In this issue…

An amalgam of topics of concern to the military professional, from Cadet Dietrich's examination of India-Pakistan relations to Cadet Smith's discussion of the arrival of the jet engine, is presented in this edition of the Airman Scholar Journal (ASJ). A common thread through four of the six papers presented in this edition is that the technological superiority of the US military is by no means guaranteed or a panacea for US military battlefield success. Both senior theses focus on pending hi-tech issues for the US military. Cadet Farkas' looks at US military dependency on electromagnetic-reliant technologies and capabilities, pointing out that the military's overreliance on this spectrum may be a significant chink in its armor. Cadet McSorley makes the case that the US military will eventually fight in space and should begin to look at developing a strike capability to ensure its dominance in space. Cadet Marmino claims that while US military technology superiority has obvious benefits for the US military, US military over reliance on technology has been a detriment, leading to a diminished focus on the ubiquitous human dimension of warfare. Taking us in a separate direction but germane to the current US military counterinsurgency debate is Cadet Hicks who discusses France's difficulties during the Algerian War of Independence.

This is my first edition as editor of the ASJ. From its inception, the ASJ has provided a forum for the military professional to present papers, generate discussion and expound on issues relevant to the military's role in national security. Recently, the trend has been to publish cadet authored papers but we are now making a concerted effort re-emphasizing military scholar and officer inputs in order to provide a better blend of what the issues are—from the top undergraduates to those who have experience and expertise in their respective topic area or career field. Today, with so many debates regarding the US military —place within the interagency; irregular versus conventional force ratio; technological dependency; role of intelligence; civil relations ; etc—we welcome inputs from those who can contribute to such a vast and varied body of knowledge. Our next call for papers will occur the summer of 2009 with an expected publication date of April 2010. We look forward to your contribution.

Michael C. Veneri, Lt Col, USAF
Strategic Studies Division, Military Strategic Studies, USAFA

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EXPENSIVE RIVALRY: India-Pakistani Relations and the Way Forward

by
C1C Joshua Dietrich,

Relations between India and Pakistan have been, and continue to be a source of international concern and regional instability. Without a resolution, it is unlikely that any measure of stability will be established in either country. After a careful analysis of the history, economic and political realities, and the strategic context surrounding the India-Pakistan conflict, the most likely solution to bring about meaningful change and regional stability requires a combination of pressure from powerful nations, a shared desire to move away from continued bloodshed, and an honest assessment of both countries' options.

The driving forces behind conflict in Kashmir and ongoing national resentment between India and Pakistan cannot be fully understood outside of the historical context. Four major events in India-Pakistan history separate it into manageable sections of analysis: the partitioning, the first Kashmir War, the second Kashmir War, and the third Kashmir War, often referred to as the Bangladesh War. During the time of British control over the areas that would become India, Pakistan, and Kashmir, there came a cultural renaissance that threatened to establish nationalist sentiments throughout the territory. Despite the history of being religiously tolerant, a void existed between the Hindus and the Muslims living in the Empire. Fearing that nationalist sentiments, spurred by the renaissance movement, would result in the overthrow of British control, British leaders set out to increase the divide between the Hindu and Muslim peoples.[1] The British believed that if significant internal strife could be cultivated, the resulting lack of unity within the Empire would keep nationalistic uprisings under control: essentially a strategy of divide and conquer. Unfortunately, British fears were realized and attempts to overthrow the British reigns were ultimately successful. There was still significant dissension among the Hindus and Muslims, however, and so when the British were ousted from power, two distinct groups who saw themselves as nations divided by religious differences emerged. The Muslims, who were formerly the rulers of India despite comprising the minority of the population, saw the Hindu peoples coming to power in a democracy through numerical superiority. Fearing that they would be powerless under the new government, many Muslims broke away from the state of India and established Pakistan. The partition of India and Pakistan took place in 1947, but the border lines were not drawn without discord.

The subcontinent stood partitioned with India and Pakistan emerging as independent dominions on 15 and 14 August respectively. Large-scale communal riots

resulted in the displacement of nearly ten million people between India and Pakistan. A million people died. Partition and its attendant violence, instead of being a catharsis leading to normality, led to further controversies.[2]

When India and Pakistan were established, there stood the princely states of Kashmir and Jammu, on the boarders of the newly formed India and Pakistan, who chose to remain independent, and were determined to become separate political entities. Although both India and Pakistan made clear their desires to have these princely states join their respective countries, Pakistan choose to use force in an attempt to coerce Kashmir and Jammu to consolidate into Pakistan. This proved to be a fatal error, and resulted in the states of Kashmir and Jammu requesting the help of India to fight off the invasion, and the first Kashmir war began. During the war, "Pakistan-inspired tribal attacks on Jammu and Kashmir reached full operational levels…Maharaja Hari Singh in panic and under pressure decided to accede to India."[3] When the issue was brought before the UN it was the ruling of the UN that the majority of the Kashmir and Jammu regions be granted to India and that the remainder of territory be granted to Pakistan.[4]

The first Kashmir War left feelings of resentment between India and Pakistan, but Pakistan in particular was left feeling betrayed, cheated, and abused by India and the UN. To make matters worse, Pakistan and India were split along the worst possible lines of economic utility. "The economic situation in the subcontinent was hardly taken into account when the scheme for partition was being decided on the basis of religious affinities. The result was that the economy of the Indian Empire was violently vivisected."[5] Essentially, Pakistan was left with the majority of the agricultural assets such as irrigated and farmable lands, while India was given an overwhelming percentage of the industrial capabilities of the old Empire. "India had 86 per cent of the total industrial establishments, and 90 per cent of the total industrial population."[6] With Pakistan capable of producing raw materials and India in control of virtually all of the industrial capabilities, one would expect an economic relationship similar to that of the Northern and Southern states prior to the American Civil War. However, due to the dissention that existed between the two countries, no such form of economic cooperation could survive. In the years that followed, the two nations sought to injure one another through any means available. Nowhere were these disputes more apparent than in the struggle over the Indus River Basin.

Because of the directional flow of the Indus River and the manner in which the boundary of India and Pakistan lies, India has control of the Indus River upstream from Pakistan, and therefore has control over how water flows into Pakistan. Seeing this control as an

opportunity to strike Pakistan;

> …The government of East Punjab (India) suddenly and without prior intimation stopped the supply of water flowing into Pakistan's central Bari Doab and Dipalpur canals. For five weeks 1½ million acres in Pakistan received no water; thousands of cultivators were faced with starvation[7]

Economic dissention and power struggles like the one described above only strengthened the hatred between India and Pakistan.

A second Kashmir War occurred in 1965 when "Pakistan sent infiltrators into Indian-Kashmir…to organize new uprisings against Indian rule."[8] This conflict ended in September of 1965, with the Tashkent Declaration, when the few territories gained over the course of the conflict were returned to their original owners. Pakistani and Indian forces clashed again during the Bangladesh War, which took place in 1971. India saw a civil war in Pakistan as an opportunity to ensure the division and weakening of the Pakistani State. Thus, when East and West Pakistan were locked in civil strife, India invaded East Pakistan with the full spectrum of its military capabilities, and allowed for the independence of the state of Bangladesh.[9]

Warfare, both economic and military, has been an enormous drain on, and a vital part of national identity for, India and Pakistan. It was this aspect of national identity that drove both states to develop and acquire nuclear weapons. Pakistan, being fully aware of the advantage that Indian military forces enjoy over Pakistani forces, also believes that, "India's long-term strategic goal is the destruction of Pakistan…"[10] Believing that India has the means and desire to destroy Pakistan has been paramount in the shaping of Pakistani national security policy, particularly as it relates to Pakistan's position on nuclear first strike. "Pakistan's nuclear arsenal…has an implicit first-use doctrine…"[Given] India's conventional superiority, nuclear weapons are seen as equalizing the imbalance."[11] Clearly taking a realist view of national security options and the international system, Pakistan's nuclear policies support the thoughts of Joseph Cirincione, highly acclaimed student, professor, and author of nuclear weapons and national security issues; "…states will do whatever is necessary to guarantee their security and sovereignty in this Hobbesian Jungle…Nuclear weapons…are the ultimate security guarantor."[12] Any nuclear policy condoning first-use should be enough to frighten the international community, but with Pakistan, the danger is magnified tenfold by internal instability. Bill Emmott, scholar of Asian security studies, quotes a summary of causes of instability within Pakistan by James Astill;

> Think about Pakistan, and you might get terrified…One-third of its 165m people live in poverty and only half of them are literate. The country's politics yo-yo between weak civilian governments and unrepresentative military ones…The army is waging war

against Islamic fanatics…Pakistan has used, and perhaps still uses, Islamic militants to fight its wars… Several thousand armed extremists are swilling around the country.[13]

With all of these internal security issues occurring simultaneously, it is not surprising that the first spark of a fourth conflict between India and Pakistan is expected to come from Pakistan. There is hope for peace on the horizon, however, as the last time Indian and Pakistani forces were openly engaged in large-scale conflict was the Bangladesh War of 1971. Not to say that there hasn't been a constant struggle caused mainly by insurgent forces conducting skirmishes within Indian territory, but these skirmishes have not erupted into an open war.

Open war has been prevented by a lack of clearly defined Indian national strategy, political pressures from the modern world to avoid war at all cost, mutual increases in conventional deterrence and Indian progress toward regional superpower status. Together, these forces prevent India from taking actions, such as massing military forces on the boarder of Pakistan, which may provoke a nuclear first-use response by Pakistan. So long as these factors continue to develop positively, there is reason to hold out hope for at least a lasting cease-fire between Pakistan and Indian military forces.

In an Occasional Paper published by the Institute for National Security Studies, author and professor of international security Dr. Stephen F. Burgess writes,

> India is in the midst of the lengthy process of moving from the status of a defensive sub-regional, middle power, without a clear security strategy, to that of a more offensive- minded major power, with nuclear weapons, with interests to defend in Southeast Asia and the Middle East, and with China as a competitor. During this process, Indian leaders and foreign and defense policymakers have been accused of lacking strategic vision.[14]

While the lack of a clearly defined strategic vision and national security strategy is never the optimal situation for nuclear powers, it has prevented a reactionary-based escalation of military actions stemming from known aggressive Pakistani conduct. In essence, by not having a rigid national security strategy, India maintains peaceful sovereign options as responses to Pakistani attacks. Had India been operating since 1971 on a national defense strategy that was prescriptive and precise in nature, Indian military responses to Pakistani-backed insurgent operations in India-controlled Kashmir would have significantly contributed to the break from small-scale conflicts to international war with Pakistan.

Not to be underestimated in the role of ensuring peace is the steady increase in conventional deterrence. Because both India and Pakistan rely heavily on the existence of their nuclear weapons to achieve national goals, Southeast Asia experts Sumit Ganguly and Devin T. Hagerty write, "…the

main source of Indo-Pakistani peace seems to have been 'boosted conventional deterrence'--the mutual fear of the adversary striking one's own nuclear facilities with advanced conventional weapons."[15] Surely if India and Pakistan were to engage with one another in open military conflict,some of the most sophisticated resources of each nation would be charged with the destruction or disabling of the nuclear capabilities of the enemy.

The most promising factor in the India-Pakistan conflict is the rate of economic growth and geopolitical desires of India. India has the drive, the political partners, and the economic power to become a major world power in the near future. With GDPs ranging from 8.6 to 9.4 percent from 2003 to 2007 there is little doubt that, as Ganguly and Hagerty put it,"Such growth stands a real chance of turning India from just a big important country into one of Asia's, and the world's, leading powers."[16] Along with a readjustment of its strategic self-image within the region, serious increases in military spending, and continued investments in the civilian sector by countries much as the U.S, Russia, and China, India has also been promised significant aid from the United States designed to help it become a world power.[17] This aid is to come in the form of the sale of U.S. aircraft, particularly the latest versions of the F-16 and the F-18, as well as analysis and advice from leading U.S. experts in the fields of nuclear energy, nuclear safety, free trade, commerce, finance, and space capabilities.[18] The willingness of current world powers, the U.S. in particular, has meaningful impact on the security options that India will likely pursue in future dealings with Pakistan.

The United States, China, Japan, Russia, and the EU make up the majority of the world's current strategic and economic powers. The one thing that these powers all require to stay in power is stability; stability across the full range of national instruments of power. Even the U.S. has lost a great deal of prestige and trust within the international community because of recent "unilateral" actions in the Middle East. First world countries simply do not appreciate regional instability. It is extremely expensive and in a global economy as interconnected as ours, instability in one region can have drastic effects in virtually every country in the world. This being said, with the help of the current world powers to become a regional powerhouse, there is also a high expectation that India will act like a true world power and seek to increase stability throughout its region of control. Once India becomes fully accepted as a legitimate power, or even a superpower, there will be little leniency given by the international community for instabilities caused by conflict between India and Pakistan. The expectations of the international community have already begun to limit India's options when dealing

with Pakistan in a positive way, and it will not be long before Pakistan realizes this limitation has begun in earnest. Upon reaching such a realization, Pakistan will be driven to stop the leeching of national resources in a seemingly endless struggle with a clearly superior neighbor. If Pakistan can realize that India has become a traditional world power with all of the military restraints and economic capabilities that go along with that status, the logical decision would be to seek Pakistan's strategic goals through a more open, economically based relationship with India. T.V. Paul, expert on enduring rivalries and the India-Pakistan rivalry, describes the necessary shift in the frame of mind from which peaceful political intercourse may be allowed to blossom.

The rivalry between India and Pakistan has existed since the British made a conscious decision to widen the gap between the Muslim and Hindu populations. In the years between the Partitioning of the old British India and 2009 the conflict between these nations has only served to widen that gap and perpetuate a deep hatred for one another. The rivalry stems from a past wrongdoings and a shared desire to control the economically and strategically valuable region of Kashmir. There is a real propensity for the regional instabilities and old animosities between India and Pakistan to reignite into an unbridled, economic, military, and possibly nuclear war. Although the opportunities for disaster are apparent, there is still hope for the end of the rivalry and the beginning of a new age of shared prosperity stemming from mutually beneficial trade and release of military tensions. A favorable outcome to the conflict will not come easily, however, and will likely require the intervention of the international community in a unified effort to promote regional stability and economic growth, the achievement of the superpower mindset in India, and the shared realization that there is more to gain through cooperation than through more years of covert military actions and the constant threat of conventional and nuclear warfare. Muslims and Hindus were once at relative peace with one another, enjoying the prosperity of a powerful and advanced geographic region in the world, and they have the capability, should they so choose, to live in peace once again.

ENDNOTES

[12] J.N. Nixit. *India-Pakistan in War and Peace* (New York: New York Routledge Taylor & Francis Group 2002), 103.

[3] Ibid., 108.

[4] Ibid., 114.

[5] Ibid., 121.

[6] G. W. Choudhury. *Pakistan's Relations with India 1947-1966* (New York: Frederick A. Praeger 1968), 141.

[7] Ibid.

