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BOLT FROM THE BLUE:
THE BALLISTIC AND CRUISE MISSILE PROBLEM

by

Stuart Mackenzie and Alan Stephens

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THE AIR POWER STUDIES CENTRE

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> *Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.*
>
> *General Giulio Douhet.*

The effectiveness of offensive missiles in warfare has been questionable. Germany's use of V-weapons during the Second World War, Iran and Iraq's exchange of ballistic missiles in the 'War of the Cities', and Iraq's Scud attacks against the Coalition and Israel during the Gulf War might all be assessed as disappointing if assessed strictly in terms of military damage. Whether the same conclusion would be drawn concerning their psychological or 'terror' value is another matter.

Regardless of past experiences, it seems highly likely that ballistic and cruise missiles will proliferate in the future, and will become the offensive weapon of choice of a substantial number of countries. There are three main reasons for this, the first relating to American air power, the second to the military technological 'gap' which divides nations and/or interest groups, and the third to the increasing potency of missiles.

For the next 40 years at least, the United States will dominate any air war in which it participates.[1] As the 1991 Gulf War demonstrated, the Americans already possess overwhelming superiority in the skies. That superiority will continue to grow. Vigorous research and development is essential to the progress of air forces. Yet other than in the United States, there is little work underway around the world on genuinely innovative manned strike systems. In Europe, platforms like Rafale and the Eurofighter 2000 will provide predictable, incremental advances over the existing generation of attack aircraft. Similarly, Russian platforms for at least the next decade will be variants of in-service machines like the MiG-29 and Su-27. By contrast, the USAF has operated the F-117 for 10 years, is introducing the B-2, and has the F-22 well underway.

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1 See Christopher Bowie et al, *The New Calculus*, Rand, Santa Monica, 1993, pp. 37–56.

America's aerospace domination will be further magnified by generally shrinking defence budgets, which will make the likelihood of anyone drawing significantly closer even more remote. The collapse of the former Soviet Union has already removed the main source of competition; and while China may eventually seek some sort of parity, it has an enormous amount of ground to make up.

That leads to the second reason why missile proliferation is likely. The supremacy of American aerospace power should by itself make success in conventional conflict not only certain in the air, but also probable on the surface. The United States' aerospace domination in fact epitomises the technological 'gap' which separates the military capabilities of nations. This technological gap—which is most pronounced in the difference in capabilities between the armed forces of the developed world and those of the undeveloped world—will make the traditional application of *any* form of military power against the United States and its allies an extremely dubious proposition.

In other words, any group wishing to apply military pressure against the United States and its allies would be wise to seek alternative forms of doing so.[2] One such alternative which is becoming increasingly available and potent, and which does not require the same level of technology, skilled operators or economic base as manned platforms, is missiles. It is that availability and potency which constitute the third reason for proliferation.

2 Director of the US Defense Budget Project, Andrew Krepinevich, has stated that 'Third World countries are talking about buying systems like cruise missiles [and] weapons of mass destruction ... They are going to come at us from a very different direction'. *Defense News*, October 25–31, 1993, p. 30.

It is no coincidence that the development and acquisition of ballistic missiles has been given high priority in the Middle East and Asia-Pacific regions in recent years. Yet while missiles and missile technology have proliferated in those areas, the missile problem has received scant attention in official circles in the Southeast Asian and Oceania regions.[3] That is not to suggest that the nations of Oceania and Southeast Asia currently face any kind of missile threat. Clearly, they do not. Nevertheless, the logic of offensive missile proliferation can be extended to our region, and the subject at the least deserves consideration.

Three observations are relevant. First, for much of the rest of the world, the missile threat is already a daily fact of life. Second, for years geography protected Southeast Asia and Oceania (especially the latter) from many of the more exotic threats which are commonplace elsewhere. That is no longer the case. There is no need to labour the point that the world is changing rapidly, dramatically and unpredictably. Economic and political engagement—not isolationism—is the driving force of international relations. Together with technology, it continues to shrink the globe. As Lawrence Freedman has commented, 'These days there can be no "faraway countries of which we know little"'.[4] The world with all of its attendant problems and tensions is coming to us, like it or not. Finally, the imperative for technologically inferior states to find different ways of exerting military pressure is unlikely to be confined to particular geographic regions, especially as the costs of weapons systems like manned aircraft and capital ships reach levels many either cannot or will not pay for.

Before discussing the details of this subject, it is probably necessary to stress the point that this paper does not suggest that the Southeast Asian and Oceania regions currently face a missile threat. What the authors do suggest is that offensive missiles are proliferating, are becoming more potent by a quantum margin, and are likely to become the preferred option for many countries and/or groups. In sum, that means that in an unpredictable world, missiles are a problem which cannot be ignored. The aim of this paper is therefore to increase awareness of the problem of ballistic and cruise missiles, and in doing so promote informed debate on this contemporary air power issue.

