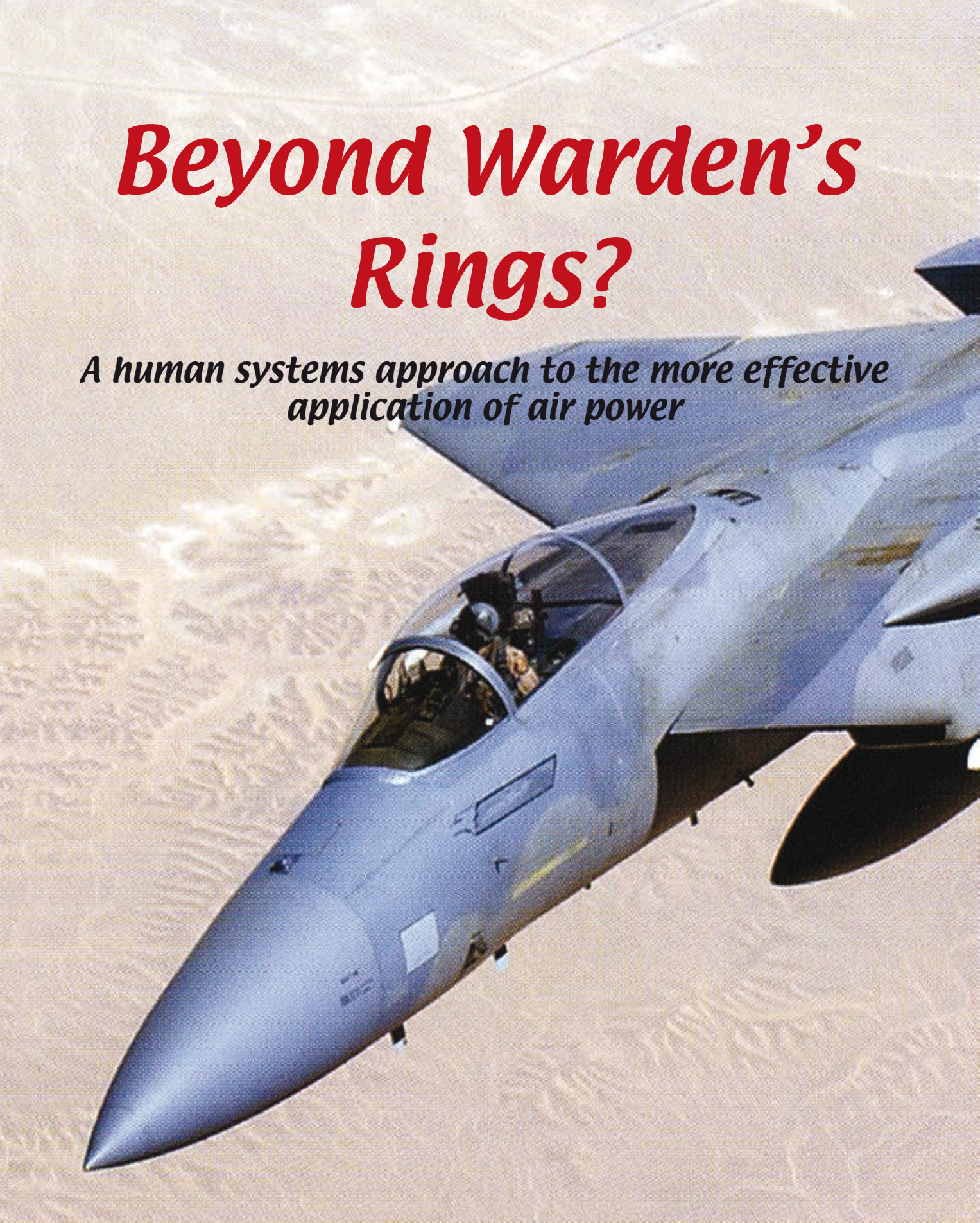
# Beyond Warden's Rings?

## A human systems approach to the more effective application of air power

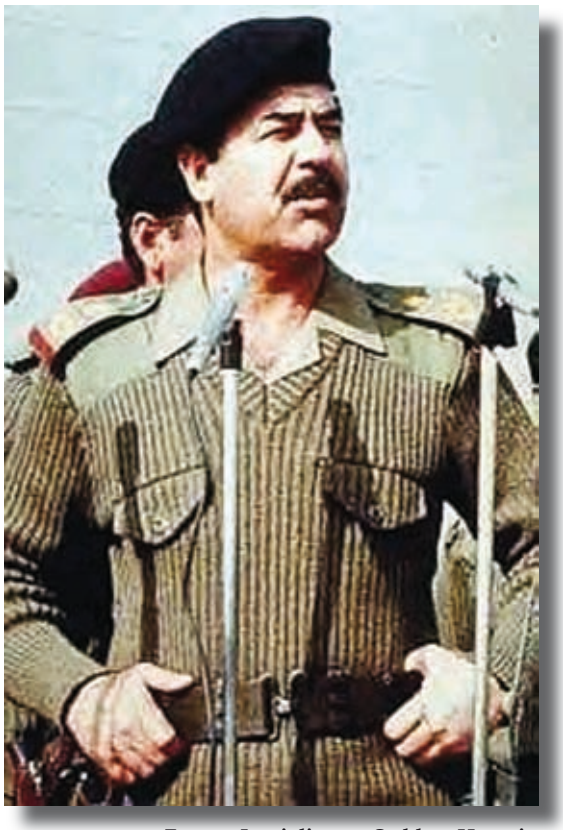


By Sqn Ldr A H Killey

*Each age has its own kind of war and has its own theory of war.*[1]

The key question for air power theorists must be 'where should air power be focused in order to contribute to effects?' The paper argues that the existing disparate air power theories are part of a continuum that can be integrated using a human systems model to provide a range of option for influencing an adversary's means and will. The model is examined in the light of campaigns in the Gulf War, Bosnia and Kosovo. The paper concludes that the human systems model offers an explicitly holistic view of the adversary as a system, and provides a conceptual framework for understanding the cascade of direct and indirect physical and psychological effects. Air power is most effective when used to influence an adversary's will, rather than his means, but its use must always be tailored to the properties of the adversary and the political objectives.

Air power transformed the conduct of war in the 20th century[2]; the end of the Cold War, the phenomenon of globalisation and now international terrorism is transforming global security in the 21st century. A 'newly volatile security landscape'[3] has emerged, in which the majority of conflicts are within, rather than



**Former Iraqi dictator Saddam Hussein**

*When influencing an adversary's will, should air power aim to paralyse his ability to decide what to do, or to change the gains the adversary hopes to make from choosing a particular course of action?*

between, sovereign states and which can have had destructive effects on regional security.[4] This evolving spectrum of security[5] has driven the UK MoD to review and restate the role and utility of the UK Armed Forces[6]:

*"to provide security for the people of the UK and the Overseas Territories by defending them, including against terrorism; and to act as a force for good by strengthening international peace and stability . . . through peace-keeping, peace-support, peace-enforcement and humanitarian assistance operations, as well as power projection, focused intervention and deliberate intervention."*[7]

The UK is adopting a more integrated and flexible use of the effects that national political, economic and military power can deliver. This implies "significant changes in the way we [UK] plan, prepare and execute operations".[8] In this context the key question for air power theorists must be 'where should air power be focused in order to contribute to joint effects?' Seemingly competing theories have emerged that variously advocate focusing the role of air power to influence the adversary's physical means or moral will. Within these arguments run sub-currents of strategic thought; should air power concentrate on influencing means at the strategic or operational level? When influencing an adversary's will, should air power aim to paralyse his ability to decide what to do, or to change the gains the adversary hopes to make from choosing a particular course of action?

The purpose of this paper is to argue that these theoretical perspectives are part of a continuum that can be integrated to provide a range of options for influencing an adversary to comply with one's will. The decision as to which portion of the continuum to use must be based on an understanding of the adversary, the objectives of both sides, and on what must happen to the adversary to achieve political objectives.[9] First, each theoretical approach is briefly reviewed, highlighting their strengths and weaknesses and employment in recent military operations. Next, a model, based upon the characteristics of human systems, is proposed as an integrating framework for the strands of theory. The integrating utility of the model is examined in the light of campaigns in the Gulf War, Bosnia and Kosovo. The paper concludes that the most effective means of applying air power is to combine these theories in an integrated framework, to provide an air power

theory with the flexibility to achieve the desired political and military objectives in a the world of modern conflict. The data for this paper was researched using secondary sources.

