

SUN TZU AND WISDOM ABOUT MILITARY ROBOTICS

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To provide a **framework** for examining the advantages of integrated military robotics, we use paraphrased excerpts from *Sun Tzu on the Art of War*, the oldest extant military treatise in the world, translated from the Chinese by Lionel Giles in 1910. The treatise is divided into sections, each section containing about two or three dozen or more maxims. These sections are:

- Laying Plans
- Waging War
- Attack By Stratagem
- Tactical Dispositions
- Energy
- Weak Points And Strong
- Maneuvering
- Variation In Tactics
- The Army On The March
- Terrain
- The Nine Situations
- The Attack By Fire
- The Use Of Spies

We accompany each selected excerpt (in italics) with our explanation (i.e., our own commentary) of the relevance of 21st century integrated military robotics - systems of systems - to Sun Tzu's ancient (about 2,400 years old) observations on warfare.

* *Sun Tzu said: The art of war is of vital importance to the state.*

Comment: While the **nature of warfare** is changing rapidly with upheavals in the geopolitical landscape and advances in technology, human nature and proclivities change hardly at all. In the coming century society will still engage in war, whether or not the nation state and Clausewitzian warfare devolve, in a kind of "back to the future," into warlords, terrorists, and tribal warfare. Or much of the world (Europe, Asia) might evolve into aggregated super states to rival the U.S. Nevertheless, the U.S. will continue to exist for the foreseeable as a nation state, a "hyperpower," which must be prepared, politically and militarily, to engage in a broad spectrum of conflicts. For the reasons we outlined in the previous discussion of "need," integrated robotic combat systems will be essential for the U.S. to maintain its ability to engage in the "art of war" - to maintain its position as the world's premier nation - throughout the 21st century.

**The art of war, then, is governed by five constant factors, to be taken into account in one's deliberations, when seeking to determine the conditions obtaining in the field. These are: (1) the Moral Law; (2) Heaven; (3) Earth; (4) the Commander; (5) Method and Discipline.*

Comment: Sun Tzu's "**Moral Law**" causes the people to be in accord with their ruler, so they will follow him regardless of their lives, undismayed by any danger. But the **moral law of warfare** is evolving rapidly. Unless the homeland is directly threatened, citizens no longer tolerate the draft, putting themselves in danger, nor casualties in their professional armed forces, especially when engaged in distant, obscure conflicts. Yet intervention in otherwise obscure conflicts may be a moral imperative, to stop "ethnic cleansing" or another holocaust. Robotic systems will allow for **moral intervention** in just causes with minimal friendly casualties. Morality in warfare is also being elevated through the implementation of international law governing warfare and the creation of tribunals to enforce international law. The international community is taking war crimes seriously. The death of civilian populations will be examined more closely in the future, regardless of the righteousness of the cause against a depraved governance of those civilians. Civil and military leaders might be held accountable for even accidental civilian deaths in an enemy country, whereas now they may be held accountable for war crimes only if civilians are intentionally targeted or suffer collateral casualties due to gross negligence by the attacking forces. Robotic systems, in the air and on the ground, can provide accurate information about the distribution of enemy forces - even guerrilla forces attempting to blend into the civilian population, and precisely target enemy forces while **minimizing civilian casualties**. If employed properly and humanely, robotic systems can **satisfy the increased expectations of morality in warfare**.

Sun Tzu's "**Heaven**" signifies **day and night, cold and heat, times and seasons**, i.e., the ability to engage in combat anytime anywhere. Robotic systems do not become fatigued, nor do they require sleep or normal biorhythms, nor do they become too cold or hot to function. They do not suffer from seasonal affective disorder. They do not need "three hots and a cot." Properly designed, they can fight anytime anywhere, "24-7."

