

UNDERSTANDING CENTERS OF GRAVITY AND CRITICAL VULNERABILITIES

by

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Part 2: The CG-CC-CR-CV Construct: A Useful Tool to Understand and Analyze the Relationship between Centers of Gravity and their Critical Vulnerabilities

In Part 1 of this article, we explored what Clausewitz really meant by the term “center of gravity”. We established beyond doubt that he intended it to be a strength, either moral or physical, and a dynamic and powerful agent in its own right. We also suggested that the current Joint and NATO definition of center of gravity is incorrect, implying it to be a *source* of strength, and that this mis-definition has been responsible for much of the confusion about the concept that exists today.

In Part 2, we will examine the role of centers of gravity in operational design, look at the relationship between centers of gravity and critical vulnerabilities, and suggest an analytical model that joint warfighters and planners on both sides of the Atlantic can use to assist strategic and operational-level planning. The model helps to analyze existing and potential vulnerabilities of a center of gravity, and determine which of those could be especially critical.

Centers of Gravity and Operational Design

In every war, campaign, and battle in history one can normally (with the benefit of hindsight) identify a point where one side irrevocably started to win, and the other side to lose. In the 1940 battle for France it was the failure of French counterattacks against Guderian’s bridgeheads on the Meuse that was the decisive act, making defeat of the Allied armies in Belgium inevitable. In the Yom Kippur War of 1973 it was Sharon’s successful counterattack and crossing of the Suez Canal at Chinese Farm that doomed the Egyptian offensive. In the Battle of the Atlantic it was the closure of the mid-Atlantic “air gap” by long range Liberators in mid-1943 that proved decisive, finally ending

German U-boat surface operations and swinging the operational advantage to the Allies. The Russian counteroffensive at Stalingrad is a commonly cited turning point on the Eastern Front in World War II (although some historians argue that Hitler's war in Russia was not irretrievably lost until Kursk in 1943).

In each of these examples we can identify what Clausewitz described as a decisive act,¹ which effectively caused the culmination of the opponent. Put another way: "They cause a favorable change in the situation or cause the threat to change or to cease planned and current activities. ... Decisive actions create an environment in which the enemy has either lost the physical capability or the will to resist."² Once culmination has been reached, victory becomes impossible unless the enemy unaccountably lets his opponent off the hook. Decisive acts are rarely "silver bullets" – single actions that alone cause the culmination and defeat of an enemy. Usually they will be the result of a number of major operations that allow one side to force the culmination of the other. French defeat at Sedan in 1940 followed German operational deception in Belgium and the Netherlands. The closure of the mid-Atlantic air gap in 1943 was just one of a long series of tactical, intelligence, and technical developments in the war of attrition between U-boat and merchantmen. The successful Soviet encirclement at Stalingrad depended on months of urban fighting to draw German reserves into the city. In our doctrine we describe these actions that support the decisive action as shaping operations. "Shaping actions set conditions for decisive actions.... Shaping makes the enemy vulnerable to attack...and dictates the time and place for decisive actions."³

The essence of operational design lies in the identification of what's going to be decisive in a joint campaign, and an understanding of what shaping operations are needed to achieve that decisive action. This results from detailed analysis of factors such as force correlation, time and space, and the environment, coupled with an intuitive understanding of the effect your own operations are going to have on the enemy – in particular on his mind. We can describe this interplay between analysis and intuition in operational design as *operational art*.

We can now see the fundamental connection between operational art and the concept of center of gravity: the decisive operation, the act that causes the culmination of the enemy, is normally that which brings about the defeat of an enemy's operational or tactical center of gravity in a given campaign or military operation. Each of the examples of decisive action above involved the defeat of a center of gravity. In 1940 the Allied center of gravity was the Franco-British maneuver armies (as opposed to the Maginot Line armies) whose advance into Belgium enabled the German Panzer Group to encircle them in their rapid breakthrough to the Channel ports. The Egyptian center of gravity was their 3rd Army that was encircled following the Israeli crossing at Chinese Farm. In the Battle of the Atlantic the U-boat fleet was the German center of gravity, which was effectively neutralized after air control was established over the entire trans-Atlantic convoy route.

The Stalingrad debacle saw the complete destruction of the German Sixth Army and a significant portion of the Fourth Panzer Army. These two armies comprised one of

two German operational centers of gravity on the Eastern Front in 1942; the other was the First Panzer Army which was driving toward the Caucasus. The continuation of the German strategic offensive in Russia was dependant upon the existence and effectiveness of *both* of these centers of gravity. After Stalingrad, the remaining Panzer divisions (not involved in the Stalingrad debacle⁴) indeed constituted a potent operational center of gravity that may have enabled the Germans to sustain a successful strategic *defensive* posture in Russia. Fortunately, this remaining CG was misused and destroyed by Hitler in the subsequent Battle of Kursk, where he directed them to attack straight into the teeth of a series of powerful prepared defenses and increasingly capable Soviet operational armored reserves. After Kursk, the German Army was incapable of mounting even a successful strategic *defensive* in Russia.

In 1940 the defeat of the Franco-British maneuver armies led to the collapse of France, and in 1973 Egypt was defeated when her 3rd Army was encircled. But in World War II Germany did not surrender after Stalingrad, or after Kursk, or upon the defeat of her U-boats in 1943. Whether the defeat of a given center of gravity leads to the quick or inevitable culmination of *national* resistance, depends on the existence of remaining centers of gravity and the potential emergence or creation of new ones – physical or moral. More often, the culmination of *national* resistance occurs only after the cumulative physical and moral effect produced by defeating or neutralizing a series of physical or moral centers of gravity in multiple campaigns at various levels of wars.

Centers of gravity can exist at all levels of war – tactical, operational, strategic. But it is misleading to think of a single center of gravity existing at a particular level of war, as if each level is a discrete component rather than a continuum from small unit actions up to grand strategy. Indeed a center of gravity – both friendly and enemy – will exist for every level of command that's got a combat mission, regardless of whereabouts within the levels of warfare that unit and mission sit.

Table 1 shows the levels of war for Operation DESERT STORM in 1991, with example missions for Coalition forces at each level. For each mission there is a corresponding example enemy center of gravity with a short explanation as to why it is a center of gravity.

