence complete development of, and officially adopt and make public, a planning procedures document relating to nuclear weapon accidents. It may be that this document will assist in improving community awareness of the plans for dealing with shipping accidents in Australian ports.