Sun Tzu's "**Earth**" comprises **distances, great and small; danger and security; open ground and narrow passes; and the chances of life and death**. Properly designed, Unmanned Air Vehicles (UAVs) can cover greater distances - and stay aloft for a longer time - than manned aircraft. And without the need to comfort occupants, Unmanned Ground Vehicles (UGVs) should also be able to travel further and endure longer in a campaign. Robotic vehicles can cover great distances, or micro robotic vehicles can cover small distances in tactically unique ways. Robotic combat vehicles can be more survivable than manned vehicles (for reasons we discussed previously), or they can be expendable in accomplishing the mission. They can face danger without fear and perfect willingness to sacrifice themselves if necessary. They can select the ideal terrain to accomplish the mission, without regard for personal safety or comfort. They can **assume whatever risk is necessary** and appropriate to accomplish the mission, without untoward focus on their chances of life or death.

Sun Tzu's "**Commander**" stands for the virtues of **wisdom, sincerity, benevolence, courage, and strictness**. It will take a different sort of commander to command robotic forces. But the

humane attributes a commander should possess, such as wisdom, sincerity, benevolence, and courage, are easier for him to reveal when he can avoid the psychological devastation of causing heavy casualties among his troops. He can afford to be benevolent to the enemy when they cannot inflict casualties. Vicious cycles of escalating violence - of attack and revenge - can be avoided or ameliorated with robotic forces.

Sun Tzu's "**Method and Discipline**" involves the **marshaling** of the army in its proper subdivisions and the control of **military expenditures**, among other considerations. The "proper subdivisions" of a robotic army will differ from that of conventional forces: tactics, strategy, doctrine, and the order of battle must be shaped to fit the new technology and capabilities. The "marshaling of the army" will be faster and simpler, with robotic systems lightweight and easily transportable - or pre-positioned in storage bunkers and initiated from a distance. Military expenditures have been rising exponentially until, by mid 21st century (according to Norm Augustine's famous prediction) a single fighter aircraft will be all that can be afforded; and it will be shared among all of the services. Robotic systems can be much less expensive than manned systems: no costs to protect, feed, pay, house, and care for troops and their families. Military expenditures can be brought under control - without losing effectiveness.

** According as circumstances are favorable, one should modify one's plans.*

Comment: Flexibility, adaptability, resilience are hallmarks of prospective modular robotic systems. They will be reconfigurable and transportable. They will be capable of providing dynamic barriers and Cyberfields for volume denial, and elastic, highly mobile, three-dimensional offense and defense. These forces should be able to "turn on a dime." Robotic forces, more easily than conventional forces, will be able to **modify plans** to take advantage of opportunities and avoid threats.

** All warfare is based on deception.*

Comment: Robotic systems, without the need to enclose people, can take **many deceptive forms**. A weapons platform can be made to look like a sensor platform, or a lethal attack UAV can look like an Electronic Countermeasures (ECM) UAV. They can be stealthy or intentionally noisy. They can cloak themselves and deceive the enemy physically, electronically, and behaviorally. They can deceive tactically and strategically, whether for small unit operations or large-scale offensives. They can create surprise and waylay the enemy.

** Hence, when able to attack, we must seem unable; when using our forces, we must seem inactive; when we are near, we must make the enemy believe we are far away; when far away, we must make him believe are near.*

Comment: Far easier than for large manned vehicles and large numbers of troops, robotic systems can **hide or maneuver stealthily**. The new tactics will emphasize dispersal, decentralization of forces, since the individual platforms will be tightly coupled through extensive C3I links. The enemy will have difficulty in locating the nexus of force.

** Hold out baits to the enemy. Feign disorder, and crush him.*

Comment: Robotic systems, being expendable, can be used as **bait** to lure him to the killing zone.

** If he is taking his ease, give him no rest. If his forces are united, separate them.*

Comment: Robotic systems are tireless. They will **implacably and remorselessly** hound the enemy. With stealth (and micro-robots) they can infiltrate enemy forces and cause them to scatter.