LEVELS OF WAR AND IRAQI CENTERS OF GRAVITY 1991

<i>Level of War</i>	<i>Coalition example missions</i>	<i>Example opposing Iraq CG</i>	<i>Why it's a CG</i>
(a)	(b)	(c)	(d)
Strategic Level			
• National Policy →	Restore the legitimate Government of Kuwait.	Saddam Hussein	Can maintain popular support and direct the Iraqi Army to hold Kuwait against international condemnation and coercion.
• Theater Strategy →	Defeat the Iraqi Army south of Euphrates.	Iraqi Army	Can defend occupied Kuwait against Coalition attack.
Operational Level			
• Campaigns →	Isolate and encircle the Iraqi Army in Kuwait.	Republican Guard	Can prevent encirclement of Iraqi Army defending Kuwait.
• Major Operations →	Cut communications from Baghdad to Kuwait.	Iraqi integrated air defence system	Can prevent freedom of action of Coalition air through high attrition of allied aircraft.
Tactical Level			
• Battles →	Penetrate the Iraqi defences along the Saudi border.	Iraqi 12 th Corps	Can prevent VII Corps penetration of Iraqi linear defences using fixed defensive positions.
• Engagements →	Defeat Tawakalna Division on 73 Easting.	Tawakalna Division reserve Tank battalion.	Can counter attack and defeat elements of VII Corps attacking Tawakalna Division.
• Small unit actions →	Breach element of Iraqi defensive line.	Iraqi defensive bunker complex.	Can defeat breaching attempt through use of direct fire weapons.

Table 1: Levels of war and Iraqi Centers of Gravity 1991 ⁵

Note that at the operational level, the Joint Task Force Commander has identified a campaign center of gravity, the Republican Guard, but there can also exist (at a lower operational level) major operations for which other centers of gravity must be defeated. The example shows the JFACC mission to cut communications from Baghdad – still at the operational level – is achievable once the Iraqi integrated air defence system has been defeated.

Similarly, at the tactical level, the three examples are example missions for VII Corps, a division, and a brigade respectively – each with a different enemy center of gravity to overcome.

So it is too simplistic to suggest that there can be, for example, only one operational level center of gravity. There may indeed be only one *campaign* center of gravity, but there are likely to be several more at lower operational levels. And at the tactical level there will be multitudes of centers of gravity. So care needs to be taken

when using terms like “strategic” or “operational” centers of gravity. Levels of warfare are not discrete or independent, but are a useful means of dividing and defining a continuum of warfare. Centers of gravity should be treated in the same way.

We have already seen that Clausewitz intended the center of gravity to be a strength. Indeed all the examples of centers of gravity above are strengths – panzer divisions, the Franco-British maneuver armies, the Egyptian 3rd Army, the U-boat fleet, and all of the Iraqi centers of gravity depicted in Table 1 above. Some people have seen a contradiction here with our maneuverist doctrine, which calls for us to avoid strength and attack weakness. As we have already seen in Part 1 of this article, there have even been calls for us to define centers of gravity as critical vulnerabilities instead of the strengths that Clausewitz so clearly described.

The way through this impasse comes from recognition that even strengths have critical vulnerabilities. At Stalingrad it was German dependence on the ill-equipped Rumanian, Italian and Hungarian divisions to protect the flanks of the German Sixth Army and Fourth Panzer Army. At Kursk it was the inability of Panzer divisions to overwhelm fixed defences in depth. In 1940 France it was weakness of the Meuse defences on the Franco-British armies’ right flank. In Yom Kippur it was the inability of the Egyptian armed forces to adapt to rapidly changing circumstances. In the Battle of the Atlantic it was the U-boats’ lack of submerged range and speed that caused a dramatic drop off in effectiveness, once they were stopped from surface operations by long range Liberators. These are all critical vulnerabilities, exploited to defeat centers of gravity.

So, experienced practitioners of the operational art aim to identify the enemy’s center of gravity and its critical vulnerabilities, then concentrate superior combat power to exploit those critical vulnerabilities, thereby forcing the enemy’s culmination and so achieve decisive success. We have already in Part 1 looked at categorization of centers of gravity. Now we can apply the same approach to critical vulnerabilities.

Critical Vulnerabilities – Heels, Ships, and Battering Rams

Thetis the goddess took her son Achilles and dipped him in the River Styx, to make him immortal. The current was so fast she was forced to hold him by the heel, which remained untouched by the magic waters. So by the heel alone could Achilles be wounded by ordinary mortals.

Ancient Greek Legend

A strength, like Achilles, may have a weakness *within* it. Some intrinsic quality may be vulnerable to attack, causing its downfall. In the Greek legend of the Trojan Wars, Achilles was feared by the entire army of Troy: an invincible warrior in all but one respect – his heel, the only part of him that was vulnerable.

But a Critical Vulnerability may also be *external*. Achilles’ ship may have been blown off course, never arriving at Troy. Or he may have needed some other part of the Greek army – perhaps a battering ram to break down the gates of Troy so he could get

inside and slaughter the Trojan army⁶. A failure of the battering ram would have foiled Achilles' aim of slaughtering the Trojans. So although in Greek legend Achilles was doubtless a center of gravity – an (almost) invincible warrior – he could have been made irrelevant by being unable to join the decisive action: perhaps because of a poorly navigated ship. Or, alternatively, he might not have been able to use his strength because of someone else's failure, maybe the inability of the battering ram crew to do their job. Either might have been critical vulnerabilities that could have rendered Achilles ineffective. And both are *external* critical vulnerabilities.

So when we look for Critical Vulnerabilities in our Center of Gravity Analysis, we need to look at intrinsic vulnerabilities (Achilles Heels); external vulnerabilities that might prevent a center of gravity ever getting to the battle (like Achilles' ship); and also the vulnerabilities of other forces relied on by the center of gravity (such as the battering ram). So there are three principal ways of defeating or neutralizing a center of gravity – and these are the areas we need to search for vulnerabilities.

Method 1: Make the Center of Gravity irrelevant. (If you're a Trojan, try not to let Achilles' ship land at Troy.) As an example, in 1944 an elaborate Allied deception campaign froze the German Fifteenth Army in the Pas de Calais, where it was unable to reinforce the German Seventh Army in the battle for Normandy until it was too late. The Fifteenth Army was a German operational center of gravity that was made irrelevant through the use of deception.

Method 2: Strip the Center of Gravity of the support it needs to be successful. (If Achilles turns up at Troy, stop those who will let him into your city. Shoot the crew of the battering ram.) In 1940 the German Army waited to invade Britain (Operation Sea Lion). But the German Air Force was unable to defeat the Royal Air Force in the Battle of Britain, and the Royal Navy stood ready to intercept the motley array of German transports and landing craft that would have carried the German Army across the English Channel. Thus the German Army, a powerful center of gravity, was effectively neutralized.

Method 3: Defeat the Center of Gravity by exploiting systemic weaknesses. (If you have to fight Achilles, aim your arrows at his heel.) During the Battle of Atlantic, German U-boats were vulnerable to Anti-Submarine Warfare (ASW) technologies and capabilities of both short-range and long-range aircraft. Very Long Range aircraft carried a combination of airborne radar, bombs and depth charges, and powerful search lights to light up and attack surfaced U-boats at night, exploiting the systemic weaknesses of the German U-boat fleet (another German center of gravity).