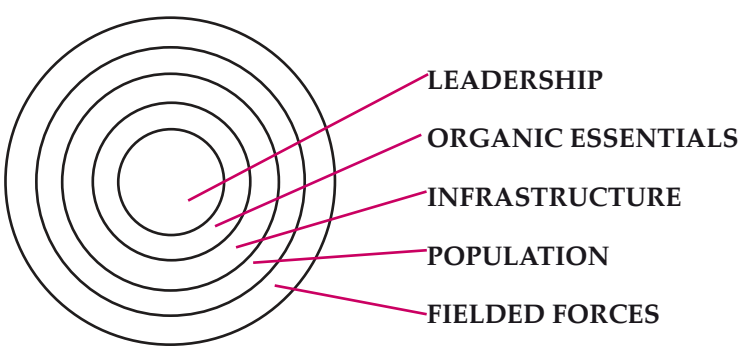
**Influencing an adversary**
**Theoretical approaches to influencing physical means**

There is considerable debate about which is the more effective strategy to enforce one's will on an adversary; by influencing his means or his will. Physical means are the personnel, equipment, materiel and organisation required to enact a decision. Moral will is the motive force that attempts to achieve objectives by action.[10] Clausewitz advocated that "Combat is the only effective force in war; its aim is to destroy the enemy's forces as a means to a further end . . . it follows that the destruction of the enemy's force underlies all military actions."[11] He did acknowledge that it was possible to "produce, by means of limited but skillfully applied blows, such paralysis of the enemy's forces and control of will-power as to constitute a significant shortcut to victory,"[12] but maintained that, "direct annihilation of the enemy's forces must always be the dominant consideration."[13] The dominance of influencing means rather than will was furthered by Warden, who contended that an adversary's strength was a multiplicative product of his means and will; driving one side of the equation to near zero made the other irrelevant. Warden argued that an adversary's means could be targeted and destroyed because "the physical side of the enemy is, in theory, perfectly knowable and predictable," but will "is beyond the realm of the predictable". Therefore "war efforts should be directed primarily at the physical side".[14]

While focusing on influencing an adversary's means, a sub-current in the theory of the employment of air power is the level of war at which it is most effective; strategic, operational or tactical. Strategic effect is the use of air power to directly achieve political objectives, and should not be directly equated with bombing targets at range from the homeland.[15] Operational effect is achieving military objectives in a campaign, and tactical effect is the application of air power on the battlefield.[16]

Like Douhet, Mitchell and Seversky,[17] Warden advocates the use of air power for strategic effect, as the best use of its speed, range and flexibility. Warden uses a five-ring model to describe the adversary as a system (see figure 1).[18]

Leadership is the most important system in Warden's model.[19] Warden's strategy strongly advocates blinding, deafening, and muting the adversary's communications and control networks, denying him centralised control of his forces[20] and effectively decapitating the entire organisation.[21] If the leadership ring is not directly vulnerable,




**Leadership – most critical ring. Decision-makers and command and control systems.**

**Organic Essentials – 2nd most critical ring. Those facilities or processes required to survive.**

**Infrastructure – 3rd most critical ring. The transportation system.**

**Population – 4th most critical ring. The society.**

**Fielded Forces – least critical and most hardened by design.**

**Figure 1. Warden's five-ring model**

force must be applied to the other rings, producing unbearable psychological pressure upon the leadership and forcing them to comply with one's will.[22] Each ring is linked to the leadership system in a hierarchical manner, so force applied to the organic essentials ring is more effective than applying force to rings further out. Within each ring is a Centre of Gravity (CofG), defined by Warden as critical to the functioning of the system. Planners must search for vulnerabilities across the system to which influence can be decisively applied. For Warden, the nature of that influence is physical. The most effective course of action to achieve physical destruction is through attacking all of the rings at once, because "parallel attack deprives [the adversary] of the ability to respond".[23]

Air power also has great effect at the operational and tactical levels. Slessor and Pape contend that air power's role was to assist and co-operate with the army in the defeat of the enemy's army"[24] focusing on exploiting the vulnerabilities of the adversary's fielded forces, in support of the ultimate goal in conflict — the occupation of territory by ground forces. This is because air power "weakens [an adversary] to the point where friendly ground forces can seize disputed territories without suffering unacceptable losses".[25]

Within this construct, Pape dismisses the utility of 'strategic effect' by arguing, "the critical element of air power is theatre attack, not strategic bombardment".[26]

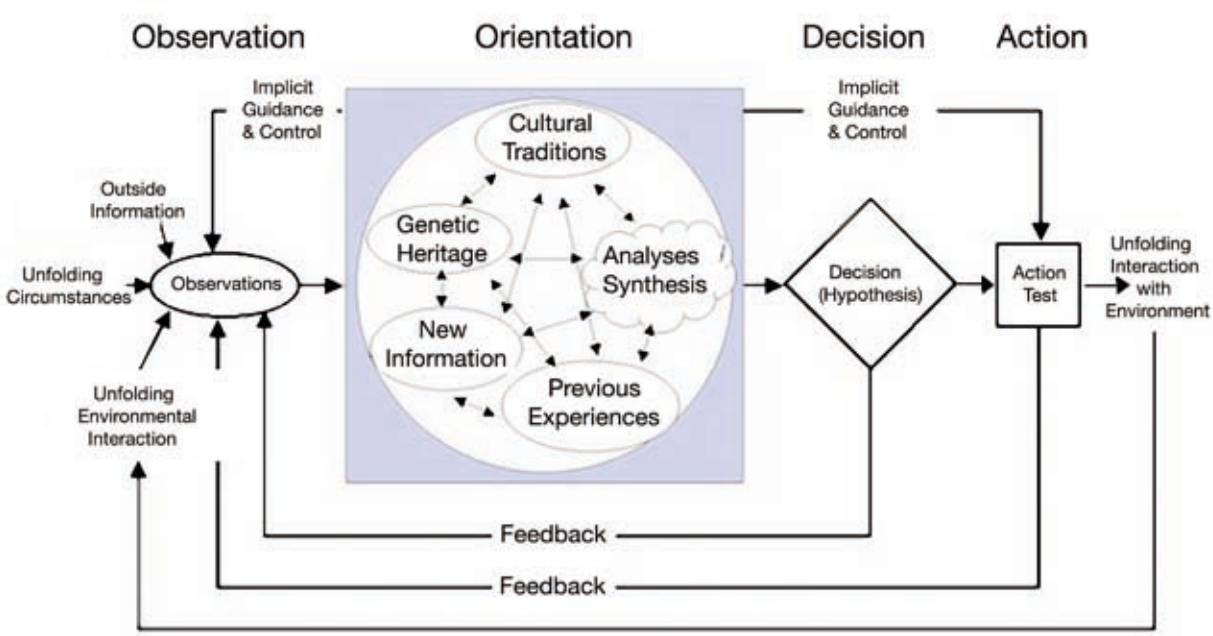
**Theoretical approaches to influencing will**

Strategy thinkers do not universally accept the focus of influence on physical means. British Military Doctrine states that "the dimension of the mind is of paramount importance in any conflict".[27] This echoes the thoughts of Sun Tzu:

*"The supreme excellence in war is to attack the enemy's plans…Those skilled in war subdue the enemy's army without battle. They capture his cities without assaulting them and overthrow his state without protracted operations…For to win one hundred victories in one hundred battles is not the acme of skill. To subdue the enemy without fighting is the acme of skill".* [28]

In stark contrast to Clausewitz and Warden, Boyd's theory of conflict advocates a form of warfare that is more psychological and temporal than physical. Boyd contends that all rational human behaviour, individual or organisational, could be depicted as a continual loop through four distinct tasks — Observation, Orientation, Decision, and Action; the 'OODA Loop' (see figure 2). Observations that match up with the decision-maker's particular

**Figure 2. Boyd's OODA loop**



understanding call for certain decisions and actions. The timeliness and accuracy of decisions are directly related to the ability to correctly orientate to events. Mismatches between the real world and the decision-maker's understanding of that world will generate inaccurate actions. Left uncorrected, inaccurate decisions and actions render the adversary powerless because he is mentally unable to cope with the rapidly unfolding, and naturally uncertain, circumstances of war. Military operations aim to create and perpetuate a highly fluid and menacing state of affairs for the adversary and disrupt or incapacitate his ability to respond by creating surprising and dangerous operational or strategic situations.[29] Unfortunately, Boyd's work was devoid of operational details as to how to accomplish these abstract aims.[30]

While Boyd focuses on the process of decision-making and will to act, other strategies focus on its substance, seeking to manipulate the benefits the adversary expects to gain from a course of action and the costs incurred in undertaking it. When the outcome of this 'cost/benefit calculus' is positive, a rational decision-maker will choose the proposed course of action. A strategy of persuasion seeks to negotiate a voluntary choice of a course of action based upon mutually acceptable costs and maximised benefits, usually using political and economic power in the form of treaties and trade agreements. Military power can be used to influence the cost-benefit calculus by decreasing the adversary's expected benefit or increasing the costs of a course of action. An adversary can be dissuaded from a course of action that upsets the status quo by reducing his expected benefits, but not explicitly raising his costs. Military power can achieve this by preventing the conflict occurring or stabilizing and containing the conflict through peace support, peace-keeping and peace enforcement actions. Military power can also be used to raise the costs of the adversary's cost/benefit calculus sufficiently to coerce the adversary to involuntarily change his course of action. Pape defines three types of coercive strategy: punishment, which targets industry and infrastructure in order to inflict pain and suffering on civilians so as to spur revolt; decapitation, which targets leadership and communication facilities in order to paralyse the adversary; and denial, which targets military forces to prevent their use.[31] Pape argues that the only way to achieve desired political objectives is by 'military coercion'.[32]

**Strategic application of theory**

All of these theories have been used, individually, or in combination, to underpin the operational art of three air campaigns: Operations Desert Storm, Deliberate Force and Allied Force. Desert Storm was undertaken to prevent the invasion of Saudi Arabia,[33] secure the withdrawal of Iraqi forces from Kuwait,[34] curb the proliferation of Weapons of Mass Destruction (WMD) in the region and enable the UN to work towards peace and stability in the region.[35] The campaign aimed to destroy the Iraqi means of occupying Kuwait and its means of threatening its neighbours in the future by simultaneously destroying the Iraqi leadership and Command and Control ($C^2$) system, the fielded forces (Iraqi army and the Republican Guard) and supporting infrastructure, and Iraq's WMD. In parallel, organic essentials were disrupted to coerce the population to overthrow the government. Deliberate Force was a coercive air campaign to force the Bosnian Serbs to lift the siege of Sarajevo and negotiate a political settlement to assure freedom of access to the safe haven cities in Bosnia-Herzegovina. Allied Force was also a coercive air campaign, meant to be swift and severe enough to force President Milosevic into discontinuing his ethnic cleansing of the Kosovar Albanians.[36] Initially, the military objective was to coerce Milosevic by disrupting the Serbian ground forces in Kosovo.[37] When this failed, the military objective became the disruption of the infrastructure and $C^2$ systems that supported to the fielded forces and finally graduated to disruption of organic essentials and destruction of industries owned by Milosevic and his closest supporters, before he conceded.[38]

Despite the apparent differences in each theory in terms of whether they address means or will, it is the contention of this paper that these influential theories are complementary when combined within an integrating framework of a human system model.