** Attack him where he is unprepared, appear where you are not expected.*

Comment: With a profusion of linked **sensors** in space, in the air, on the ground - unattended and mobile - the robotic system of systems will more easily determine where the enemy is unprepared.

** Now the general who wins a battle makes many calculations in his temple ere the battle is fought. The general who loses a battle makes but few calculations beforehand. Thus do many calculations lead to victory, and few calculations to defeat: how much more no calculation at all! It is by attention to this point that I can foresee who is likely to win or lose.*

Comment: The system of systems will include **decision aids**, such as rule-based (i.e., expert) systems, along with the ability to model the future battle through, for example, virtual reality-based distributed interactive simulations. Human decision makers will have voluminous data processed and presented to them in clear graphics, along with recommendations made by the embedded machine intelligence. Autonomous platforms will calculate and model potential tactical outcomes through **distributed machine intelligence** throughout the robot collective.

** Sun Tzu said: In the operations of war, where there are in the field a thousand swift chariots, as many heavy chariots, and a hundred thousand mail-clad soldiers, with provisions enough to carry them a thousand li, the expenditure at home and at the front, including entertainment of guests, small items such as glue and paint, and sums spent on chariots and armor, will reach the total of a thousand ounces of silver per day. Such is the cost of raising an army of 100,000 men.*

Comment: Armies have always been **heavy, unwieldy, and expensive**. Heavy and expensive armor protected the troops, and heavy chariots transported them. The logistics tail was an expensive drag on the army - and the treasury. The robotic force will lighten the force, shrink the logistics tail, and save the silver.

** When you engage in actual fighting, if victory is long in coming, then men's weapons will grow dull and their ardor will be damped. If you lay siege to a town, you will exhaust your strength.*

Comment: Robots are infinitely **patient** and **persistent** - their ardor is never damped. Their strength cannot be physiologically exhausted. Although, like all machines, they can deteriorate and fail, they can be designed for easy maintenance and the ability to degrade gracefully.

** There is no instance of a country having benefited from prolonged warfare.*

Comment: **Swarms** of robotic systems of systems, able to pervade the enemy's space with **three-dimensional** net-centric sensors and respond rapidly to threats and opportunities with lethal and non-lethal weapons, will likely shorten warfare considerably. Because they can move fearlessly into the guerilla's mountainous redoubts, or among the terrorists urban warrens, robotic forces can flush out and destroy or capture the enemy before chronic cycles of conflict take hold.

** It is only one who is thoroughly acquainted with the evils of war that can thoroughly understand the profitable way of carrying it on.*

Comment: With a shift in public morality and a growing perception of the evils of warfare, with no heart for casualties and a loss of patriotic zeal for the glories of combat, the public is ready to employ robotic systems to achieve military objectives in a more **humane** way.

** Captured soldiers should be kindly treated and kept.*

Comment: In a famous incident during Desert Storm, Iraqi soldiers surrendered to a Pioneer UAV - the first known incident of people **surrendering to a robot**. (Aside: the first known incident of a person being *killed* by a robot occurred when an industrial robotic arm accidentally collided with a worker in Japan). Robotic combat systems need not kill anything that moves. They can take **greater risks** of self-destruction by employing non-lethal weapons against the enemy or attempting to capture, rather than kill, them. They can **capture the enemy** with greater patience and effectiveness and move them to secure camps. Robot security guards are not craven, sadistic, or corrupt as are some human guards.

** In war, let your great objective be victory, not lengthy campaigns.*

Comment: Robotic systems have no need for psychological or career fulfillment or existential glory - they do not crave to be generals or "love the smell of napalm in the morning." They will strive for victory within appropriate, **ethical** objective constraints.