These examples show that vulnerabilities may be technical, or geographic, or in the mind. There may also be inequality in some element of combat power, or vulnerability in a national psyche, or some way of waging war. The list of potential vulnerabilities is endless. What in some cases may be a strength may in others be a weakness: Adolf Hitler's obsessive tendencies may have been a strength in 1939-40, but became a severe weakness once the tide of war turned. But of all the possible

vulnerabilities, there is one factor that turns up more than any other – time. Many centers of gravity (especially *physical* ones) have vulnerabilities that are transient. Achilles may only expose his heel for an instant; be quick with your bow.

Center of Gravity Analysis: a Model

We have explored the importance of the concept of center of gravity to operational design, and exposed the areas in which we need to look for critical vulnerabilities. By using accurate analysis of centers of gravity, we can recognize what is going to be decisive in an operation, and what shaping operations are necessary to make it happen. Here we offer a model that permits insightful analysis of centers of gravity, using four inter-related concepts:

- Centers of Gravity.
- Critical Capabilities.
- Critical Requirements.
- Critical Vulnerabilities.

In our model we define each of these concepts below.

Centers of Gravity (CG) are physical or moral entities that are the primary components of physical or moral strength, power and resistance. **They don't just contribute to strength; they ARE the strength.** They offer resistance. They strike effective (or heavy) physical or moral blows. At the strategic level, they are usually leaders and populations determined to prevail. At operational and tactical levels they are almost invariably specific military forces.

Critical Capabilities (CC): every center of gravity has some primary ability (or abilities) that makes it a center of gravity in the context of a given scenario, situation or mission – including phases within campaigns or operations. Mostly simply stated: what can this center of gravity do to you that puts great fear (or concern) into your heart in the context of your mission and level of war? Within a critical capability, the key word is the verb: it can *destroy* something, or *seize* an objective, or *prevent* you from achieving a mission.

Critical Requirements (CR) are conditions, resources and means that are essential for a center of gravity to achieve its critical capability. Examples are:

- Good weather, precise intelligence, fuel and ammo re-supply, chemical gear, ability to go 35mph across open desert for 6 hours.
- Force X must accomplish its mission as a precondition before force Y can accomplish its mission.
- A robust sea train for a warfighting fleet operating long periods at sea.
- Political leader Y needs no less than X% popular support.

- International support for a given U.S. military operation to provide political credibility, regardless of overwhelming U.S. military superiority over country Y.

Critical Vulnerabilities (CV) are those critical requirements, or components thereof, that are deficient, or vulnerable to neutralization or defeat in a way that will contribute to a center of gravity failing to achieve its critical capability. The lesser the risk and cost, the better. Critical vulnerabilities may, unusually, be of the silver-bullet type: so if success can be achieved by focusing on just a single vulnerable critical requirement, then that's great! An example might be where one precisely targeted cruise missile destroys the enemy leadership and results in an immediate end to conflict. More typically, critical vulnerabilities are of the lead-bullet type; where final success can only be achieved by focusing on a combination of vulnerable critical requirements that can be neutralized, interdicted or attacked simultaneously or sequentially. Here it is the *cumulative* effect that produces decisive results. This involves seeking a series of successive battlefield advantages that will lead to the unbalancing and eventual culmination of the enemy, with or without a final dramatic decisive act.

Below is an example of the center of gravity analysis model used on the Battle of the Atlantic 1942-1944, based on the definitions above. Start with the CG box, shift right to the CC box, then jump down to the CR box on the left, then right to the CV box.

The Battle of the Atlantic 1942-44 – German Center of Gravity Analysis

<p>German CG German U-boat fleet.</p>	<p>CC</p> <ul style="list-style-type: none"> • Overwhelm Allied ASW warships during prolonged convoy battles. • Sink Allied merchant shipping faster than it can be replaced (target: 700,000 tons per month) to deprive UK of minimal level of imports necessary to sustain life and industry. • Disrupt/retard passage of US military personnel and equipment to UK.
<p>CR</p> <ul style="list-style-type: none"> • Achieve an operational strength of 250 U-boats (stipulated by Admiral Dönitz). • Intelligence re convoy locations: <ul style="list-style-type: none"> - long-range German reconnaissance aircraft (Condor FW 200), - breaking Allied maritime codes. <p>(continued on next page)</p>	<p>CV</p> <ul style="list-style-type: none"> • IF U-boat attrition exceeds U-boat production. • IF Allies employ counter FW 200 operations. • IF Allies change code settings frequently or adopt an unbreakable code system. <p>(continued on next page)</p>

The Battle of the Atlantic 1942-44 – German Center of Gravity Analysis (continued)

<p>German CG German U-boat fleet.</p>	<p>CC See above.</p>
<p>CR</p> <ul style="list-style-type: none"> • Centralized control (from land): <ul style="list-style-type: none"> - heavy U-boat radio transmissions to land HQ, - secure radio C2 system for HQ direction of wolf packs to convoy intercept locations. • At-sea logistics to extend range and time at sea, and effectiveness, per sortie by use of <i>Milch</i> cow U-boats. • Ability of U-boats to use their greater surface speed to: <ul style="list-style-type: none"> - maneuver faster operationally to intercept reported convoys, - engage, race ahead, then re-engage an intercepted convoy, - fight more effectively at night. • Manage U-boat attrition to: <ul style="list-style-type: none"> - reach goal of 250 U-boats, - maintain skill level of expanding U-boat fleet. • Maintain tactical advantage over convoy ASW escorts, so U-boats can: <ul style="list-style-type: none"> - sink more merchant ships, - survive convoy battles. • Maintain technological advantages re C2 and weapons systems: <ul style="list-style-type: none"> - code system, - stealth, torpedo and propulsion technology. • No ‘all-out’ U.S. production of merchant ships (and faster ones at that) and ASW warships. 	<p>CV</p> <ul style="list-style-type: none"> • U-boat locations compromised by traditional RDF techniques. • IF Allies break ENIGMA code system. • Re-supply rendezvous points comprised by breaking ENIGMA code. • <i>Milch</i> cows and other U-boats are very vulnerable to air attack while on the surface during re-supply procedures. • Future Allied employment of long-range aircraft and convoy escort carriers could force U-boats to remain submerged in daylight, both operationally and tactically. • IF new merchant ships have faster speeds. • IF Allies develop more effective radar capabilities. • IF U-boat attrition exceeds production. • IF too many of the small number of bolder, more successful U-boat commanders are lost. • IF quantities and qualities of convoy ASW escorts out paces corresponding U-boat quantities and qualities. • Allied electronic and technological advances may out pace German developments. • German electric U-boats, etc., may be too late. • A timely U.S. decision to produce massive quantities of new and faster merchant ships, and ASW warships.

