## Chapter 9

# Cultures, Designs and Design Cultures

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Military equipment accounted for much of the advanced technology transferred to developing countries during the Cold War period. These technologies offer clear examples of differences reflecting institutionally varied frameworks of invention and innovation. Their performance driven extremes also reveal characteristics that are less clearly exposed in the development and deployment of more mundane and robust technologies.

This chapter continues the examination of design processes though the notion of "design cultures" as an explanation of distinctive outcomes from processes addressing essentially the same technology in different social and cultural settings. Chapter 3 looked at continuities in technical understanding and motivation through the Cold War period and Chapter 6 provided case studies and examples which included military technology. The complex socio-technical systems described here also illustrate the assertions of the Actor-Network Theory set out in Chapter 3. The artifacts encapsulate the values and objectives of the actors who created them and the setting in which they were created, and in turn influence the further development of their context.

While design processes and their outcomes can be seen to reflect their cultural setting, a simple invocation of the role of culture may become a means of avoiding further exploration of difference. National stereotyping gives associations such as style and capability which are of value in branding and marketing, for example, German or Italian automobiles. However, such "national" characteristics reflect distinctive outcomes based on differing priorities among designers in different settings. Culture must therefore be disaggregated into a constellation of tradition, ethnicity, organisational and institutional frameworks.

This chapter explores major differences between the U.S.A. and U.S.S.R in their design of military equipment. Following the end of the Cold War, Western observers often explain away these differences simply in terms of the West's manifest technological superiority. However, this is as an insufficient explanation for the stylistic, doctrinal, economic and social influences embodied within the design of Soviet and American weapons systems. A distinction must be drawn between the task environment in which a weapon exists as a destructive device and the institutional environment which spawns it. In the case of the U.S. in particular, a large array of institutional factors, fallacious arguments, assumptions and assorted sophistries have combined to produce a design culture- a constellation of design characteristics- which produces weapons that are often dysfunctional at the level of the task environment. In contrast, the Soviet Union often developed reliable, cost-effective armaments under the influence of different institutional influences, including compulsory military service and ultimately unsustainable levels of arms spending.

## Deconstructing Culture

The key technologies underpinning globalisation have been modified by cultural orientations and preferences which are in turn incorporated into popular accounts of difference in organisational practices. Such accounts themselves may carry a significant emotional charge reflecting anxieties played out at a national level (e.g. Lewis and Allison; 1982, Isahara; 1991).

O'Hara-Devereaux and Johansen (1994) argue for a distinction between work cultures, both professional and corporate, and the primary culture in which an organisation is embedded. For them the synergy between levels is a potential resource, but the tendency towards a convergence determined by the primary culture is seen as an obstacle to cross-cultural working. Kaplinsky and Posthuma (1994) map cultural dimensions of industrial innovation onto the micro and macro layers of economic analysis, offering one way to achieve an overview of a highly complex area.

The macro level view is represented by writers who refer to culture in terms of national differences in social and economic organisation. Latin, Anglo-Saxon and traditional cultures are reflected in distinctive organisational types identified in studies examined by Lammers and Hickson (1979), or the broad groupings of cultures arrived at by Hofstede (1980) and considered in specific national contexts in Part III.

Unfortunately, simply to ascribe differences in outcomes to "cultural difference" between adopters offers little guidance for either potential adopters or for policy-makers. Additionally, regional variations, often reflecting divergent historical and institutional traditions make the notion of a homogenous "national" culture problematic, even in relatively small countries. Culture can be de-composed into issues related to the historical, geographical and institutional setting in which organisation and individual must operate. For example, Selznick (1957) invoked notions of culture in his explanation of the emergence of institutionalised organisations, and differences in institutional culture can be identified at national and regional levels. As noted in the previous chapter, Johnson (1983) identifies the U.S. state as "market rational", relying on the regulation of competition in order to maximise efficiency in contrasts to "plan rationality" developmentally oriented states, like Japan with close working relationships between industrial sectors and the relevant ministries in pursuit of common goals with maximum effectiveness.

Both these approaches have historical roots based in nineteenth century technical and economic developments[1]. Johnson (1983) argues that this essentially different view of the role of public institutions in the economic arena accounts for a great deal of misunderstanding between these trading partners as to what constitutes "fair trade". U.S. inspired reforms after World War II modified business relationships, but much of the economic friction evident in the global economy reflects differences in accepted institutional relationships and expectations.

The micro level of cultural variation is represented by writers such as Eldridge and Crombie (1974) who define organisational culture as characteristic of individual organisations or by Strauss et al's (1973) description of a range of cultures within a single organisation. Morgan's (1986) paradigm of "organisation as culture" is incorporated into popular texts which promote the notion of organisational culture as a variable amenable to management intervention (Peters and Waterman; 1982). Thompson (1967) supplies the concept of an organisational constituency capable of entering into coalition with other constituencies in order to promote its interest. This emergent 'dominant coalition' would then be in a position to determine overall corporate culture.

However, Turner's (1971) description of industrial subcultures which can be identified across individual organisations implies a meso-level of culture. Such inter-organisational cultures which are distinctive from both primary culture and individual corporate cultures add considerable complexity. As noted in the previous chapter, Stinchcombe (1965) argues that the industry to which an organisation belongs is a strong determinant of organisational structure and culture. Comparison of the age of an industry with its technological base suggests a related argument that core technologies reflect the age of an industry rather than that of any individual enterprise within it. This technically determined line of argument would suggest that industries would retain key features, even as they diffused across very different cultural and social settings. The business recipes and frameworks grounded in these differences offer a meso-level view of "culture" of more direct value to actors (Marceau; 1992).

## Framing Culture

The theme of this chapter is that it is possible to identify and describe cultures of design. Weapons are designed to function in the most demanding and extreme circumstances. As Kaldor (1981) points out, the argument for additional functionality and performance can always be made on the basis of literal "life or death" importance, and on the assumption that failure is unacceptable. Cultures which are distinct in terms of the values and ideologies that are brought to bear in the design process produce weapons systems that have identifiable characteristics and capabilities that derive from these same values and ideologies. This theme is both specific and general, relating at once to popular beliefs about high technology that have important consequences in the very expensive business of equipping armed forces, while at the same time providing an analysis of the systemic nature of the differing weapons design processes in the U.S. and USSR as they existed during the Cold War period.

The analysis presented here requires a differentiation between task and institutional environments as set out in Chapter 8. The former refers to those features of an environment that are relevant to an organisation as a production system. In the case of weapons manufacturers this involves the transformation of design research and materials inputs into working weaponry. Hence, at this level, the organisation is concerned with the task in hand (an attack helicopter or tank for example) and the design, performance and materials decisions that will determine its utility as a destructive engine.

On the other hand, at the institutional level, the organisation is concerned with the political, economic and competitive influences that will affect its continued existence in the marketplace. These levels are obviously mutually interactive since, in the case of weapons manufacturers, political and economic considerations determine to a large extent the designs they create (task level), while these designs in turn help determine the political, economic and strategic agenda that the organisation must face (institutional level).