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3 See, for example, Department of Defence, *The Defence of Australia 1987*, AGPS, Canberra, 1987; *The Defence of New Zealand 1991*; Department of Defence, *Force Structure Review, 1991*, AGPS, 1991; and Department of Defence, *Australia's Strategic Planning in the 1990s*, 1992.

4 Lawrence Freedman, 'The Future of Air Power', in *The Hawk Journal*, 1993, p. 37.

The Psychology of Missile Attack: A Terror Weapon

Ballistic and cruise missiles historically have been developed and employed as weapons of terror or retaliation. It is a characteristic of offensive missiles that they generally require less organisational effort on the part of the attacker than the defender. By placing the onus of preparedness on the defender, missiles generate a disproportionate response, which is one reason for their appeal to less-developed states.

Cruise and ballistic missiles were first used in large numbers in the Second World War. The German V-1 and V-2 missile campaign against the United Kingdom exerted a powerful psychological force, placing a major strain on the allies in terms of social cohesion and war making effort. It is estimated that at the peak of the campaign some 1,450,000 people evacuated London.[5] Together with time spent in air-raid shelters and absenteeism, this caused a 10 per cent reduction in work-force productivity in the London area. Studies conducted by the British Air Ministry in November 1944 concluded that the costs incurred by the allies to defend against the V-1 threat were four times greater than those incurred by the Germans to mount the offensive.[6] On top of this the allies lost nearly 450 aircraft and 2900 aircrew in a largely ineffective bombing campaign when they diverted approximately half of all available bombers to target V-1 launch sites and production facilities.[7] Although the German High Command did not achieve the material destruction on the scale predicted, their relatively simple and inexpensive weapons nevertheless had a tremendous psychological impact.

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5 Air Chief Marshal Sir Michael Armitage, *Unmanned Aircraft, Brassey's Air Power: Aircraft, Weapons Systems and Technology Series*, Volume 3, Brassey's, London 1988, p. 17.

6 *loc. cit*.

7 *ibid*, pp. 12–13.

Ballistic missile attacks were next used extensively in the 'War of the Cities' during the Iran/Iraq War. Between 1980 and 1988 Iraq launched 428 missiles, while Iran retaliated between 1985 and 1988 with 425.[8] Iraq's early use of missiles inflicted extensive damage on Iranian cities, including Teheran, and caused many casualties. It was largely because of the psychological effect on its population that the Iranian leadership sought a retaliatory missile capability.

It took Iran until 1985 to acquire that capability. When it did, the Iranians initially seem to have targeted military facilities rather than population centres, concentrating on the southeast of Baghdad, where an air base, a military camp, the Presidential palace, and water, power and oil production infrastructure were all located. Large numbers of civilians were, however, killed by missiles which fell on residential areas, and Iraqi morale reportedly deteriorated significantly.[9]

Iraq responded by further developing its own missile force. Modifications made to some of its Soviet supplied Scuds in 1987 represented a significant technological achievement. By reducing the size of the warhead from 1000 kgs to 135 kgs, the Iraqis produced a missile with a range of about 650 kilometres, sufficient to strike Teheran from within Iraq. Because the warhead impacted at a speed in excess of mach 1.5, the modified missile was still formidable, especially against residential areas.[10]

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8 Steven Zaloga, 'Ballistic Missiles in the Third World', in *International Defense Review*, November 1988, pp. 1423–7.

9 Nick Childs, 'The Gulf War: Iraq Under Pressure', in *Jane's Defence Weekly*, 9 May 1987, pp. 899–901.

10 Steven Zaloga, *op. cit*., pp. 1423–7.

With the war reaching a crisis point in 1988, the Iraqi leadership made no pretence that military targets were its objective. Missile accuracy became irrelevant as a strategy of terror attacks on population centres was adopted. The combination of extended-range Scud and strike aircraft attacks using conventional warheads caused chaos and panic in Teheran, leading to a general evacuation of the city.[11]

One unexpected, but in hindsight predictable, response to the perceived effectiveness of missiles during the Iran–Iraq war was the acquisition by a state not directly involved in the conflict (as it happens, Saudi Arabia) of intermediate range missiles with which it could threaten Teheran. In 1988 the Saudis bought 30 Chinese CSS-2 missiles, which have a range of about 3000 kilometres. The acquisition of the CSS-2s illustrated not only the imperative of arms proliferation, but also the fallacy of the notion of warning time. Because the transaction did not require any of the in-country development and testing which United States' reconnaissance systems look for and generally detect, the missiles were discovered by the Americans only after they had arrived in Saudi Arabia; that is, too late for any preventive action to be taken.[12] A weapon system with the potential to shift the regional balance of power had been introduced without any warning time.

Iraq's use of Scuds during the 1991 Gulf War is the most recent instance of an intensive missile campaign. Coalition pre-war planning took full account of Iraq's missiles, which were identified as a military and psychological threat to Coalition forces; a threat to civilian populations in Israel, Saudi Arabia and other Gulf countries; and a long-term threat to regional stability.[13] The probability that Saddam Hussein would attack Israel with Scuds in an attempt to divide the Coalition was also recognised. Consequently, from the outset, counter-measures were planned. Iraq's strategic offensive capability—including Scud production, assembly and storage—was identified as a key target in the Coalition air campaign; while Patriot anti-missile systems were deployed to Israel. Nevertheless, when Iraq's Scud attacks came, they proved both difficult to stop and psychologically highly effective.