Here (above) we have selected as the German center of gravity their U-boat fleet. It is a definite physical strength – from the Allied perspective it struck heavy and terrible blows throughout 1942 and into the spring of 1943 in a strategic attempt to interdict the Allied sea lines of communication to England.⁷ According to Prime Minister Winston Churchill the only thing that ‘kept him awake at night’ during the war was the U-boats – the possibility that some electronic, code breaking, or U-boat-weapon-system development might occur that would give them a decisive edge in the ‘Battle of the Atlantic’. The reason why the U-boats were a center of gravity is reflected in their critical capabilities: from 1940 right through to the middle of 1942 they *sank* Allied merchantmen faster than they could be replaced and periodically overwhelmed escorting convoy warships in ferocious multi-day convoy battles (even as late as March 1943). As late as April 1943 they threatened at the very least to seriously delay the buildup of U.S. divisions and supplies for Operation OVERLORD.⁸

The critical requirements (CRs) state seven major conditions for the U-boat center of gravity to be effective, i.e., to achieve its critical capabilities: sufficient operational mass, convoy intelligence, effective centralized control from land, operational and tactical conditions permitting them to use their superior surface speed, a tactical edge over convoy ASW escorts (surface and air), the maintenance of technological advantages in C2 and the U-boat as an effective weapons-system, and no all-out American production decision to build massive amounts of merchant ships and ASW warships. For each critical requirement there are a combination of ‘known existing’ and ‘probable, possible, and potential’ critical vulnerabilities that might contribute to failure of the center of gravity. Note that the Germans could attempt to ‘achieve’ or at least influence the first six of these CRs, but that they could not ‘achieve’ or influence the last CR which was solely up to the Americans.

The Center of Gravity Analysis Model used as a Forward-Planning Analytical Tool.

Now let’s take a look at the Battle of the Atlantic from the Allied perspective. It will be readily obvious that the CG-CC-CR-CV model works effectively as a Monday-morning, after-the-fact, why-did-the-Allies-win (or the Germans-lose) analytical tool. But more importantly, we wish to emphasize now (as well as later below) that it also works as a forward looking/planning analytical tool. All one needs to do is to **conduct two side-by-side** CG-CV analyses, one for the **enemy** CG and another for the **friendly** CG. In **both** cases, make a list of all relevant critical requirements associated with the friendly or enemy center(s) of gravity and its associated critical capabilities (CCs), and then opposite each CR list all related critical vulnerabilities (CVs) – known, probable and possible. A central point here is that the analysis above for the U-boats could just as well have been prepared by the Allies as by the Germans! Conversely, the analysis below on “Allied naval and maritime air forces operating in the Atlantic region” could be a German or an Allied product. But for now, let’s assume that we are Allied planners conducting a friendly CG analysis. See the chart below.

The Battle of the Atlantic 1942-44 – Allied Centers of Gravity Analysis

<p>Allied CGs</p> <p>(#1) US/UK Strategic Bombers based in the UK.</p> <p>(#2) Allied naval and maritime air forces operating in the Atlantic region.</p>	<p>CC Generally stated:</p> <ul style="list-style-type: none"> • (Strategic) <i>Prevent</i> Germans from sinking Allied shipping faster than it can be replaced (strategic). • (Strategic/operational) <i>Suppress</i> activity and offensive potential of U-boats in order to: <ul style="list-style-type: none"> - (1st) sustain a minimal level of imports to the UK. - (2nd) enable the passage of US military personnel and equipment for a major cross-Channel invasion. • (Tactical) (For CG #1:) Destroy/retard U-boat production in Germany, and destroy/disrupt U-boat logistic bases in France via bombing raids. (For CG #2:) Destroy/suppress U-boats in convoy engagements.
<p>CRs for #1 continued next chart</p>	<p>CVs for #1 continued next chart</p>

The Battle of the Atlantic 1942-44 – Allied Center of Gravity Analysis

CG # 1: US/UK Strategic Bombers based in the UK.

<p>Allied CG #1</p> <p>#1: US/UK Strategic Bombers based in the UK.</p>	<p>CC</p> <ul style="list-style-type: none"> • Delay German ability to achieve effective operational mass of U-boats via heavy bombardment of the sources of U-boat production in Germany. • Interdict logistic sustainment of U-boat operations via heavy bombardment of U-boat pens in France.
<p>CR</p> <ul style="list-style-type: none"> • Intelligence regarding U-boat production facilities in Germany and U-boat pens in France. • Effective and sustained bombing of U-boat production facilities. • Effective and sustained bombing of U-boat pens in France. • A <i>timely</i> victory over the U-boat menace. 	<p>CV</p> <ul style="list-style-type: none"> • (No CV here. Intelligence was not the problem. See below.) • Hardened final assembly facilities. • Poor bombing accuracy in 1942-43. • Number of available bombers overall and other bombing priorities, precludes a <i>sustained</i> bombing effort against this target set. • Pens are <i>exceptionally</i> hardened targets. • Poor bombing accuracy in 1942-43. • Number of available bombers overall and other bombing priorities, precludes a <i>sustained</i> bombing effort against this target set. • An effective solution via strategic bombing could take two years, and even then ????

The CVs listed above for Allied CG #1 would/should/did indicate to Allied leaders and planners that reliance on strategic bombers is/was a dead horse given the urgency of a *timely* victory over the U-boats.⁹ They would therefore view, and turn to, Allied CG #2 as the horse that would have to win the race in the anti-U-boat campaign. In sequential order they would: first, analyze the current and potential capabilities (CCs) of that horse. Second, determine what was necessary (CRs) to makes its potential critical capabilities (CCs) real and mitigate its actual and potential weaknesses (CVs). Finally, they would establish priorities regarding R&D, production programs and schedules, and available human and physical resources.

The Battle of the Atlantic 1942-44 – Allied Center of Gravity Analysis

CG # 2: Allied Naval and Maritime Air Forces operating in the Atlantic region.