**The human systems model**

**Description of human systems**

Human organisations adopt a course of action as a result of their means and will to do so. Means and will are the collective outputs of the systems that make up a human organisation, be it nation-state, transnational corporation, or a terrorist group. A system is a collection of elements connected together to achieve a common purpose.[39] Although there are many methods to classify systems, this paper adopts the definition used by Warden's five-rings model[40] as it permits a common frame of reference for analysis.

Human systems, those systems in which humans form an integral element, possess a high level of internal linkage, the ability to self-regulate, adapt and respond unpredictably. All human systems are made up of two components: an activity component that produces goods, services, organisations; and information, overlain by a cognitive component that decides how the activity component behaves (see figure 3).[41]

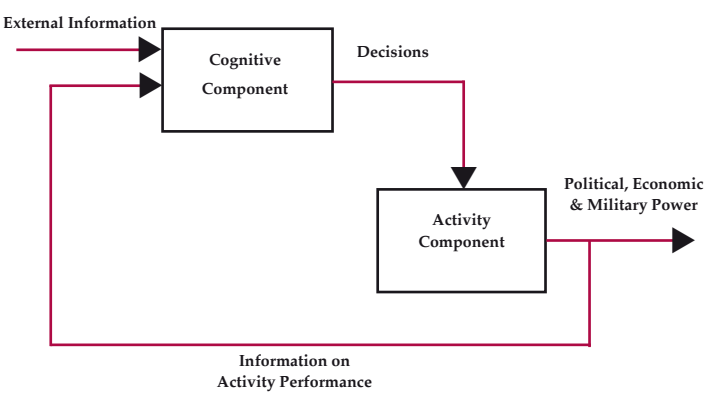
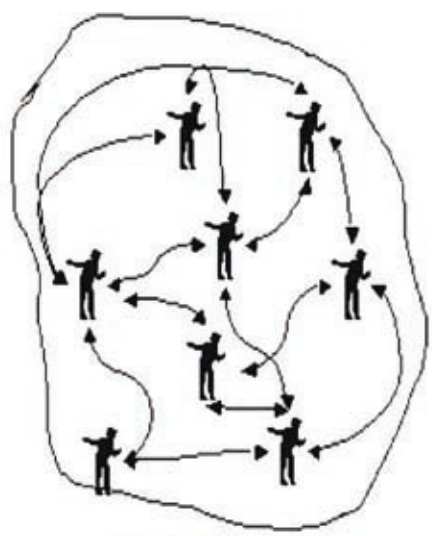



**Figure 3.**
**Relationship between the physical and cognitive components of a human activity system (Source: Adapted from Wilson, 1990, p28)**

**The cognitive component**

The activities in a human system are controlled and coordinated by the cognitive component. This is made up of collections of individuals and groups, connected by interpersonal relationships at both the individual and group level (see figure 4). These individuals and groups make decisions on the basis of what they observe about the output of activities, analyse what they perceive, make judgements about the situation, decide how to respond or act and then control the activities to perform in a required manner. The processes used to observe, perceive, judge and decide are described in Boyd's OODA Loop model (see figure 2). It is the combination of the activity component producing outputs and a cognitive component making decisions that give human systems the properties of self-regulation, adaptation and unpredictable responsiveness.



**Relationships are interpersonal**

**Elements are people doing the activities through particular 'Hows'**

**Figure 4.**
**The Elements and links in the cognitive component (Source: Adapted from Wilson, 1996, p 28)**

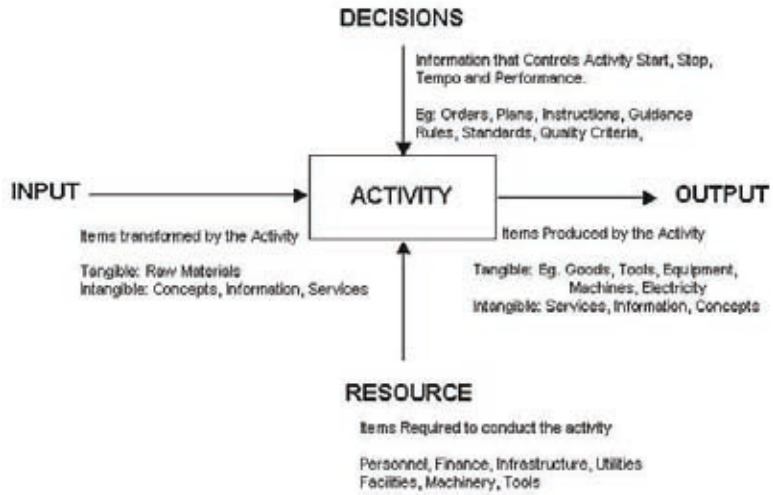



**Figure 5. Activity, inputs, outputs, resources and decisions (Source: Adapted from IDEF0[42] )**

**The activity component**

The activity component of a human system is made up of a collection of linked physical activities that transform inputs into desired outputs, in accordance with decisions, using resources (See figure 5). One activity's outputs are another activity's inputs or resources. Inputs can be tangible items such as raw materials for a manufacturing process, or intangibles such as information input into a computer system. Outputs can be tangible, such as manufactured products or services, or intangible items such as concepts or information. Resources are required for the activity to take place, but are not transformed into the output; e.g. the people required to carry out procedures; production machinery, infrastructure, i.e. factories and offices in which to conduct work; power, heating and lighting. The information controlling when activities start and stop, the rate at which they transform inputs into outputs, the use of resources, the standards to work to and the targets to reach, are all derived from decisions made by the cognitive component.

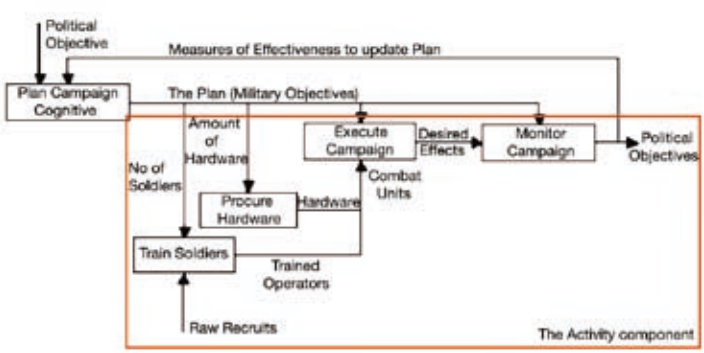



**Figure 6. The elements and links in the activity component (Source: Adapted from IDEF0[43] )**

Activities provide outputs that are used by other activities, whether as inputs or resources, and these link activities together and make them dependant upon each other. For example, an activity that outputs petroleum products is producing an input for a military system, and an activity that outputs electricity is providing a resource for all activities that require electrical power.

This dependency of activities upon outputs is as important as the transformation carried out by the activity itself. It is the combination of individual outputs that defines the system's collective output, and human systems need a minimum degree of connectivity for the output to be produced. [44] For example, national military power is the sum of all the activities that design, manufacture, transport and support combat equipment, and those activities that recruit, train and administer the personnel. As more and more activities stop delivering their outputs, the system reaches a point at which it cannot deliver military power. Human organisations systems are not only dependent upon the connectivity of their internal activities; they are also dependent upon outputs from the internal activities of the other systems, producing a network of interdependence (see figure 7). In this respect the human systems model differs substantially from Warden's hierarchical model. Like Warden's model, each system can be continuously broken down in more and more detail to provide greater definition of the connectivity between activities. The relative dependence between each system is contingent on many factors, including the size, purpose and culture of the organisation.[45] The increasingly