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11 Douglas A. Kupersmith, *The Failure of Third World Airpower: Iraq and the War with Iran*, Air University, Maxwell, 1992, p. 50.

12 Jeffrey T. Richelson, 'US Space Reconnaissance After the War', a paper presented at the conference Australia and Space, SDSC, ANU, November 1991, p. 20.

13 Final Report to Congress, *Conduct of the Persian Gulf War*, US Department of Defense, April 1992, p. 97.

The Scuds were not especially accurate, but they still caused substantial property damage.[14] Their real value, though, was psychological. The missile which hit troop barracks in Dhahran on 25 February, killing 28 United States soldiers and wounding another 100, gave Iraq its major propaganda victory of the war. Given that casualties are now the centre of gravity of developed nations, similar attacks might have led to popular demands from some members of the Coalition for the withdrawal of ground forces.[15]

As it was, the Dhahran attack led to intensified efforts to destroy the Scud threat. An enormous amount of effort was diverted into 'the seemingly intractable problem of how to find and destroy Scuds'.[16] A special planning cell was established, ad hoc groups to develop options were formed, intelligence resources were multiplied, and vast numbers of sorties—estimated at 2500—flown by aircraft including the TR-1, RF-4C, B-52, A-10, F-16, F-15E, A-6E and JSTARS. While the sheer volume of the Coalition response made it difficult for Scud systems to move about and fire their missiles, after two weeks no mobile launchers had been confirmed as destroyed.

14 *ibid*, p. 168.

15 See pp. 7–8 below.

16 *Conduct of the Persian Gulf War*, p. 168.

The New Centre of Gravity

The official United States Department of Defence report to Congress concluded that if the Scuds had been more accurate, they 'might have inflicted serious damage on military targets, including the large troop concentrations at Saudi ports at the start of the war'.[17] If that had happened, it may well have been a decisive blow for the Iraqis. There is strong evidence that the attitude of developed nations towards military conflict has undergone a fundamental transformation. It is increasingly clear that the value of human life is now their centre of gravity.[18] Consequently, it will be possible to exert undue influence over those nations by relatively unsophisticated means if the action results in a level of casualties which is perceived as unacceptable.

The past decade has provided numerous examples of this crucial attitudinal shift. In 1983, following the death by car bomb of 241 American Marines on peace-keeping duties in Beirut, President Reagan immediately withdrew the remainder of the force. More recently, the United Nations has persistently refused to consign ground forces to other than (largely ineffectual) peace-keeping activities in Bosnia-Herzogovina.[19] Similarly, several national leaders stated unequivocally that their troops would be withdrawn from the United Nations Transitional Authority in Cambodia (UNTAC) if open war had broken out between Cambodian government forces and the Khmer Rouge.[20] American (and other developed world) citizens were shocked in October 1993 by television footage of mutilated United States Rangers being dragged through the streets of Mogadishu after an abortive attempt to capture supporters of General Mohamed Farah Aideed. Public reaction resulted in the deployment of more firepower to Somalia, an almost immediate reversal in United States policy from confrontation to compromise, and a guarantee from President Clinton that all American forces would be withdrawn by March 1994, with little prospect that the job they went there to do will have been completed.

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17 *ibid.,* p. 169.

18 See Alan Stephens, 'The Transformation of "Low Intensity" Conflict', *Air Power Studies Centre Paper No. 14*, APSC, Canberra, June 1993, pp. 5–9.

19 'Sarajevo Attacked as World Watches Srebrenica Siege', in *The Times*, 23-3-93, p. 11.

20 'Troops to Stay in Cambodia for Now, Says (Australian Foreign Minister) Evans', in *The Canberra Times*, 12-4-93, p. 1.

The acceptance of casualties as the centre of gravity in war could be seen as a humane development in an inhumane business. However, until that attitude is held universally, it will provide great leverage for those who reject it and who employ terror weapons.

Proliferation and the Missile Technology Control Regime

Ballistic and cruise missiles have been recognised for many years as a very difficult and unpleasant problem to defend against. That problem largely explains the establishment in 1987 of the Missile Technology Control Regime (MTCR) by the United States, Canada, the United Kingdom, Italy, Japan, Germany and France. Member states agreed to ban the export of both ballistic missiles capable of carrying warheads of 500 kilograms or more over distances greater than 300 kilometres, and missile related technology. By late-1993 the number of signatories to the MTCR had risen to 23, and the warhead weight limit was expected to be reduced to 150 kilograms.[21]

The fact remains, though, that many nations have not signed the regime. It is significant that all of the original members were from the developed world. Some nations from the developing world who have not endorsed the regime consider the MTCR a self-serving attempt by the 'haves' to maintain their privileged military position in the world, a perception not without some justification.