<p>Allied CG Allied naval and maritime air forces operating in the Atlantic region</p>	<p>CC</p> <ul style="list-style-type: none"> • <i>Prevent</i> Germans from sinking Allied shipping faster than it can be replaced. • <i>Suppress</i> activity and offensive potential of U-boats – operationally and tactically – to enable the passage of US military personnel and equipment, and to sustain a minimal level of imports to UK.
<p>CR</p> <ul style="list-style-type: none"> • Interdiction of U-boat at-sea re-supply from: <ul style="list-style-type: none"> - surface cargo ships, - <i>Milch</i> cow U-boats. • Convoy avoidance of U-boats when possible to reduce overall shipping losses and stresses/strains on available ASW warships and crews: <ul style="list-style-type: none"> - an intelligence advantage for re-routing convoys around wolf packs. <p>(continued next page)</p>	<p>CV</p> <ul style="list-style-type: none"> • <i>Milch</i> cow U-boats are hard to detect and intercept <i>without</i> decoded radio intercepts that reveal their precise re-supply rendezvous points. • Possible changes to Enigma system if Germans realize British cryptographic capability. • Possible changes to Enigma system if Germans realize British cryptographic capability. <p>(continued next page)</p>

The Battle of the Atlantic 1942-44 – Allied Center of Gravity Analysis

CG # 2: Allied Naval and Maritime Air Forces operating in the Atlantic region (continued)

<p>Allied CG Allied naval and maritime air forces operating in the Atlantic region</p>	<p>CC</p> <ul style="list-style-type: none"> • <i>Prevent</i> Germans from sinking Allied shipping faster than it can be replaced. • <i>Suppress</i> activity and offensive potential of U-boats to enable the passage of US military personnel & equipment and to sustain a minimal level of imports to UK.
<p>CR</p> <ul style="list-style-type: none"> • Convoy protection by ASW warships when convoy re-routing is not possible, to protect convoys and increase attrition of U-boats so they are unable to reach a ‘critical mass’: <ul style="list-style-type: none"> - increase in ASW warships and experienced crews. - ASW hunter-killer surface groups to augment attrition of U-boats engaged but then left behind by convoy-bound ASW escorts. - small ‘jeep’ aircraft carriers for convoy defense. <p>⇒ decision to build more ASW warships, incl. ‘jeep’ carriers, and to commit them to the Atlantic.</p> <ul style="list-style-type: none"> - increase in ASW technological and tactical advantages over U-boats. <p>⇒ decision to augment technological and tactical R&D.</p> <ul style="list-style-type: none"> • More use of medium-range land-based aircraft: <p>⇒ decision to allocate more this type aircraft and aircrew for ASW.</p> <p>(continued next page)</p>	<p>CV</p> <ul style="list-style-type: none"> • Ugly force ratios when a wolf pack or two does engage a convoy. • Increases in German submarine production may swing attritional balance. <ul style="list-style-type: none"> • Failure to envision growth of U-boat fleet/menace. • Deployment of too many ASW ships to the Pacific. <ul style="list-style-type: none"> • IF conversion of ships to ‘jeep’ carriers is given too low a priority. (Or, IF USN demands their use in the Pacific.) • IF no decision to build in 1942 huge # DDs and DEs that will become operational in 1943. • IF Germans achieve some unexpected dramatic breakthrough, such as development of silent, speedy electric U-boats; or break Allied radio codes. <ul style="list-style-type: none"> • Resistance from US/UK army and air commanders in UK and Africa to the diversion of more of these assets to anti-U-boat operations. <p>(continued next page)</p>

CG # 2: Allied Naval and Maritime Air Forces operating in the Atlantic region (continued)

CR	CV
<ul style="list-style-type: none"> • Eliminate the ‘air gap’ using long-range aircraft and ‘jeep’ carriers to force U-boats to operate submerged, thereby limiting their operational ability to maneuver, and forcing them to adopt to ever more risky tactics when attacking convoys. <p>⇒ decision to allocate more VLR (very long range) aircraft and train more aircrew for ASW in the Atlantic.</p> <p>All of the above CRs seek to achieve battlefield advantages that will lead to eventual culmination of the U-boat fleet.</p>	<ul style="list-style-type: none"> • Resistance from US/UK bomber ‘barons’ and US Navy to the diversion of these assets from CBO and Pacific war. (Service parochialism; inter-service rivalry.)

Here (above) we have selected as the Allied center of gravity their naval and maritime air forces. They are a definite physical strength – from the German perspective they struck heavy and effective blows against the U-boat fleet, and they resisted German attempts to interdict the Allied sea lines of communication. The reason why the Allied naval and maritime air forces are a center of gravity is reflected in the critical capabilities: collectively they can *suppress* U-boat activity, *prevent* the Germans from sinking Allied shipping faster than it could be replaced, and *enable* the safe and timely passage across the Atlantic of millions of American soldiers and millions of tons of cargo for Operation OVERLORD in June 1944.

The critical requirements state four major conditions that needed to be achieved for the center of gravity to be effective, i.e., to achieve its critical capabilities: interdiction of U-boat logistical operations; convoy avoidance of U-boats when possible; convoy protection when engaged by wolf-packs; and use of more land-based medium- and especially long-range aircraft to compel the U-boats to operate submerged operationally and tactically or else take increasingly deadly risks. As per the German U-boat analysis, for each critical requirement there is a combination of known/existing, and probable, possible or potential critical vulnerabilities that might contribute to failure of the center of gravity.

Regarding the Allied CRs, none of them *by themselves* would be considered ‘silver-bullets’ against related German U-boat CVs. But it is (and was) fairly easy to discern that Allied breakthroughs in code breaking and especially airborne radar

electronics *coupled with* an American decision to commit large numbers of long-range (B-24) aircraft to the battle/campaign would prove decisive in the campaign. This combination of CRs clearly would deprive the U-boats of their operational freedom of maneuver, and compel them either to accept deadly risks in future convoy battles or to concede the battle.

Analyses of enemy and friendly CGs, such as depicted in all of the above charts for the Battle of the Atlantic, will give leaders and their staffs at all levels of war a much better ability to determine what is going to be decisive in a given campaign. They can then begin to envision what shaping operations will be required to enable it to succeed. In other words, they can develop their campaign plans based on their enemy and friendly centers of gravity analysis.

Developing a Joint Campaign Plan.

A joint campaign can be defined as a series of military operations that work together in a joint environment to achieve a strategic or operational objective within a given time and space.¹⁰ A campaign thus consists of a series of joint objectives achieved by maritime, land, air, and other components working together in pursuit of the common strategic objective. These joint objectives comprise the Decisive Action (or Act) and the shaping operations that allow that Decisive Action to succeed.

Our model for center of gravity analysis allows us to determine what is going to be decisive in defeating or neutralizing an enemy center of gravity, and points us to which critical vulnerabilities to exploit on the way. Therefore, many of the joint objectives that make up a campaign can be derived from center of gravity analysis.

In the following section we will show how center of gravity analysis can be used to develop a joint campaign plan, using the Battle of the Atlantic as an example.

BATTLE OF THE ATLANTIC

At this point a CG-CC-CR-CV analysis of the German U-boat fleet would surely include the following two sets of CRs and their corresponding CVs, for example:

CR: Torpedo, fuel and food at sea re-supply to extend range and time at sea per sortie.

CV: (1) Allies have broken codes used in German radio communications to co-ordinate rendezvous times and location, and therefore,
(2) German re-supply submarines (*Milch* cows) are now highly vulnerable to long-range air attack.