This chapter presents evidence of inconsistencies and fallacies at both levels of the arms development process. On the one hand, the institutional environments in which competing arms manufacturers find themselves result in designs that are often defective, even in the narrow performance sense applicable to the task environment of the arms designer. On the other hand, such defective designs serve as indictments of the institutional aims and agenda of arms developers and arms development itself.

This constitutes the higher level framework within which a further argument pertaining to the factors that influence the nature of arms developers' institutional environments can be developed. In the US and USSR, differences in the mix of institutional factors spawned different task environments which in turn resulted in stylistic differences in weapons design- patterns of design that here are termed “design cultures”.

## Weapons Design Cultures

By the last decade of the Cold War, operational inadequacies and questionable cost-effectiveness of modern hi-tech weaponry were well recognised. Widespread criticisms were being levelled at the U.S. system of weapons development and procurement. These views were promulgated in publications such as Mary Kaldor's “The Baroque Arsenal” (1981) and James Coates' and Michael Kilian's book, “Heavy Losses” (1986). The picture emerging from such publications is one which characterises the American defence industry in particular, as corrupt, inept, inefficient and incapable of producing functional weaponry at reasonable cost.

A specific focus of Kaldor's work has been her thesis that despite the massive investments made in their continued development, modern Western weapons systems reached a point of diminishing returns in terms of their functional capability. She also notes that this situation has existed previously, most clearly in the British shipbuilding industry near the turn of the nineteenth century, when the dreadnought was regarded as the principal weapon of its era. Here, the escalating costs of dreadnought development remained secondary to the national prestige and security that a fleet of dreadnoughts was believed to bestow. In particular, the establishment of an industry that required continuity of orders to maintain employment levels and its multiplier effect on other, dependant industries, contributed to the need to establish a dreadnought export industry, as well as a sustained internal demand for new warships.

It is this situation that Kaldor terms *baroque*: a direct feedback loop between weapons supply and demand, a demand that is sustained by arguments of increased capability in the face of escalating costs, and in the absence of evidence of either improved capability, or even the need for it. Furthermore, this process is augmented by the symbolic power that such weapons have and the ideological role this plays in procurements for national defence.

The Dreadnought case history is particularly illuminating in that it depicts an arms industry that was insulated from what are generally understood as market forces. The proxy "market" was driven by particular military and technical ideologies and, for its maintenance, consumed a massive amount of domestic capital. Moreover, it is one which has strong parallels with the American situation in the closing stages of the Cold War. It may be argued, the U.S. national economy was being strained to produce the equivalent of a new generation of dreadnoughts with the development and prospective deployment of the Strategic Defense Initiative (SDI). It is a tribute to the durability of the institutional environment that ten years after the removal of its raison d'etre, SDI is being promoted in a revised form as Ballistic Missile Defense, necessary for security against rogue states and terrorists.

Kaldor's criticisms have targeted the existing Western system of weapons procurement and development and culminated in a plea for greater numbers of cheaper, simpler and basically effective weapons. The list of weapons systems castigated by Kaldor and other critics includes the M1 Abrams tank, the Bradley Fighting Vehicle, the Aegis fleet defence system and the "Sergeant York" air defence system, among others. Their shortcomings can be summarised generically in terms of the problems that very complex (and, potentially, very capable) systems of any sort experience; namely, a tendency to chronic unreliability, a tendency to fail in complex, unpredictable ways and a tendency for their operators and buyers to overestimate their operational capabilities. Of these systems, only the "Sergeant York" was abandoned (Wilentz, 1985). Over time the others were brought to a degree of functionality which justified their presence in the inventory of the armed forces.

This perseverance mirrors the Cook-Craigie recommendation of the nineteen-fifties that aerospace design and development should overlap by progressively modifying production aircraft (Marschak et al 1967). However this tactic was a technical response to the newly discovered discrepancy between the performance of hand-built prototypes and aircraft built on expensive production jigs. Kaldor and other critics are describing an institutional system for creating early lock-in to escalating commitment. Discrepancy between the lengthening technical development timeframes and institutional decision-making and budgeting frames made commitment at an immature stage of development necessary in order to secure the resources needed for completion.

In the West, the Cold War period saw an alarming, exponential growth in the per unit cost of modern, complex weapons, and publications of the "Baroque Arsenal" type have emerged as one form of response. A rather graphic illustration of the literally exponential growth in the per-unit cost of U.S. aircraft was given by Augustine (1975), beginning with the Wright brother's first machine to the U.S. army and ending with the F-15. His graphs show that if such trends continue, then in the year 2054, the projected U.S. defence budget would be able to afford a single aircraft-shared between the Air Force and Navy. The current B-2 strategic stealth bomber fleet of just twenty-one aircraft certainly fits this trajectory.

Such escalations in cost has been justified in terms of the increased functional capabilities of these weapons; that is, more money for fewer units with greater capabilities. Their proponents argue that these capabilities compensate for both increased cost and diminished numbers. However, it is not merely that the actual effectiveness of these weapons can be severely criticised, or even that their exponential costs have not provided concomitant exponential growth in effectiveness. It is that there are a variety of factors, ideological, historical, economic and political, that have led to this situation and which maintain it in the face of severe criticism and condemning evidence. These institutional factors find their expression at the task environment level to form a weapons design culture. In the West, this is distinctive in terms of the characteristics of the weapons it creates. In particular, the values embedded in such weapons are starkly different from those produced by the design culture of the Soviet Union. In the post-Soviet period, however, Russian designers are beginning to address export markets beyond the old spheres of influence which were required to follow their approach.

Design cultures, as described above, are the result of a myriad of factors and influences which occur at the level of the institutional environment. Indeed, a weapons design culture can be defined in just these terms: the systemic combination of a hierarchy of factors on the design commonalities that can be seen to exist in a nation's arsenal. These factors range from political and economic dispositions to military strategic objectives, historical factors, the availability of capital and even national manpower and education levels. It is precisely because of the difficulty in teasing out the separate influences of such factors and their relative magnitude, that a design culture must be viewed in systemic terms.

## Nothing personal: men, machines and smart weapons

In a very crude sense Western, and in particular U.S. built weapons are the result of a complex, profit-driven set of relationships first characterised as the Military-Industrial Complex by President Eisenhower in his retirement address (Eisenhower, 1961). Clearly, the ideologies concerning technology which are a part of Western culture are key components of this system. The ideology of technocracy (and its manifestation in the economic/political process of arms manufacture in the U.S) and the West's cultural technological imperative[2].

In addition, there was a clear difference between the Soviet Union and the U.S. in terms of the extent to which they succeeded in using technology as a potential substitute for human operators or soldiers. Although this may be due at least in part to differences in technological capability and sophistication, this remains an incomplete explanation. Certainly the USSR had considerable strengths for example in the development of automatic resupply rockets for its space stations and has the capability to develop complex remotely piloted vehicles, yet it largely refrained from developing military systems with remote operators or with semi-autonomous sensor based intelligence. In terms of the United States however, one can trace a trend, most clearly evident in the Vietnam era, in which the withdrawal of manpower from the battlefield, and its replacement by ostensibly more efficient technology, has been looked upon as a more than favourable development.