The United States' invocation of the MTCR to impose a two-year ban on the Indian Space Research Organisation for trying to buy Russian-made rocket engines deeply angered many Indians.[22] Chinese leaders reacted similarly when their country became the subject of limited American sanctions, following accusations from the Clinton Administration that Chinese missile technology had been sold to Pakistan.[23] There is also a belief, again justifiable, that the MTCR has been used unfairly to protect commercial interests. The Russians, for example, have suggested that the American attempt to prevent the sale of rocket engines to India was motivated not by any real concern over weapons proliferation, but rather by calculated business considerations to support domestic aerospace industries.[24]

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21 Roy Braybrook, 'Ballistic Missiles a Mounting Threat', in *Asia-Pacific Defence Reporter*, October-November 1993, pp. 32–4.

22 Aabha Dixit, 'Test Awaits Indo-US Ties', in *Defense News*, September 20–26, 1993, p. 19.

23 'Chinese Bite Back in Missile Brawl', in *The Canberra Times*, 28-8-93, p. 9.

24 Steven Zaloga, 'Russia Exporting Top-of-the-Line Weapons', in *Armed Forces Journal International*, December 1992, p. 46.

The Russians have further challenged the rationale of the MTCR by trying to sell the advanced, defensive S-300V missile system in the Middle East and Asia, claiming that such systems provide an antidote to the alarming spread of cheap ballistic missiles in those regions.[25] In a somewhat idiosyncratic extension of that logic, the Russians have also suggested that such exports are the only way for them to disarm their bloated arms industry. That may seem an odd outlook, but the subject of arms transfers is one in which perceptions can be more influential than logic. As long as the United States, France and the United Kingdom remain major arms exporters, their demands for an MTCR will, in the eyes of many Third World countries at least, be tinged by an element of hypocrisy.

Because of the kinds of perceptions, attitudes, pressures and commercial imperatives outlined above, many nations will continue either to ignore or circumvent MTCR. Recent reports indicate that a new North Korean missile, the Rodong-2, will shortly be test fired in the Iranian desert following close financial and technical collaboration between the two countries.[26] Rodong-2 is expected to have a range of 2000 kilometres and thus be capable of threatening Israel and Japan from within Iran and North Korea respectively. The extent of the problem of missile proliferation (and defence) becomes even more apparent when the list of countries currently involved in ballistic, cruise, and low observable missile technology is examined: in addition to North Korea and Iran, that list includes Brazil, China, France, Germany, Iraq, Israel, Italy, Japan, Sweden, Taiwan, India, Argentina, the United Kingdom, South Africa, Chile, the United States, Russia and Sweden.[27] By the turn of the century, as many as 24 countries may have ballistic missiles, with ranges in the order of 3000 to 5000 kilometres considered likely.[28]

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25 *loc. cit*.

26 Kevin Rafferty, 'Asia Alarmed at Iran-N.Korea Missile Collaboration', in *The Canberra Times*, 27 October 1993, p. 8.

27 *Jane's Strategic Weapon Systems (Issue 12)*, Jane's Information Group, United Kingdom, June 1992; Steven Zaloga, 'Ballistic Missiles in the Third World', pp. 1423–7; and Roy Braybrook, *op. cit*., pp. 32–4.

28 Roy Braybrook, *op. cit*., pp. 32–4.

The fact is, in MTCR terms, the horse has long since bolted. Parallels can be drawn with the Nuclear Non-Proliferation Treaty. The NPT has not prevented the proliferation of nuclear weapons; it has simply retarded it. There is no reason to believe MTCR will achieve any more; indeed, on the current evidence it seems likely to achieve a lot less.

The Utility of Missiles

In the past, ballistic missiles were generally regarded as 'strategic' weapons. Offensive missiles are, however, becoming more widely available, more flexible and more potent, to the extent that the distinction between 'strategic' and 'tactical' weapons has become blurred. The flexibility and accuracy of cruise missiles in particular now means that a range of only 1500 kilometres is adequate to strike every major military target in the world without having to penetrate the borders of that country,[29] using launch platforms such as small vehicles and ships. It is therefore essential for security planners to appreciate the changing nature of the missile threat.

Missiles as weapons of influence have three main attractions. They are relatively cheap; they do not require anything like the training system, operator skill level, and infrastructure needed to support advanced strike aircraft; and they are very hard to defend against. On the other hand, they are relatively inaccurate, carry small warheads, and are inflexible. Those shortcomings are conspicuous in any comparison with manned aircraft. As Richard Hallion has noted, in general, manned aircraft are a far superior weapons system: they are immensely flexible, can discriminate between targets up to the last moment because they have a 'man in the loop', are reusable, carry much greater payloads, and with modern weapons can almost guarantee precision strikes.[30] Hallion has also argued that the costs of a strike force based on manned aircraft can be less than one based on missiles.

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29 *Jane's Strategic Weapon Systems* (Issue 12), Jane's Information Group, United Kingdom, June 1992.