[8] Ibid., 157.

[9] Kanishkan Sathasivam. *Uneasy Neighbors: India, Pakistan and U.S. Foreign Policy* (Ashgate Publishing 2005), 8.

[10] Ibid., 10

[11] Ibid., 11

[12] Sathasivam, *Uneasy Neighbors*,

158.

[13] Joseph Cirincione. *Bomb Scare: The History and Future of Nuclear Weapons* (New York: Columbia University Press 2007), 51.

[14] Bill Emmott. *Rivals: How the Power Struggle Between China, India and Japan Will Shape Our Next Decade* (Orlando: Harcourt, Inc. 2002), 245-246.

[15] Stephen F. Burgess. *India's Emerging Security Strategy, Missile Defense, and Arms Control*, INSS Occasional Paper (# 54), June, 2004. Available from the Institute for National Security Studies @ http://www.nti.org/e_research/official_docs/other_us/inssjune.pdf.

[16] Sumit Ganguly and Devin T. Hagerty, *Fearful Symmetry: India-Pakistan Crises in the Shadow of Nuclear Weapons* (Seattle: University of Washington Press 2005), 189.

[17]Emmott, *Rivals*, 143.

[18] "US Wants to Help India be a Superpower" 26 March, 2005, Available from Sify News @ http://sify.com/news/othernews/fullstory.php?id=13702274.

[19] Ibid.

[20] T. V. Paul,. *The India-Pakistan Conflict: An Enduring Rivalry* (Cambridge University Press 2005), 264.

ALGERIAN SOUP: APPLYING NAGL'S ANALYSIS TO ALGERIA

By

C1C Parker Hicks

Whether or not it is a given that future wars will all fit the mold of an insurgency or a terrorist campaign is irrelevant. The fact is that the United States is *currently* embroiled in not one, but two wars that possess elements of insurgency. In Afghanistan, the Taliban struggles to hold on to some territory and uses terrorist tactics to destabilize the government and its coalition allies. In Iraq, various militias and terrorist cells fight asymmetrically, hitting and running in order to put pressure on both the legitimate government and multinational forces.

Lieutenant Colonel John Nagl, recognized as one of America's primary theorists on counterinsurgency, began his career with a dissertation on counterinsurgency efforts in Malaya and Viet Nam. This study eventually became the book, *Learning to Eat Soup with a Knife*. While his opinions changed slightly after his counterinsurgency experience in Iraq, the analysis he performed on Malaya and Viet Nam is still useful. Not only does it review the histories of two different counterinsurgencies, it also provides two different frameworks for analyzing an army's chances of success in any counterinsurgency. The first is a series of questions regarding the army's adaptation to changing circumstances. The second addresses whether the army's doctrine was relevant to the demands posed by the insurgency.[1] The two lenses provided a method of extracting lessons learned from each of the two wars. Many important ideas can be gleaned from Nagl's analyses. Applying them to other wars could result in even more insights.

This study will apply the second framework to another important counterinsurgency of the twentieth century, the French colo-

nial war in Algeria (1954-1962). There are five questions in this framework:

- Did the military structure itself in an appropriate manner to deal with the threat at hand?
- Did the military use the minimum amount of force necessary to accomplish the mission?
- Did the army contribute to the setting of realistic national goals in the conflict?
- Did the military accept subordination to political objectives?
- Did the doctrine adopted achieve national goals in the conflict?[2]

On 1 November 1954, the *Front de Libération Nationale*, or FLN, made their proclamation, declaring a goal of "national independence through…restoration of the Algerian state…within the framework of the principles of Islam."[3] The French Prime Minister, Pierre Mendès-France, responded with a resounding speech on 12 November, saying unequivocally "*Ici, c'est la France*"—*this* [Algeria] is France.[4]

The outcome of the war is obvious—Algeria is France no longer. On 3 July, 1962, the French government officially recognized Algerian independence. Just a few short years after that, there was no French military presence in the state.[5] France failed to meet its original objective.

It might be hard to understand why. General Paul Aussaresses, a behind the scenes troubleshooter and intelligence officer for the French military through several different phases of the conflict, tells a story of multiple successes—of an open rebellion in Phillipeville quelled, of one leader of the insurgency spontaneously betraying his comrades upon capture, and another killed in a tremendous explosion.[6] When one examines only the military aspect of this insurgency, especially the ruthless Battle of Algiers, it appears that the French should have won. In Algiers specifically, bombs stopped going off in March of 1957.[7] In the end, however, the French "won the battle of Algiers; but that meant losing the war."[8]

Question 1: Did the Military Structure Itself in an Appropriate Manner?

The armies of a state thrive on control. Armies throughout history have been organized as rigid hierarchies. Very defined—although not always clear—lines of communication run both up and down the chain of command. Especially when the state is as established as France, bureaucracy can bind a military until it is no longer flexible enough to get out of its own way.

Insurgencies, on the other hand, thrive on chaos and decentralization. If the insurgents can delegitimize the incumbent government, they will create a void that they can then fill. By showing that the current government cannot maintain control, they force the people to demand a replacement—or convince the government it is

no longer worth fighting. Because the cells of a terrorist insurgency are small, and often only loosely connected, they can take advantage of the disorder they create to cloak future operations.

This was the situation France faced in the Algerian conflict. It is fortunate, then, that France had fought an insurgency in Indo-China and been forced to withdraw just prior to the war in Algeria. The first reinforcements the French sent to Algeria were the 25th Parachute Division, led by Colonel Paul Ducournau. Ducournau had led troops in Indo-China, and had deeply studied the enemy's tactics. He was able to apply lessons that he learned firsthand fighting the Viet Minh to suppressing the FLN.[9]

Ducournau was not the only Indo-China veteran. Jean-Jacques Servan-Schreiber, a lieutenant who documented his experience in Algeria, frequently wrote of comrades referring to the enemy as "gooks," and of one of his superiors who even called them "Viets," regardless of the fact that they were about as culturally separate from the Viet Minh as possible.[10]

The experience of the commanders—and a weak government at home—gave the troops in Algeria a certain amount of flexibility. A practical example of this flexibility is the latitude that Aussaresses was given to prosecute his mission—at least, the latitude he *perceived* he was given. When he arrived in Algiers in 1957, the general in command, General Jacques Massu, told him "figure it out for yourself; it's your job now."[11] Aussaresses in turn created two mutually unaware teams for intelligence gathering. He allowed these teams to operate practically independently, feeding him information as they collected it. Occasionally he would accompany them on arrests, and he supervised much of the torture and summary execution he deemed necessary to break the insurgency's back.[12]

In this manner, the military had structured itself properly, but it was a secretive structuring, offering those in Aussaresses's chain of command plausible deniability. There was no doubt about the need for this to him—he writes that he needed a "safety net should someone in authority to find out what we were doing during our strange nightly runs."[13]

Question 2: Did the Military Use the Minimum Amount of Force Necessary?

Aussaresses's superiors needed this deniability because he used torture and summary execution to make his point and gain his information. Was this conduct necessary? Is it "impossible for [an] army to avoid using extreme measures"[14]?

This is the question that many modern academics focus on, especially because of its similarity to current debates within the U.S. government. Before assessing

whether the French used the minimum amount of force, however, it is important to consider that there were essentially two different strategies they could have chosen.

The first, and the strategy the United States is using in Iraq and Afghanistan, is to win the hearts and minds of the populace. By painting themselves as providers and protectors, and the insurgents as destructive murderers, the countering force can maintain the moral high ground and eventually ostracize the insurgency. This is used in contemporary counterinsurgencies because the United States is acting on behalf of a partner government. This method allows for the partner government to retain some sort of control over their nation.

The second strategy is based on complete domination. This avenue was open to the French because they were not supporting a host government—they *were* the government, and anyone who said otherwise was a rebel. The military established unity of command over the colonial government early, in order to facilitate this strategy. Martial law ruled much of the country. In January 1957, General Massu, Aussaresses's superior, took complete responsibility for the peace and welfare of the capital, Algiers.[15] This was not an extraordinary circumstance—in 1956, Major Jean Pouget guaranteed safety and security for the vicinity of Bordj de l'Agha under similar circumstances.[16]

Both of these strategies were used in different areas throughout Algeria. Pouget's stint at Bordj de l'Agha is a wonderful example of how an intelligent commander can, given enough rein, use diplomacy and personal relationships to convince a host population to shun the rebels. Massu used harsher tactics in Algiers, as Aussaresses tells us in his memoir. The troubleshooter suggests this is because the European (*pied-noir*) population in Algiers was already at the boiling point, and "going soft" on the insurgency would have led to vigilantism and revolt.[17] Zervoudakis, in describing Pouget's command, notes that the lack of *pieds-noirs* was an important factor in his success.[18]

While the mixed population complicated matters, it is difficult to accept that the harsh behavior imployed by Massu and Aussaresses was the only viable option. Horne agrees, and explains that while using torture may have expedited matters, its long term effect—ostracizing innocents and creating FLN converts—was extraordinarily counterproductive. In doing so, he quotes Ausseresses's replacement, Yves Godard, who said, given command in Algiers, he would execute only those caught red-handed in acts of terrorism and that "there is no need to torture."[19] While it was expedient at the time, the military's use of torture and excessive violence[20] only alienated the population—and led to major political

problems later.

Question 3: Did the Army Contribute to the Setting of Realistic National Goals?

Questions 3 and 4 get to the heart of the French experience in Algeria. The politics of French Algeria were complex, with at least four different groups operating, all with slightly different agendas. Three were in Algeria itself—the insurgents, the *pieds-noirs*, and the military. The relationship between the Algerian French and the military has already been discussed. The settlers and the generals cooperated, as long as the generals were fighting the war. Back in France, however, passions were significantly less inflamed.

National goals in Algeria started out as drastically oversimplified and unrealistic. The "This is France" doctrine mentioned earlier was the extent of early goal-setting—and for one political faction, the *pieds-noirs*, that was more than enough. Military command shared the same stance, although for different reasons. After the embarrassing withdrawal from Indo-China *and* the Suez Canal incident, the French military needed to redeem themselves somehow, and they felt Algeria was the perfect opportunity.

By contrast, the French in France quickly lost their will for the war, especially after reservists and conscripts were called into action. Much like the United States in Viet Nam (and perhaps Afghanistan), those on the home front fatigued quickly, and ended up shifting national objectives away from the absolutism of "This is France." The two strong-willed French Algerian factions, in concert with the inherent instability of France's Fourth Republic, resulted in a military far more attached than its political overseers to the war. Because the French and the French in Algeria had different levels of political will for the mission, and were not willing to see eye to eye, the military could not and would not effectively contribute to overall national policy.

Question 4: Did the Military Accept Subordination to Political Objectives?

The same problems that led to miscommunication over political objectives also gave rise to military insubordination. The friction between the different political stances came to a head not once, but twice. The first time was in 1958. General Charles de Gaulle, leader of the Free French Forces during the Second World War and a Cincinnatus eagerly awaiting his recall, rose as the hero of the Algerian French because of a masterful piece of misdirection by local Gaullists. His supporters saw "the government's inability to resolve the Algerian problem, coupled with the insurrectionary potential of…the *pieds-noirs* and some of the army could provide the opportunity…[for] de Gaulle."[21]

Unfortunately, history shows their feigned concern over Algeria was merely "a pretext for a change of regime."[22]

Horne writes that before his return to power, de Gaulle's "ambiguity was particularly pronounced" when it came to Algeria.[23] Nevertheless, agitators in Algeria were able to convince the *pieds-noirs* that de Gaulle was the sort of confident, decisive, military man they needed—the kind of leader who could help erase the mistakes the last few governments had made in Algeria. In May of 1958, transplanted *pieds-noirs* and students, still swollen with the pride of Imperial France and smarting from recent capitulations to the FLN, charged the seat of government, supported by squads of paratroopers and commandos. By June, de Gaulle was installed as the new president of France. Two of his demands upon installation were dictatorial control for six months and the dissolution of the National Assembly for four. The Assembly agreed, and though he had still been ambiguous on Algeria, the *pieds-noirs* and the military believed they had got the man they needed.[24] Their first revolt had turned out in their favor.

It did not take long for their trust in de Gaulle's empty words on Algeria to turn on them. In October of 1958, the General began setting the stage for the next potential round of military insubordination. On October 13th, after understanding that there was to be no victory over the FLN, he offered Algeria a *paix des braves*—a peace of the brave. This smacked of capitulation to *pieds-noirs* and the military commanders, and while the FLN rejected the proposal and continued terrorist strikes, it worried the fiercely independent Algerian French.[25]

About a year later, in September of 1959, de Gaulle made another overture to the insurgents, promising "self-determination." While this received accolades at home in France, in Algeria it was met with frustration. Horne personally witnessed one young officer "explode."[26]

The *pieds-noirs* did not respond much better. In January of 1960, a paramilitary group of *pieds-noir*, passively supported by the paratroopers, barricaded themselves in an Algiers building, armed with automatic weapons, to protest de Gaulle's handling of the FLN insurrection. Their leader claimed the "revolution" would start in Algiers and move to Paris. As is to be expected in any demonstration where the protesters are armed with automatic weapons and plastic explosives, it did not end well. A brief battle on the 24th between the demonstrators and the police was the beginning of "Barricades Week."[27]

Although this French rebellion was put down, passions were stirred again a year later—and that time, the generals joined in. The

pieds-noir formed a vigilante terrorist organization, again with the tacit support of many in the military.[28] In April of 1961, the generals moved beyond tacit assistance and made their *putsch* to seize control of Algiers. Radio broadcasts in France warned of vengeful paratroopers falling from the skies to bring the battle to Paris.[29]

Their revolt was put down in just a few days, but it marked the height of military insubordination.[30] The FLN were able to take advantage of the turmoil and, very soon after, negotiated a favorable peace agreement.

Question 5: Did the Doctrine Adopted Achieve National Goals?

The resolution of France's Algerian tale has already been shared. In the end, the *pieds-noirs* evacuated and Algeria became independent. The answer to this question is obvious. While national goals changed over the course of the eight-year conflict, those of the military and the *pieds-noirs* never did.

Although the French government did give the Army the flexibility it needed to address the insurgency, this was not so much because of any foresight. Rather, it was due to a lack of proper civilian oversight. This led to the Army taking several questionable approaches to combating the FLN and an eight year escalation in violence from both sides.

This lack of oversight also led to the growing discontinuity between the goals of the *pieds-noirs*, the Army, and the government. When combined with France's internal political turmoil, this made for weak doctrine overall. In the end, the war in Algeria was almost as destructive to France as it was to Algeria. The answer to Question 5 is an unequivocal no. The doctrine utilized did not support French goals or, in the end, even the goals of the *pieds-noirs* and generals who subverted France's mission.

While there is no question of France's failure in Algeria, Nagl's construct offers a way to evaluate *why* it occurred with some accuracy. This sort of analysis has tremendous value in ensuring future counterinsurgents do not repeat past mistakes. By applying his analysis to additional wars throughout history, modern soldiers can learn from their predecessors—and avoid making the same mistakes.