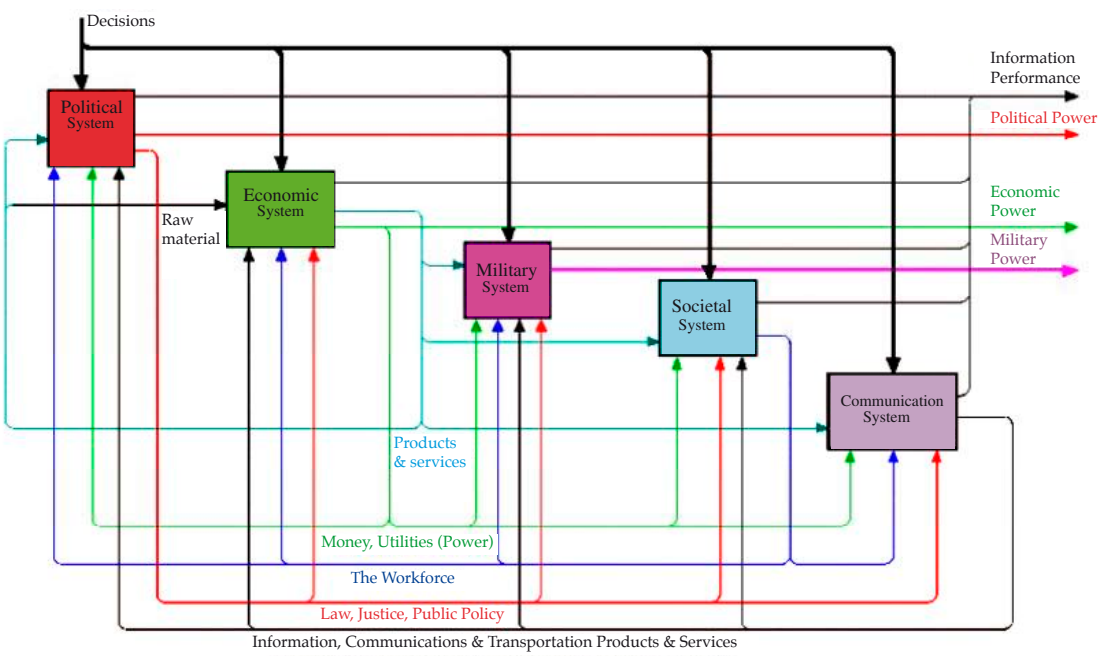



**Figure 7.**
**The Interdependence of systems in the human system. Illustrative only**
**(Source: Adapted from IDEF0[47] )**

detailed analysis of the elements and links within systems and sub-systems will lead to a detailed understanding of how the systems deliver outputs, and will identify which activities are critical for the production of a given output.[46]

**Centres of gravity (CofG)**
Within each system there will be a region where the number of elements and density of links both between the elements within the system and between the cognitive and activity components is relatively high. This is the region of the system that makes the most significant contribution to the system's collective output. An adversary's CofG is a region where sufficient connectivity exists among the elements to enable the system to deliver an output that is critical to providing the adversary with the means and will to undertake a course of action, at a specific time (a critical capability[48]). These critical outputs are not necessarily the adversary's greatest strength or weakness and unless the adversary has sufficient connectivity, he may not necessarily have a CofG.[49] As each system may have a region of high connectivity, the adversary may have more than one CofG, as is the case with Warden's 5-ring model. Where sufficient connectivity does exist, the Human Systems model can be used to identify the elements and links that form the CofG. This concept of a CofG is mirrors Clausewitz's contention that a CofG is the "hub of all movement and power".[50]

**System self-regulation and adaptation**
Human systems are constantly subjected to influence from their external environment and they possess the ability to respond to it by making decisions that modify the outputs that activities deliver. The rate at which activities produce outputs depends not only on decisions but also on the availability of inputs and resources. Consequently, changes in an activity's performance may propagate along the output links and affect the performance of activities that use that output. The cognitive component coordinates all the changes necessary to respond or adapt to environmental influences. Performance information from activities is used by the cognitive component to decide how to adjust activities in the system. These adjustments may work to minimise the impacts of external influences, or to adapt the system to its new environment if this leads to survival or a more effective method of achieving the common goal.

For example, military systems are able to react to the consumption of assets resupplying itself in order to maintain a relatively constant level of combat potential. Human systems have too many elements and links to exist in a steady state of activity and are inherently dynamically unstable as influences and decisions work their way through the output links in the system. The ability to cope with or adapt to its environment means that the same influence applied to the same point of the system at a different time may result in a very different outcome because the system has adapted. This means that the effects of external influences can be time-sensitive.[51]

However, a human system's ability to cope with or adapt to external environment is constrained in two ways.[52] Firstly, the range of output that an activity can deliver is limited by the quantity of input or resource available. Secondly, the changes brought about by an external influence can exceed the cognitive component's ability to perceive, recognise, control and coordinate changes to performance across many activities. The role of perception and judgment in the cognitive domain and the inherent dynamic instability of human systems mean that they often display non-linear responses to external influences: seemingly powerful influences may have limited effect whilst small ones may have a disproportionately large effect.[53] Furthermore, external influence may have little effect until some 'critical mass' is reached or have no effect unless some other condition is present.[54] For example, a fielded force in combat can continue to fight whilst taking casualties, until a critical level of degradation is reached, at which point the force collapses.

**Application of human systems to air warfare**
The ability of an organisation to behave in a certain manner is a product of its physical means and moral will to act. Means are the collective output of the activity component and will is the collective output of the cognitive component. Shaping an organisation's behaviour requires

exerting influence on their means, will or both. The application of the human systems model to warfare identifies three strategic approaches for exerting influence on an adversary; destruction of the system's elements, disruption of the system's connectivity and exploitation of the systems control mechanism. These three strategic approaches are assessed in the light of three recent operations, Desert Storm, Deliberate Force and Allied Force.

**System destruction strategies**

System destruction strategies aim to destroy the elements of an adversary's system with the objective of denying the adversary the means to pursue a course of action. Moral will is an abstract concept and cannot be targetted directly by physical means. Consequently, the focus of system destruction strategies is on the system's physical elements, particularly the fielded forces, although all systems have physical elements that, theoretically, could be destroyed.[55]

In Operation Desert Storm, fielded forces provided Iraq with the means to occupy Kuwait. Up to 12,000 Iraqi troops were killed, the combat effectiveness of many units was reduced by 100% and the Iraqi army in Kuwait collapsed and

*System destruction strategies aim to destroy the elements of an adversary's system with the objective of denying the adversary the means to pursue a course of action. Moral will is an abstract concept and cannot be targetted directly by physical means*

**A destroyed Iraqi tank**

**An Iraqi Su-22M Fitter in its HAS (Hardened Aircraft Shelter)**

*Although the Coalition achieved air superiority within 48 hours of the start of the operation, it still sought the physical destruction of the Iraqi air force. Despite destroying runways, taxiways and hardened aircraft shelters, nearly 45 per cent of Iraq's aircraft emerged from the war unscathed*

was defeated. However, it took 23,430 sorties, approximately two thirds of the Coalition's air power, to achieve this defeat, and more Iraqi soldiers deserted than were killed.[56] The key political objectives of the complete destruction of the Republican Guard and Iraq's nuclear, biological, and chemical weapons programmes were not achieved despite the Coalition's overwhelming military power. The Republican Guard suffered about 24% attrition, but remained sufficiently capable to withdraw from Iraq and subsequently suppress Kurdish and Shiite rebellions. Only 25% of Iraq's nuclear weapon programme sites were attacked and the efforts to destroy Scud missile systems and chemical and biological weapons were disappointing.[57] Furthermore, although the Coalition achieved air superiority within 48 hours of the start of the operation, it still sought the physical destruction of the Iraqi air force. Despite destroying runways, taxiways and hardened aircraft shelters, nearly 45 per cent of Iraq's aircraft emerged from the war unscathed.[58]

One of the strategies implemented in Desert Storm was the destruction of a small number of political targets in the hope of decapitating the regime, leading to regime change or decision-making paralysis. However, political targets proved difficult to locate and strike effectively. Decapitation may have been unachievable and undesirable as there was no evidence that the death of Saddam Hussein would have resulted in the reins of power being taken up by someone with the ability or desire to unconditionally

withdraw the Iraqi army from Kuwait.[59] Saddam Hussein's regime was not decapitated and remained sufficiently in command of its forces in Kuwait to coordinate the orderly withdrawal of the Republican Guard from Kuwait.[60]

Targeting the adversary's systems for wholesale destruction is a strategy that has not been employed since Rolling Thunder in Vietnam. The destruction of organic essentials and infrastructure to debilitate the fielded forces was a central tenet of the strategic air offensives against Germany and Japan during World War II.[61] However, as this demonstrated, these systems are difficult to destroy entirely, requiring precision bombing, and having considerable capacity to absorb punishment and regenerating or finding alternative sources for inputs and resources and re-routing outputs.[62]

The destruction of the adversary's population, as genocide or ethnic cleansing, involves mass-murder, systematic terrorization and enforced relocation of an ethnic group and has been a feature of recent intra-state conflicts. Up to one million Muslims were expelled from their homes in Serbian-occupied areas in Bosnia between 1992 and 1994.[63] In Kosovo, Serbian security forces killed up to 10,000 and created an estimated quarter of a million refugees.[64] However, as the perpetrators of such crimes against humanity have discovered, not only it is extremely difficult and morally reprehensible to destroy a population entirely, it is illegal under international law.

Despite the perceived relative ease of finding targets for physical destruction as compared to targeting an adversary's will, the level of force and effort required means that physical destruction of a system may not be the cheapest, quickest, or even legal method of achieving political ends. Decapitation may remove the only means of establishing a dialogue with the adversary. Attempts to destroy command and control have not been effective and the destruction of lines of communication, particularly bridges, can impede the movement and resupply of friendly forces. The destruction of organic essential systems and infrastructure systems has some significant disadvantages for the state of the peace afterwards. For the resulting organisation to rebuild itself post conflict, those elements of the system that have been destroyed may need to be rebuilt rapidly. In addition, the mass casualties and extensive collateral damage that such economic warfare produces is increasingly politically unacceptable to modern western liberal democracies.