This removal of humans from the trauma of combat by using increasing amounts of long range firepower, long range sensors and electronic replacements for the surveillance, reconnaissance and combat functions of soldiers, airmen and sailors, has been in evidence from at least the Vietnam era, if not before. Certainly, the Vietnam conflict acted as an enormous incentive to the development of electronic sensors and data collection devices such as sniffer aircraft and motion and heat sensors for example (Dickson, 1976). Moreover, in more limited engagements, or in covert activities, the removal of the possibility of the death or capture of personnel offers a political benefit. recognised in the West since the 1961 destruction of Gary Power's U2 aircraft. The human cost of the surveillance activities of that period has only been verified with the ending of the Cold War (e.g. Burrows, 2001).

By the Vietnam War period pilotless reconnaissance aircraft and satellites were replacing the more dangerous reconnaissance missions formerly flown in secret by crewed aircraft (Wagner 1982). These aircraft, developed from target drones, are the ancestors of the current generation of Global Hawk, Raptor and Predator surveillance and strike systems (Streetly, 2003). In the post Cold War period, there is considerable political advantage in being able to conduct hostilities with minimal or no exposure to harm for military personnel.

In the last decade of the Cold War a generation of "smart" munitions emerged (Perry and Roberts, 1982). These included autonomous, intelligent mines and torpedoes that "pattern match" tank or submarine heat signatures or noise emissions to their stored memory of enemy targets These represented the fruits of more than 20 years of continuous military funding of artificial intelligence research. These were followed by "intelligent", man-portable surface-to-air missiles and anti-tank missiles, as well as intelligent anti-armour weapons (Skeet and SADARM (Search and Destroy Armour) for example) launched from artillery or mortar tubes to search for tanks while dangling from a parachute and then pierce their thin, uppermost armour with an explosively formed projectile (Jackson, 1985).

The Defence Research Projects Agency (DARPA) sponsored research into the development of intelligent, autonomous reconnaissance vehicles, and intelligent "pilot's assistants" as well as knowledge based tactical assistance systems (Stefik, 1985). Indeed, the terrain-following capabilities of cruise missiles rely heavily upon the incorporation of intelligent pattern matching procedures to assist their inertial guidance systems.

In essence, these efforts converge in their attempts to incorporate a spectrum of intelligence into weapons systems; this spectrum ranging from simple detection of a laser target designator or the use of other forms of sensor, to intelligent target recognition and autonomous control of an attack sequence and even artificially intelligent fleet defence systems or battle control assistants. It was initially on the grounds of cost-effectiveness that this replacement of human intelligence with limited machine intelligence was supported. That is, the price of such systems relative to their targets, or (for defensive systems) their defensive concerns (aircraft carriers, aircraft or tanks), is such that an advantageous economic tradeoff can be achieved even if several such weapons are needed to disable the target, or, in the case of a defensive system, if the defended entity such as an aircraft carrier, can be made to survive a sustained attack. However, it must also be acknowledged that the automation of almost all processes whether industrial, professional or military, is clearly manifested at almost all levels of Western society and has precipitated similar outcomes in the removal of high levels of human involvement from the decision loop[3].

These ideologies re embedded in the design of modern Western weapons and the escalating costs of their development and manufacture can be contrasted with the Soviet characteristic of relying heavily on manpower equipped with cheaper, less sophisticated, and more reliable weapons in greater numbers. From this one can denote a central ideological difference which has a number of facets, including a schism in the envisaged role that technology may play as a replacement for human presence, decision making and risk.

These differing emphases on the relative capabilities and deficiencies of machines versus humans are an important distinction between U.S and Soviet weapons design cultures and the weapons they have traditionally produced. That is, in American weapons systems, humans are deliberately being phased out as an essential part of the decision loop[4]. This is not only because the United States has the technical expertise to do so, particularly in the context of serious manpower shortages in its defence forces, but also because the West's technological and economic imperatives have traditionally automated all specifiable processes and this history supports the belief that such systems are actually more effective.

In addition to these different histories and motivations for deskilling and automation, the sources of such ideological differences may very well have reflected the different levels of available manpower in the U.S. and U.S.S.R and different cultural values and powerful, even militarily traumatic historical experiences.

## Cold War Practicalities: Sophistication and/or Functionality

The potential economic efficiency of precision guided munitions and other intelligent weapons that are the products of Western weapons design culture must be acknowledged. However, their functionality in environments or under conditions that are less than optimal for their performance must be questioned. The susceptibility of these weapons or defensive systems for instance, to adverse weather or battle conditions such as fog, dust, smoke (deliberately laid smoke screens or the incidental outcome of combat), snow, or rain, the distracting effects (for the weapons operator) of enemy fire, as well as rather simple enemy countermeasures, is now a matter of public record. For instance, a constant research effort is conducted to provide software that allows air-air missiles to "filter" infrared or radar data supplied by their sensors, so that spurious sources of heat (flares, fires, the sun etc.) or false radar returns, can be distinguished from the heat emissions, or radar returns of real targets. Despite these efforts, even very simple countermeasures, decoys and sub-optimal conditions, continue to be problematic for many modern missiles and smart munitions. Snow, for instance, is a hazard that the topology matching algorithms of the cruise missile find difficult to handle, as are the changing densities of leaves throughout the seasons.

A number of video recordings of the successful use of precision guided munitions were released for television broadcast during the 1992 Gulf war against Iraq. These were widely considered to represent the total of successful deployments in a bombing campaign that was conducted ninety percent with Word War II munitions technology. This was despite the environment being much closer to the desert proving grounds in which the weapons were tested and developed than the theatres for which they were originally intended.

There is a belief, peculiar to Western modes of thinking, that a weapon's performance is something that stands in isolation; that whether a weapon is effective or not depends on its technology alone, not the environment in which it finds itself. Hence, for Western weapons manufacturers and purchasers, there is a tendency to confuse sophistication and technological complexity with actual functionality. This in turn leads purchasers to an assessment of sophistication and apparent capability rather than actual capability when making their decisions. In other words, the issue here is the difference between efficiency within essentially hypothetical system goals and actual effectiveness in a realistic environment.

The significance of this point may be better clarified by an example. The F-15 fighter for instance has a radar system that allows it to simultaneously track up to 24 targets and simultaneously engage any six of them. This remarkable apparent capability is permitted by the complexity of the radar and avionics systems. However, this capability is not only bought at a price in real dollars terms, it is bought at a price in terms of reliability, maintenance time, spare parts, and training of pilots and maintenance personnel, not to mention the possibility that this capability, even when it is working, may be irrelevant.