CR: U-boats need to use their faster speed on the surface, day and night, both to intercept convoys upon receipt of their course and speed via radio, and to keep up with a convoy in a multi-day running engagement.

CV: Closing the mid-Atlantic air-gap by VLR aircraft equipped with radar and flood lights (Leigh lights) forced U-boats to submerge much of the time, day and night

- severely restricting their speed and range, thus reducing significantly their operational and tactical effectiveness.

Because these two CVs (possibly among others) become apparent when we do an enemy CG Analysis, critical components of our campaign plan will be to compel them to operate submerged as much as possible, day and night, and to attack U-boat re-supply assets. Moreover, we can craft our joint objectives to attack enemy CVs while simultaneously achieving our own CRs.

Potential Joint Objectives:

From an analysis of our own CRs and enemy CVs, we can develop a series of potential joint objectives that are effects-based – i.e., a series of tasks whose success is measurable, and whose purpose ties them into the overall campaign plan. Examples regarding Allied campaign planning in the Battle of the Atlantic might include:

- Jt Obj 1. Avoid wolf packs through intelligence-directed convoy re-routing, in order to neutralize this German CG.
- Jt Obj 2. Enhance close-in tactical protection of convoys via reinforced convoy escorts, surface hunter-killer groups, electronic ASW enhancements, and improved depth-charge weapons and techniques to reduce merchant shipping casualties and increase attrition of U-boats.
- Jt Obj 3. Achieve air control over as much of the convoy routes as possible in order to reduce U-boat threat outside the mid-Atlantic air gap.
- Jt Obj 4. Close the mid-Atlantic air gap in order to force U-boats to operate submerged, day and night.
- Jt Obj 5. Attrit *Kriegsmarine* (German Navy) C2, intelligence, re-supply, and support facilities, in order to reduce German ability to deploy, control, and sustain U-boats at sea. (Jt Obj 5 could in fact appear in any order on this list.)

In the historical case, upon reaching the conclusion that bombing U-boat assembly facilities in Germany and U-boat pens along the French Atlantic coast was not a viable anti-U-boat strategy, Allied strategic leaders confronted the following questions/decisions:

- (1) What was the threat potential from the U-boat fleet?
- (2) How many millions of tons of merchant shipping should be built in 1942 and 1943?
- (3) How many ASW warships should be built, when, and what type?
- (4) What priority of effort should be given to code-breaking and code-protecting operations?
- (5) Should the allocation of medium-range, and especially very long-range (B-24) aircraft be reviewed?
- (6) And most importantly, what priority should be given to winning the ‘Battle of the Atlantic’ in the context of Anglo-American World War II coalition strategy?

Although American and British strategic and operational leaders obviously did not use the CG-CC-CR-CV process as developed in this essay, they did have a practical appreciation of strengths and weaknesses which guided them in their analysis and decision-making process. In attempting to measure the potential of the U-boat menace and what it would take to master it, they ultimately came round to taking no chances. This led to a series of decisions that worked synergistically to win the Atlantic campaign: to produce millions of tons of new and faster merchant shipping in 1942 and 1943, millions more than the Germans could hope to sink;¹¹ to produce and have operational in 1943 hundreds of new and deadly Destroyer Escorts,¹² and a growing number of hastily-converted 'jeep' escort aircraft carriers; to redouble Anglo-American code-breaking and code-protecting efforts – which resulted in breaking the German Enigma system, while the Allies took measures to change/protect their own codes (unlike the Germans who arrogantly assumed their system was 'unbreakable'); and to press ahead with all manner of radar R&D which resulted in improved ship-borne and even airborne radars which the U-boats could not match. Most importantly, all of these activities were given added stimulus when, at the Casablanca Conference in February 1943, the Anglo-American political and military leaders made winning the Battle of Atlantic their highest strategic priority. That decision led them finally to commit American long-range B-24 bomber aircraft to suppressing U-boat surface operations in the remaining North Atlantic 'air gap'. Many historians cite this as the final decisive act that led to the dramatic Allied victory over the U-boats in May 1943. In fact, it was the overwhelming synergistic effect of multiple Allied assets (CRs) working together that led to the destruction of over 40 U-boats in a single month and Admiral Dönitz's decision to withdraw his U-boat fleet from the Atlantic, hopefully in order to fight again another day.

Centers of Gravity analysis and the CG-CC-CR-CV model applies to any conflict or situation.

The center of gravity - critical vulnerability concept and the CG-CC-CR-CV analysis model presented herein can be readily applied to any conflict. During the first Persian Gulf War in 1991, Iraqi centers of gravity included, among others, Saddam Hussein (strategic/moral), the Iraqi integrated air defense system (IADS) (operational), the Republican Guard (operational), and in some cases heavy concentrations of Iraqi artillery units (tactical). The U.S.-Coalition air and ground forces defeated each one of these Iraqi CGs because each was seriously weakened by numerous critical vulnerabilities. The CVs of the Iraqi IADS when confronted by the high-tech, electronic, and stealth capabilities of the US Air Force are widely known, and pertained to an even greater degree during the recent 2003 Iraqi War. In 1991, once the Iraqi IADS was neutralized, U.S.-Coalition air forces declared open season on Iraqi ground forces – decimating key artillery units and front-line Iraqi conscript units that already suffered from shabby equipment; lack of food, water, medical and sanitation facilities; and poor morale. All of these were critical vulnerabilities of the front-line Iraqi units including their dependence on the Iraqi IADS to keep U.S.-Coalition air forces at bay. In 1991, and to an even greater degree in 2003, the Republican Guard divisions suffered from numerous critical vulnerabilities. They were, for example, vulnerable to air attack, blinded by the absence/destruction of friendly reconnaissance assets, and unable to 'see'

through smoke and haze in contrast to American tank gunners with infrared sights. Highlights among Saddam Hussein's critical vulnerabilities in 1991 would include the will of President Bush (Sr.), Saddam's expectations of Arab support, and his dependence on his military forces to at least inflict serious casualties on U.S.-Coalition air and ground forces. In the end, Saddam Hussein's military forces were ignominiously driven out of Kuwait or died there because of a plethora of critical vulnerabilities of which U.S.-Coalition campaign planners took skilful and full advantage. You don't kill ten (or twenty?) thousand of your enemy and suffer remarkably few friendly casualties without possessing impressive centers of gravity and without the enemy's centers of gravity being riddled with one or more or many serious critical vulnerabilities.¹³ The same goes for the 2003 Iraq War.¹⁴

In the war in Afghanistan after 9/11 the Taliban military forces were defeated by an American center of gravity that Taliban soldiers often did not even see. American cooperation with the Northern Alliance compelled the Taliban forces to hold ground in fixed positions – a critical requirement for them that was soon transformed into a deadly critical vulnerability. U.S. Special Operations forces simply painted targets that could be obliterated by precision munitions dropped from B-52s or bat-like aircraft flying at very high altitudes. The Taliban had no defense of any kind against such firepower and capabilities. *In this case*, the Northern Alliance and U.S. Special Operations Forces functioned as a critical requirement in support of the U.S. Air Force center of gravity.