The horrific loss of life and cost in national treasure that fighting entails, illustrated by two world wars, has always stimulated the search for more effective ways of influencing the adversary's means and will by disrupting the output from these systems rather than to attempt a systems destruction by hard fighting.[65]

**System disruption strategies**

The connectivity between and within human systems is a vulnerability as well as the source of its collective outputs. An adversary's fielded forces are dependant upon outputs from the leadership, organic essentials, and infrastructure and population systems (see figure 6). System disruption strategies target a system's connectivity with the intention of reducing it below the level of minimum essential connectivity, not its destruction. At this point the functioning of the system is degraded to such an extent it is no longer able to deliver its outputs and the adversary will be denied the use of his fielded forces.

In all the case study operations, the disruption of the connectivity in the military $C^2$ activities aimed to deny the military system any enhanced combat effectiveness through integration. This is best illustrated by the efforts to deny the air defence output provided by an Integrated Air Defence System (IADS) in order to gain access to the rest of the military and other systems. In all cases, the IADS was disrupted by physical strikes on communication nodes, disruption of electrical power, and destruction of the early warning radar sites, surface to air missiles guidance radars and missile launchers, and sector operations centres. In all cases the IADS were driven into systemic failure in the first 48 hours, successfully forcing the adversary's air defences to operate autonomously, if at all, and permitting access to all the adversary's systems.[66]

In all three case studies, one of the strategies chosen was to target the infrastructure system to disrupt (interdict) resupply to the fielded forces. Military depots, storage facilities, supply infrastructure and transportation systems were attacked.[67] During Desert Storm, the Coalition substantially degraded supply capacities.[68] In Deliberate Force, this disruption strategy so successfully denied the Bosnian Serbs their essential war stocks that they seized UN Protection Force personnel as hostages and chained them to storage buildings in an effort to halt the bombing.[69] However, "anybody that does a campaign against transportation systems [had] better beware! It looks deceivingly easy. It is a tough nut to crack".[70] The Iraqis proved ingenious at using pontoon bridges, ferries, causeways, alternate routes, and underwater bridges to keep sufficient supplies flowing into theatre.[71] After achieving their initial objectives in Kuwait, they adopted a static posture, using stockpiled ammunition and diesel fuel sufficient for weeks or even months of combat.[72] There were some frontline units who experienced extreme shortages of food and water[73] but overall the Iraqi army was not defeated due to lack of supplies.[74]

During Operations Desert Storm and Allied Force, oil refining, distribution and storage facilities, and military production facilities were all struck by air power. The objective in targeting selected organic essentials activities was to cripple specific outputs; military materiel and refined petroleum products.[75] During Desert Storm the Coalition reduced oil refining capability by 93% and 20% of petroleum products held at refineries and major depots were destroyed. During Operation Allied Force, 50% of Serbia's war industries were largely destroyed. Oil refineries were targeted and petroleum reserves dwindled,[76] dual-use vehicle manufacturing plants and chemical industry plants were struck to deny the Serbian military resupply and reinforcements. The effectiveness of disrupting organic essentials is dependant upon the resupply requirements of the fielded forces; for example, the Iraqi army had limited resupply requirements, so disruption of organic essentials did not affect the fielded forces in any significant manner.[77]

An additional purpose of targeting electricity generation plants during Desert Storm and Allied Force was to disrupt power to the communication and information system that linked decision-makers and military commanders. The Iraqi electrical supply was reduced by 88%.[78] As with the attempt to destroy the $C^2$ system in Desert Storm, the attempt to disrupt $C^2$ was not effective in Allied Force, as Milosevic had sufficient control to withdraw the Serb forces from Kosovo promptly and in good order.[79]

Disruption strategies can be differentiated by the choice of system to influence, and the depth to which the system is disrupted. Disruption can be achieved without applying the same level of force as system destruction and potentially exposes fewer personnel to risk. Its effectiveness in denying the adversary his means can be decisive, as the disruption of IADS in all three case studies shows. However, the effectiveness of the disruption of $C^2$ and resupply to the fielded forces is entirely contingent upon the character, posture and intent of the fielded forces. As such, the use of a system disruption strategy needs to be matched to the military context.

System disruption strategies have been described only in terms of achieving purely Clausewitzian physical effects. However, "Physical force does not win a war, mental force does not win a war . . . what does win a war is the highest combination of these forces acting as one force".[80] Every activity in a human system is controlled by a cognitive component and all physical effects will inevitably have a psychological effect on the adversary's cognitive component. Therefore, system disruption strategies can initiate a cascade of physical effects that have psychological effects on the adversary's decision-making. System exploitation strategies seek to exploit the linkage between the activity and cognitive components in one of two ways; either by influencing the cost-benefit calculus of the decision-making process so that the adversary chooses an acceptable course of action, or manipulating the system's limited self-control capability.

**System Exploitation Strategies**
**Cost/Benefit Manipulation**

Within the cognitive component decisions are based on the decision-maker's perception and judgment of the costs and benefits of a course of action. A rational actor will adopt a course of action that maximises the benefits and minimises the costs.[81] System exploitation strategies seek to use national power to influence the adversary's cost-benefit calculus, either by dissuasion or coercion. In human system terms, dissuasion strategies involve the use of military power to block an adversary's course of action without actually imposing a cost on the adversary. The NATO operation in Bosnia prior to Deliberate Force was Deny Flight. This operation was intended to dissuade the Bosnian Serbs from attacking the Croats and Muslims simply by the physical presence of NATO forces between both sides of the conflict. Coercion is the employment of a system disruption strategy, but the primary aim is psychological effect, not physical influence. When the decision-makers are not rational, coercion may fail, as decisions are not made on the basis of cost/benefit analysis, but on some other basis. In these cases it may be necessary to adopt a system destruction strategy described earlier.

Both Operations Deliberate Force and Allied Force were primarily aimed at influencing the adversary's cost/benefit calculus by increasing the costs of continued action by the adversary. In the case of Deliberate Force, the coercion was applied almost exclusively by inflicting pain upon the Bosnian Serb Army. In the case of operation Allied Force, the coercion graduated from hurting the fielded force, to inflicting mild pain on the Serbian elite, to punishing Milosevic and his closest supporters.

Operation Deliberate Force aimed to influence the Bosnian Serb leadership's will using both military and political power. NATO specifically permitted sufficient connectivity between the decision-making leadership and the fielded forces so that the leadership had a complete and accurate picture of what was happening to its forces. This strategy was specifically aimed at influencing the adversary's will by exploiting the connectivity between cognitive and activity components, rather than specifically disrupting it. Air power disrupted $C^2$ sufficiently to ensure that the Bosnian leadership was unable to respond militarily to NATO's action, whilst still remaining in contact with its commanders in the field. Political power, (i.e. diplomacy), was interspersed with the use of military force to spell out the political terms the Bosnian Serbs would have to meet. The interplay between air and political power was at its most powerful when NATO 'paused' the operation on 1 September to permit diplomatic efforts between the Bosnian Serbs and both the UN and Ambassador Holbrook. When it became obvious that the Bosnian Serbs were not meeting the UN-NATO demands, Deliberate Force resumed. Ambassador Holbrooke observed "if the bombing had not resumed that day, the negotiations would have been very adversely affected".[82]

The Bosnian Serb government received a complete and accurate picture of the damage to its fielded forces and the message about the size of NATO's military power and its determination to use it. Initially, the Bosnian Serb Government discounted NATO's threat. NATO's efforts to destroy the Bosnian Serb Army's heavy weapons besieging Sarajevo were frustrated by the practical difficulties of locating, identifying and striking small, well-concealed and dug-in targets.[83] This reduced the credibility of the threat, as did the physical and moral support it received from the Serbian government. However, a decade of sanctions had taken its toll on the Serbians' morale and political cohesion[84] and convinced Milosevic to withdraw his support from the Bosnian Serb government in order to preserve his own political power in Serbia.[85] This loss of alliance cohesion caused the Bosnian Government to reassess its cost/benefit analysis of the situation, and, as the costs of its course of action rose, it was successfully coerced into agreeing to NATO's terms, despite having resisted them for so long.[86]

Operation Allied Force began as an attempt to coerce Milosevic by hurting his security forces in Kosovo. NATO's efforts to destroy the Serbian Army's heavy weapons in Kosovo simply drove them into hiding,[87] making subsequent attacks largely ineffective. Milosevic was not coerced by the disruption of his fielded forces or the systems

providing support to them and the Serbians managed to sustain their ethnic cleansing action.[88] NATO decided to exploit the links between the Serbian political and social systems. A decade of sanctions had caused a significant stagnation in the Serbian economy; per-capita GDP roughly halved to £8,000 year and unemployment was about 50%.[89] The electricity grids were severely damaged, 85% of Serbians had limited electrical power, and the water supply to Belgrade was under threat.[90] The business premises owned by Milosevic and his closest supporters were destroyed and income from smuggling activities was reduced, quite unintentionally, by the destruction of bridges. NATO's actions increasingly threatened to bankrupt the Serbian elite, who, in response, sent their families out of Yugoslavia and put considerable pressure on Milosevic to capitulate.[91]