Cold War preparations focussed on the standoff between NATO and Warsaw pact forces in Western Europe. NATO's defence was based in part on a belief that their fewer hi-tech weapons would be more than adequate to meet the greater numbers of less sophisticated Soviet weapons. In any outbreak in Western Europe, the favoured scenario in the anticipated air conflict, was that the opposing airforces would meet en masse and Western fighters would achieve air superiority by picking off Soviet aircraft at long range (out of sight) with their very accurate, long range air-to-air missiles. Hence, it was believed that the Warsaw Pact's numerical advantage would be whittled away by superior Western capability.

However, if one considers the more realistic situation involved in such a full-scale aerial conflict, then this view becomes much less convincing (see Coates and Kilian, pp. 256-257). In a situation where hundreds, perhaps thousands of objects (if one considers missiles, drones, remotely piloted vehicles and other miscellania) would have been airborne over the middle of Western Europe at any one time, where both enemy and friendly squadrons were taking off, carrying out, or returning from airstrikes, where high and low speed aircraft were providing tactical fire support for ground forces, where others were performing forward air control or reconnaissance missions and where Electronic Counter Measures, jamming and chaff had created widespread confusion in radar, radio and satellite communications, then the convenient opportunity for an F-15 to pick off its targets may never have appeared.

In such circumstances, even an Airborne Warning and Control aircraft (AWAC) may be hard pressed to assist in vectoring friendly forces or processing target data, even if it was able to divert attention from its own immediate survival. In support of this, Coates and Kilian (1986) recount the case of an A-6 Intruder accompanied by two F-106 fighters making a successful sortie against an AWAC in an exercise off Hawaii by jamming the modern aircaft's radar with their nineteen-sixties technology.

Moreover, NATO's assured superiority involved a situation that so far has never actually happened on any scale in aerial warfare; the situation where large numbers of targets are identified as enemy and then attacked, solely on the basis of electronic data. Given the total pandemonium of the first few days of a NATO-WP conflict, it seems very unlikely that this procedure would actually have been followed. After all, the fact that an aircraft, or even groups of them, do not respond to radio or electronic "Identification Friend or Foe" (IFF) procedures may merely be the result of damage sustained in returning from enemy territory. It may be the fault of a communications anomaly or dead spot, broadband jamming, even radioactive fallout or the effects of Electromagnetic Pulse.

It seems highly unlikely that mass engagements would have proceeded without visual identification, both because of the extensive electronic and physical confusion involved in such a conflict and the susceptibility of complex weapons (as described above) to "spoofing" by even simple countermeasures. Indeed, the difficulties of beyond visual range identification in even very simple scenarios can be seen in reports that during the 2003 war in Iraq anti-aircraft missiles were "ripple fired" against single targets to improve the probability of hits and a British aircraft, along with its crew, was destroyed, in an environment of very limited opposition monitored by a system described as delivering "network centric warfare" (Brookes, 2003).

In the circumstances likely to have prevailed in a full scale Western European conflict the apparent capabilities of the F-15 would not have been converted into actual capabilities. Aircraft would be forced to close to visual ranges at which, experience has shown, the numerical superiority of even quite unsophisticated aircraft, is the deciding factor in most aerial engagements (Miller et al 1981).

There is a tendency to equate apparent capability- that which has not been tested in real circumstances- with actual capability. Since it is the sophistication of the technology that denotes the apparent capability of modern weapons, then this is what most purchasers tend to buy. The comments of the MIT computer scientist Joseph Weizenbaum are most apt in this regard. He calls the rampant pursuit of high technology the "pig principle"- the notion that because some is good, then more must inevitably be better (Weizenbaum, 1976). Yet in the context of a heavily armed Europe, it is important to note that not only was the pig principle rigidly adhered to, but it was also made more ludicrous by the illusory military capabilities it provided.

## Bangs and Bucks: Quality, Quantity and Asymmetric Warfare

Within Western design culture there has always been a constituency interested in quantity traded against quality, and indeed, as has been illustrated by the above discussion, this ideology has held an enormous amount of sway in projections of the effectiveness of high technology weapons against more numerous, but less sophisticated weaponry. In effect, as discussed above, this is a position that Western powers are forced to take if they are to justify the ballooning costs associated with the development of sophisticated weapons systems.

It is interesting and appropriate at this point to recount some of the historical evidence which contradicts the claimants for quality. In the Korean War for instance, the MiG-15 was seen by U.S. pilots to be an effective, although relatively crude weapon, while these same pilots had very few good words for many of the supposedly advanced features of their own aircraft (Marschak, Glennan and Summers, 1967, p.111). The veteran Russian pilots now known to have piloted the MiGs were restricted in their area of operations to so-called "MiG Alley" by the need to avoid capture or identification if shot down and this reduced the effectiveness of their operations.

The history of the Northrop F-5 and its application also yields much that is disconcerting for the supporters of quality versus. quantity in weapon evaluations This aircraft, a lightweight, cheap, yet effective and extremely reliable tactical fighter was intended for the export market to match the MiG-21 which itself was being exported by the Soviets in what became known as "MIG diplomacy" (Sweetman; 1985). In terms of export volume, the F-5 was a remarkable success, but its application in the U.S.A.F. has been confined to training and especially to the emulation of the MiG-21 in training exercises (the "aggressor" role), a task to which it is eminently suited because of its similarities in size and handling characteristics. In this application however, and in the numbers expected of MiG-21 formations, its performance gave rise to considerable concern when it carried out visual attacks from low level utilising cheap heat-seeking missiles, even against aircraft with sophisticated "look-down, shoot-down" capability, such as the F-15 (Coates and Kilian, 1986).

A further concept that underlies Western adherence to advances in quality at the expense of quantity is the notion of the "force multiplier". This is the expectation that superior communications and force coordination, earlier warning, and better intelligence- all qualities that high technology weapons systems are potentially able to provide- have a multiplying effect on any given force, so that numerical inferiority can be multiplied into a superior position.

Perhaps the most highly regarded example of such a force multiplier is the Airborne Warning and Control aircraft or AWAC. Yet, despite the anticipated multiplier effects of such systems, Ford (1985) argues that their effectiveness is often downgraded by the demands on resourcing actual weapons hardware, which is often deployed with inadequate spares because of unit cost inflation during development. The force multiplier argument can be seen to reflect the need to justify such high unit costs, and derives in turn from the quantity versus quality position taken by the West.

The flaw within the multiplier argument, is that the cost involved in the loss of force multipliers may also have a multiplicative effect, but in a negative sense. Consider for example, that while a single AWAC may genuinely have the capacity to monitor the airspace of the entire Middle East, its loss would be prohibitively expensive not only in dollar terms, but in terms of the effectiveness of the highly expensive fighters that would be reliant (in a tactical sense and in a design sense) upon its targeting data. This is precisely the situation in which the British found themselves during the Falklands War, when they desperately shielded their two aircraft carriers from Argentinian attack, since the loss of either ship would almost certainly have ended their campaign's chances of success. This multiplicative loss effect may also be the reason why U.S. naval computerised combat simulations reputedly do not provide for the loss of Nimitz class aircraft carriers, regardless of the amount of damage sustained.