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(Endnotes)

[1] John Nagl, *Learning to Eat Soup with a Knife: Counterinsurgency Lessons from Malaya and Vietnam* (Westport, Conn.: Praeger, 2002; Chicago: University of Chicago Press, 2005), xi, 10. 30.

[2] Nagl, *Learning to Eat Soup with a Knife*, 30. This is not the order in which Nagl presented these questions, but rather the order they will be addressed in for this work.

[3] Alistair Horne, *A Savage War of Peace: Algeria 1954-1962* New York Review Books Classics ed. (New York: New York Review of Books, 2006), 95.

[4] Horne, *A Savage War of Peace*, 98.

[5] Martin Alexander *et al.*, *France and the Algerian War 1954-62: Strategy, Operations and Diplomacy* (London: Frank Cass, 2002), xvii.

[6] Paul Aussaresses, *The Battle of the Casbah: Terrorism and Counter-Terrorism in Algeria 1955-1957* (New York: Enigma Books, 2005), 43, 162.

[7] Horne, *A Savage War of Peace,* 207.

[8] Paul Teitgen, quoted in *A Savage War of Peace*, 207.

[9] Horne, 102.

[10] Jean-Jacques Servan-Schreiber, *Lieutenant in Algeria* (New York: Alfred A. Knopf, 1957), 4, 8.

[11] Aussaresses, *The Battle of the Casbah*, 78.

[12] Ibid., 91.

[13] Ibid.

[14] Ibid., xxi.

[15] Alf Heggoy, *Insurgency and Counterinsurgency in Algeria* (Bloomington, Indiana: Indiana University Press, 1972), 233.

[16] Alexander Zervoudakis, "A Case of Successful Pacification: The 584th Bataillon du Train at Bordj de l'Agha (1956-57)," in *France and the Algerian War 1954-62* ed. Martin Alexander, 55.

[17] Aussaresses, *Battle for the Casbah*, 77.

[18] Zervoudakis, "A Case of Successful Pacification" in *France and the Algerian War 1954-62* ed. Martin Alexander, 58.

[19] Yves Godard, quoted in *A Savage War of Peace*, 205.

[20] Servan-Schreiber writes of an incident in which an elderly Algerian was shot while attempting to calm a young man who had gotten in a soldier's way. After realizing the man was dead, the soldier and his companion fled, causing the local *pied-noir* population to blame six young Arabs. Eventually, the story was transformed through retelling, and a different army unit was dispatched to deal with the "motorized commando"—six young field hands who had not even been present when the original murder took place. Servan-Schreiber, *Lieutenant in Algeria*, 13-27.

[21] Stephen Tyre, "The Gaullists, the French Army and Algeria before 1958: Common Cause or Marriage of Convenience?" in *France and the Algerian War*, ed. Martin Alexander, 100.

[22] Ibid.

[23] Horne, *A Savage War of Peace*, 281.

[24] Ibid., 285, 289.

[25] Ibid., 306.

[26] Ibid., 346-47.

[27] Ibid., 359-62.

[28] Ibid., 440.

[29] Ibid., 457-59.

[30] Ibid.

SHIFTING IDEAS ON TECHNOLOGY

by

C1C Marc Marmino

In his January 1961 farewell address, American President Dwight Eisenhower made the following observation: "Akin to, and largely responsible for the sweeping changes in our industrial-military posture, has been the technological revolution during recent decades" (Poast, 50). The former president was alluding to the rapid technological innovations that influenced the outcome of military battles throughout history. Since the turn of the twentieth century, advancements in military technology have been crucial to military operational success. As a result, the United States' warfighting capability has emerged as superior to every other nation because of its continued commitment to developing new technologies. Further, recently developed capabilities in advanced weapon systems have served to better protect the warfighter. However, warfare has recently evolved to non-conventional methods rendering some of the advanced capabilities ineffective. Thus, the U.S. must adapt to the fight in the human domain rather than in the "machine domain" and resolve not to rely on superior technologies alone. This paper focuses on the United States' technological over-reliance by providing three examples where technology benefited the U.S. military and three examples where technology hindered the U.S. military.

In order to understand U.S. reliance on technology, one must first understand how the U.S. obtained the most advanced weapon systems in the world.

The United States may credit its superior military weaponry to the Cold War. When the "iron-curtain" fell across Eastern Europe following World War II, the United States entered into more than forty-years of conflict with the Soviet Union. Also from 1965-1971, the United States fought in Vietnam. While the conflict in Vietnam did not result in a U.S. victory, it provided many valuable lessons for the American military and further advanced its understanding of modern weapon systems. After America's involvement in Vietnam ended, tensions with the Soviet Union continued for nearly twenty more years. Moreover, the Cold War dynamic had created an arms race involving massive spending on both sides to procure and acquire the latest weapon innovations. This trend continued and "with each wave of machine innovation, warfare shifted further from the human domain of conflict" (Hagerott, 2). At the peak of the conflict, "substituting machines for manpower accelerated so much that the fate of the world depended on command and control systems and calculations of throw weight, warning, and reaction times" (Hagerott 2). The result of the United States' continued resolve to achieve con-

ventional military superiority left it with the foremost military capabilities in the world when the Russian economy collapsed in 1989. At the end of the Cold War, the U.S. had no clear enemy to pursue and possessed incredible new technologies. Developments in military technology made war-fighting more efficient. Efficiency is illustrated through maximizing precision and effectiveness while minimizing manpower and collateral damage (Meilinger 12). The advanced capabilities of the United States Military were showcased two years later when the U.S. led Operation DESERT STORM.

In 1991, the U.S. overwhelmed Iraqi Forces principally through the use of their technologically superior weapon systems. When Iraqi President Saddam Hussein invaded Kuwait, the U.S.-led coalition forces engaged the Iraqis and liberated Kuwait. The Coalition thrust into Kuwait, known as Operation DESERT STORM, was characterized as an incredibly swift and decisive victory for the United States due to its superior military technology (Vizard 22). An example of this superior technology was the F-15C aircraft that "shot down 33 Iraqi aircraft without a single loss" (Bevin 63). The U.S. air campaign during the Gulf War was efficient in decimating strategic military targets while minimizing Iraqi civilian causalities through the use of "smart bombs" guided by Global Positioning Satellite (GPS) technology. GPS-guided maneuver units in DESERT STORM "helped minimize fratricide, registered artillery, and precisely located land mines" (Griggs 9). The use of GPS-guided munitions saved innocent lives on the ground during the war and illustrated how technology made warfare more efficient. Furthermore, there were only 148 United States military casualties in the Gulf War (Vizard 22). Even considering the brevity of the conflict and operations, these numbers were significantly lower than what the U.S. had previously experienced in combat. The efficient results displayed in Operation DESERT STORM reaffirmed the importance of technology in combat. This was a major step forward for warfare technology, the benefits of which are still seen today during the Global War on Terror.

Operation Enduring Freedom (OEF), conducted in Afghanistan, provided another example of how military technologies benefit the warfighter. The battles fought during OEF revealed increased integration of technology and the soldier. During a bombing raid in Tora Bora, "a plume of smoke was reported to have covered an area of two square kilometers after a cave complex filled with enemy munitions was struck" ("The USMC in OEF" 7). Deep-penetrating "daisy-cutter" munitions demolished otherwise impenetrable cave structures built deep into the ground. In another instance, "At Bishqab on 21 October 2001 U.S. Special Operations Forces [SOF]

pinpointed Taliban targets at ranges of over 8km." This was incredibly effective towards fortifying our Afghan allies when "skeptical Northern Alliance commanders peered through their binoculars at Taliban positions that had stymied them for years and were astounded to see the defenses suddenly vaporized by direct hits from 2,000lb bombs" (Biddle 14). Strengthening these soldiers' resolve was critical to successful initial operations as "victories were credited to coordination among Northern Alliance commanders" ("The USMC in OEF" 6). Technology clearly provided the U.S. with some added benefits in this new generation of warfare.

One area where technological benefits need to be applied is in helping minimize friendly fire casualties still experienced in battle. These losses can occur from over reliance on technology or from human error. In the Gulf War, for example, 35 of the 148 U.S. military casualties resulted from friendly fire (Vizard 22). To mitigate this problem, "the Pentagon and its NATO allies are developing combat identification systems that detect transponders on friendly tanks and other units to help avoid mistakes" (Vizard 22). In addition to these measures, several other anti-fratricide systems are currently being developed. One system is a "wireless Internet system [that] could show the deployment of troops with enemy forces in red and friendly forces in blue" (Kaldor 4). This system will reduce fratricide and allow a greater focus on deterring enemy forces from reaching their objectives. Another example involves "precise weaponry with very small warheads" that has been tested by the Air Force Research Laboratory (Gingras 4). This technology lessens fratricide by improved precision delivery and limited blast radius. Essentially, smaller warheads will "increase lethality with reduced explosives" so that "no longer must weaponeers select multiple large blast/fragmentary weapons in the 500 to 2,000 pound range for point targets" (Gingras 4). This offers another example of how the U.S. military's reliance on advanced technology benefits the warfighter through reduced fratricide and collateral damage.

In 1988, the U.S. Navy was overly reliant on technology and mistakenly killed many innocent Iranian civilians as a result. The USS *Vincennes*, while engaging an Iranian gunboat, incorrectly identified an inbound civilian aircraft on its radar as a hostile Iranian fighter jet. After several attempts to make contact with the aircraft, Captain Will Rodgers, Commander of the USS *Vincennes,* decided it was "approaching with hostile intentions" and shot it down by firing two missiles (Swartz 1). The aircraft was later identified as Iran Air Flight 655 carrying 290 passengers and crew destined for Mecca. This tragedy begged the question of whether or not the U.S. military was too reliant on its technology. It

is still highly debated to this day if this decision was justified given the circumstances and rules of engagement. It is certain however, that the technology onboard the *Vincennes* failed the crew that day. The commander of the ship had to make a swift decision regarding the intention of the non-responding aircraft. Intelligence provided to him "told that the craft was descending (and not ascending, as it actually was)" and the "craft's Identification, Friend or Foe (IFF) reading, designed to distinguish between civilian and military craft was Mode II (military) and not Mode III (civilian as it actually was)" (Swartz 4). It was later revealed that prior to this incident, engineers knew of the potential for this grave error to occur. Matt Jaffe, one of the engineers who worked on the combat display system onboard the *Vincennes*, said that he "recognized the complexity of the information it provided–specifically, the confusing way to read the altitude" (Swartz 5). Jaffe revealed that he had advocated the necessity of an indicator which would display the status of the aircraft as ascending or descending but the recommendation was rejected by his supervisor. If the indicator was present however, "the *Vincennes*' Tactical Informational Officer might have determined the correct trajectory of Flight 655 and the disaster could have been averted" (Swartz 5). This deficient software design caused Captain Rodgers to order the missile launch that ended the lives of many innocent civilians. In this instance, the United States relied too heavily on its technology with devastating consequences. Not only did the crew of the USS *Vincennes* rely on the technology, but the crew from a neighboring vessel, the USS *Sides,* did as well.

The USS *Sides* picked up the correct signal for an inbound commercial airliner but did not challenge the *Vincennes'* determination of the aircraft's intent, apparently relying on the *Vincenne's* radar system as well (Swartz 6). Experts in the field of human-computer interaction believe that the crew of the *Vincennes* placed too much faith in the Aegis radar display, which put them under a more powerful illusion that an enemy aircraft was actually inbound (Swartz 6). A combination of fear and the bad intelligence that was streaming into the system is credited with creating this illusion. This is because "it was one thing for humans in the Combat Information Center to speculate that the contact was an F-14, but when that information was displayed on a seemingly objective computer monitor, it took on a life of its own" (Swartz 6). The Aegis is only a machine, and therefore the information presented must be received with a certain degree of skepticism. If not, the sailors will "blindly trust the 'system' of which they are unknowingly a part" (Swartz 6). This blind faith placed in man-made machines is extremely dangerous, the conse-

quences of which are illustrated in the actions taken by the captain and crew of the *Vincennes* in 1988. It is also dangerous to rely heavily on technology when enemy tactics are evolving to make them less susceptible to the United States' superior ability to wage conventional warfare.

Today, terrorists employing insurgent tactics have fielded a "so called 'fourth generation of warfare'" (Hagerott 38). Experts now contend that for "too long the U.S. Military has focused its resources on fielding ever more advanced machines of war" and "neglected the human dimension of combat" along the way (Hagerott 38). U.S. Forces are essentially attacking the wrong center of gravity in the War on Terror when they employ technologically advanced weapons on a non-conventional and elusive enemy. Cold War doctrine and weapons are being used to fight current wars rather than the counter-insurgency doctrines and methods necessary for success. An example of this mismatch occurred during "Operation 'Anaconda' in March 2002, [where] an intensive pre-battle reconnaissance effort focused every available surveillance and target acquisition system on a tiny, 10x10km battlefield" (Biddle 15). In that same heavily-scrutinized battlefield, "fewer than 50% of all the al Qaeda positions ultimately identified on this battlefield were discovered prior to ground contact" (Biddle 15). This demonstrates the advantage of new enemy tactics over our most complex surveillance capability. Further, possessing superior technology does not make the U.S. impenetrable to "low-tech" weaponry as illustrated when "old rocket-propelled grenades are downing the most advanced military helicopters" in Iraq today (Walker 13). Superior technology does, however, provide an extraordinary advantage with respect to our ability to obtain swift, efficient, and decisive victories in conventional warfare.

The U.S. is clearly experiencing a shift in the way that wars are fought and must adapt its focus to achieve success. The trajectory of war has moved "away from an evolution of greater machine technology back to the human domain" where the enemy's technology is "widely available, including bombs rockets, and sniper rifles" (Hagerott 3). This does not mean that our advanced capabilities are now meaningless. Rather, it means that when "faced with limited resources, we must objectively assess our existing and emerging technologies to find those most effective in the human domain" (Hagerott 3). Failures in the human domain will be extremely costly in waging this generation of warfare. An example of this occurred when terrorists bombed the USS *Cole* in 1995. How could an extremely advanced U.S. Navy vessel undergo an attack by a small boat loaded with explosives? The *Cole* was a "multibillion dollar ship" carrying a "full wartime load

of missiles and ordnance; networks and computers [that] had been upgraded with the latest software" (Hagerott 4). Superior technology was certainly not the deficiency in defending the ship. Instead, it was "our understanding of the human domain of Yemen [that] was deficient" (Hagerott 4). This case highlights another example of the United States' susceptibility to "fourth generation" threats that exist even with their possession of superior technology. Currently in Iraq, enemy combatants realize "a more effective way to fight in the human domain of urban alleys, air waves, and symbols" (Hagerott 4). In order to find them in the human domain we must "speak the language, know the culture, and interact with the people" (Hagerott 4). Unfortunately the U.S. is suffering a "severe shortage of Arabic linguists" (Hagerott 4). The *Cole* attack provides evidence that the United States must adapt its technological advantages to the human domain in order to achieve continued success in military operations. The U.S. needs to adapt to these low-order threats while maintaining its development and use of advanced weapons to realize fully its military potential based upon the advantages that technology already provides in combat.