Consider also two relatively simple CG-CC-CR-CV charts relating to enemy and friendly centers of gravity in the war against terrorism post 9/11 focused on al Qaeda and President Bush (Sr.). Drawn up quickly ten days after 9/11, they show no pithy details or brilliant insights.¹⁵ But they do illustrate that a simple CG-CC-CR-CV chart can be used to capture and convey basic concepts fundamental to any strategic or operational situation. Simple and early charts such as these can serve as useful points of departure for more detailed CG analysis as required. (See below.)

War Against Terrorism, Post 9/11

Center of Gravity Analysis

= Strategic Endstate: “a significant reduction in the threat posed to Western democracies by extremist Middle Eastern terrorist groups”.

Enemy Center of Gravity Analysis

<p>CG Enemy Middle Eastern terror groups centered on al Qaeda.</p>	<p>CC Force the withdrawal of the USA from the Middle East through persistent terrorist attacks against US targets, thereby creating the conditions where extremist groups can topple moderate Middle East regimes.</p>
<p>CR</p> <ul style="list-style-type: none"> • Secure bases for training, logistic support, command. • Continuing recruitment of committed followers for the long war: <ul style="list-style-type: none"> ○ The Cause – the Arab-Israeli conflict, ○ Transmit the Message. • Charismatic leadership. • Financial backing to position and sustain long-term “sleepers” in Western states. • Technological know-how to develop and use weapons of mass destruction – to force the eventual ending of the West’s will to win. 	<p>CV</p> <ul style="list-style-type: none"> • Bases need host nations, upon whom military, diplomatic, and economic pressure can be mounted. • A resolution of the Arab-Israeli conflict will remove the most potent Cause for recruitment. • Majority of Muslims world-wide are moderate, thereby isolating extremists in most societies and limiting spread of the Message. • Charismatic leaders can be found and removed from influence – although care to avoid martyrdom. • Worldwide financial network and movement of money can now be monitored through advanced IT, potentially identifying terror groups’ sources of funds. • Limiting flow of know-how to developing nations will make leakage of technology and materials to terror groups more difficult.

War Against Terrorism, Post 9/11

Center of Gravity Analysis

= Strategic Endstate: “a significant reduction in the threat posed to Western democracies by extremist Middle Eastern terrorist groups”.

Friendly Center of Gravity Analysis

<p>CG Friendly The President of the USA.</p>	<p>CC Lead a concerted and sustained campaign to defeat the extremist Middle Eastern terror groups.</p>
<p>CR</p> <ul style="list-style-type: none"> • Committed support of the US population (and therefore Congress) for the long war. • Excellent intelligence on terror groups organizations, personalities, and intentions. • Bases in the Middle East and Central Asia from which military and other operations can be mounted. • Worldwide support for US actions to give legitimacy to any military action, increase diplomatic pressure on host states, and ensure international application of anti-terror measures. 	<p>CV</p> <ul style="list-style-type: none"> • Possible loss of interest if lack of observable activity over a long period. • Possible reaction against campaign if mass casualties mount over time. • Lack of HUMINT within terror organizations. Shortcomings of technical intelligence in this form of conflict. • Depends on support of Russia and Islamic states – which are vulnerable to criticism of US pro-Israeli bias. • Such support may ebb in the long term as narrow national interests begin to re-emerge.

In Conclusion:

Centers of Gravity should not be confused with characteristics, capabilities and locations.

Centers of gravity are not “characteristics, capabilities and locations”. They are instead physical or moral entities that strike effective blows in operations and campaigns designed to defeat enemy centers of gravity. Obviously, centers of gravity must possess certain characteristics and capabilities, otherwise they would indeed not be centers of gravity. In some cases a center of gravity may also have to operate in a given

location/terrain to have a reasonable expectation of accomplishing its mission. Characteristics, capabilities and locations are critical requirements (CRs) for a given center of gravity, and they should not be confused with actual centers of gravity. Take for example the case of Betio/Tawara in November 1943. The Japanese center of gravity on Betio was Shibasaki's 2600 elite Japanese naval marines, reinforced with numerous attached light artillery and automatic weapons units. An essential characteristic was that they were elite, fanatical, and well-trained troops. An essential capability was their ability to direct all manner of devastating artillery and automatic weapons fire into predictable approach lanes used by invaders in an amphibious assault. Location was also an essential factor: the difficulty of Betio's natural approaches as governed by the surrounding coral reef and dodging tides, and the small size of the island itself made it impossible for an attacker to land on an undefended beach or flank.

**Apples and leaves,
and
Centers of Gravity and Critical Requirements**

Apples share the following characteristics:

- they grow on trees;
- they grow on branches, and branches of branches;
- they are biodegradable; and
- they are a fruit.

Leaves are not apples even though they share three of these characteristics.

Now consider a list of seven descriptors on the left below that are commonly used in defining and describing centers of gravity. Apply these descriptors to the four generic entities on the left: a port whose possession is absolutely vital for the logistics sustainment of a given campaign; a C2/C3/or C4 system that is essential for a complex scheme of maneuver and co-ordination; the will to fight; and the primary ground combat formation – let's call it the 7th Corps – not supported by robust air or naval forces.

Descriptors:	Port	C2/C3/C4 System	Will to Fight	7th Corps
- it is essential;	X	X	X	X
- a dominant characteristic;	X	X	X	X
- every thing depends on it;	X	X	X	X
- hub of all power and movement;	X	X	X	X
- an effective target for a blow;	X	X	X	X
- offers resistance; and	-	-	-	X
- strikes effective or heavy blows.	-	-	-	X

Regarding the concept and definition of a center of gravity, support for all seven of the above descriptors can be found in selected sentences and passages in *On War*. Yet, the essential questions are: (1) 'Must a candidate for center of gravity meet **all**, and not just some, of the above descriptors?' And (2) 'Are some of these descriptors more

central to a holistic Clausewitzian concept of a center of gravity (physical or moral) than others, and if so, which are they?’

Our answer to both questions is ‘Yes’. Let’s consider the second question first. “Fruit” is a more central descriptor of an apple compared to a leaf than the other three descriptors we listed. Based on our discussion in Part I of this essay, it seems equally logical and obvious that the last two of the seven descriptors (resistance & strikes) are more central (or key or specific) to the concept of a Clausewitzian center of gravity than the first five. (But if we did not convince you in Part 1, we will not repeat the attempt here.) Regarding the first question, the ‘7th Corps’ as the primary instrument of resistance and the primary means of striking an effective blow also automatically conforms to the other five descriptors. That is, it is automatically *ipso facto* an essential component and a dominant characteristic of friendly strength. Of course everything would depend on it and it would be the hub of all power and movement. And because it offers resistance and strikes effective blows, it is therefore both an obvious and an effective target for a direct or indirect blow. Therefore, our ‘yes’ answer to the first question is based on the observation that all of the other five descriptors “will” automatically apply given the latter two, thus pre-empting whether they “must” also apply.