Each B-2 Stealth Bomber deployed in Kosovo in 1999 operated with a minimum of fourteen combat air patrol and escort aircraft, electronic counter measures and other support requiring eighty-five aircrew, not counting the overall AWACS control (Brookes, 2003). As noted, the B-2 fleet itself has been restricted to 21 aircraft and the bulk of bomb delivery will continue to be undertaken by the aging B-52 fleet. This is currently scheduled for service until 2040, that is eighty-eight years after the first flight of the prototype aircraft.

Another problem with an argument for weapons quality at the expense of quantity is that once the difference in sophistication between combatants becomes very great, then much of the sophistication of one's high technology systems may actually become useless. For example, the encounter by a U.S. taskforce of 1908 vintage Russian mines in the Persian Gulf, during the Iran-Iraq Gulf war, illustrates how a technology, so unexpected in its primitiveness, could create distinct problems. A similar argument can be applied to the irregular and open-ended "War on Terrorism" in which the West's opponents deploy the civilian infrastructure as weapons of mass destruction. Together with many of the still unlearned lessons of Vietnam, this represents a difficulty that remains unaccounted for by the supporters of quality.

Even the "Rolling Thunder" bombing offensive which led up to the Paris peace talks of 1968, while thought capable at the time of destroying North Vietnam's war effort, actually appeared to have little effect upon an economy that was already quite rudimentary in terms of its technological basis. Yet it was this same economy which nevertheless had successfully opposed U.S. forces in South Vietnam for a number of years (Dickson, 1976, p.20) and which ultimately brought about the frustration of U.S. military intentions, a point which should inform current policies in Afghanistan and Iraq.

## Forty Years On: the Military-Industrial Complex in the Twenty-first Century

One component of US weapons design culture involves the nature of the relationship between American arms manufacturers and the military itself; Eisenhower's Military-industrial Complex of 1961. The intimacy of this relationship has been identified as a profound handicap to the development of weapons that at least meet the technical specifications demanded of them.

In Coates and Kilian's terms, the almost incestuous relationship between these two entities, whereby personnel routinely move from one camp to the other, (the "revolving door" as it is termed by these authors) eliminates the separation between arms manufacturer and arms buyer, so that the normal benefits of the market, such as open competition and impartial evaluation, cannot prevail. The result is a system of weapons development in which kickbacks and bribes continue to play their part, where the confidentiality or secrecy needed for fair competition can be breached by the free trade in personnel between contractors and the military, and where the general market requirements of cost-effectiveness and quality have not always received a reasonable share of attention[5].

In addition to this, there is the continuing institutional process in the U.S. military, whereby promotions are increasingly offered to those involved in administrative, political or bureaucratic roles rather than to those tasked with combat or operational commands. On top of this rush to bureaucratic duties by the highly ambitious, it has been shown that the system of promotion in the American military forces, works to deny advancement to those individuals whose project cost-cutting exercises reduce their staff and budgetary requirements[6]. Indeed, because of the military bureaucracy's steeply tapering pyramid at its highest echelons, those who are promoted beyond their colonelcys (or equivalent) are generally those who have shown an ability to conduct a large and expensive project, rather than the ability to administer within budgetary limits. This tendency can be observed well beyond the military sphere. Even universities are routinely ranked by equivalent input measures such as the consumption of research funds.

According to Coates and Kilian's evidence, by equating size and cost with project importance and by downplaying outcomes such as cost-effectiveness and role capability, inflation of project costs can be regarded as a desirable goal for ambitious individuals, and military careers are thereby allowed to flourish in an environment that has been almost freed of real accountability. It is in this environment that cost-overruns, shortfalls in anticipated performance, reshaping of original specifications and indeed even complete rethinking of weapon roles has become endemic and almost expected as a matter of course.

The most striking example in this regard was the DIVAD system, or Sergeant York air defence gun, where the intended targets changed from high-speed low-flying fixed wing aircraft, to helicopters taking evasive action, to helicopters in level flight as continued development revealed the difficulty of reaching the original specification.

However, that the nature of this relationship between weapons users and developers serves not only to preserve a commercial system that has mutual internal advantages for those who are members of the club, but also acts as a filter or gatekeeper to those that are not already part of it. Armacost (1985) for instance, recounts how Chrysler received a great deal of interference from the existing aerospace companies when it became interested in missile development at the beginning of the "space race".

Clearly, the preceding discussion does not concern itself directly with the larger issues of what purpose military budgets actually serve and how measures of “effectiveness”, success or failure can be attributed to activities which are essentially wasteful of resources and skills. Yet it does illustrate that even within the narrow definitions of success and failure that permeate the U.S. arms industries and military establishments, by the end of the Cold War the domain of arms procurement and purchase in the United States was corrupt, inept and in terms of its own “rationality”, verging on dysfunctional.

**Eggs and Baskets: Omnibus Designs**

One major consequence of cost increases in the West, has been a diminishing variety of weapons and the tasking of individual weapons systems with a greater range of combat roles. The European Tornado aircraft for example, the F/A-18 and F-111 were all touted as being capable of fulfilling attack/interceptor/bomber/fighter roles, a burden now passed to the new generation of technology represented by the Eurofighter and U.S. Joint Strike Fighter (JSF) programme. Such “mission creep” has been a means of achieving commitment to a specific design project. Chapter 8 describes this aspect of the Space Shuttle programme but the approach dates back to Robert MacNamara’s tenure as U.S. Secretary for Defense in the nineteen-sixties.

The TFX fighter-bomber project was extended to reduce cost by delivering a common design to both the Air Force and Navy. The winning variable geometry (“swing wing”) design by General Dynamics promised 91%commonality between land and ship-based versions compared with only 44% in the rival Boeing proposal. Because of the variance in performance requirements, however, the Navy was able ultimately to make its case for a separate aircraft from what was essentially an Air Force design. The surviving Air Force version was ultimately produced in a variety of versions and in numbers that achieved little economy of scale (Gunston, 1983). Ironically in June 1973 the Wall Street Journal claimed that the eventual termination of F-111 production was intended to ensure commitment to the next generation Rockwell B-1 bomber by removing a fall-back alternative (Levine, 1973).

The F-111 showed that success in achieving a range of demanding requirements is likely to be elusive. Even more than with naval versus land-based aircraft, the design requirements of defensive fighters and attack bombers are in conflict. Indeed, they are essentially incompatible in that while one role may demand low level stability for weapons delivery, another demands high level maneuverability; while one sacrifices fuel capacity for the haulage of large amounts of ordnance over short distances, another demands long range and large internal fuel capacity.