It is advantageous for the U.S. to remain technologically superior to all other nations. If U.S. military members become overly reliant on these technologies, however, they will place blind faith in the information presented to them and in turn will potentially make decisions with disastrous consequences. With the new composite of the modern battlefields, strengthening our skills in the human domain is becoming far more crucial to victories against enemy insurgents. Therefore, the U.S. must continue to excel in the technology and machine domains yet devote more resources towards developing their skills in the human domain. The enemy has simply shifted its center of gravity away from those of conventional warfare methods. In response, the U.S. must shift its attack to one focused on developing better linguists, urban-combat tactics, and cultural awareness. Relying on superior technology to wage this type of war is compared to a sporting metaphor: "while most of the U.S. military is lining up against one opponent in the football stadium, another of our opponents scores points by slashing tires in the parking lot" (Hagerott 1). If we fail to realize how to combat that other opponent, we will continue to fail in the wars we wage.

Technology plays a valuable role in sustaining the United States' position as a super-power possessing the advanced weapons; nonetheless; the country must maintain awareness of the danger associated with becoming too reliant on such technology. In 1988, the U.S. Navy relied on technology which failed them and resulted in the tragic death of 290 passengers

onboard a commercial Iranian Airliner. In contrast, the strengths of the United States' technological advantage revealed themselves in the Gulf War of 1991. Since then, recent conflicts in Afghanistan and Iraq continue to showcase a "fourth generation" of warfare illustrating the need to improve our tactical skills in the human domain. *Sixty Minutes* news reporter Andy Rooney once said "Technology is dominated by two types of people: those who understand what they do not manage, and those who manage what they do not understand." The United States military must not be overly reliant upon applications of its superior technology. Instead, it should know and understand advanced technologies, yet always maintain awareness and respect for overconfidence, evolving forms of warfare, and the human domain.

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"DEMANDING SUPERIORITY: THE JET AGE"

by

C1C Robert J. Smith

This paper will analyze why and how the jet age came about. The interrelated theories laid out in the books of Stephen Rosen and Williamson Murray will be applied to the turbojet revolution to determine its innovative qualities. This paper will focus on the innovative aspect of jet powered aircraft; technical discussion of their workings and quantitative capabilities will be limited. And although, jet engines have come to be utilized on many different types of aircraft, the employment of jet engines in fighters will be the primary focus of this paper, as this was how they were first largely used. In particular, the development of the German Me 262 will be closely examined since this was the first and only jet fighter to see combat in World War II.

History of the Jet Revolution

"It is understood today that modern warfare demands technological advancement. Without it, any military force deteriorates and crumbles in the face of a new, modern, and technologically superior enemy, Therefore, states have a duty to encourage advancement and technological innovation of their armed services."[1] This idea points up the state-sponsored scientific research that has resulted in the creation and continuous development of many impressive combat systems such as the tank, machine gun, and aircraft. The obligation of the government was further enhanced by the Industrial Revolution that established "the idea of military invention as a permanent and systematic feature of modern war."[2] The exhaustive development of the propeller driven aircraft and subsequent innovations associated with the jet age lend further support to this conclusion.

Conventional piston engine technology was indeed being exhausted during World War II. The need to be technologically superior to the enemy had pushed propeller driven aircraft to their limits.[3] The *Merlin* III, which powered the Supermarine *Spitfire*, was a V-12 engine that produced 1440 hp. America's top rated engine was Pratt and Whitney's behemoth eighteen cylinder radial engine that could produce 2,500 hp.[4] However, engineers were beginning to face ever increasing challenges to improve upon the piston engine. "Materials engineering had built lighter yet powerful engines, but the piston engine was still constrained by fundamentals. The engine was made up of the block and the individual pistons; further modifications to these parts were nearly impossible."[5] Engine developers were at the point at which a linear increase in power required an exponential increase in weight. Obviously, this was counterproductive in a technology where there is such a fine balance between speed, range, and payload. Also, adding to the difficulties was propeller technology. Ironically, as engines became more powerful, and turned bigger propellers faster, propeller efficiency began to fall due to the tips reaching supersonic speeds.[6]

Fortunately, four engineers had been developing a new type of engine, the turbojet. According to Edward Constant, "Turbojets emerged independently from the work of these men: Frank Whittle in England, and Hans von Ohain, Herbert Wagner, and Helmut Schelp in Germany."[7] They based their turbojet on antecedents that shared the same structural principles and components with the existing turbine engine. These structural antecedents in the technological heritage of the jet engine include: water turbines, turbine water pumps, steam turbines, rotary air compressors, and piston engine superchargers and turbo superchargers.[8] While these individu-

als did draw on prior technology and preconditions, the turbojet was personally and individually their invention. Whittle, notably, is credited with being the first to design a turbojet using sound aerodynamic principles.[9] Of his proposed design Whittle noted, "Once the idea had had taken shape, it seemed rather odd that I had taken so long to arrive at a concept which had become very obvious and of extraordinary simplicity. My calculations satisfied me that it was far superior to my earlier proposals."[10]

The jet engine had many advantages over the piston engine. "First and foremost, it was lighter."[11] It also deleted the propeller efficiency difficulties by not having one. Without the propeller and other limiting factors of the piston engine, a jet fighter would be able to operate at significantly higher altitudes and speeds. For these reasons the turbojet proved superior the most advanced piston engines as the premier form of propulsion. "The turbojet engine was the answer to the presumptive anomaly of the piston engine for aircraft."[12] Whittle's results were presented to an Air Ministry subcommittee in 1937. The subcommittee's chairman saw the possibilities of the design. He realized that the high flying jet fighter would have a "tremendous advantage over the lumbering bombers of an attacking force."[13] Remember at this time it was still thought by many that the "bomber would always get through." The chairman thus became an advocate of the new technology.

"It's got wings like a C-47."

"Ever see a C-47 traveling at 500 miles per hour?"

"It's got a tail like a P-51."

"Ever see a P-51 with a paint job like that?"

Conversation between two P-47 pilots after being shot at by a Me 262.[14]

The Jet Age officially began when the Germans built the first operational jet fighter in late 1944, followed shortly by the appearance of the German Messerschmitt Me 262 in air-to-air combat. After a flight in a Me 262 German General Adolf Galland exclaimed, "It felt as if the angels were pushing."[15] General Galland saw the aircraft as the only way to regain air superiority. He claimed that with 300 planes he would be able to shoot down at least 200 bombers a day.[16] However, the Me 262 was unable to contribute much for the Germans in the closing months of World War II. Nevertheless, it pointed to the enormous potential of future jet fighter aircraft. "They [the Me 262] would demonstrate that the new technology of the jet engine would make obsolete all previous combat aircraft."[17]

See Appendix: Jet Aircraft and Innovation Theory

Figure 1: A Model of Innovation: This chart combines Rosen's factors affecting innovation (top row) and Murray's contributors and inhibitors of innovation (in green and red) with other concepts to

form a model to analyze attempts at military innovation. This model also shows how many factors are interrelated to determine the outcome.

See Figure 1 in Appendix

Military innovation is the "interplay of literally hundreds, if not thousands of independent variables, and is more of an art than a science."[18]

Stephen Peter Rosen's factors will be applied to begin the analysis of the jet engine within an innovative framework.. According to Rosen, "A major innovation is defined as a change in one of the primary combat arms of a service in the way it fights or alternatively, as the creation of a new combat arm…or a downgrading or abandoning of older concepts of operation and possibly of a formerly dominant weapon"[19] The jet fighter revolution fits this definition, possibly on a couple of different levels. The last piston engine fighter to enter service was the Grumman F8 Bearcat in 1945, while the last piston fighter to be produced was the Vought F-4U Corsair which ceased production in 1952. (The F-4U began production before the F-8, but its production ran longer.)[20] From the sudden halt in piston engine fighters following the introduction of jet engines you can conclude that, due to jet fighters, the abandonment of a "formerly dominant weapon" had occurred. Also, the jet fighter came onto the scene just prior to the United States Air Force becoming an independent service in 1947. However, while there is a significant correlation between the two events, many factors played a role in the creation of USAF, and sole credit will in no way be given to the emergence of jet fighters.

Rosen's first factor in innovation, *Intelligence*, informs or fails to inform planners about the capabilities and military plans of enemies and thus drives the development of countermeasures, new weapons, and concepts of operations.[21] In the case of the jet engine, this portion of Rosen's model is not as relevant as one might think at first glance. As noted earlier, both the British and the Germans created the jet engine independently of each other. The next factor contributed more directly to the development of the jet engine than did intelligence, although the two played a similar role with the context of World War II..

Perhaps the biggest driving force behind the jet engine was the *strategic environment*. The environment during World War II was one in which both sides were coming out with increasingly better airplanes. To maintain/gain the advantage each side must continuously develop its technology, as was emphasized earlier. This created "command technologies," or situations in which the government and armed forces pushed for the development of more effective

weaponry.[22] The strategic environment prodded the Germans perhaps more than the Allies as the prospects for German victory began to slip farther away. "The incessant Allied air bombardment, and the increasing tempo of battlefield defeat, provided the motivation of desperation."[23] Since piston engine technology had been pushed to its limits, exacting increasingly high burdens for marginally higher performance[24], an innovative aircraft propulsion technology was needed. These factors made the immature technology of the jet fighter look increasingly attractive to the Germans. The Allied environment was a bit different. They could rely on their overwhelming numbers and tried and tested operational tactics and planning to effectively negate the German Me 262's performance advantage.[25]

"Technological innovation may or may not be the result of technology push, demand pull, or a qualitative arms race with an enemy."[26] The reoccurring theme here of constant development is illustrated in this factor in innovation. Each side in World War II was trying to gain the technological advantage which shows a demand pull to hurry the development of a *technology*. As Figure 1 shows, and demand pull demonstrates, technology and strategic environment are interrelated.

Rosen's final factor, *simulation*, is where the Germans failed in their innovative process. The Germans deployed the new jet fighters in largely the same way they did their propeller driven aircraft. In addition to this lack of doctrine adaption to the new technology, small production numbers limited how many Me 262s were deployed. The Germans deployed the very capable aircraft in small numbers and in the same methods they did the piston engine aircraft, which allowed the Allies to adapt their tactics to limit the strategic affect of the new jet fighter.[27] For its part, the strategic environment forced the Germans to rush the Me 262 into service without properly running any simulations to better determine the correct use of the new technology.

Williamson Murray provides a different, but useful and related (as seen in Figure 1), method of framing innovation. "The relations among technological innovations, the fundamentals of effective military operations, and innovation in concepts, doctrine, and organizations that govern those operations are fundamentally nonlinear: changes in inputs like weapons systems, whether large or small, do not necessarily yield changes of proportionate magnitude in outputs or combat dynamics."[28] It might be noted that Germany misused this principle. Instead of using the new plane in innovative ways, they tried to implement the Me 262 in the same fashion in which they customarily employed piston engine fighters. In other words the new plane was just applied in a linear way to the existing situation. Germany simply

treated the jet fighter as a means of doing the job better, instead of as the innovation that it was.

Murray proposes two contributing factors to innovation: *specificity* and *military culture*. The jet answered a specific military problem and offered a significant advantage to furthering the achievement of national strategy.[29] The strategic environment dictated a specific problem, the need for air superiority, which the jet engine helped solve. Germany's military culture also propelled their quest for innovation. "In all forms of hardware, the Germans were dedicated to developing the highest quality weapons by pursuing the boundaries of theoretical knowledge."[30] Working against military innovation is the *misuse of history* and *rigidity.* The first inhibitor did not play a significant role in the development of the jet engine. History had shown that, as noted repeatedly in this paper, continuous development is required to survive in war, and both sides were aware of this truth. Rigidity, for the Germans, was overcome by their precarious situation at the end of the war. The "motivation of desperation" caused them to turn to any technology that offered an advantage. Also as noted, the German military culture embraced new technology. Great Britain, on the other hand, experienced the negative impacts of rigidity. Early in the development of his turbojet, Whittle was turned away by the government. "Unfortunately for Whittle, his thoughts and ideas proved almost too revolutionary for the time. The aircraft industry knew only piston engines, the performance of which was improving steadily as the war approached."[31] It was only when development of the piston engine was exhausted did Great Britain begin looking seriously at the jet engine. Murray's factors of innovation heavily favored the German development of the jet engine while Great Britain and America lagged behind.

Conclusion

The turbojet powered fighter was truly a military innovation. It made even the most advanced piston engine powered fighters obsolete in a matter of years. The air operations of the Korean War point this out by being almost universally dominated by jet fighters.[32] The beginning of the Jet Age fits into both Rosen's and Murray's frames of military innovation. The strategic environment called for an improved technology to maintain/gain air superiority over the enemy. However, the German failure to simulate the outcomes of the jet fighter caused considerable setbacks in realizing its true potential. There was specificity since the strategic environment left little to the imagination. Germany's situation and military culture was conducive to the development of the turbojet and thus overcame any rigidity. Great Britain, on the other hand, did not fare as well when it came to rigidity. All of these interrelated factors resulted in the German use of innovative

jet technology by the end of World War II. Fortunately for the Allies, improper use of the new jet fighter permitted them to end the war before there were sufficient numbers of jets and a relevant doctrine to affect the outcome.

APPENDIX

Innovative Ways to Overcome Setbacks in the Design Process

"The ad hoc nature of the first American jet test program was illustrated by another incident with the second prototype. Stanley repeatedly reported stiff rudder controls at high speed, but Bell designers on-site could not come up with a quick fix. One day Stanley,landed and taxied in fast, directly at the open hanger. He turned the aircraft and stopped abruptly, then boosted the jet engines briefly, blowing exhaust and dust on the Bell men working inside. Stanley got out of the cockpit and climbed up on the XP-59A's elevator. "Jack Russell," He shouted to the crew chief. Bring a hacksaw out here." Without hesitation, Russell brought out the saw. Stanley cut a few inches off the top of the rudder, squaring off the rounded edge. He threw the excess pieces of the rudder and the saw to the ground, walked back to the cockpit and taxied away for take-off. "works much better that way," Stanley said later."[33]

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[3] Sterling Michael Pavelec, *The Jet Race and the Second World War* (Westport: Praeger Security International, 2007), 160.

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[5] Ibid.

[6] Ibid., 161.

[7] Edward W. Constant II, *The Origins of the Turbojet Revolution* (Baltimore: The Johns Hopkins University Press, 1980), 179.

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[9] Ibid., 179.

[10] Ibid.

[11]Pavelec, *The Jet Race and the Second World War,* 161.

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[13] Jensen, *War in the Age of Technology*, 253.

[14] David C. Isby, *Fighter Combat in the Jet Age* (London: Harper Collins Publishers, 1997), 8

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[15] Ibid., 14.