** Sun Tzu said: In the practical art of war, the best thing of all is to take the enemy's country whole and intact; to shatter and destroy it is not so good. So, too, it is better to recapture an army entire than to destroy it, to capture a regiment, a detachment or a company entire than to destroy them.*

Comment: Precision weapons thus far have had a somewhat perverse effect. They are designed primarily to attack from the air. The emphasis is on destroying targets, including urban buildings, bridges, and other infrastructure, even if they are carefully selected and justified on the

basis of military relevance. While mostly very accurate, the air to surface weapons occasionally miss their targets (or are given incorrect targets based on faulty information) and cause **collateral damage**. Multitudes of refugees flee the air threat. Because of the heightened expectations of a sanitary war, each untoward death - and hordes of refugees - leads to recriminations and political consequences. But because of the great disparity between air and ground “smart” weapon capabilities, the U.S. is now fighting its wars primarily from the air. But it is the ground forces that would be better able to distinguish friend from foe, military from civilian, and chemical warfare plants from aspirin factories. It is the ground forces that occupy enemy territory and ultimately subdue and placate the enemy. The coming robotic forces will balance the “smart” weapons equation, allowing air and ground power each to do what it does best. Robotic ground forces will allow entire units - or entire countries - to be captured with **minimum damage to the infrastructure or the population**.

** Hence to fight and conquer in all your battles is not supreme excellence; supreme excellence consists in breaking the enemy’s resistance without fighting.*

Comment: With the integrated robotic system of systems - the netcentric collective – “**resistance is futile,**” as *Star Trek’s* Borg are wont to declare. It will be possible to break the enemy’s will without destroying him or his society.

** Therefore the skillful leader subdues the enemy’s troops without any fighting; he captures their cities without laying siege to them; he overthrows their kingdom without lengthy operations in the field.*

Comment: While robotic forces will be technologically capable of achieving these goals, they will need the accompanying **tactics, strategy, and doctrine** to actually accomplish them.

** With his forces intact he will dispute the mastery of the Empire, and thus, without losing a man, his triumph will be complete. This is the method of attacking by stratagem.*

Comment: More so than in the time of Sun Tzu - or the present - it will be possible, with robotic systems, to engage military forces “without losing a man.” In addition to use of the correct stratagem, robotic technology will **prevent battlefield casualties**.

** It is the rule in war, if our forces are ten to the enemy’s one, to surround him; if five to one, to attack him; if twice as numerous, to divide our army into two. If equally matched, we can offer battle, if slightly inferior in numbers, we can avoid the enemy; if quite unequal in every way, we can flee from him.*

Comment: After all these centuries, Sun Tzu’s force ratios still apply to modern armies. But the **proper tactical ratios** will need to be recalculated (using distributed interactive simulation, for example) for the future robotic army.

** Hence, though a small force may make an obstinate fight, in the end the larger force must capture it.*

Comment: A robotic force can put up “**an obstinate fight**” if it will contribute to the mission - and not be concerned about being captured.

** Hence the saying: If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle.*

Comment: Pervasive sensors in the three-dimensional battlefield will allow detailed knowledge of the enemy. The netcentric force, globally positioned, will allow detailed knowledge of itself: its disposition, operational status, plans, and encounters. **Information about friend and foe** will flow among the collective platforms.

** To secure ourselves against defeat lies in our own hands, but the opportunity of defeating the enemy is provided by the enemy himself.*

Comment: **Persistence** on the battlefield - or in the mountain redoubts, or crowded tenements of the city - will allow the robotic force to wait for tactical advantage over the enemy. Its responsiveness will allow it take advantage of enemy weakness when it occurs.

** Security against defeat implies defensive tactics; ability to defeat the enemy means taking the offensive.*

Comment: **New tactics**, defensive and offensive, must be developed for the new technology, the integrated systems of UAVs, UGVs, and manned platforms and dismounted troops.

** Standing on the defensive indicates insufficient strength; attacking, a superabundance of strength.*

Comment: The lightweight, modular robotic force can be reconfigured from the defense and easily moved to **concentrate** a “superabundance” of strength for the attack.

** To see victory only when it is within the ken of the common herd is not the acme of excellence.*

Comment: The netcentric system, with massively parallel processing, will be able to model and simulate forces and combat before the engagement, varying tactics and other variables in the distributed interactive simulation to **forecast victory** or defeat.