The result of this multitasking requirement where designs are asked to perform every conceivable role, is the production of smaller numbers of more costly, complex aircraft that are possibly less capable in any individual role than the aircraft they replace. The Tornado aircraft for example, the outcome of the European Multi-role Combat Aircraft project and once called "the milk giving, wool growing, egg laying sow" (Kaldor, p.142), proved too expensive to be used in its ground support role. Its losses were the highest suffered in the 1992 Gulf War, leading to an abandonment of the Royal Air Force's low-level bombing tactics. By 1999 the R.A.F. was dropping guided munitions from 13,000feet in Kosovo, in one instance leading to the misidentification and destruction of a civilian refugee convoy.

The omnibus aspect of Western design culture may be regarded as the institutional outcome of the technology driven approach on sophistication and unit cost aiming to lock-in the institutional customers to a single solution. It represents a political response to budgetary restraints which produce a downward spiral of fewer units, which therefore need greater capability, which means greater unit cost and fewer units. As a consequence, new economies of scale are sought by addressing an ever wider range of tasks, thereby continuing the spiral.

There are signs that the ambitious omnibus design is under re-consideration with the F-35, winner of the JSF design competition being offered in significantly different forms allowing a short take-off and vertical landing version alongside simpler, more conventional variants. This is a move from a single type towards achieving economy of scale through commonality as understood by the designers of civil aircraft. The Eurofighter Typhoon and the Saab/BAe Gripen, however offer conversion from fighter to bomber at the touch of a button while Soviet designs, such as the Sukhoi Su-30 fighter are now being offered to export markets as multi-role aircraft in the Western tradition, with mixed results (Lake 2001).

## Weapons Development and Application: The Soviet Experience

The essential culture of weapons design and development as it still exists in the West contrasts with the culture of weapons development as it existed in the Soviet Union. The differences highlight key advantages and disadvantages of the two systems, as well as the persisting characteristics of the weapons they produced.

Although Cold War accounts credited the Soviet Union with being technologically backward and possessing large numbers of crude weaponry, the technology of which has been stolen or copied from the West, such an account hides much that is fascinating about the Soviet's historical and cultural values toward weapons and the processes by which they are developed. A crucial difference is that while the Soviets traditionally considered technology as important, for them it was only relevant to military matters in so far as it can help achieve particular tactical or strategic goals. Indeed, whereas there remains an implicit assumption in the West, that if it can be made, it should be, and implemented as well, on the whole, Soviet planners often ignored technological potentialities unless they represented a means by which their military objectives could be assisted. The MiG-25 for instance, involved design compromises that were virtually unthinkable in the West, in order to achieve a specific mission - neutralising the threat from the proposed B-70 supersonic bomber.

> "In spite of Soviet appreciation of the importance of technology, the weapons produced for the Soviet forces often lack refinement. Their ruggedness and simplicity, often mistaken for crudeness, is the result of a deliberate design policy which eschews all unnecessary complexity. A Soviet weapon, whether it be an assault rifle or an air superiority fighter aircraft, is designed first and foremost to carry out a military task. However, ease of production and ease of maintenance are also important requirements, the latter especially so in a largely conscript-manned service. Therefore, new technology is only introduced when it provides the sole solution to a designer's problems. Otherwise, existing equipment will be modified to undertake new tasks." (Robinson, 1985)

This tendency to refine existing designs rather than incorporate new technology, can be seen in a number of major Soviet weapons systems, and it is the extent of this refinement and the longevity of many Soviet designs that acts as a significant counterpoint to U.S. technology driven design strategies. The MiG-21 aircraft for instance, has seen a series of dramatic refinements since its inception in 1959, remained in front line Soviet service for almost forty years. The MiG-27 "Flogger" as well, originally designed as an interceptor, has been incrementally developed into a ground attack aircraft, the "Flogger-D", by redesigning its engine intakes, armaments and avionics. Yet, while such incremental refinements do occur with Western aircraft of a similar vintage allowing them to serve in the twenty-first century, such upgrades tend to be performed only by secondary military powers[7]. American military forces characteristically pass their older aircraft on to reserve units and re-equip their front line forces with the latest designs. As a consequence, the Air National Guard generally achieves a greater level of combat readiness than equivalent front line units.

The longevity and extensive reworking of Soviet designs had the major advantage of allowing production runs to continue with minimal disruption, certainly without the level of disruption that the frequent introduction of new designs would cause. Secondly, this continuity of production permitted larger production runs and lower per-unit costs, with the costs of initial development being written off quite quickly. This emphasis on volume can be seen to be reflected in the selection of single engine aircraft designs, which allow high volume production and simplified maintenance at the expense of redundancy and some reliability in use. It is interesting to note for example, that Robinson (1985) quotes an increase in maintenance man hours per flight from 22 to 45 when the Egyptian Air Force replaced MiG-21 and 23 aircraft with U.S. F-4s following a change in political alignment.

Furthermore, it is clear that Soviet factories, unlike their Western counterparts, have tended to be more adaptable to wartime needs, partly as a function of the lower complexity of the products they manufacture and partly through deliberate provision for conversion. For example, in the 1930s Stalingrad and Chelyabinsk, two of the world's largest tractor factories, produced only half of the output of comparable U.S. factories, yet their conversion to tank manufacture at the outbreak of war, was achieved almost instantaneously (Cooper, 1976).

Although this convertibility has declined, nevertheless the doctrinal commitments to simplicity, commonality and design inheritance are important advantages in Soviet utilisation of commercial facilities for weapons production, as discussed in the context of Western military specifications. The existing gap between these and commercial quality requirements represents not only a barrier to Western exploitation of commercial facilities in the event of need, but also supports a small cadre of specialist arms suppliers and manufacturers whose relationship with the military is based purely upon satisfaction of these needs in a restricted marketplace.

## Systemic Robustness

A significant advantage of the Soviet system was that weapons and indeed, most technological efforts, such as space exploration, tended to be subsumed under a broader national purpose. When allied to a constancy of funding that the West would find difficult to justify, this resulted in a degree of systemic functionality that was at least impressive. That is, while individual units or weapons were, in general, less capable than those of the West, they possessed a greater measure of reliability and a more clear-cut and achievable role. This resulted in a military system, which, as a system, was more integrated and robust to individual weapons system failures.

That is, as we have seen, one of the effects of increasing costs in Western weapons development, has been the production of fewer ostensibly more versatile designs. If we contrast this with the more specific design targets of Soviet weapons and their numbers, it is possible to assess the robustness of the respective defence systems to the total failure of individual designs. In other words, in the event of an important weapons system failing disastrously, for example, if American F-16s and F-15s had been swamped by Soviet MiG-29s in Western Europe, or American carrier battlegroups had proved more vulnerable to anti-ship missiles than had been thought, then the systemic consequences of such failures would have been much more problematic for the U.S. than for equivalent failures in the Soviet system. This is because the overlap of weapon roles in Soviet weapon systems, as well as redundancy in the designs that perform these roles, made the Soviet system more robust to individual design failures.

This notion is strongly related to the negative force multiplier discussed above. Due to their unit cost, highly complex weapons take upon multiple roles and hence, role overlap of weapons diminishes so that design failure produces a negative multiplicative effect both because of fewer absolute numbers and because a catastrophic design failure simultaneously eliminates many roles from the weapon spectrum.