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[21] Rosen, *Winning the Next War*, 60.

[22] Jenson, *War in the Age of Technology*, 43

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[23] Isby, *Fighter Combat in the Jet Age*, 12.

[24] Ibid.

[25] Ibid., 9.

[26] Rosen, *Winning the Next War*, 52.

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Diagrams

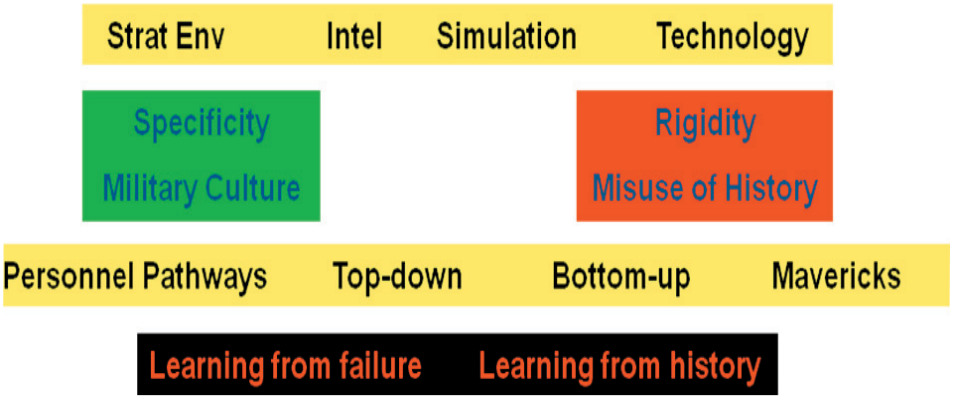

Figure 1

ELECTROMAGNETIC WARFARE AS A COMBAT ORGANIZATION

by

C1C Ron Farkas

INTRODUCTION

Research Question

As the United States increasingly relies on technologies utilizing the electromagnetic (EM) spectrum, we become dependant on them as a means to achieve military objectives. This dependency has created an identifiable and exploitable Center of Gravity (CoG) for the United States. This CoG is vulnerable to disruption, denial, and destruction through a number of means. Moreover, the will to strike these vulnerabilities exists and is evident in the actions of other nations. Based on the foregoing, does the United States military need organizations solely dedicated to Electromagnetic Warfare?

See Figure 1 in Diagrams

Background

The Army has infantry, armor, and artillery. The Navy has its surface, subsurface arms, and aviation components. The Air Force has its air and space functions and organizations dedicated to their execution. These are some of the primary combat arms of the three services. Though one may argue over a few details, every modern power breaks their forces up more or less in this manner. Support elements, such as transport and communication typically play a seemingly ancillary role in the grand scheme of things, as they are never the "pointy end of the spear." However, as the adage goes, "Amateurs deal with tactics; professionals do logistics." In today's information age, electromagnetic manipulation has become a lynchpin in all forms of warfare. Just as Napoleon's campaign into Russia displayed the disastrous consequences of failing to appreciate the importance of "support" operations in combat, so too will a modern army fail if it does not learn to utilize and integrate EM warfare into its doctrine.

Since World War I, the United States military has increasingly utilized technologies such as radio, radar, and data transfer that exploit the properties of EM energy. Current trends toward a slim, high-tempo, precision strike military rely heavily on lightning-quick intelligence. Ground commanders and even individual units have a real time view of the battlefield delivered by reconnaissance Unmanned Aerial Vehicles (UAVs). Soldiers on the battlefield expect their radio communications to be reliable and clear, and pilots anticipate functional radar and communications to find and eliminate their targets. Navigation utilizing the Global Positioning System (GPS), communications, data transfer, and electro-optical imagery are key assets provided by satellite systems. These are just a few examples of how the U.S. military exploits the EM spectrum.

Some of these technologies are new and have exciting possibilities, while others are seen as a given and assumed to be a part of the war fighting capability in any environment *without interruption*. These assumptions have been justified by the United States' ability to use the EM spectrum with near impunity to drastically increase the effectiveness of military operations, especially over the last two decades. It is important to realize, however, that this asymmetrical advantage is not guaranteed in the future. Many threats exist to electromagnetic capabilities. Electromagnetic Pulses (EMPs), large scale and limited jamming, and kinetic strikes all have the ability to disrupt, disable, or destroy technologies the U.S. military has come to heavily utilize, if not rely on. Awareness of the importance, the vulnerabilities, and the threats of and to EM technology will better prepare the U.S. to fight in the modern age.

Limitations

The purpose of this paper is not to provide detailed solutions or countermeasures to EM threats and vulnerabilities. Nor does it propose a comprehensive strategy for the U.S. employment of EM assets. Rather, this paper seeks to augment our understanding of the risks associated with relying on the EM spectrum. In no way is the author advocating giving up technologies that help give the U.S. military its superiority. On the other hand, the U.S. military, cannot afford to ignore the scope of the threat posed by its EM vulnerabilities and examine options for mitigating them.

It is also important to understand that this paper focuses only on the electromagnetic spectrum, which is a subset of many other technologies, systems, and strategies, though, "…it is often said that the electromagnetic spectrum is the commanding height of the electronic battlefield. To control it for oneself, and to deny its use to the enemy, is one way of expressing the general strategic aim of electronic warfare."[2] Many of the threats, vulnerabilities, and effects that will be discussed here apply equally to other technologies as well; however, those other technologies will not be discussed in this study.

Finally, a full scope of EM warfare would include directed energy weapons. While some of these technologies are coming into fruition, such as the airborne laser and Active Denial System, they are not yet relied upon by the military in the ways other EM assets are.[3] For the purposes of this paper, all EM assets are used in an informational sense.

Preview

To begin, this paper will discuss how EM assets are used in the military and why they are so important. Like most technologies, EM capabilities were militarized soon after their development, but it wasn't until World War II that the first practical efforts were made to use radio waves for tools other than auditory communication.[4] Radio communication was

arguably already a strategic asset, and the use of radio waves for aircraft navigation and detection started the movement that led to the "invisible battlefield." The scope of EM technology's influence has increased dramatically throughout the last century. EM capabilities have reached the point where they no longer influence only the outcome on the battlefield or theater of operations. They now influence how a nation chooses to wage war, and not just its ability to do so.

Now that the importance of EM capabilities has been established, specific vulnerabilities will be addressed. The largest strategic threat to the exploitation of the EM spectrum is a nuclear generated electromagnetic pulse (EMP). An EMP has the ability to devastate the hardware required to exploit EM properties. Technology to deliver these weapons has continued to develop and spread. Coupled with the rise in power of non-state actors, the likelihood that such a weapon will be used has also increased.

Another, more discriminating form of large scale EM warfare is jamming. Jamming can take place on massive scales, such as the disruption of Radio Free Europe broadcasts into Eastern Europe by the Soviet Union during the Cold War. Large scale jamming continues to take place in a handful of countries around the world in order to censor information delivered to their people.[5]

Focused, limited jamming can have just as much of a strategic effect as indiscriminate, large scale jamming. China's attempts to blind U.S. electro-optical satellites with a laser are indicative of other countries' intentions to reduce the asymmetrical technological gap by focusing on systems that have few or no redundancies.[6] The cost of operating satellites limits the numbers that are available for use, and therefore makes them prime targets.

Along with jamming, many kinetic threats exist to satellite systems on the ground and in space. Anti-Satellite (ASAT) weapons can physically strike satellites, or can carry conventional or nuclear payloads. Mini-satellites are being developed to attach themselves to larger hosts and disable them clandestinely.[7]

The final theme is the willingness of other nations' and non-state actors to exploit these vulnerabilities. Though it is touched on during discussion of the vulnerabilities themselves, it is important to understand that the adversary always has a say in how warfare is fought. The United States' perception of warfare is not ubiquitous, and if it the intentions of others are unknown, the U.S. may be forced into a type of warfare for which it is not prepared.

Throughout the paper, mitigating circumstances will be discussed that lessen the vulnerabilities or will to attack EM assets. For example, EMP hardening can be achieved for a very reasonable cost. Broadband data transfer, frequency

hopping, and hardware modifications are just a few of the ways interference can be overcome. Cheaper satellites will give the systems redundancy that makes it useless to attack them individually. If these circumstances and technologies lessen the threat enough, then one could argue there is no need to place further emphasis on EM assets.

Ultimately, the evidence points to the conclusion that current EM assets are too vulnerable in relation to their importance. Though the future may bring advancements in technology and the changes in political climate necessary to protect them, the U.S. military needs to decide in what direction to take its EM programs. The best way to do this is to create an organization dedicated to Electromagnetic Warfare.

Definitions and Assumptions

Definitions

Data Transfer- Using EM energy to transmit and receive information. In realty, most EM assets are simply different forms of data transfer that are employed just for different purposes. The most common type is radio communication of auditory messages.

Electromagnetic Pulse (EMP) – "A time varying intense electromagnetic field."[8]

Electromagnetic (EM) Warfare or Combat - A subset of Electronic Warfare. Any military action designed to control the electromagnetic spectrum or to disrupt, degrade, deceive, or deny its use from an adversary.

Electronic Countermeasures (ECM) – "The offensive actions taken to disrupt the enemy's use of electronics including both jamming and deception."[9]

Electronic Counter-Countermeasures (ECCM) – "The defensive measures, which are taken to protect and retain the use of friendly communication and non-communication systems, including both preventative and remedial actions."[10]

Electronic Warfare or Combat - Any military action designed to disrupt, degrade, deceive, deny, or destroy an adversary's electronic technological infrastructure.

Jamming - The use of EM energy and/or its properties to disrupt, degrade, or deny useful EM energy from being received and processed.

Radioelectronic Combat (REC) - An integrated set of measures intended for detection, suppression, destruction, or neutralization of enemy radioelectronic resources as well as protection of friendly resources. This includes kinetic weapons and destruction of hardware.[11]

Assumptions

All satellites relevant to this

discussion collect or transmit EM energy to produce useful data. The definitions of Electronic and EM warfare are effects-based and are not required to use the same medium of the system that is being attacked or defended. For example, blinding an electro-optical satellite with a laser and destroying it achieve the same results; therefore, both are forms of EM warfare. Finally, all EMPs discussed are a result of a nuclear detonation.[12]

LITERATURE REVIEW

The Importance of EM Warfare

To properly understand the military importance of Electromagnetic Warfare, one must recognize what it encompasses and on what levels it occurs. The decision to place electronic combat on a tactical, operational, or strategic level is instrumental to developing an EM organization. In 1985, David Chizum studied the Soviet perspective of what was then called Radioelectronic Combat (REC). Based largely on declassified Soviet government documents and texts from Soviet generals, Chizum explains the Soviet perspective on electronic warfare. "By Soviet definition, radioelectronic combat is a form of operational, or battle, support (operativnoye [boevoye] obespecheniye)."[13]

Other texts, written in the late seventies to early eighties, give a similar definition, or imply that electronic combat is operational capability. In 1979 while researching at the U.S. Air Force Academy, Major (Ret) Richard Fitts used Churchill's "Wizard War" as an example of the importance of Electromagnetic Combat. The cat and mouse relationship between the large-scale German attempts to use radio signals to target and bomb British cities in World War II, and the British attempts to disrupt, degrade, and deceive these attempts, set the stage for the future of EM combat.[14]

These texts illustrate the mindset for the use of EM combat in the Cold War era. Both the Soviets and Americans prepared themselves to fight an adversary that relied on advanced technologies. This gave Electronic Combat a role on a grander scale than the tactical level, especially by the Soviets.

According to John Foster, Director of Defense Research and Engineering for the Department of Defense from 1965–1973 and his team, the United States' asymmetrical technological advantage over most of the world can "invite and reward" a large scale electromagnetic pulse on our vulnerable and interdependent infrastructure.[15] His team of nine commissioners who specialize in a number of different fields, to include retired USAF General Richard. L. Lawson, has this to say about the level of threat an EMP poses to the U.S. "An EMP attack is one way for a terrorist activity to use a small amount of nuclear weaponry—potentially just one weapon—in an effort to produce a catastrophic impact on our society…."[16] Depending on the characteristics of the attack

such as the type of weapon, yield, and altitude of the burst, "Unprecedented cascading failures of our major infrastructures could result. In that event, a regional or national recovery would be long and difficult and would seriously degrade the safety and overall viability of our Nation."[17]

Other authors also offer their views on how electronic and information warfare should be viewed. Dr. Alfred Price, a retired Royal Air Force (RAF) electronic warfare specialist, states, "Information Warfare is a strategy, not an operational art in itself."[18] Technologically advanced militaries have the ability to use their information capabilities to get inside an adversary's military decision cycle, "the ability to observe, orient, decide, and then act…"[19] Effective information warfare can lengthen and manipulate that decision cycle.[20]

When analyzing the effects of targeting critical command utilities such as communication networks, as well as the disproportionate effects that one or a few weapons can achieve on a technologically dependant adversary, it is clear that at least some of these weapons belong on a strategic level in the modern age. Each contemporary author recognizes the severity of the damage caused by denying an adversary the use of the EM spectrum. Using offensive capabilities to deny the use of EM energy in more than just the theater of military operations has an undeniable strategic effect on the enemy's ability to wage war.

Contemporary Threats to the EM Spectrum

Electromagnetic Pulse (EMP)

The EMP resulting from a nuclear blast is the most common example of how an adversary could deny and disrupt the United States' EM capabilities. Dr. Rabindra Ghose, founder of the Nucleonics Corporation of America, provides a concise but useful definition of an EMP. "The Nuclear Electromagnetic Pulse (EMP) is as intense time-varying electromagnetic field which originates from a nuclear detonation."[21] It essentially spikes the affected electronics with an extremely high induced current that lasts only microseconds. There are also longer term, less intense effects depending on the burst yield, distance from the burst, and length of line exposed to the EMP (such as wires in a circuit or even as long as power lines connecting cities).[22] Ghose looks beyond the typical effects of heat, pressure, and radiation associated with a nuclear blast. "Electromagnetic pulse resulting from a nuclear detonation... is one of the most serious nuclear effects of concern to electronic and weapons systems…"[23]

Foster further clarifies how an EMP damages electronic systems as well as the scope of the effect of an EMP caused by a nuclear detonation. "(An) EMP will cover the wide geographic region within line of sight to the nuclear weapon."[24] A nuclear weapon detonated

around 400 kilometers over Chicago could affect electronics from Quebec to Dallas.[25] Damage from an EMP occurs in three forms: the first of which is:

> A free-field energy pulse with a rise-time measured in the range of a fraction of a billionth to a few billionths of a second. It is the 'electromagnetic shock' that disrupts or damages electronics-based control systems, sensors, communication systems, protective systems, computers, and similar devices. Its damage or functional disruption occurs essentially simultaneously over a very large area… The middle-time component covers roughly the same geographic area as the first component and is similar to lightning in its time-dependence, but is far more geographically widespread in its character and somewhat lower in amplitude… The most significant risk is synergistic, because the E2 component follows a small fraction of a second after the first component's insult, which has the ability to impair or destroy many protective and control features. The energy associated with the second component thus may be allowed to pass into and damage systems…. The final major component of EMP is a subsequent, slower-rising, longer-duration pulse that creates disruptive currents in long electricity transmission lines, resulting in damage to electrical supply and distribution systems connected to such lines. The sequence of E1, E2, and then E3 components of EMP is important because each can cause damage, and the later damage can be increased as a result of the earlier damage.[26]

In addition to the tangible damage an EMP causes, the threat of an EMP caused by a high altitude nuclear detonation has increased in the post-Cold War era. Damage from an EMP caused by nuclear weapons was not a priority during the Cold War since it was assumed that any nuclear conflict would be total in nature and physically destroy much of the hardware that would be affected by an EMP. During the Cold War, the use of a nuclear weapon in the atmosphere as an EMP would most likely result in massive nuclear retaliation. The danger now is that non-state actors with no national identities have less to fear than a nation upon which the U.S. could retaliate. This makes them more likely to use these types of weapons.[27]

In 2004, Representative Roscoe G. Bartlett discussed the implications of Foster's EMP report.