** To lift an autumn hair is no sign of great strength; to see the sun and moon is no sign of sharp sight; to hear the noise of thunder is no sign of a quick ear. What the ancients called a clever fighter is one who not only wins, but excels in winning with ease.*

Comment: The robotic system will employ a **multiplicity of sensors**, to detect the slightest movement, vibration, sound, or magnetic field, night or day. The cleverness will arise from its machine intelligence.

** He wins his battles by making no mistakes. Making no mistakes is what establishes the certainty of victory, for it means conquering an enemy that is already defeated.*

Comment: The machine intelligence can be given various criteria for **decision making**, such as maximizing the expected value - or the more conservative one of minimizing regret. If making no mistakes is given the highest value in the system's value-driven logic, then it can seek to minimize regret and make no mistakes.

** Hence the skillful fighter puts himself into a position which makes defeat impossible, and does not miss the moment for defeating the enemy. Thus it is that in war the victorious strategist only seeks battle after the victory has been won, whereas he who is destined to defeat first fights and afterwards looks for victory.*

Comment: Knowledge, patience, persistence, lack of stress and bodily needs will allow the robotic system to wait for the **opportune moment** to defeat the enemy.

** In respect of military method, we have, firstly, Measurement; secondly, Estimation of quantity; thirdly, Calculation; fourthly, Balancing of chances; fifthly, Victory.*

Comment: The distributed, integrated robotic system, with netcentric parallel processing, is ideally designed for this Sun Tzu military method path to victory. The system will be able to **measure** accurately a multitude of variables (e.g., location of enemy and friendly forces, environmental terrain and weather conditions, enemy order of battle, etc.) and estimate accurately the **quantity** weapons systems and enemy personnel, the amount of munitions and other supplies needed to sustain the battle, etc. **Calculations** can be performed very rapidly in the distributed system, which will have the aggregated computational ability of a supercomputer. **Balancing the chances** of victory for various maneuvers and tactics will be accomplished with near real-time modeling and simulation throughout the network and suitable risk analyses. The quality of tactical decisions will be sound, with fewer precipitous or reckless decisions.

** Sun Tzu said: The control of a large force is the same principle as the control of a few men: it is merely a question of dividing up their numbers.*

Comment: Task **decomposition** is used in the NIST hierarchical Real-time Control System (RCS) to break complex missions into simpler, more doable task elements - the same way human hierarchies have done it for thousands of years. Any intelligent control system used to control the robotic system of systems is likely to employ the same approach.

** Fighting with a large army under your command is nowise different from fighting with a small one: it is merely a question of instituting signs and signals.*

Comment: Suitable **semiotics** must be developed for the complex C4ISR (Command, Control, Communications, Computers, Intelligence Surveillance, and Reconnaissance) of the robotic system of systems.

** In all fighting, the direct method may be used for joining battle, but indirect methods will be needed in order to secure victory.*

Comment: The scattered, distributed system of systems, ill defined to the enemy and the order of battle obscure, can more easily than conventional forces use **indirection** in its maneuvers to secure victory.

** There are not more than five musical notes, yet the combinations of these five give rise to more melodies than can ever be heard. There are not more than five primary colors, yet in combination they produce more hues than can ever be seen. In battle there are not more than two methods of attack - the direct and indirect; yet these two in combination give rise to an endless series of maneuvers.*

Comment: When conventional weapons platforms are replaced by robotic platforms on the ground and in the air, the unique combinations generated among a multitude of platforms will lead to a vast array of **potent tactical maneuvers** never before seen. Of course, these maneuvers must be developed even as the systems are developed.

** The quality of a decision is like the well-timed swoop of a falcon which enables it to strike and destroy its victim. Therefore the good fighter will be terrible in his onset, and prompt in his decision.*

Comment: The netcentric machine intelligence will include **decision aids** to allow the human commander to make quicker, better quality, and more focused tactical decisions. Decisions can be prompt without being precipitous.