## Bureaux and Bureaucracies: Soviet Research and Design

As would be expected, the Soviet system of weapons development and procurement was inevitably highly centralised. In many ways, the relationship of Soviet industry to the Warsaw Pact members avoided the difficulties experienced by Western nations in their attempts to coordinate international procurements. In the Warsaw pact, the Soviet design became, with few exceptions, the de facto standard. This advantage was increased however, through the relationship between research, design and production organisations.

Sweetman (1985) and Robinson (1985) both give accounts of the different way in which competition was introduced into the Soviet system. While NASA, like its predecessor NACA, provides scientific and design data to both civil and military aviation companies, the centralised Soviet system ensured that innovations which were judged appropriate by TsAGI, the central aeronautical research institute, were adopted by the relevant design bureaus. In turn, the bureaux were required to evaluate alternative features within the same basic design programmes. This was the case with the MiG-21 for which prototypes were produced with both swept and delta wings. Thus, fly-offs and competitive evaluations occurred within the bureaux rather than between them, thereby producing competitive designs with minimum resources. Production runs were then assured for selected designs, handled by separate GAZ factories. It is interesting to contrast this approach with the intense profit-oriented rivalry occurring in the U.S. and which introduces cost considerations into a design's earliest moments.

Because of the features of the Soviet process, innovations proceeded in a more incremental fashion; first being evaluated by the research agencies, from which appropriate selections were passed on to the design bureaux for incorporation into prototypes, and eventually, production models. This preselection process met the criterion of choice of technical alternatives identified in Chapter 6 as a key to successful incremental innovation and robust design. Preselection in the Soviet system also reflects military doctrine and the spectrum of existing deployed systems, rather than pure technical feasibility alone. Thus the basic airframe of the MiG-25 has been utilised for a different role as the MiG-31, while the MiG-29 and Su-27 families share the same basic configuration.

At the same time, particular design bureaux might produce relatively few production designs, or only small volume production models, yet would deal with a generally higher level of innovation which was fed back to the research institutes, eventually to emerge in the large volume designs of other bureaux. As an illustration, the Kamov helicopter design bureau performs a role in redressing the generally conservative trends of Soviet designs by pioneering technical developments which may not be justifiable for general adoption without further investigation or refinement.

Lastly, a feature of Soviet weapons design was the political enmeshment of successful designers and the wielding of their political authority to secure favourable conditions for their activities. Well known examples of this include Academician Paton and the aircraft designers, Antonov, Ilyushin, Tupolev and Yakovlev (Cooper, 1984). It remains debatable whether this political involvement was counterproductive to competition and innovation in the manner that Coates' and Kilian's revolving door operates, or whether it was beneficial in terms of allowing those best qualified to judge designs (namely designers), better access to the resources they need for efficacious development. Certainly though, this smoother discourse between technical and institutional environments appears to have been less destructive than U.S. inter-service rivalries which have often terminated or delayed promising joint projects and common purchases, such as the Boeing-Bell JVX troop transport discussed by Coates and Kilian (1986, p. 140-141). This ambitious programme is still under development as the V-22 tilt-rotor aircraft while the ageing CH-46 helicopter it was intended to replace is exhibiting increasing unreliability, including a fatal accident in Iraq in March 2003.

## Reliability and Availability

An important difference between Soviet and American designers lay in their differing conceptions of reliability, and the differences between longevity of individual weapons and weapon availability. That is, for the Soviets, weapons reliability occurred when the weapon was functional whenever needed. It was of little consequence that the period of availability of the weapon, or its durability was limited, since these factors were taken into consideration when planning equipment rotation, overhaul and replacement. What mattered to the Soviets was not how long the period of high availability lasted, merely that such a period existed and was reliably known, so that planners could consider resource estimates as accurate. In contrast, the Western military concept of reliability is that a weapon remains constantly serviceable until it is effectively made obsolete, destroyed, or worn out. Highly reliable weapons in this view have extensive service lives and during this lifetime, malfunction infrequently until eventually they are no longer serviceable as a whole. Hence, for the West, it is the durability and availability of individual weapons that defines the concept of reliability, and it is this that must be maximised. For the Soviets, it was merely the known availability of the weapon and the period for which this could be guaranteed, regardless of how long or short this period was.

This difference in the concept of reliability can even be seen in the manner in which American and Soviet airforce units were committed to combat. For example, U.S. tactical strike units were expected to sustain heavy losses and perform indefinitely with the assistance of replacement aircraft and pilots, until they either prevailed or were effectively destroyed. Soviet units were expected to perform at a frantic pace for very short periods (generally five days) after which they were retired, refreshed and re-equipped before returning to combat status (Robinson, 1985).

It is probable that Soviet procedures were ideologically grounded in the experiences of the Great Patriotic War (WWII) where the source of victory lay in the consumption of enormous amounts of unsophisticated ordnance and weapons. Longevity was never important so long as the great factories of the East were churning out materiel.

It is interesting to note that the influence of these views in their respective design cultures appears almost paradoxical. While U.S. designers strive for high weapon availability in combination with maximum longevity and often fail to achieve either of these goals due to the complexity of their designs, Soviet designers on the other hand, while not being ideologically committed to the production of durable weapons, generally succeed in producing longer lasting, less failure prone designs by virtue of their simplicity and the extent to which they were incrementally developed.

## Learning from extremities: the post Cold War design environment

The purpose of this chapter has been to provide an account of the differing institutional influences in Soviet and American weapons design, the systemic combinations of which result in stylistic patterns of design decisions termed "design cultures", and which in turn, manifest themselves in weapons characteristics that are distinct and identifiable.

A distinction has been drawn between the task environment in which a weapon exists and the institutional environment which spawns it. In the case of the U.S. a large array of institutional factors, fallacious arguments, assumptions and assorted sophistries have combined to produce a design culture which produces weapons that may be plainly dysfunctional at the level of the task environment. That is, if one accepts that weapons systems are engines of destruction whose performance in this capacity can be rigorously evaluated, then it is evident that factors operating at the institutional level in the U.S. have prevented the production of weapons that are effective in this most primary of senses.

At a superficial level, this analysis of weapons design cultures may be said to contribute nothing more than a listing of factors that distinguish between the economies and political systems of the United States and Soviet Union, and it is these that determined the form that weapons design took. Such a view is both naive and simplistic. It is not merely the capital available to weapons designers that determines the form their designs will take, nor is it merely the influence of the military or political systems. In essence, it is a dynamic combination of these and other influences, including prevailing ideologies and dominant values and even historical lessons and geographical realities. Moreover, the complex interaction of these influences represents an identifiable culture of weapons design in much the same way that we regard different architectures of the world as stemming from a cultural basis that is comprised of economies, values, politics and world views.