> Iran has conducted a number of flight tests of its Shahab III medium range missile, which have been described as failures by the Western media because the missiles did not complete their ballistic trajectories, but were deliberately exploded at high altitude. Iran has described these same flight tests as successful. Is the West misinterpreting Iran's purpose for these missile flight tests?[28]
>
> Rep. Bartlett goes on to explain the difficulty of determining the source of a ballistic missile launched from the sea. "EMP Commissioner Lowell Wood calls EMP attack a 'giant continental time machine' that would move us back more than a century in technology to the late 1800s."[29] The information on EMPs in these texts and reports clearly underscore the importance of preparation for these kinds of attacks. "America's technological superiority could be our Achilles' heel unless we pay attention to the EMP threat."[30]

As technology has progressed, the ability to deliver nuclear weapons has spread all over the world. Technology has also improved the yield of these weapons, increasing their destructive power and radius. Finally, the instability of regions

controlled or heavily influenced by non-state actors has decreased the effectiveness of older deterrence policies relying on massive retaliation.

Kinetic Threats

Kinetic threats to the EM spectrum are those that aim to physically destroy or disable hardware that either produces or collects EM energy. Prime targets for kinetic weapons are satellites or satellite ground stations. Air Force Gen. Howell M. Estes III, former Commander in Chief, North American Aerospace Defense Command and U.S. Space Command, had this to say to the Senate Armed Services Committee. "There are over 500 satellites in space today -- over 200 of those are U.S. satellites, about half of which are military. They are technical marvels, and we are critically dependent upon them both in peace and war."[31] To emphasize the threat to ground stations, even in sovereign territory, he states, "In addition, we have no capability to defend ourselves from a ballistic missile launched against North America."[32]

A report for the U.S. General Accounting Office (GAO) further outlines critical aspects of satellite systems.

> Satellites are vulnerable to various threats. Protecting satellite systems against these threats requires attention to (1) the satellite; (2) the satellite control ground stations, which perform tracking and control functions to ensure that satellites remain in the proper orbits and which monitor satellite performance; (3) the communications ground stations, which process the data being sent to and from satellites…[33]

Many other kinetic threats exist for a number of systems that utilize EM energy, but they are not as specialized as those with the capability to target satellites or satellite ground stations out of theater. Strategic kinetic threats to EM systems are currently limited to targeting satellites and satellite infrastructure. Satellite systems are expensive, difficult to operate, relatively unhardened, and are few in number. Striking just a few of these assets with kinetic weapons can have a much larger effect than targeting other, more plentiful but less critical EM systems.

Jamming

Minister of Communications and Informatics of Lithuania, Rimantas Pleikys, shares that the premier example of jamming EM signals on a wide scale was the Soviet's attempt to deny any "anti-Soviet" propaganda from transmissions such as Voice of America (VOA) and Radio Free Europe during the Cold War. "The scale and magnitude of this operation was unprecedented. Massive jamming of foreign radio broadcasts was initiated by the USSR in February of 1948. It was targeted at VOA and BBC Russian language broadcasts. Eventually jamming developed into a true monster, the greatest jamming network in the world."[34] Though this practice has ended in Russia and the Eastern European nations with the end of the Cold War, they still persist in other countries that use censorship as a form of control. "By the end

of 2003, the most active jamming countries are China, Cuba, Iran and Vietnam. The jamming emissions were also traced in North Korea, South Korea, Morocco, Saudi Arabia and Mianmar. Cuba and Iran are involved in satellite television jamming."[35]

As discussed before, satellites are prime targets to achieve EM disruption or denial. In Operation Iraqi Freedom, the Iraqi army used Global Positioning Satellite (GPS) jamming to disrupt the United States' ability to perform precision strikes. "U.S.-led forces have destroyed six devices being used in attempts to jam GPS signals during the fighting in Iraq, according to Air Force Major General Victor Renuart, Director of Operations at U.S. Central Command. The devices 'had no effect on us,' Renuart told reporters during a March 25 (2003) briefing in Qatar."[36] Though they failed completely, the concept of jamming on a theater wide scale emerged once again.

Jeremy Singer, a Space News staff writer, states that these lessons have not been lost and new technologies are being developed to secure these systems. "A new generation of satellites, dubbed GPS 3 and designed from the outset to be highly resistant to jamming, is tentatively slated to start launching around 2012."[37] The United States is very aware of the increasing technological capabilities of other countries and strives to maintain its advantage. "Countries like Russia and China probably have jamming equipment that is far more effective than the devices used by Iraq."[38]

Jamming can take many different forms, such as the use of lasers to blind electro-optical satellites. In response to Chinese testing just such a laser, Andrew Krepinevich of the Center for Strategic and Budgetary Assessments in Washington had this to say, "China's burgeoning anti-satellite capabilities are further evidence of Beijing's focused military strategy that aims not to engage the United States in direct confrontation, but through asymmetric means."[39] Once again, the strategic effect of denying the use of a powerful but limited resource has an undeniable strategic effect. "The United States operates three large optical reconnaissance satellites of the Keyhole-series by Lockheed Martin that were introduced some three decades ago. The loss of any of the three would prove a blow to U.S. space capabilities…"[40]

Jamming EM energy is an effective way to prevent or degrade the adversary's use of their technology. It has traditionally been used on a limited, tactical level, but has been proven to be effective on a near continental scale. Large scale jamming was utilized in Operation Iraqi Freedom, highlighting the threat. Jamming specific, high-value systems as China is attempting to do can have the same or even greater affect as the indiscriminate Soviet radio jamming. Through jamming, a country reduces the asymmetric technological advantage of another nation without

engaging the adversary in direct hostilities. The ability to jam with limited repercussions adds yet another element to strategic vulnerability.

Defending EM assets

Electronic Counter-Countermeasures (ECCM)

The majority of the threats to EM capabilities are forms of EM energy themselves. Using prosperities of the EM spectrum combined with technology, solutions for these threats can be produced. One example is spread spectrum technology. Spread spectrum technology is the process of using much more bandwidth than necessary to transmit data. "A sophisticated receiver processes the wide bandwidth RF signal to recover a much lower bandwidth version of the original signal, from which the desired data or audio information can then be efficiently extracted."[41] A paper produced by Lectrosonics, a company that specializes in audio and signal amplification, explains frequency hopping, one type of spread spectrum technology. "In the transmitter a frequency synthesizer is controlled by a microprocessor or a roughly equivalent controller device. The transmitter frequency is changed to a different pre-assigned channel several times per second ("hopped")."[42] A receiver and a transmitter programmed to "hop" at the same rate on the same frequencies are negligibly affected from one or even a band of frequencies being jammed.

EMP Hardening

Without going into the technical details of EMP hardening, it is sufficient to say that the means to do so are not overwhelmingly expensive. Foster states,

> The primary features of EMP attack mitigation in each infrastructure include elements of protection of critical functions, identifying where damage within the system is located, dispatch/allocation of resources to allow for timely restoration and development of operational procedures including simulation of both individual and interacting infrastructures, training, testing, and governance… New units can be EMP-hardened for a very small fraction of the cost of the non-hardened item, e.g., 1% to 3% of cost, if hardening is done at the time the unit is designed and manufactured.[43]

Using this information as an example, it is clear that ECCM strategies and technologies are not overlooked in system designs. Ever-evolving threats demand adaptation and the foresight to plan for the unknown. Prevention is not only more effective than remedying a situation, it is more cost effective.

BODY

The Impact of Electromagnetism on the Battlefield

The modern battlefield is long past the point where EM assets are considered revolutionary. In fact, they are not even a nicety anymore; they are a necessity. A military operating without EM assets will not be able to maintain the scope, speed, coordination, or discrimination expected on the modern conventional and unconventional battlefields.

Following is a list of EM capabilities at the commander's disposal: surface to surface data transfer, satellite data transfer, satellite imagery (full spectrum), ground based imagery, Identify Friend of Foe (IFF), GPS, target designation, Radio Detection and Ranging (RADAR) and radio navigation. Of course, the ability to use EM energy to deny all members of the previous list is included as well. This list alone is not all inclusive, and is a bit deceiving to one who does not understand the vast realm of just a single item. The uses of radar, for example, are so vast and varied the author could not hope to discuss them all.

Examination of each of these capabilities yields support for their importance and impact on the battlefield. For the purposes of this paper, data transfer (radio), unique satellite capabilities, IFF, and precision enablers (GPS, laser) will be discussed to show the broad scope of effects EM energy has on the battlefield.

Radio

Data transfer is a good place to start, as that is what the bulk of EM assets are designed to do. The term "data transfer" is used to describe all communication of information. Within this group, radio communication is the best known and most prominent type. Radio communication increases the scope of the battlefield and allows for near instantaneous communication. Constant communication permits military units to maintain coordination and organization, even on large scales.

Devereux reveals that radio communication, even in its infancy, had an enormous effect on the coordination of the battlefield. Navies were the first to utilize the technology on a large scale, providing the fleet the ability to communicate discreetly and in some ways, more reliably. From 1904-1918, the radio developed from a tactical nicety in the battle of Tsushima during the Russo-Japanese war to a strategic implement that brought about the stalemate of Jutland in WWI.[44]

On the ground, radio was implemented more slowly. This was likely due to the fact that there were more alternative means of communication as compared with the sea. However, eventually the radio found its way, along with mechanization, to the mobile warfare of the Blitzkrieg at the start of WWII. Without radio communication, the German army would not have been able to coordinate such an intricate attack over such a long distance in a short period of time to capture Paris. The German actions in WWI serve to highlight this point. Robert Doughty of the U.S. Military Academy points out that in WWI, even without the advantage of mechanized warfare, the German army had the opportunity to take Paris as a result of the success of the Schlieffen Plan. However, they stopped prematurely, a victim of their success, in fear they would be outflanked. By the time the order came to take Paris, it was

too late. Such was the beginning of trench warfare in WWI.[45] In WWII, it was not just the mobilization of the Blitzkrieg that allowed the Wehrmacht to take Paris; it was mobilization coupled with instant communication to issue the orders. This theme of communication developing along side other technologies is even more apparent in air power.

With the exception of the operations immediately around the airfield, aircraft are completely reliant on radio emissions for communication. Without radio, aircraft of the past and future would be able to do little more than strike preplanned targets or patrol an area and operate completely independent of the commander and one another. One cannot overemphasize the importance of the radio in air operations. Losing radio communication is effectively the same as losing many air capabilities.[46] Unlike being on the ground or at sea, the lack of radio would not just degrade communication, it would prevent it. The purpose of this paper is not to examine airpower per se, but it is important for the reader to understand that radio is essential in air operations. Air power redefines the scope and speed of warfare providing the ability to transcend the battlefield and strike anywhere. Similarly to the Wehrmacht, but to an exponentially greater degree, air forces only reach their full potential when they are able to communicate on both the tactical and strategic level.

These examples are from the infancy of radio, and are included for the express purpose of demonstrating radio's initial importance. Imagine how much has changed today. Even in the beginning, the ability to instantly communicate while remaining mobile radically shaped the battlefield. In modern warfare, the scope, speed, and coordination of the battle space has increased tremendously. The sheer magnitude of the impact of radio communication on the battlefield is almost unfathomable. Imagine if every message must be passed through carrier or some other visual or auditory signal. Communication with and among air forces becomes severely limited, and ground and naval units beyond the range of these signals are completely independent. The scope of the commander's control becomes heavily restricted. Though hard lines would exist, they could not be used in anything that resembles mobile warfare. Radio provides the ability to instantly communicate over extremely long ranges; an undeniable necessity in modern warfare.

Satellites

Satellite data transfer and imagery warrant a special place in EM warfare, as these systems operate in an EM specific environment and are particularly capable compared to terrestrial based counterparts. With only a few exceptions, gathering and transmitting EM data is the sole *raison d'être* for satellites. Satellites have a truly exceptional capability to collect information

that is unattainable from even the highest mountain. This capability has changed warfare along with the political environment in which it is fought. It is the strategic impact on warfare, not just as a part of warfare, which warrants special attention. In terms of information transfer, they are just highly capable data transfer devices. From up above, though, they see all; cutting through much of Clausewitz's fog and dramatically shaping the political environment.

Karen Litfin, a professor of political science at the University of Washington, gives an excellent explanation of this effect. Referring to what she calls the "Globalization of Transparency," satellite imagery has allowed nations to "peek" at one anther like never before. No large scale operation of any type can be hidden from the world.[47] The transparency, whether it is forced or welcomed, has had a stabilizing effect on the world as a whole. The ability to surprise an adversary is often a major factor when determining if a military action is worth the risk. This transparency has eliminated many opportunities for one nation to surprise another.

The reasons nations choose warfare has been significantly impacted by satellite technology. One could point to the loss of surprise as a mitigating affect on the effectiveness of war plans. Others would say the globalization of economies and information brought about by satellite communication makes war too expensive. Ideologically, some would even argue that satellites, through breathtaking imagery of our planet, have helped people to transcend the traditional political and cultural paradigms to a humanity-based approach. Whatever the stance, it is clear that "the ultimate high ground" has had a tremendous effect on society and warfare, all through the manipulation of EM energy.

IFF

The use of EM energy for Identify Friend or Foe (IFF) technology is quite remarkable. It allows the commander to polarize the battlefield and react to situations instantly without verification delay. Taken one step further, it will soon add to the commander's ability to have complete battle space awareness.

USAF Col (Ret) Kurt Dittmer describes how Blue Force tracking is a U.S. military concept designed to identify, designate, and track all forces on a battlefield. In its most developed form, it provides all friendly forces with IFF transmitters as well as the ability for them to provide information to a centralized command structure. The command element can then issue orders based on vast amounts of information.[48] It almost turns battle into a video game for the commander. With so much information, the adversary has little opportunity to exploit weakness, and could be overwhelmed by friendly forces' ability to mass and disperse with near instantaneous precision.