In Milosevic's cost/benefit calculus, the decision by NATO's leaders to forgo the threat of a ground invasion meant that NATO's threats were not credible.[92] The mounting damage caused by the air campaign, NATO's increasingly convincing statement about a ground invasion and increasing internal political pressure, gradually raised the cost, to Milosevic's position of power, of holding on to Kosovo. Additionally, his failure to destabilise neighbouring countries or split the alliance[93], signalled to Milosevic that the tactical tide was turning against him[94] and his own defeat was inevitable.[95] Milosevic decided that he did not value Serbian control of Kosovo above his own survival.[96] As with operation Deliberate Force, the support of Serbia's Russian ally played a key role in the outcome of Allied Force. Initially, Russia was a strong supporter of Milosevic, but as the conflict progressed, Russia grew increasingly willing to co-operate with the US in the pursuit of a diplomatic solution.[97] Possibly the final straw was Moscow's silence in response to the indictment of Milosevic for war crimes on 25 May 1999. This eliminated any remaining chance that Russia might change course and resume its support for him.[98] Capitulation became his best course, both to minimise further damage to Serbia and its military and secured his position in power while NATO and the UN were still willing to talk with him.[99]

As all the adversary's systems have a cognitive component, they are all liable to psychological influence. During Desert Storm, some Iraqi power plant managers took their plants off-line in a pre-emptive move in order to preclude damage[100] and the Coalition specifically planned to convince the Iraqi population to rid themselves of the Ba'athist regime by disrupting the electrical and telecommunications facilities. This was supposed to demonstrate to the people of Baghdad that the Iraqi president was powerless to counter the US air offensive. Planners wanted to "make [every Iraqi household] feel they were isolated . . . [we] didn't want [the Iraqi people] to know what was going on".[101] There is no hard evidence that using air power to turn out the lights in Baghdad broke the population's will or affected the population's attitude toward Saddam and his regime in any significant manner.[102]

In operations Desert Storm and Allied Force, considerable efforts were made to apply psychological pressure on the decision-making calculus of all individuals in the fielded forces. In addition to heavy bombing of ground formations with substantial numbers of dumb bombs to create fear, more overt psychological pressure was exerted through leaflet deliveries and television and radio broadcasts.[103] During Desert Storm up to 100,000 troops, 30% of Iraqi soldiers, deserted.[104] During Allied Force troop desertion rates reached 300+ per day and an increasing numbers of Yugoslavs evaded reserve call-ups.[105] Post WWI strategists like Douhet and Mitchell advocated bombing centres of population in the belief that the fear that this would cause would make the people force their governments to give in. However, the bombing of major cities in WWI and WWII failed to break the will of the people[106] and the deliberate targeting of non-combatants is illegal under international law, although this is a core strategy of terrorist organisations.[107]

**Systemic paralysis**

A system paralysis strategy aims to exploit the system's self-regulation capability by overwhelming it.[108] Boyd provides an excellent description of how this effect is achieved in his OODA loop model. In the context of the Human

System model, the 'menacing environment' that Boyd desires is achieved by using air power to disrupt outputs. The disruption of an output will propagate to all downstream activities and indirectly affect the downstream activity through the input and resource dependencies. Indirect physical effects may also cascade upstream as those upstream activities are affected by the changes in the use of their outputs. More importantly, the cognitive component will start to receive performance information about changes in outputs and will try to match the pattern of changes to those learnt or experienced before.[109] Based upon the degree of match, the cognitive component will make a judgement about what is happening and decide how to adjust outputs in response. "Rapid and repeated combinations of ambiguous, but threatening effects and deceptive, but non-threatening ones"[110] will reduce the accuracy of the match and lead to increasingly inappropriate responses. If the speed at which the cognitive component process information falls below the speed at which it receives it, decisions are more and more likely to be out of touch. Inappropriate controls will result in mismatches between inputs, outputs, controls and resources that the adversary must eliminate if decisions are to result in actions that enable him to adapt to such an environment. If the adversary cannot do this, his reactions become totally inappropriate to the situation and paralyse his ability to reorientate to a rapidly changing environment.[111] The inevitable consequence of failure is chaotic behaviour in the activity component, and decision-making paralysis in the cognitive component that will result in defeat.

**Model summary**

Each case study operation used air power to prosecute one or more of the strategies described. In all cases air power's kinetic effects were used, either just for physical effects, or to initiate a cascade of physical and psychological effects. Peace support operations appear in the conflict continuum, but were not specifically covered in the case studies.

Despite the concentration of air power roles on offensive capability, air power plays a critical, non-combatant role in these operations, where its speed and reach make it ideal for the rapid deployment and projection of national power at the strategic level. Thus, using the human systems model approach, the separate theories for the employment of air power can be viewed as specific zones of a continuum of strategies to influence an adversary through will and means, using high or low levels of national power (See figure 8).

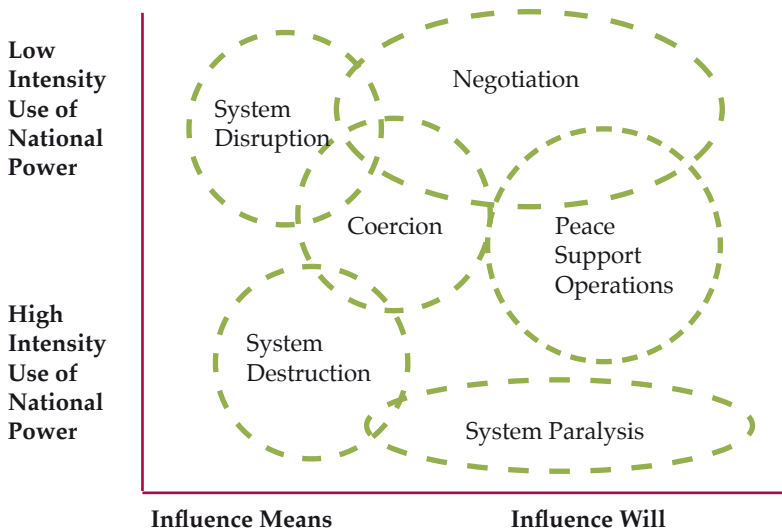



**Figure 8.**
**Spectrum of conflict: The continuum**

**Effectiveness of focusing air power on an adversary's means**

The effectiveness of air power across the range of strategies employed in each of the case studies operations is summarised in Tables 1a and b. Both tables show the same data. In *Table 1a* the data is organised by operation, summarising the effectiveness of combining strategies in an air campaign, and in *Table 1b*, the data is organised by strategy, summarising the effectiveness of air power when employed in each strategy. This summary indicates that air power is effective in system destruction strategies when focused at the operational level, for example, air power successfully destroyed the Iraqi Army in Kuwait

during Desert Storm. Air power was effective because the structure of modern military systems is relatively well understood and air targeting and precision weapon systems are optimised for finding and applying kinetic effects to the military hardware elements of the system. Hardware is capital intensive to replace and destruction has a high degree of effectiveness. During Desert Storm direct physical effects accumulated to have a decisively destructive effect on the function of fielded forces at the operational level. However, this required an enormous military effort. At the strategic level, destruction of military hardware was less effective, for example, the failure to destroy Iraqi WMD and Scud missile systems. This is indicative of the difficulties of using air power in a destruction strategy against systems, or parts of systems, where elements are few, well protected and information about them is extremely limited.

Attempts to use air power to destroy non-military systems also appear to be relatively ineffective. In human system terms, the number of elements in these non-military systems can be vast by comparison to a military system and the links between elements resemble a network, rather than a hierarchy, which means that connectivity is robust. Therefore, significantly more air effort is required to destroy enough elements or links to disrupt the connectivity in non-military systems. Furthermore, the military weapon systems are not optimised for influencing the non-military, the structure of these systems is not well understood and can vary considerably from society to society, and concerns about collateral damage limit the level of force that can be brought to bear on non military systems which significantly limits the potential effectiveness of system destruction strategies. The effectiveness of employing air

| Operation | Strategy | Leadership/C2 | Organic Essentials | Infrastructure | Population | Fielded Forces |
|---|---|---|---|---|---|---|
| Desert Storm | | | | | | |
| | System Destruction | N | N | N | | Y/N |
| | System Disruption | Y/N | N | | | Y |
| | Cost/Benefit Exploitation | N | N | | N | Y |
| | System Paralysis | N | | | | |
| Deliberate Force | | | | | | |
| | System Destruction | | | | | |
| | System Disruption | Y | Y | Y | | Y |
| | Cost/Benefit Exploitation | Y | | Y | | Y |
| | System Paralysis | | | | | |
| Allied Force | | | | | | |
| | System Destruction | | | | | |
| | System Disruption | Y/N | N | N | | |
| | Cost/Benefit Exploitation | Y | Y | Y | Y | |
| | System Paralysis | | | | | |

**Table 1a.**
**Summary of effectiveness of system strategies (by operation)**

| Strategy | Operation | Leadership/C2 | Organic Essentials | Infrastructure | Population | Fielded Forces |
|---|---|---|---|---|---|---|
| | Desert Storm | N | N | N | | N/Y |
| | Deliberate Force | | | | | N |
| | Allied Force | | | | | |
| System Disruption | | | | | | |
| | Desert Storm | N | N | | | Y |
| | Deliberate Force | Y | Y | N | | |
| | Allied Force | N | N | N | | |
| Cost/Benefit Exploitation | | | | | | |
| | Desert Storm | N | N | | N | Y |
| | Deliberate Force | Y | | | | Y |
| | Allied Force | Y | Y | Y | Y | |
| System Paralysis | | | | | | |
| | Desert Storm | N | | | | |
| | Deliberate Force | | | | | |
| | Allied Force | | | | | |

**Table 1b.**
**Summary of effectiveness of system strategies (by strategic approach)**

**Key to both tables**
'Y': Strategy attempted & effective
'N': Strategy attempted & not effective
'Y/N': Strategy attempted & effective at one level of war, but not effective at another

power in a system disruption strategy was also variable. At the operational level, air power was very effective when focused upon elements of a military system integrated primarily by information outputs, for example, the successful disruption of IADs in all three operations by targeting early warning and surface to air missile sites and $C^2$ nodes. However, when applied to organic essentials and infrastructure systems to deny fielded forces resupply, disruption strategies were much less effective, due to the self-sufficiency of the adversary's military system, their ability to repair or regenerate elements of the infrastructure and the impermanence of air power.