The bottom line is that any concept and definition of a center of gravity based on some or all of **just the first five** of the above descriptors is bound to be fundamentally flawed and untrue to Clausewitz’s original holistic concept of a center of gravity. Finally, the port, C2-4 system, and the will to fight listed above are clearly critical requirements (CRs) necessary for the 7th Corps to function as a center of gravity. Critical requirements (CRs) are no less essential than their supported center of gravity – that is why they are called ‘critical’ requirements. Because CRs, too, are critical, it is logical and not surprising that the first five entries on our list of descriptors (above) apply to them. And, it is therefore also not surprising that in the past what are in fact critical requirements (CRs) have frequently been confused with centers of gravity.

And finally,

Centers of Gravity and Critical Vulnerabilities are not a single entity.

By now it is obvious that centers of gravity and critical vulnerabilities are not a single entity, and that they are two separate though closely related concepts. Therefore, the possible absence of critical vulnerabilities does not mean *ipso facto* the absence of a center of gravity. Assuming for the moment, for example, that there were no critical vulnerabilities in the Japanese defenses on Betio enabling the Marines to take the island without suffering horrendous casualties, that does not mean there was no Japanese center of gravity on Betio.¹⁶ In fact, just the opposite! Eleven hundred dead United States Marines should be sufficient evidence that there was a very real Japanese center of gravity on Betio – capable of fierce resistance and striking terrible blows – and that centers of gravity are no myth.¹⁷

End

End Notes

¹ Clausewitz "Guide to Tactics" paras 156-188a, p 269-273, translated by Colonel J J Graham, 2nd edition, Kegan Paul, Trench, Troebner & Co, 1911.

² MCWP 5-1, Marine Corps Planning Process, Chapter 2: 'Mission Analysis,' pp 2-9.

³ MCWP 5-1, pp 2-9.

⁴ Including those transferred to Russia from the West during and after Stalingrad.

⁵ Based on levels of war Figure 2-3 in US Army *FM 3-00*.

⁶ Of course, according to legend, the Greeks used a wooden horse to get inside the walls of Troy, but by then Achilles was already dead, undone by an arrow shot into his Achilles Heel.

⁷ This was the case long after the British had sunk, damaged or neutralized the major elements of the German surface fleet, which, according to German hopes and Allied fears, had the potential to assist the U-boats as a supporting CG had the surface ships themselves not been an early victim of their own CVs.

⁸ When examining the flow of U.S. troops and cargo to the U.K. in from January 1943 to May 1944, there was a marked increase in June 1943 and the really heavy flow did not begin until October 1943, with a flood of troops and cargo arriving during the four months before D-Day in June 1944. The point here is not that the U.S. had much more to send before June 1943, but to ponder what might have been, had the U-boats not been so dramatically and decisively beaten in May 1943. For U.S. troop and cargo flow to the UK see Roland G. Ruppenthal, *Logistical Support of the Armies*, Vol I: *May 1941 – September 1944 (United States Army in World War II, The European Theater of Operations)*, OCMH, Dept. of the Army, 1953, four tables on pp 129, 135, 232 and 237.

⁹ See above for discussion of trans-Atlantic shipment of U.S. personnel and cargo from July 1943 to May 1944 for Operation OVERLORD.

¹⁰ See definition of "campaign" and "4. The Campaign," in [U.S.] *Joint Pub 3-0, Doctrine for Joint Operations*, 1 February 1995, pp GL-3, and III-4 and -5.

¹¹ For an excellent discussion of shipping production versus the U-boats' ability to sink ships, see Marc Milner, "The Battle of the Atlantic," *The Journal of Strategic Studies* (Special Issue: *Decisive Campaigns of the Second World War II*, ed. by John Gooch) March 1990, Vol. 13, No. 1, pp 45-66

¹² Three hundred and six were produced in 1943. See Alan Gropman, *Mobilizing U.S. Industry in World War II*, McNair Paper 50, INSS, National Defense University, August 1996, p 96.

¹³ It is disingenuous to argue, as does Colonel Mark Cancian, USMCR, ("Centers of Gravity Are a Myth," U.S. Naval Institute *Proceedings*, September 1998, pp 30-34) that all attacks directed against Iraqi critical vulnerabilities during Operation Desert Storm "failed in their ultimate objective, to change the nature of the regime." "Nothing we did," Cancian contends, "forced Saddam out of power or made him change his basic attitudes." (Cancian, p 31.) It is very convenient for an essayist critical of CGs and CVs to focus on an unstated objective, instead of the clearly- and often-stated U.N. Coalition objective of liberating Kuwait. The latter was indeed accomplished, and with so few casualties that military pundits immediately contended that Operation Desert Storm would be a very hard act to follow by future commanders in conflicts of a similar magnitude and scale. In fact, the amazingly low friendly casualties resulted from a masterly identification and exploitation of Iraqi critical vulnerabilities relative to expulsion of the Iraqi Army from Kuwait.

¹⁴ A revised third edition (forthcoming likely at the end of 2004 with Colonel Iron as co-editor) of Dr. Strange's *Centers of Gravity & Critical Vulnerabilities: Building on the Clausewitzian Foundation So That We Can All Speak the Same Language* (1996) will contain separate chapters with numerous charts regarding the 1991 PG War, Kosovo conflict, 2001 War in Afghanistan, 2003 Iraq War, and the War vs. al Qaeda since 9/11.

¹⁵ E-mail, Colonel Iron to Dr. Strange, 20 September 2001.

¹⁶ Colonel Mark Cancian contends that the absence of critical vulnerabilities in the Japanese defense of Betio, and in implied countless other historical examples, proves that centers of gravity themselves are a myth. He therefore cites and refers to the concept of 'centers and gravity and critical vulnerabilities' as a singular entity. See Cancian, *op. cit.*

¹⁷ For a contrary view see Cancian, *op. cit.* [And, just because there *may* have been no critical vulnerabilities in the Japanese tactical defense of Betio, that does not mean that none existed at the operational level when looking at the Gilbert Islands as a whole. Our forthcoming revised 3rd edition of *Centers of Gravity: Building ...*, referred to in footnote # 14, will contain a chapter on Betio/Tarawa that

illustrates the existence of CVs in the Japanese defense of Betio in particular and of the Gilberts in general, which American planners in 1943 failed to appreciate for a variety of reasons, to include a few questionable assumptions.]