IFF and Blue Force Track-

ing systems use EM energy to galvanize the battlefield, reducing the risk of fratricide and streamlining force employment. It is an impressive and innovative way to use the informational capabilities of the EM spectrum and an excellent example of how information is becoming (has become?) more important than ammunition in warfare.

Precision

GPS and laser guided munitions provide unparalleled precision in modern warfare. Circular Error Probability (CEP), the probability that a munition will fall within a certain radius, is now measured in feet instead of miles. The effects of increased accuracy are obvious. Smaller payloads, increased efficiency, and less collateral damage are important, but not necessarily revolutionary. However, when a capability is developed that can change the force required to achieve an objective a thousandfold, one can only stand in awe at its power.

See Figure 2 in Diagrams

Figure 2 represents the number of aircraft and munitions necessary to destroy the same target over the evolution of air power. It really is quite astounding. The ability to do more with less is the result of a number of technologies from a multitude of fields. Though important, this evolution would not have been possible without the EM advancements in radar, navigation, and targeting. GPS and laser guided munitions can turn a thousand pound bomb into a surgical scalpel designed to completely destroy its target, and *only* its target.

Always remember, war is an extension of politics. No king, president, or despot retains any power without people. Though it is a democratic ideal, the people have always provided the power to any polity. History has proven people can shoulder the pains of war, but it is often not in the aggressor's best interests to inflict unnecessary suffering on an adversary's populous. Force applied with precision can mitigate damage and causalities, particularly in a world where military conflict has become urbanized. Precision aided by EM energy can even make military options viable, where they had not been before, due to collateral damage. Again, precision provides an example of how EM energy has affected warfare itself, not just its execution.

Though examples abound of how EM energy is used in warfare, these examples demonstrate the profound effect EM energy has *on* warfare. EM energy changes how wars are fought and even affects their ability to be waged. The tremendous effect of EM manipulation on warfare may justify a force or organization dedicated to its use. However, it often takes the loss of an asset before one realizes its true value. As important and influential as EM assets are, they are nonetheless vulnerable. If the importance of EM capabilities is not a persuasive argument for the creation of dedicated EM combat organiza-

tions, perhaps understanding their vulnerabilities will serve to make the case.

Vulnerability of EM assets

The means exist to disrupt, deny, and destroy many EM assets. The threat from Electromagnetic pulses is of special concern, as it presents a wide scale and powerful force unique to Electronic Warfare. Jamming, kinetic destruction, and interception are all liabilities to EM assets that must be understood and assessed if they are to be used to their full potential. Interception of communications, however, will not be discussed, as encryption concerns are not direct threats to the assets.

EMP

The Electromagnetic pulse is dangerous to EM assets due to its ability to destroy electronic circuits over a large area through non-kinetic means. Ghose discusses how the EMP generated from a nuclear detonation has the potential to destroy most unhardened electronic devices by inducing a current in the systems so strong it can physically destroy the electronic components. It is a Line of Sight (LOS) capability, so a high altitude detonation has the potential to have a continental impact.[50]

See Figure 3 in Diagrams

It is difficult to discern if the EM subset of Electronic Warfare is more or less vulnerable to an EMP than the non-EM electronic technology. On one hand, one could say that since EM assets are designed to transmit and receive EM energy, a "hole" exists, for lack of a better term, in any hardening that may have been applied. Since EM assets cannot be completely shielded from outside EM sources, they may be more vulnerable to the effects of an EMP. On the other hand, *since* EM assets are designed for accepting EM energy, the devices may be better able to handle the electronic shock. If EM assets are more vulnerable than their self-contained counterparts, a stronger argument for EM specific organizations, as opposed to the more general realm of Electronic Warfare, could be made.

Though this is the greatest threat to EM assets, there are ways to reduce the vulnerability to such an attack. Devices can be hardened to withstand the induced current from an EMP for a relatively low cost if it is done in the production phase.[52] Again, it is difficult to determine how much hardening is necessary without examining specific systems as well as the anticipated strength of the EMP. One generalization that can be made, however, is that satellite hardening will increase weight and launch costs, often making it an undesirable budgetary option. As satellites are especially vulnerable to such an attack, one must carefully assess the risk to capabilities made possible by satellites; perhaps a job for an EM organization.

Jamming

Jamming is the practice of using EM energy to interfere with a

device designed to receive a signal. This is typically accomplished by saturating the frequencies an adversary uses with a higher power signal, effectively drowning out the desired signals from being received. EM energy can be focused or dispersed. Unlike hardline communication, there is usually no single point from which an EM receiver is acquiring its information. The EM receiver, then, is susceptible to interference from the frequencies for which it was designed to receive. Focused EM energy, such as laser light, is difficult to interfere with, as systems utilizing laser transmissions typically operate over a relatively narrow spectrum and in a small area of space. Most EM assets, however, are designed to send and receive information over a wide LOS and a wide variety of frequencies. These assets are the most vulnerable to interference from other sources of EM radiation.

Localized jamming is defined as the interference of EM signals in a limited area over a narrow spectrum. There are numerous examples of nations using limited jamming capabilities to deny the use of an EM asset. Jim Garamone of American Force Press reported that in Operation Iraqi Freedom, off the shelf GPS jammers were used in an attempt to send GPS guided munitions off course.[53] Muradian describes how in 2006 the Chinese used a laser to temporarily blind a U.S. spy satellite passing over its country.[54] Again in 2006, according to Robert Waller of the Associated Press, military communication testing in Colorado inadvertently saturated the frequency used on common garage door openers, rendering them inoperative.[55]

Jamming over a large area for a large band of frequencies operates under the same principles as localized jamming, but has a greater, strategic effect. Admittedly, it is very difficult to achieve. It is limited by LOS considerations, but more importantly, power limitations. It takes an extraordinary amount of energy to create a jamming signal that is strong enough to interfere with systems over a large area over multiple frequencies. However, it has been done. Mr. Peleikys explains how, at the onset of the Cold War, the Soviet Union began jamming Western radio signals from entering Eastern Europe in an attempt to isolate their population from Western influence. While ultimately unsuccessful, it was the first example of blocking large swaths of the EM spectrum over a vast geographic area.[56] In the near future, with improved output, it is quite possible that the energy and technology will exist to effectively "blackout" large portions of the EM spectrum on a subcontinental scale.

Like EMP protection, means exist to reduce the effectiveness of jamming. The emitted jamming signal must be of the same frequency(ies) as the receiver to be effective. Frequency hopping is a technique that changes frequencies rapidly over a spectrum, so that the

adversary will not know what frequency is in use.[57] It takes a large amount of power to jam large frequency bands, making the practice very difficult. Should an adversary gain this capability, Anti-Radiation Missiles (ARMs) designed to track and destroy EM output devices would be perfect weapons to deal with the threat. Finally, to reduce the vulnerability, the receiver could simply be designed to be sensitive to a smaller portion of the EM spectrum, though that may degrade its effectiveness.

Physical Destruction

In many cases, it may be feasible to simply destroy high value EM assets rather than interfere with their operation. Again, satellites provide the most noteworthy example. According to a report by the GAO, Anti-Satellite (ASAT) weapons are not a new concept, and have been designed and tested as far back as the late 1950's. These weapons may also be armed with conventional or nuclear explosives and are not required to directly impact the target.[58] For example, recently, both the United States and China have displayed their ability to destroy Low Earth Orbit (LEO) satellites by ground and sea based missiles.

Commander John Klein of the U.S. Navy reveals how a nation wishing to act in a more subtle manner may follow the microsatellite route. Microsatellites may be designed to attach to larger satellites to disable or destroy them, or to push them out of their orbits, rendering them useless. Microsatellites may be launched discretely along with a legitimate payload to avoid detection, increasing the probability of success.[59]

Klein continues by conceding that while satellites are an important, costly, and soft asset, there are ways to mitigate their vulnerabilities. As satellite technology and launch costs fall, it may be possible to put many more in orbit, creating ample redundancy. Satellite hardening, whether it be from EM interference, microsatellites, or projectiles, may be more feasible in the near future as well. Currently, however, cost, weight, and technological limitations leave satellites extremely vulnerable.[60]

According to Klein, there are a number of viable targets that can drastically affect and even deny satellite capabilities. Satellite ground stations are necessary to collect the data transmitted from space. If struck, the satellite itself is worthless, as there is nowhere to send the data it collected. Launch sites are another limited asset that provide a static CoG for an adversary to strike. Launch facilities are large, complex, and difficult to build. Destroying these would greatly reduce a nation's ability to exploit space based EM assets in the near future.[61]

There are ways to reduce the threat to ground platforms. Ground stations need not be stationary. Mobile ground stations present a difficult target and are much easier to construct than satellites. More capable and important permanent

ground stations often reside deep within friendly territory. Intercontinental Ballistic Missile (ICBM), strategic airstrike, or sabotage are the only feasible ways to sever the link in this manner. The same applies for most launch sites.

EM vulnerabilities, coupled with the importance of the assets, present a clear case for the necessity of an "EM force." What remains, though, is a credible threat that is focused on the vulnerabilities. How other nations have treated EM assets in the past and present will greatly affect how the U.S. should treat them today and tomorrow.

An Adversary's View of EM Conflict

Both in the past and today, nations have placed great emphasis on the importance of denying EM usage by their adversaries. This is even more striking when one sees that these nations were and are competitors to the United States, namely the Soviet Union and China. Warfare is not a one-sided affair, and it is critical to consider howan actual potential adversary may choose to fight.

Russia

When the Cold War began, the Soviet Union faced a relatively new and influential threat from the West. Radio broadcasts, such as from Radio Free Europe and Voice of America, threatened the Soviets' hegemonic influence over their East European territories. In response, the Soviets initiated a massive jamming campaign, proving that such an act was possible over a geographically large area.

As the Cold War progressed, so did Soviet military doctrine. REC became a fundamental part of Soviet military strategy. Chizum states, "The general tenor of the Soviet articles on REC suggests that few major military decisions can now be made without considering REC as part of the picture… Marshal of the Soviet Union Kulikov, Commander in Chief of the Combined Forces of the Warsaw Pact… associated chemical, biological, and nuclear weapons with REC."[62]

These quotes epitomize the need to examine warfare through the adversary's eyes. Even in the post Soviet Era the ideology remains. According to Bartlett, during a 1999 trip to Vienna to reduce tensions between the United States and Russia over Operation Allied Force, Russian member of the Duma International Affairs Committee, Vladimir Lukin, and senior Communist Party member Aleksandr Shabonov had this to say to Representative Bartlett,

> 'If we really wanted to hurt you with no fear of retaliation, we would launch an SLBM [submarine launched ballistic missile] and detonate a single nuclear warhead at high altitude over the United States and shut down your power grid and communications for six months or so.' Shabonov added, 'and if one weapon wouldn't do it, we have some spares.'[63]

One mitigating force against the threat of EMPs is the political ramifications of the nuclear detonation. Foster notes it is highly unlikely a nation would risk the political fallout of such an action unless

already committed to total warfare. In today's globalized society, they would almost certainly do damage to their own economic and militaristic capabilities as well. However, the U.S. faces threats from more than just nation states. Non-state actors may choose the EMP as an effective weapon to use on a technologically dependant United States.[64]

China

In a Sun Tzu-like approach, the leaders of China's Peoples Liberation Army (PLA) have chosen information as their ammunition. Muradian notes that accounts of Chinese development in the broader arena of Information Warfare include the EM realm. The most prominent examples have been the recent shoot-down of a defunct weather satellite and an attempt to blind a U.S. optical satellite with a ground-based laser. Growing Chinese ASAT capabilities, both kinetic and non-kinetic, display their resolve to fight the type of technological modern warfare to which the U.S. has become accustomed.[65]

The Chinese have made clear efforts to achieve, or at least deny to others, technological superiority in modern warfare. In a 2005 report to Congress by the Secretary of Defense, it was stated that, "The PLA (People's Liberation Army) sees CNO (Computer Network Operations) as critical to seize the initiative and 'electromagnetic dominance' early in a conflict, and as a force multiplier."[66] To deal with the adversary's EM assets, The PLA, "…has imported both the Israeli-made HARPY UAV and Russian-made anti-radiation missiles. China's doctrine calls for seizing 'electromagnetic superiority' early in a conflict."[67] Finally, though the mitigating political circumstances may exist in some cultures,

> Some PLA theorists are aware of the electromagnetic effects of using a high-altitude nuclear burst to generate high-altitude electromagnetic pulse (HEMP), and might consider using HEMP as an unconventional attack, believing the United States and other nations would not interpret it as a use of force and as crossing the nuclear threshold.[68]

Recommendations

U.S. EM Warfare organizations should be as ubiquitous as the arena they operate in. Marine Radio Battalions, Air Force Electronic Intelligence (ELINT), and "Wild Weasel" organizations exist to deal with these issues, but are limited assets.[69] Using the logistics analogy once again, just as each military organization has its own logistics system, so should they have ready access to EM warfare capabilities designed to protect and attack EM assets. What level of access they should have is left up to debate, as it would require specific knowledge about the role of the organization in question.

There are many ways this could be achieved. Each service could develop their own EM Warfare units, or there could be a single entity for all services to use. Due to the ubiquitous nature of EM energy, a single organization may be the best solution. If the case for the necessity of EM forces has been made, then further study into what exactly the U.S. needs is a logical next step.

CONCLUSION

Summary

Is there evidence that the United States needs organizations dedicated to EM warfare? The content of this paper is quite broad, but is designed to show that the combination of the importance of EM assets, their vulnerabilities, and the will to strike them justifies and may even necessitate the creation of an "EM force." Radio has increased the speed and control of the battlefield allowing for an enormous scope of operations to take place with unity of effort. The efficacy of the radio in its infancy serves to underscore just how important it is today. Radio communication is vital to the modern Air Force, as it allows aircraft to exploit the vastness of their environment.

Satellites have changed the political environment, acting as a stabilizing effect on large nation states by eliminating much of the element of surprise necessary to win a military conflict. They also offer a unifying perspective for humanity dues to their truly global perspective. IFF capabilities galvanize the battlefield, further reducing the fog of war that is quickly dissipating in the EM era. Precision guided weaponry shapes the battlefield, providing a military option in urbanized conflict that may have not been previously available. It also allows for a level of efficiency that is unparalleled in the history of warfare.

These vital capabilities are vulnerable. All EM transmissions, especially omnidirectional ones, are susceptible to jamming. Jamming can be wide spread or localized, over a large or narrow band of frequencies. Jamming has been, and continues to be, practiced all over the world.

Since all EM assets require electronic technology, they are liable to the damaging effects of nuclear generated EMPs. EMPs are extraordinarily capable weapons and can all but eliminate electronic capabilities on a regional scale. Satellites are especially vulnerable, since an atmospheric nuclear blast may not face the same retaliation and political ramifications that were expected in the Cold War.