**Effectiveness of focusing air power on an adversary's will**

The analysis indicates that focusing air power on influencing the adversary's will by manipulating his cost/benefit calculus was very effective at the strategic level, for example, the coercive effect of damaging industries owned by Milosevic's closest supporters in Allied Force. However, aerial coercion was not effective when combined with system destruction strategies, for example, the combination of aerial coercion and decapitation strategies was not effective during Desert Storm. In the context of the Human system model, the aerial coercion process uses three stages of effects in a cascade.[112] Direct physical effects are applied to an element of the system. The neutralization, disruption or destruction of this element has an effect on the function of the activity related to the element. In turn, this functional effect may have an indirect physical effect on activities that use the output(s), or provide inputs and resources to the affected activity. These direct and indirect physical and functional effects alter the performance information fed to the cognitive component, where it has a psychological effect

(see figure 9). Contrary to Pape's assertion, both military and non-military coercion appear to be effective. In Deliberate Force, the combination of direct physical effects on the military system with diplomacy resulted in a cascade of effects sufficient to coerce the Bosnian Serb government. In Allied Force, although the same combination was not effective, the cascade process was successful when direct physical effects were applied against those system elements most highly valued by Milosevic. In the context of the human systems model, the cognitive component must have sufficient connectivity with the activity components to receive, understand, and act upon a coercive message, and be sufficiently dependent upon the activity component for its disruption to influence the cost/benefit calculus. Killing political leaders or destroying strategic and operational $C^2$ systems will not facilitate an aerial coercion campaign because it removes the necessary link between the activity being targeted and the decision-making cognitive component. The same principle applies to the use of air power to achieve system paralysis. Paralysis was a military objective of the Desert Storm campaign, but although air power was employed in a parallel and simultaneous manner,[113] with the intention of employing an effect-based campaign, it became an exercise in servicing a target list as planners did not wait for actions to take effect.

**Importance of effects cascade and centres of gravity**

On of the advantages of the Human Systems model over Warden's five-rings model and Boyd's OODA loop is that it provides a tool for predicting the route of cascading of physical and psychological effects, as they must travel along the links between activities and the activity and cognitive components. (see figure 9).

Planners can 'shape' the effects of air power by knowing which elements and links need to be preserved for the effects cascade and which need to be disrupted to initiate it. Effects must be shaped to influence the CofG consistent with the desired political objectives. Analysis of elements and links is necessary to identify their relative importance to the CofG, their vulnerability to kinetic and non-kinetic effect, and the permissibility of applying national power against them.

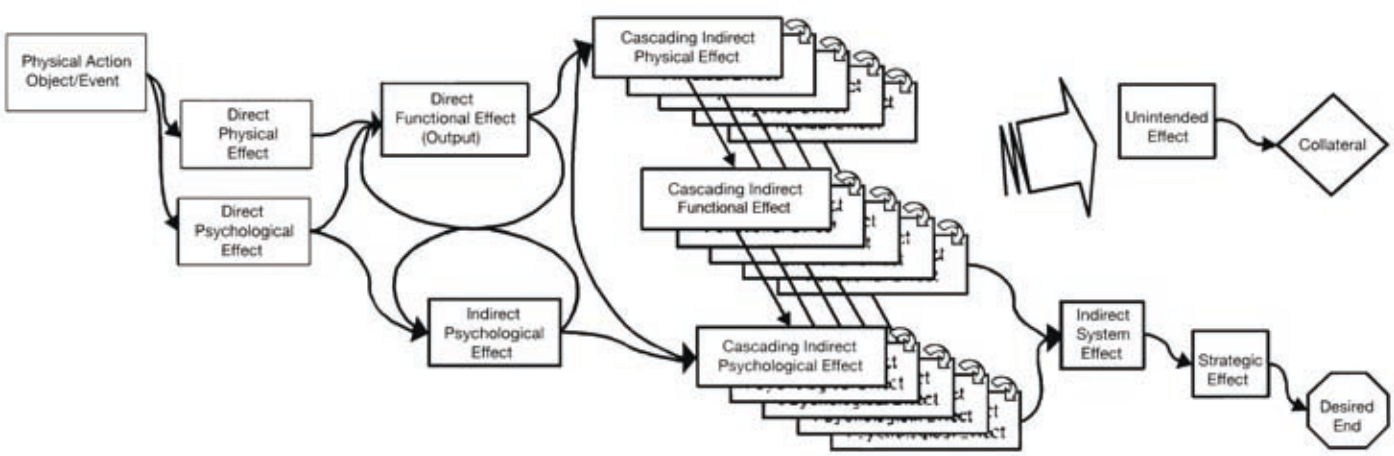



**Figure 9.**
**The effects cascade ( Source: Adapted from Smith 2002), p. 317 and Enderby et al 2002, p. 33)**

Overall, focusing air power on influencing the adversary's means is a less effective use of air power that influencing the adversary's will, because its effect is primarily constrained to the operational level. Air power was particularly effective when the effects created by its employment were able to cascade through the adversary's systems. However, the complexity and non-linear response capability of human systems mean that it is very difficult to analyse the effects cascade and the adversary's strategic response. This analysis differs slightly from Operational Net Assessment (ONA) in that the primary focus of ONA is on the targeting of physical nodes to achieve effects, whereas the Human Systems approach is focused on understanding system activities and outputs; the selection of physical targets occurs after the desired effect cascade has been selected. Both forms of analysis require a very high level of information about the adversary. Sun Tzu's dictum "know the enemy and know yourself; in a hundred battles you will never be in peril"[114] ring even truer in the modern age. The human system model indicates that the most effective way to employ air power is to approach each adversary as a unique rather than generic opponent, conduct detailed analysis of his systems to identify the inputs, resources and decisions that are critical requirements for the CofG, and tailor a campaign plan aimed at attacking his critical vulnerabilities that enable the application of air power to have decisive effect.[115]

**Conclusion**

**The utility of the human systems model**

The human systems approach is an all-encompassing construction offering an explicitly holistic view of the adversary as systems, links and elements. The model also provides a conceptual framework for understanding the cascade of direct and indirect physical and psychological effects through systems. This provides the starting point for detailed campaign planning by helping planners categorise the elements and links of an adversary's system. This enables them to visualize the CofGs that may exist at the strategic, operational, and tactical levels. Campaign planners can then analyse critical capabilities, requirements and vulnerabilities and conceive means to influence them in a way that will achieve political objectives.[116] Political objectives and the properties of the CofG guide the selection of national power needed to induce effects, and the level of force to apply, if any. The range of strategic options identified by the human systems model, and their varying effectiveness, indicates that it is important that the application of force on a critical vulnerability can be directly linked to influence on a CofG. In turn, the disruption, destruction or neutralization of a CofG must be coherently linked to the desired political objectives.[117] A key strength of the human systems model is that the interdependence of the cognitive and activity components overcomes the tendency of Warden's approach to assume that a 'template' campaign can be applied to any adversary. Implicit in Warden's model that an adversary will comprise broadly the same systemic construction as the United States and that the adversary's systems are 'static', unresponsive. The human system model inherently assumes that an adversary's systems are unique and can respond to attempts to influence it. This requires military planners to anticipate the dynamic interaction of friendly and adversary power and likely adversary courses of action. Finally, it overcomes the criticism of Boyd's OODA Loop model that it provides no practical guidance for the implementation of coercive or paralysis strategies. However, the human system model provides guidance on what has to be done, but the how — the operational art — is still the preserve of the commander's judgement.

**More effective application of air power**

Air power's three more recent tests, the Gulf War, Bosnia and Kosovo, represent different zones of the spectrum of conflict and the analysis indicates that no one air power theory alone exemplifies the panacea of air power. They need to be combined and tailored using the Human Systems framework. Air power can be precisely targeted and its primary emphasis on kinetic weapon seems to make it a useful instrument for influencing an adversary's means. However, strategies that focus air power exclusively on the adversary's means make the assumption that physical means can be completely destroyed. This requires the destruction of all the elements in the system, or the

disruption of all the links in order to be decisive, because the cognitive component will always seek to adapt and overcome. As long as the adversary has the will to resist, he will, with whatever means at his disposal. Disruption or destruction of fielded forces promises a long war of attrition and ignores the inherent flexibility of air power. Deliberate Force and Allied Force highlighted the limits of air power effectiveness in targeting enemy forces, especially in the absence of a supporting ground threat. Air power can effectively disrupt systems that rely upon a very high degree of electronic communications to integrate their outputs because air weapons are optimised for this type of effect. Consequently, air power should only be focused on system destruction strategies after careful assessment of the system against the political objectives to ensure cohesion between ends and means, and that system destruction is a proportional response to the causes of conflict.