The arguments here call into question the rationality of Western, and particularly U.S. design culture which emerged during the Cold War and to contrast it with that of the Soviet Union. While criticisms of the Soviet Union at the level of the task environment have been somewhat less severe, this is not to say that Soviet design culture should be regarded as a model for technological development, or that the process of arms development in the U.S.S.R was a more rational one.

The Soviet system tended to produce weapons systems which have an identifiable set of properties: reliability, maintainability, integration into a weapons spectrum etc., and in many circumstances these properties are more than a match for the West's expensive, high tech, unreliable gadgetry. However, while at the task level the U.S.S.R. can be accorded certain advantages and disadvantages, this is not to say that at the institutional level, it was not guilty of equal or even greater irrationalities. After all, although ease of maintenance may be regarded as a desirable quality of weapons, such a requirement is derived from the institutional level where compulsory military service limits the technical training and experience of the users of the equipment. The institutional rationality behind conscription as an appropriate and productive application of a nation's youth may be questioned, but the estimated 10% to 14% of Soviet GNP (Holloway, 1983) committed to the development and production of weapons has proven ultimately unsustainable. While the post-Soviet system still produces significant designs, these are generally poorly resourced and developed, with current government priorities lying elsewhere than in defence.

The U.S. design culture impacts in turn upon the institutional environment. Assumptions of technological superiority and a technicist perspective determine the advice given to political decision makers by military advisors. This is evident at macro and micro levels. At the micro level the results are tragedies such as the inadvertent destruction by the U.S.S. Vincennes of an Iranian A-300 airbus, referred to in the previous chapter, result from the deployment of complex and unreliable systems in crowded international corridors, ostensibly to protect the right of free passage. The deaths of 3-400 people in a Baghdad (Amaria) air raid shelter identified as a command and control centre and the deaths in the Chinese embassy in Belgrade resulted from out of date target data. The deployment of guided munitions from 13,000 feet in Kosovo was claimed to be for the restriction of civilian casualties, the unintended destruction of a refugee convoy demonstrated that the real concern was in fact with military casualties. Similar destruction of civilian life and property in Afghanistan during 2002 demonstrates the consequences of an ideology combining remote delivery of weapons with limited presence in the area of operations.

At the macro-economic level the military-industrial complex has dictated the direction of development of a significant proportion of research and development, not just in the United States but also in the economies of Cold War allies. In the United Kingdom the defence sector has controlled a significant proportion of high technology through out the Cold War period and beyond. Lovering (1988) argues that this military near monopoly of high technology from the Korean War onwards is a striking feature of Britain. As a consequence an export industry has developed across the developed Western economies beyond that required for mutual defence during the Cold War confrontation. Pythian (2000) argues that this has consistently constrained British foreign policy decisions and the international arms trade generally is seen increasingly to have constrained progress in developing countries.

In turn foreign policy in the United States seems to be driven by the capabilities of weapons systems rather than the longer term interests of that country and its allies. In the post-Cold War environment US military investment has continued at levels far higher than those maintained by other nations. The Project for the New American Century[8] is an influential think-tank which premises a global role for the United States based on unassailable military might. However, the post-Cold war period changed its character after September 11 2001. The unchallenged military superiority of the United States was in effect circumvented by the "weaponisation" of the civil transport infrastructure. The response, in both Afghanistan and Iraq has been shaped by the characteristics of the very weapons systems that offered no defence from the 9/11 attacks. A "war on terrorism" has quickly shifted to a recognizable high-technology conventional conflict against those targets that are suited to the application of such measures[9].

The scale of the U.S. military-industrial complex creates and supports technologies which other nations can only emulate through collaboration and consortia, either with U.S. companies, as is increasingly the case in the United Kingdom[10], or with others former Western allies, as with Eurofighter and the military Airbus design A-400M[11].

The post-Cold War reconfiguration of Europe, as foreshadowed by Delamaide (1994) is now under strain because the expansion of NATO and the demands for regional security beyond its traditional sphere are placing a burden upon economies seeking to close the gap between East and West Europe. European and U.S. manufacturers compete for sales to the new NATO members, while both former Eastern bloc and Western countries vie for up-grade contracts for the surviving Soviet era hardware.

Elsewhere developing countries are similarly distracted. The Republic of South Africa retains significant human and technical resources in infrastructure developed to ensure military self-sufficiency during the isolation of apartheid. In a post apartheid context there are both actual costs and opportunity costs to be addressed.

India and Pakistan pursue nuclear technology and delivery systems development. India is a customer for the Russian Su-30 fighter-bomber and both nuclear and conventional warships.

Military technology is an extreme case, but the examination of extreme situations reveal issues that may not surface in an environment in which elements can be seen in the transfer of technology more directly useful for development The account presented in this chapter provides a number of cautions. It reinforces the points made in earlier chapters about the nature of designed artefacts and the need to pursue design policies that are sustainable in terms of the human and material resources that they require. It also places design and deployment of artifacts and systems in a technical and institutional context and argues that the technical drivers of advanced weapons are shaping global strategies, to the detriment of broader views of the priorities of global development. This is typified by the gulf between the level of funding available for the application of military force and the funding available for the amelioration of the consequences of that application of force. This has been detailed by Monbiot (2003) in the current case of Iraq.

It has been necessary to examine in detail the complex interactions between the constraints and opportunities presented by the development of high technology systems. The final section of this book examines the decision space available to developing regions and communities in which to develop an appropriate response to the determination created by the interests and actions of their developed counterparts.

## Notes

1 See Chapter 10 for a more detailed discussion of the development of Japan
2 See Chapter 3 and Morrison (1986).
3 The automated battlefield along with the workerless factory and the paperless office forms a technocratic triptych at the centre of Western technological aspirations in the Cold War period.
4 See for instance Morrison, 1984; Parnas, 1985 and Mosco, 1987 on the autonomous nature of SDI.

5 See for example, Tyler (1986) and Franklin (1986) on the history of General Dynamics - a history of extensive bribery, corruption and the source of the largest cost overruns in U.S. military history.

6 See for instance Coates and Kilian's account of the A-10 aircraft project, pp.154-155.

7 Laureau, (2003) describes the upgrade option for the F-4 Phantom adopted by Greece.

8 See http://www.newamericancentury.org/ for their clear explanation of the underlying philosophy.

9 Ironically, the US White Sands testing range bears more resemblance to the Iraq desert than to the North German Plain, the assumed theatre for many of the weapons developed there. The shift from a ten percent to a ninety percent proportion of smart weapons between the 1991 and the 2003 Iraq wars reflects both growing maturity and declining costs in the technology, and the similarity between the test and deployment environments. The reported failure rate remains at around ten percent however.

10 British Aerospace Systems is in partnership with Lockheed Martin for the F-35, the successful bid for the JSF programme, a member of the Eurofighter consortium and a partner with Saab in the design and production of the Gripen fighter.

11 There is clearly an agenda within Europe to maintain independence from U.S. technology, and this extends to military satellites and global positioning technologies, which deliver both civil and military functions and which will be examined in the concluding chapter.