EM assets are also vulnerable to kinetic threats. Physical strikes on key terrestrial facilities may render some capabilities useless. Microsatellites and ASATs can target high demand, low availability assets, such as satellite constellations, as they are difficult to replace.

Lastly, U.S. competitors in the past and present have displayed the will to target these vulnerabilities.

The old Soviets, modern Russians, and Chinese have displayed their readiness to close the asymmetrical gap EM assets provide a technologically advanced military, such as the U.S., by assaulting the vulnerabilities to EM assets. Soviet radio jamming in the Cold War proved that it is possible to deny effective radio transmission over a geographically large area. Chinese satellite blinding with lasers displays an unconventional threat to orbiting assets, as do successful ASAT tests. Russian EMPs remain a credible threat due to the new, competitive political arena along with their massive stockpile of nuclear weapons available. Proliferation of nuclear weaponry may also allow non-state actors to strike U.S. interests. These are all examples of others' recognition of U.S. vulnerabilities.

Mitigating circumstances can lessen the vulnerabilities to some degree. Technological improvements and frequency hopping reduce the jamming threat, cheaper satellites provide redundancy to the system, cheap EMP hardening, and the political fallout of nuclear detonation all reduce the risk to EM assets.

Further Research

Due to the broad nature of this topic, there are a number of avenues available for further research. Each EM capability and vulnerability is worthy of independent in-depth study. Current U.S. EM Warfare capabilities could be analyzed to asses their effectiveness. Perhaps the most interesting direction to take this topic would be to evaluate the United States' ability to operate without EM assets. For example, if the U.S. was hit with an EMP or if a satellite constellation was lost, how would our forces be trained to fulfill their missions without these technologies? Just as the information EM assets provide is vital to the modern battlefield, so is the information necessary to properly align and orient a future EM force.

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ENDNOTES

[1] Tony Devereux. *Messenger Gods of Battle. (*London, United Kingdom: Brassey's, 1991), p. 17.

[2] Ibid. p. 18.

[3] Though they are not included, they do provide a visible example of what one would expect from an "EM force" since they do direct damage to the enemy. This role is still very different from how EM energy is used in an informational sense, which is another reason they are left out of the discussion.

[4] David G Chizum. *Soviet Radioelectronic Combat*. (Boulder, CO: Westview Press, 1985), p. 1.

[5] Jeremy Singer. "War in Iraq Boosts Case for More Jam Resistant GPS." Space News. 7 July 2005. http://www.space.com/spacenews/archive03/gpsarch_040703.html. accessed on 22 Oct. 2006.

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[8] Rabindra N Ghose. *EMP*

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[9] United States. U.S. Army Command and General Staff College. U.S. Army. *Electronic Warfare*.
Fort Leavenworth, KA: U.S. Army Command and General Staff College, 1975. p. 1-2.

[10] Ibid.

[11] Chizum, *Radioelectronic Combat,* p. 95-96.

[12] While the technology exists to generate a non-nuclear EMP, it is not highly accessible to the world and is not nearly as powerful as a nuclear generated one. If the U.S. is ever subject to an EMP attack, it will almost certainly be generated by a nuclear device.

[13] Chizum, *Radioelectronic Combat,* p. 61.

[14] Richard E Fitts, ed. *Strategy of Electromagnetic Conflict*. Vol. 1. Alexandria, VA: Defense Documentation Center, 1979. p. 3-6.

[14] John S Foster et al. *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*. U.S. House Armed Services Committee. 2004. http://www.globalsecurity.org/wmd/library/congress/2004_r/04-07-22emp.pdf. p. *v*. accessed on 11 Oct. 2006.

[15] Ibid p. 7.

[16] Ibid p. 1.

[17] Alfred Price. *War in the Fourth Dimension*. Mechanicsburg, PA: Stackpole Books, 2001. p. 239.

[18] Ibid p. 239.

[19] Ibid p. 204.

[20] Ghose, *EMP Environment,* p. 1.2.

[21] Ibid.

[22] Ibid.

[23] Foster, *EMP*, p. *v*.

[24] Ibid p. 7.

[25] Ibid p. 5-7.

[26] Ibid p. 2.

[27] Roscoe G Bartlett. "Military Information Technology Online Archives." Military Information Technology. 19 Nov. 2004. http://www.military-information-technology.com/article.cfm?DocID=639. accessed on 26 Sept. 2006.

[28] Ibid.

[29] Ibid.

[30] Estes, *Sustaining the Strategic Space Advantage*.

[31] Ibid.

[32] *Critical Infrastructure Protection: Commercial Satellite Security Should Be More Fully Addressed*. General Accounting Office. 2002. http://www.gao.gov/htext/d02781.html. accessed on 18 Oct. 2006.

[33] Rimantas Pleikys. "Radio Jamming in the Soviet Union, Poland, and Other East European Countries." 2003. http://www.radiojamming.info/. accessed on 22 Oct. 2006.

[34] Ibid.

[35] Ibid.

[36] Singer, "War in Iraq."

[37] Ibid.

[38] Muradian, "China Attempted to Blind U.S. Satellites."

[39] Ibid.

[40] "Spread Spectrum Technology." Lectrosonics. 4 Apr. 1996. http://www.lectrosonics.com/WPapers-Magazines/SpreadSpectrum/sstechnology.htm. accessed on 22 Oct. 2006

[41] Ibid.

[42] Ibid.

[43] Devereux, *Messenger Gods,* p. 43-44, 59.

[44] Robert A Doughety. Etc. *Warfare in the Western World.* Vol II. New York, NY: Houghton Mifflin, 2001. p. 523-553.

[45] It is extraordinarily difficult to imagine effective CAS, interdiction, strategic bombardment, air defense, etc. without the ability to communicate via radio. The enormous scope of the air environment would

render an Air Force without radio communication all but ineffective.

[46] Karen T Litfin. Ed. James N Rosenau. *Information Technologies and Global Politics.* Albany , NY: New York Press, 2002. p. 65-85.

[47] Kurt Dittmer. *Blue Force Tracking: A Subset of Combat Identification.* U.S. Army Combined Arms Center. Military Review Sep-Oct 2004. http://usacac.army.mil/cac/milreview/download/English/SepOct04/ditt.pdf. accessed on 30 Mar 2008.

[48] David A Deptula. *Effects Based Operations.* Aerospace Education Foundation. http://www.aef.org/pub/psbook.pdf. accessed on 30 Mar 2008. p.8.

[49] Ghose, *EMP Environment,* p. 1.2.

[50] Gary Smith. Testimony. "Electromagnetic Pulse Threats" Subcommittee on Military Research and Development. Committee on National Security, U.S. House of Representatives. 16 July, 1997.

[51] Lectrosonics, "Spread Spectrum."

[52] Jim Garamone. "CENTCOM Charts Operation Iraqi Freedom Progress." Defenselink. 25 Mar. 2003. http://www.defenselink.mil/news/newsarticle.aspx?id=29230. accessed on 3 Apr. 2008.

[53] Muradian, "Blind U.S. Satellites."

[54] Robert Weller. "Military Radios are Jamming Garage Doors." AAAremotes. 4 Dec. 2006. http://www.aaaremotes.com/airforcejams.html. accessed on 3 Apr. 2007.

[55] Pleikys, "Radio Jamming in the Soviet Union" (2003).

[56] Lectrosonics, "Spread Spectrum."

[57] General Accounting Office, *Critical Infrastructure Protection.*

[58] John J Klein. *Space Warfare.* New York, NY: Routledge, 2006. p.77.

[59] Ibid. p. 155-164.

[60] Ibid.

[61] Ibid. p. 44-45, 52.

[62] Bartlett. "Military Information Technology."

[63] Foster, *EMP,* p. 7.

[64] Muradian, "China Attempted to Blind U.S. Satellites"

[65] "The Military Power of the People's Republic of China." Report to Congress. Office of the Secretary of Defense. http://www.defenselink.mil/news/Jul2005/d20050719china.pdf . 2005. p.36. accessed on 3 Apr. 2008.

[66] Ibid. p. 30.

[67] Ibid p. 40.

[68] "Wild Weasels" is the traditional designation of the U.S. Air Force's Electronic Warfare squadron.

DIAGRAMS

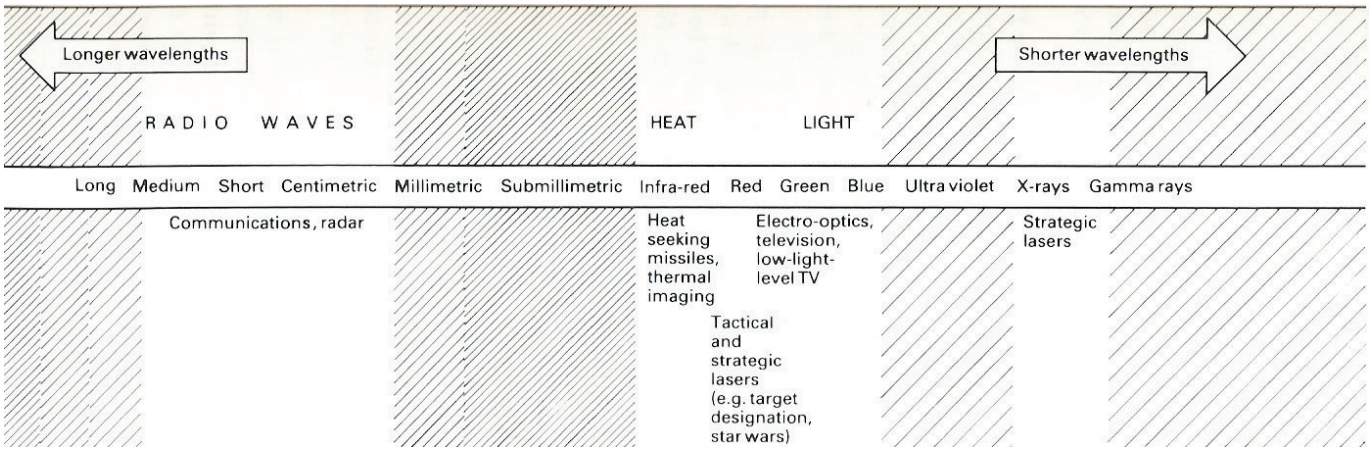
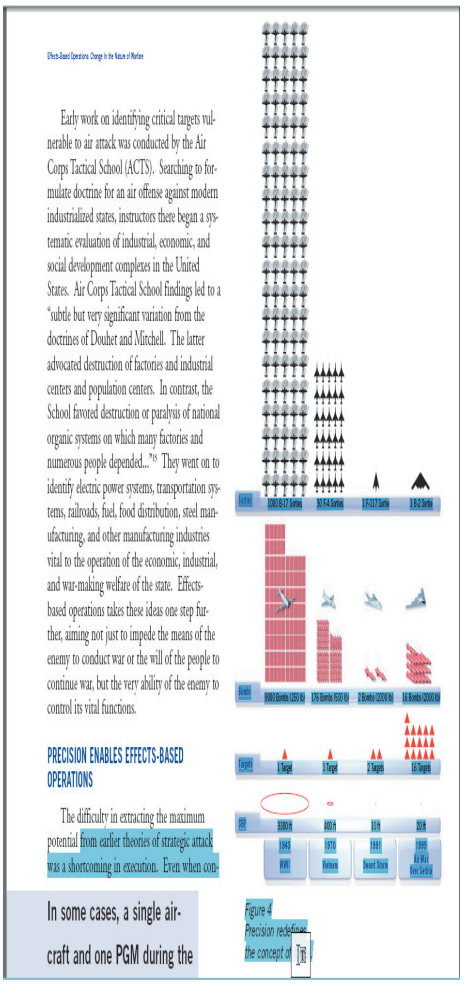


Figure 1-The Electromagnetic Spectrum[1]



Early work on identifying critical targets vulnerable to air attack was conducted by the Air Corps Tactical School (ACTS). Searching to formulate doctrine for an air offense against modern industrialized states, instructors there began a systematic evaluation of industrial, economic, and social development complexes in the United States. Air Corps Tactical School findings led to a "subtle but very significant variation from the doctrines of Douhet and Mitchell. The latter advocated destruction of factories and industrial centers and population centers. In contrast, the School favored destruction or paralysis of national organic systems on which many factories and numerous people depended..."[9] They went on to identify electric power systems, transportation systems, railroads, fuel, food distribution, steel manufacturing, and other manufacturing industries vital to the operation of the economic, industrial, and war-making welfare of the state. Effects-based operations takes these ideas one step further, aiming not just to impede the means of the enemy to conduct war or the will of the people to continue war, but the very ability of the enemy to control its vital functions.

PRECISION ENABLES EFFECTS-BASED OPERATIONS

The difficulty in extracting the maximum potential from earlier theories of strategic attack was a shortcoming in execution. Even when con-

In some cases, a single aircraft and one PGM during the

Figure 4
Precision redefines the concept of

Figure 2-Efficiency of Precision[49]

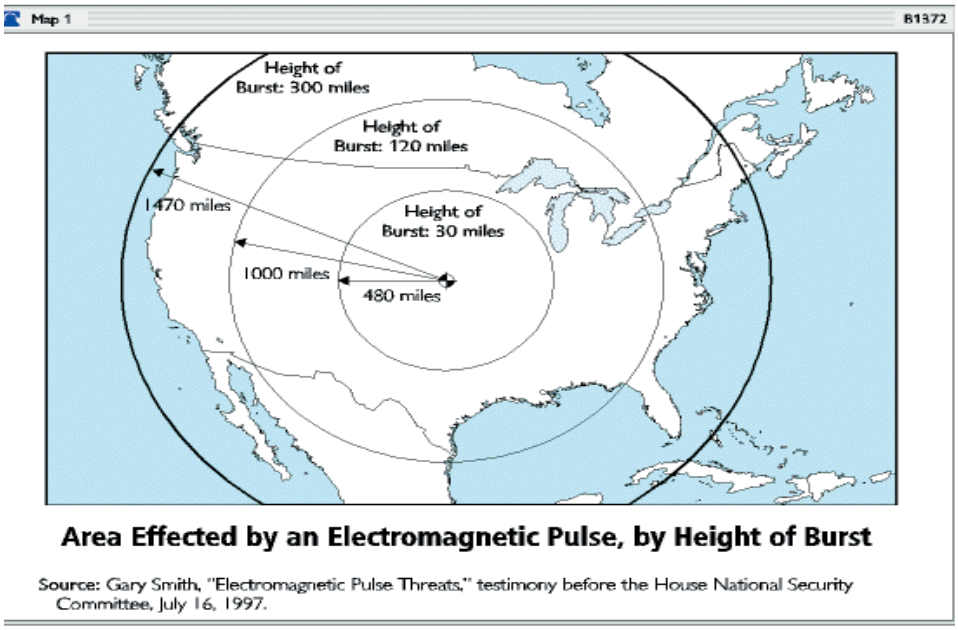


Figure 3-Affected Area of EMP Burst by Height[51]