** Amid the turmoil and tumult of battle, there may be seeming disorder and yet no real disorder at all; amid confusion and chaos your array may be without head or tail, yet it will be proof against defeat.*

Comment: The robotic collective can behave as a **swarm of army ants**: without a leader yet able to engage in tactical maneuvers. The ant collective acts through the aggregated actions of the multitude of individuals, where a few critical states of individuals are sensed and reacted to by other individuals. While there is apparent turmoil and confusion to the untutored observer - and to their victims - the swarm of ants (or the robot collective) is focused on achieving its goal.

** Simulated disorder postulates perfect discipline, simulated fear postulates courage; simulated weakness postulates strength. Thus one who is skillful at keeping the enemy on the move maintains deceitful appearances, according to which the enemy will act. He sacrifices something, that the enemy may snatch it.*

Comment: The robotic system of systems, having perfect discipline, courage, and strength, can easily deceive the enemy by simulating disorder, fear, and weakness. As an inherently distributed system all of whose disparate and distant elements are closely linked, it can assume the configuration and dynamics of chaos and fear, drawing the enemy into **precipitous combat**. Unmanned units can be sacrificed - as needed to achieve victory - without a second thought.

** Thus the energy developed by good fighting men is the momentum of a round stone rolled down a mountain thousands of feet in height.*

Comment: The robotic collective, in the air and on the ground, can develop a “**swarm inertia**,” even as the implacable army ants of the Amazon and the unrelenting African bees.

** Sun Tzu said: Whoever is first in the field and awaits the coming of the enemy, will be fresh for the fight; whoever is second in the field and has to hasten to battle will arrive exhausted.*

Comment: The **nimble and fast** machine systems will be able to arrive first on the field of battle, without physiological exhaustion.

** If the enemy is taking his ease, he can harass him; if well supplied with food, he can starve him out; if quietly encamped, he can force him to move.*

Comment: The robotic systems need no rest and can harass the enemy with unmatched **persistence and perseverance**.

** Appear at points which the enemy must hasten to defend; march swiftly to places where you are not expected.*

Comment: Operating in the air and on the ground, moving rapidly with stealth, the robotic collective can **appear suddenly** anywhere, around or within the enemy force.

** Hence that general is skillful in attack whose opponent does not know what to defend; and he is skillful in defense whose opponent does not know what to attack.*

Comment: The “**shape-shifting**” nature of the agile robotic collective, reconfiguring into forces with different elements and abilities, will leave the enemy with an inability to know what to best defend or attack.

** O divine art of subtlety and secrecy! Through you we learn to be invisible, through you inaudible; and hence we can hold the enemy's fate in our hands.*

Comment: The robotic platforms will be smaller, faster, quieter, and designed for **stealth** in all parts of the electromagnetic spectrum. Their low observables and inherent stealthiness, coupled with secure C3I links, will secure their presence and intentions from the enemy.

** You may advance and be absolutely irresistible, if you make for the enemy's weak points; you may retire and be safe from pursuit if your movements are more rapid than those of the enemy.*

Comment: Unattended ground **sensors**, mobile sensor platforms in the air and on the ground, HUMINT (Human Intelligence) and ELINT (Electronic Intelligence), and all manner of information pouring into the C3ISR network of the system and processed by the distributed network, will allow the force to determine the enemy's weak points with greater accuracy. The smaller, faster platforms will allow for more rapid movement than the enemy.

** If we wish to fight, the enemy can be forced to an engagement even though he be sheltered behind a high rampart and a deep ditch. All we need do is attack some other place that he will be obliged to relieve.*

Comment: The **3-D battlespace** swarming with UAVs and UGVs (large, small, and micro), allows the enemy to be engaged regardless of his defensive position.