30 Richard P. Hallion, *Storm over Iraq*, Smithsonian Institution Press, Washington, 1992, pp. 250–1.

Hallion's argument applies, however, only to First World air forces which are able to exploit superior technology and training. The point for developing countries is that those essential elements of modern air power are immensely difficult and expensive to acquire and maintain. Taking costs first, for many nations the prices of 'traditional' weapons systems are becoming prohibitive, especially when compared to missiles. As an example, the program cost (which does not include recurrent training, personnel and maintenance costs) of an F/A-18A-D is A$47,600,000;[31] while ballistic missiles can be bought for as little as one million dollars each and attract far less recurrent costs.[32] The price differential presumably is even greater for genuine leading-edge, war-winning technologies like the F-117, F-15E, B-1 and B-2, and their associated infrastructure.

In any case, simply acquiring the hardware is not sufficient. Over the past 30 years countries like Syria, Egypt and Iraq have outlaid billions of dollars on traditional air power weapons, only to have been routinely humiliated by their vastly better trained opponents in the 1967 War, the Yom Kippur War, the Beka'a Valley, and the Gulf War.

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31 Ted Nicholas and Rita Rossi, *US Military Aircraft Data Book 1989* (11th ed.), Data Search Associates, Fountain Valley, 1988, pp. 2–86.

32 Steven Zaloga, 'Ballistic Missiles in the Third World', pp. 1423–7.

The Iran/Iraq War would seem to offer a more realistic and cost-effective model for developing nations wishing to apply offensive air power. Each side had limited numbers of aircraft, was not especially skilled in using them operationally, and had restricted resources to support them with. At a cost of about A$40 million per aircraft, plus support, the economics of an attrition rate of, say, 10 per cent on deep strikes, would soon have become disastrous. Not surprisingly, both sides demonstrated a reluctance to risk high attrition rates, fearing that heavy losses might not only leave them vulnerable to punishing air attack from the other side, but also deprive them of their deterrent force.[33] Their ballistic missiles, by comparison, cost about only one million dollars each and required comparatively little operational skill;[34] consequently, 853 were fired.

The simple fact of proliferation indicates that many nations have decided to accept the inherent limitations of missiles, and focus instead on the political leverage they can confer. The centre of gravity of potential enemies is the crucial factor in the utility of missiles. For example, the use of approximately 2000 Scuds by Soviet-backed forces against the *Mujahideen* in Afghanistan achieved little. The *Mujahideen* fought with their forces widely dispersed and were largely independent of sophisticated infrastructure. More importantly, their centre of gravity was a profoundly-held cause, which could not be targeted. In combination, these conditions effectively denied their opponents a point of leverage against which to focus their attacks. By contrast, missile attacks against developed economies can focus on centres of gravity such as casualties or key infrastructure, a strategy which would not only avoid confrontation with qualitatively superior combat forces in the field, but which also would offer great political leverage.

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33 Ronald E. Bergquist, *The Role of Airpower in the Iran-Iraq War*, Air University Press, Maxwell, 1988, p. 75.

34 Steven Zaloga, 'Ballistic Missiles in the Third World', pp. 1423–7.

The Offence versus the Defence

Concern in the developed world over Third World ballistic missiles stems from their ability to project force over considerable distances, and the lack of effective defences.[35] The continuing utility of offensive missiles will depend on that balance between the offence and the defence.

The striking power of missiles continues to improve. Striking power is a function of range, warhead and accuracy. North Korea's Rodong-1 has a reported range of 1000 to 1300 kilometres. Its successor, the Rodong-2, has almost double that range.[36] Taiwan's first indigenous missile, the Green Bee, has a range of 130 kilometres; its second, a surface-to-surface missile code-named Sky Horse I, has a reported range of 1000 kilometres. India's Prithvi missile was first tested successfully in 1988 and has a range of 240 kilometres, while the Agni, tested a year later, has a range of 2500 kilometres. China's CSS-2 is capable over 3000 kilometres. Those kinds of trends will, in effect, make the world a smaller place.

Warhead lethality will also increase. While existing high explosive warheads are already effective for terror attacks, far more disturbing prospects are emerging. Pentagon officials have expressed concern over the probable development of small cluster munitions which could be dispersed from ballistic missiles in large numbers over cities.[37] According to a 'defence official', up to 100 cluster munitions could be carried by a Scud and dispersed at an altitude of about 60 kilometres. Instead of high explosives, the sub-munitions would carry chemical, biological and nuclear materials, and would have the potential to 'depopulate a city for centuries'. Development of such warheads is considered technically feasible using commercially available materials within 18 to 24 months from program commencement. Higher up the technology scale, electromagnetic pulse warheads will offer the possibility of throwing a more developed nation's computer-dependent defence systems into chaos.[38]

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35 Andrew Mack, 'Missile Proliferation in the Asia/Pacific Region', *Working Paper No. 82*, Peace Research Centre, Canberra, 1990, p. 15.