Aerial coercion was effective, but only in combination with either diplomatic power, or the presence of ground forces, and aerial coercion air power seems to be a somewhat blunt instrument for influencing the adversary's will.[118] Conversely, air power's inherent capability to deliver parallel and simultaneous effects at the strategic, operational and tactical levels and use precision kinetic and non-kinetic weapons means that it is well suited to the application of military power to influence the adversary's will. Both coercion and paralysis require effects to cascade though the adversary's systems, and are, therefore, likely to be incompatible with system destruction strategies in the same campaign. This incompatibility, and the necessary difference in operational tempo between coercion and paralysis strategies, means that military planners must rigorously address the coherence of political objectives, CofGs and operational means before and throughout a campaign. Using air power to manipulate the adversary's cost/benefit calculus, or paralyse his cognitive and activity components fundamentally assumes that sufficient connectivity can be found to disrupt. It may not, either because although it exists, there is insufficient information to discern its form, or the adversary has specifically minimised internal linkages, such as is the posited model of Al Qaeda organisation.

Where connectivity cannot be found, systemic exploitation cannot be planned, and influencing means is the probably the most viable option until better information reveals the details of the adversary's systems.

The human systems model is a contribution to thought regarding the effective employment of air power. It conceives air power as part of effects-based operation planned in a systems framework exploiting links and elements to influence the adversary's means and will. It considers the full range of direct, indirect, and cascading physical and psychological effects, which may be achieved by the application of political, economic and military power against a CofG's vulnerabilities.[119] The human systems model strives for a better understanding of the contribution that air power makes to war fighting and the means by which that contribution adds value to the military endeavour. It builds upon earlier models, but it is by no means the end.

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**Notes**

1 Clausewitz (1832),p.593
2 Krepinevich (1994)p.36
3 Forster(1995),p.9
4 For examples See Kaplan (1996) and Ignatief (1999),pp.43-61
5 Bellamy,(1998),p.37
6 Strategic Defence Review(SDR),(1998), SDR New Chapter(2002), Defence White Paper(2003)
7 Defence White Paper,(2003),p.4 and Supporting Essay 2
8 Ibid,p.1
9 Warden,(1995),p.42
10 Fuller,(1925),p.96
11 Clausewitz(1832),p.97
12 ibid,p.228
13 ibid,p.228
14 Warden,(1995),p.43
15 For details of the 3 ways in which AP3000 3rd Edition uses the term strategic effect.See Lock-Pullen,(2002)pp59-67
16 See British Military Doctrine,(1996),pp.4-9 to 4-10
17 See Warner,(1943),pp.485-501 for a discussion of theories of air warfare by Douhet, Mitchell and Seversky
18 Warden,(1995),p.49
19 Ibid,p.49.
20 Pollock,(2000),p.448
21 Warden used the human body as an analogy with leadership representing the brain. Hence, by removing or neutralizing leadership, one is "decapitating" the enemy.
22 Fadok,(1997),p.373
23 Warden,(1995),p.46
24 Mielinger(19917)
25 Pape,(1996),p.97
26 Ibid,p.95
27 British Military Doctrine,(1996),p.4-15
28 Sun Tzu(6th Century BC),pp.77 &79
29 Lind,(1979),p.22
30 An operational example of Boyd's ideas is the Russian concept of the 'udar' (operational shock) to be carried out by the 'opertivnaia manevrennaia gruppa' (Operational Manoeuver Group), a soviet combined-arms team of raiders, paratroopers, and diversionary units designed to split enemy formations from within by operating in the enemy's depth. See Naveh,(1997), pp.64-167 & 257-260
31 Ibid,p.97.
32 Pape,(1996),p.4
33 President Bush,(1990)
34 UN Security Council Resolution 660 and 661
35 President Bush,(1990)
36 Bacon, Kenneth H. DOD news briefing, 23 March 1999. See http://www.defenselink.mil/news/Mar1999/t03231999_t0323asd.html. Accessed 20 Jan 2004.
37 Clarke,(2001),p.245
38 The targets of "unique strategic value" included national command and control facilities; infrastructure such as bridges, POL production, and communications and, later, Serbia's electrical power grid. See Grant,(1999),pp.30–37
39 That is to say that, working together, the elements produce something greater than if the activities worked in isolation See Wilson,(1990),p.24
40 Warden,(1995)

41 Wilson,(1990),pp.24-28
42 FIPS PUB 183,(1993),pp37-42
43 FIPS PUB 183,(1993),pp37-42
44 Wilson,(1990),p29
45 This is in sharp contrast to Warden's 5 ring model, which had a rigid hierarchy between the systems See Warden,(1995),p.47
46 More detailed illustrations are at Appendix 1
47 FIPS PUB 183,(1993),pp37-42
48 Strange,(1996), p43-92, for a detailed analysis of critical capabilities, requirements and vulnerabilities.
49 Echevarria,(2003),p
50 Clausewitz,(1832),p.976
51 Ilachinski,(1996),pp.139-140
52 Rosenau,(1997),p.83
53 Ibid,p.86
54 Wilhelm,(1998),pp,1-3
55 Fuller,(1925),p47
56 Hosmer (1996),pp141–76. &153,
57 Despite claims that Iraq's nuclear, biological, chemical weapons programmes had been destroyed by six weeks of bombing, the United Nations team soon discovered that more than 100 Scud missiles survived, as was as missile production equipment, and at least 19 mobile launchers, and components from new, two-stage missile. In addition, 70 tons of nerve agent and 400 tons of mustard gas also escaped destruction. Atkinson,(1993), p.496
58 However, even after the conflict, Iran did not return many of the Iraqi aircraft that successfully sought refuge across the border. Though the exact number is questionable, these must be counted as physical attrition for the Iraqis even though the actual aircraft were undamaged. GWAPS, vol. 2, pp127-129 & 153–56.
59 Watts et al,(1993),p27
60 Mark.(1994),p224 and Pollack,(1996),pp.548–55.
61 Gorrel,(1978),p.143.
62 Meilinger,(1997),p.60
63 Burg et al,(1999),p.171
64 Daalder et al,(2000),p.193
65 Liddell Hart,(1943),p.21
66 In each operation low level air operations were still prevented by the proliferation of hand held surface to air missiles and anti-aircraft artillery
67 Daalder et al,(2000),p.200
68 GWAPS(1993),vol.II,PtI,p.188,192 and 200. These GWAPS references discuss specific calculations in "tons per day" and how the capacities varied over the course of the conflict
69 Beale,(1997),p.33
70 General Horner, cited in Beagle,(2001),p.62
71 GWAPS,(1993),vol 2,Pt 2,p.201
72 Mark,(1994),p.311
73 Ibid,pp.197–200.
74 GWAPS,(1993),vol.2,pt.1 p.194,p.371.
75 GWAPS,(1993), vol.2,pt.2 p5, vol.2,pt.1,p.40,44
76 Daalder et al,(2000),p.201
77 GWAPS,(1993) vol.2,pt.2,p.201
78 Warheads filled with special carbon-fiber wire detonated over switching stations and high-power lines at Iraqi electrical power plants, causing massive short circuits. By mid-1992 Baghdad's main generator back to 90%. See GWAPS (1993) vol.2,pt.2,p.37
79 Clarke,(2001),p.406
80 Fuller,(1925),p.145
81 Allison et al,(1971),p.16-18,143
82 Owen,(Ed),(2000),p.114
83 Pollock,(2000),p.445 and Beale,(1997),p.37
84 Owen,(Ed),(2000),p.22
85 Lane,(2004),p.189
86 Burg,et al,(1999),pp.328-360
87 Clarke,(2001),p,198
88 Lambeth,(2001),p.231
89 Daalder et al,(2000),p.201
90 Lambeth,(2001),p.79
91 Daalder et al,(2000),p.4 and Lambeth,(2001),p71
92 Lambeth,(2001),pp.xiv,70-71 and Judah (2000) p228
93 Daalder et al,(2000),p.202,Judah(2000)o.271 and Lambeth,(2001),p-xiv
94 Daalder et al,(2000),p.202
95 Lambeth,(2001),p-xiv
96 Judah,(2000),p.231
97 Daalder et al,(2000),p.5,Judah,(2000).pp.272-279
98 Lambeth,(2001),p.70
99 Daalder et al,(2000),p.5 & p.206, Clarke,(2001),p.326
100 GWAPS,vol.2,Pt.2,p.37
101 Beagle,(2001),p.54
102 GWAPS,(1993),vol.2,Pt.2,p.28
103 AWOS Fact Sheet,(2000),pp.6-8.
104 Hosmer,(1996),p.153
105 DOD news briefings,(1999)
106 Clark2,(2003),p.3
107 Davidson Smith,(1990),pp.11-15
108 Lind,(1979),p.22
109 Robbins,(1993),pp.133-160
110 Fadok,(1995),pp.13-20
111 Lind,(1979),p.56
112 Smith(2002)
113 Deptula(2001),pp.2-6
114 Griffith,(1971),p.84
115 Strange, op cit
116 Pollock,(2000),p.437
117 Pollock,(2000),p.443
118 Lambeth,(2001),p.xxiv
119 Davis,(2001),p.7