36 Jon Wolfsthal, quoted in Vago Muradian, 'Japanese May Deploy a Version of THAAD', in *Defense News*, September 20–26, 1993, pp. 1, 29.

37 David A. Fulghum, 'Small Clustered Munitions May Carry Nuclear Wastes', in *Aviation Week & Space Technology*, October 11, 1993, p. 61.

38 See Carlo Kopp, 'A Doctrine for the use of Electromagnetic Pulse Weapons', *Air Power Studies Centre Paper No. 15*, APSC, Canberra, 1993.

The final factor in missile striking power—accuracy—inevitably will improve dramatically simply by utilising commercially available navigation systems like GPS or the Russian Glonass.

A disturbing element has been added to the offence/defence equation by cruise missiles. Compared with ballistic missiles, cruise missiles are relatively cheap, powerful and accurate; and their technology is easier to master. Since the Gulf War, United States officials have identified a growing trend in international arms transfers for states to acquire cruise missiles in preference to more expensive and often less accurate ballistic missiles.[39] Although the MTCR addresses some cruise missile technologies, a good deal of the necessary information and hardware is now commercially available.

The currently restricted range of some cruise missiles will be extended by the next generation of power plants, which will feature improved fuel consumption and reliability.[40] Reported ranges for the General Dynamics' BGM-109A Tomahawk Land Attack Missile and the Russian SS-N-21 Sampson are already 2000 and 3000 kilometres respectively.[41] It is certain that countries like China will at least equal those distances in the near future.

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39 David A. Fulghum, 'Cheap Cruise Missiles a Potent New Threat', in *Aviation Week & Space Technology*, September 6, 1993, pp. 54–5.

40 The Allison Gas Turbines company has recently demonstrated an expendable turbo-jet engine in the 270 lb thrust class. The engine is 17 inches long, has a maximum external diameter of 8 inches and has a production target weight of 23 lbs. See 'Expendable Engines Tested for Army Missiles', in *Aviation Week and Space Technology*, September 6, 1993, p. 26.

41 *Jane's Strategic Weapon Systems (Issue 12)*, Jane's Information Group, United Kingdom, June 1992; and Ted G. Nicholas, *US Missile Data Book*, pp. 2–112/113.

As will be the case with ballistic missiles, a key factor in the increasing appeal of cruise missiles will be the accuracy achievable from GPS or Glonass. Circular Error Probables (CEPs) of 100 metres will be possible, and will enable terrorist groups or states wishing to avoid direct air combat to target an opponent's centres of government and national power.[42]

Cruise missiles developed outside the United States are likely to be less sophisticated than the Air Launched Cruise Missile (ALCM), the BGM-109 Tomahawk and the AGM-129. They will be less capable than the American missiles, but significantly cheaper and more numerous. They are likely to be built on a limited budget, using readily available commercial technology and materials wherever possible. Composite materials and advanced plastics may be utilised, which together with other design features will give a stealthy radar cross-section. Existing missile and Unmanned Aerial Vehicle bodies are one probable source of platform. Harnessing GPS and Glonass will facilitate their use against specific targets, although many existing missile seeker-head designs could be readily adapted to provide terminal guidance at a low cost.

In sum, the ready availability and improving performance of cruise missiles has been described by authoritative sources as an 'ominous' security development.[43]

Turning to the defence, the protective measures available to nations other than the United States and its closest allies must at the moment be regarded as highly problematical.

The preferred military option for dealing with a threat often is a pre-emptive strike, as the Israelis demonstrated with their attack against the Iraqi nuclear reactor at Osirak in 1981. If pre-emption were not possible, a strike against the source after open hostilities were declared would be favoured. However, neither of those options may be available, as each carries political sensitivities.

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42 This assumes that the US government will not invoked ‘selective availability’ on the GPS constellation. Selective availability effectively reduces the accuracy of the GPS signal thus inducing errors in GPS derived navigation. Even if GPS were affected, Glonass might still be available.

43 David A. Fulghum, ‘Cheap Cruise Missiles a Potent New Threat’, pp. 54–5.

As the following paragraphs will explain, the alternative strategy of adopting a purely defensive posture is enormously expensive and technologically demanding.

Following the Scud scare in the Gulf, the Pentagon has initiated an urgent program to construct a Theatre High Altitude Area Defence (THAAD) system; additionally, Patriot is to be upgraded. Japan, South Korea and Israel—all of which perceive an immediate threat from missiles (from North Korea for the Asian states, and Iraq and Iran for Israel)—are cooperating in the THAAD program.[44] (The Israelis have also been developing their own 'Arrow' missile defence system, with American assistance, for some years.) USAF Lieutenant General Buster Glosson has stated that THAAD is required in place by the turn of the century.[45]

Those kinds of initiatives are all very well for countries which can afford them, or which like Israel receive massive American defence subsidies. Where they leave the rest of the world is another matter. The fact is, for most nations, defence against missiles remains uncertain. As is the case with the more traditional forms of air power, the necessary combination of technological expertise and financial strength is the almost exclusive preserve of the United States.

The costs are enormous. One presumably authoritative source has stated that the United States has spent A$49 billion on theatre missile defence research and development in recent years.[46] THAAD alone is a A$12.3 billion dollar program. For that investment, the United States Army will end up with approximately 80 launchers, each capable of engaging targets within an area of about 1000 square miles; that is, a circular area 35.5 miles in diameter, less than the size of scores of cities.[47] Perhaps for that immense investment—which exceeds the entire annual Australian or Asean defence budgets by 25 per cent—the Americans will end up with several THAAD systems; perhaps also, for a small country like Japan, several 'theatre' systems could in fact serve as a national system.

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44 See Vago Muradian, *op. cit*, pp. 1, 29; 'South Korea may Joint THAAD Program', in *Defense News*, October 25–31, 1993, p. 3; and *The Canberra Times*, 25-9-93, p. 12.

45 Lieutenant General Buster Glosson, 'One on One', in *Defense News*, October 18–24, 1993, p. 86.

46 'US Senate Rebuffs Missile Defence Burden-Sharing Plan', in *Defense News*, October 18–24, 1993, p. 6.

47 Vago Muradian, *op. cit*., pp. 1, 29.

Yet the defensive problem will still be formidable. An early report from the United States' research and development program has suggested that neither the upgraded Patriot (PAC-3) nor THAAD will be able to distinguish between decoys and warheads, a deficiency which marred the performance of Patriot batteries during the Gulf War.[48] According to the report, United States' missile interceptors will prove 'particularly ineffective' against Scud-type targets which release cluster munitions equipped with chemical, biological or nuclear warheads. The report's findings are also considered to have 'serious implications' for the Israeli's Arrow. Some United States government sources are now suggesting that a boost phase intercept of ballistic missiles may be the only solution to cluster munitions, decoys and the evasive manoeuvring missile. This concern is not yet reflected in Pentagon budget allocations, as less than A$746 million of the planned A$27 billion expenditure on missile defences is earmarked for projects to destroy missiles in the boost phase.[49]

Like THAAD and Patriot, other prototype defensive systems rely on complex technologies which are the preserve of few nations. The Raptor/Talon combination, for example, currently under development in the United States, utilises the Raptor Unmanned Aerial Vehicle and the Talon anti-missile missile, and is intended to defeat ballistic missiles during their boost phase. Raptor is a high flying UAV designed to operate above 65,000 feet, and which is equipped with infra-red sensors to detect a ballistic missile launch.[50] The Talon is a small, hyper-velocity kinetic kill missile which is automatically launched from the Raptor when the infra-red exhaust plume of a ballistic missile is detected. Raptor/Talon will be confined to operating either over friendly territory or in a favourable air situation, unlike a satellite/ground based interceptor such as Patriot. It will be best suited to a short range, static threat where it can be close to the probable point of launch, very much the situation confronting Israel. Raptor/Talon would always engage its target in the boost phase so that the ballistic missile debris would most probably fall on the launch nation, a particularly important consideration if the missiles are fitted with The Raptor UAV is a relatively low-risk program, but the Talon missile is still under development.

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48 Barbara Opall, 'DoD Targets Missile Nemeses', in *Defense News*, November 8–14, 1993, pp. 1, 34. Opall's article was subsequently criticised by the American Institute of Aeronautics and Astronautics, who prepared the cited report: see 'AIAA Clarifies Views on Ballistic Missile Defense Technology', in *Defense News*, November 15–21, 1993, p. 19. The AIAA did not, however, dispute the substance of Opall's report, which was that missile defence systems are enormously complex and expensive, and that the effectiveness of any system against 'the spectrum of threats' remains 'a major issue'.

49 *loc. cit*.

50 David Fulghum, 'Missile-Killing UAV Makes Initial Flights', in *Aviation Week and Space Technology*, August 23, 1993, p. 74.

Commercial and inter-service competition will further compound the defensive problem. The USAF's proposed Follow-on Early Warning System (FEWS) satellite program, intended by its proponents to replace the Defence Support Program (DSP), was recently cancelled amid allegations that the project's costs and performance data had been deliberately misrepresented to senior procurement officials.[51] FEWS had been costed at about A$17 billion. Some USAF officials are now promoting an alternative defensive system, known as Short-Range Attack Missile/Lightweight Exoatmospheric Projectile (SRAM/LEAP). Critics have labelled SRAM/LEAP as nothing more than an Air Force attempt to avoid missing out in the inter-service competition to control missile defence programs. According to one United States Defence official, 'The atmosphere is charged and emotion is high because what is at stake is the future of any meaningful Air Force participation in ballistic missile defence.'[52] Rivalries will inevitably drive up costs.

The kinds of defensive systems briefly described above are intended to counter the spectre of ballistic missiles. But the enormous research and development investment they represent may not be sufficient. The advent of cruise missiles means that any system presently on the drawing board almost certainly will have to cope with more complex threats.

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51 Neil Munro, 'US Air Force Official Impugns FEWS Data', in *Defense News*, 11–17 October 1993, p. 1.

52 David A. Fulghum, 'SRAM/LEAP Concept Stirs Interagency Conflict', in *Aviation Week & Space Technology*, October 11, 1993, pp. 59–60.

Cruise missiles are readily modified to accommodate stealthy properties and materials, and are likely to have much smaller radar cross-sections than ballistic missiles, which are limited by the aerodynamic requirements of hypersonic speeds and re-entry heating. Additionally, cruise missiles have a small in-flight infra-red signature, whereas ballistic missiles cannot escape the intense infra-red plume they emit during the boost phase, and which is currently the prime method of detection by space based platforms and, soon, high flying UAVs.[53] The detection and interception of cruise missiles is further complicated by the low altitudes at which they fly. Their pre-programmed and often evasive flight path is much less predictable than the gently curving path of the ballistic missile. Finally, cruise missiles do not require the complex fuel handling procedures of liquid fuelled ballistic missiles; and, being smaller, they are easier to hide and transport.

Defence planners now believe that an integrated system of infra-red, radar and, perhaps, acoustic sensors, together with AEW&C, fighters and surface-to-air missiles will be necessary to engage stealthy cruise missiles.[54] Research and development funding is already being channelled into anti-cruise missile systems in the United States. The classified USAF 'Have Yak' program is currently developing jamming pods which will be used to disrupt the low-pulse radar signals many advanced cruise missiles employ for navigation.[55] Alternative strategies to defeat a cruise missile threat could range from targeting production and storage facilities in a pre-emptive strike, to denying navigation and targeting data from GPS and similar systems. Each of those alternatives would involve difficult political decisions.chemical warheads.

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53 See David A. Fulghum, 'Solar Powered UAV to Fly at Edwards', in *Aviation Week & Space Technology*, October 4, 1993, p. 27.

54 David A. Fulghum, 'Cheap Cruise Missiles a Potent New Threat', pp. 54–5.

55 Barbara Opall, 'US Aims Jammer At Cruise Missiles', in *Defence News*, 18–24 October 1993, p. 4.

The USAF has set a deadline of the end of this decade for an operational theatre missile defence system. Whether or not a reasonably secure system can be constructed inside that deadline remains to be seen. Roy Braybrook has cautioned that whatever system eventuates, we can be sure it will be expensive and late.[56] Given the diverse and expanding range of threats, the enormous costs involved, and the inherent advantage of the offence over the defence in missile warfare, his warning seems fair.

56 Roy Braybrook, *op. cit*., pp. 32–4.

Summary

No nation will be able to bring significant pressure to bear against the United States or any country it supports through the traditional use of air power for the next four decades. That American dominance in the skies will in turn ensure dominance in conventional warfare in all three environments. Nations or groups wishing to apply military pressure against the United States and/or its allies are therefore likely to seek 'non-traditional' ways of doing so.

Since their first use in World War II, ballistic and cruise missiles have proven extremely difficult to defend against. In recent years the capabilities of those missiles have improved greatly, to the extent that the capacity to construct any sort of reasonably effective area defence system is beyond the technological and financial capabilities of all bar the United States.

At the same time, casualties have become recognised as the centre of gravity of developed states. Missiles aimed at soft targets are, therefore, likely to become the offensive weapon of choice of less developed states seeking political leverage. Ballistic and cruise missiles are in fact already proliferating, and there is no reason to believe that they will not continue to do so.

This article started with a quote from General Douhet: 'Victory smiles upon those who anticipate the changes in the character of war, not those who wait to adapt themselves after the changes occur.'[57] That is not simply a proposition, it is a truism which the commander of any force must bring to his forward planning.

There is little evidence that defence planners in Southeast Asia and Oceania are applying Douhet's aphorism in relation to ballistic and cruise missiles. As it now takes in the order of 15 years for major force structure changes to be implemented, those planners need to be confident that the missile threat which is a fact of life in much of the rest of the world, and which is proliferating in numbers and quality, will not have spread here within the next 15 years. It may be the case that regional governments will adopt a strategy based on either diplomatic resolution of any threat; or armed intervention (including the provision of defensive systems) by the United States. They may also do nothing, which need not necessarily be inappropriate, but

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57 From *Military Air Power, The CADRE Digest of Air Power Opinions and Thoughts*, by Lt Col Charles M. Westenhoff, Air University Press, Maxwell AFB, October 1990, p. 85.

which should at least be an intentional response. The first step in developing any strategy is, of course, acknowledging that a problem may arise.

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Cruise missile and ballistic missile defense. This chapter examines the information aspects of ship defense against ASCMs while those ships conduct TBMD. Overall, the defense problem is analyzed as a double-queuing problem. First, the launched ASCMs and ballistic missiles in a given time period, T, en-ter an initial engagement queue based on an assessment of the like-lihood that cruise missiles will be a threat to the defenders (two Aegis cruisers) or that the ballistic missiles will be a threat to critical infra-structure targets.