** If we do not wish to fight, we can prevent the enemy from engaging us even though the lines of our encampment be merely traced out on the ground. All we need do is to throw something odd and unaccountable in his way.*

Comment: The robotic force will be ideal for "throwing something odd and unaccountable" in the way of the enemy. **Subterfuge and guile** will be programmed into the system; deception will be embedded in the soul of the machine.

** The spot where we intend to fight must not be made known; for then the enemy will have to prepare against a possible attack at several different points; and his forces being thus distributed in many directions, the numbers we shall have to face at any given point will be proportionately few.*

Comment: The distributed system will be able to **feint and maneuver**, reconfigure and deceive. The point of attack can be kept uncertain until it is too late for the enemy to mass his forces.

** Numerical weakness comes from having to prepare against possible attacks; numerical strength, from compelling our adversary to make these preparations against us.*

Comment: With sensors distributed throughout the 3-D battlespace, high-speed sensor processing, and machine intelligence-based risk analysis, the robotic force can more **accurately predict** the location of attacks and avoid wasting resources on needless preparations.

** Though the enemy be stronger in numbers, we may prevent him from fighting. Scheme so as to discover his plans and the likelihood of their success.*

Comment: With an extensive C4ISR network, models and simulations, and decision aids performing **risk analysis**, the system will discover the enemy's plans and estimate his **probability of success** of failure with greater accuracy.

** Do not repeat the tactics which have gained you one victory, but let your methods be regulated by the infinite variety of circumstances.*

Comment: The tactics of the future combat system (which must yet be developed) can be far more varied than for conventional systems. Prospective tactics can be tested in near-real time by **distributed interactive simulators** embedded within the system.

** Water shapes its course according to the nature of the ground over which it flows; the soldier works out his victory in relation to the foe whom he is facing. Therefore, just as water retains no constant shape, so in warfare there are no constant conditions.*

Comment: The robotic system will be sufficiently agile so as to **adapt** its configuration and dynamics to the enemy it confronts.

** Having collected an army and concentrated his forces, he must blend and harmonize the different elements thereof before pitching his camp.*

Comment: The multiplicity of platforms and components of the system of systems, unmanned and manned, must be arrayed into a **coherent force**, able to function as if it were a single entity.

** After that comes tactical maneuvering, than which there is nothing more difficult. Maneuvering with an army is advantageous; with undisciplined multitude, most dangerous.*

Comment: The robotic collective, in the air and on the ground, must maneuver as a disciplined, focused force. **Heterogeneous robot group control** is within the technology and can make the disparate, dispersed elements into a single body.

** We are not fit to lead an army on the march unless we are familiar with the face of the country - its mountains and forests, its pitfalls and precipices, its marshes and swamps.*

Comment: With 3-D sensing in space, air, and ground, and with virtual reality, **telepresence tours** of the countryside and cities, the commander can know well the battlefields before engaging the enemy.

** Whether to concentrate or to divide your troops must be decided by circumstance.*

Comment: The **reconfigurability and agility** of the future combat system will allow the robotic platforms to be concentrated or divided quickly, as warranted by the enemy's disposition.

** Let your rapidity be that of the wind, your compactness that of the forest.*

Comment: The robotic force, **smaller and lighter**, UAVs and UGVs, can move speedily and while occupying less space (if maximum dispersion is undesirable).

** Ponder and deliberate before you make a move.*

Comment: The embedded **decision aids and simulators** in the robotic force will allow the commander to contemplate and analyze his moves with suitable deliberation, but expeditiously.

** He will conquer who has learnt the artifice of deviation. Such is the art of maneuvering.*

Like a chess-playing supercomputer, the distributed computational network will include **cunning ruses** in the creation of its maneuvers.

** The Book of Army Management says: On the field of battle, the spoken word does not carry far enough: hence the institution of gongs and rums. Nor can ordinary objects be seen clearly enough: hence the institution of banners and flags.*

Comment: The netcentric cohort, with RF links (and air and space relays) of **many frequencies** and, perhaps, fiber optic and laser links, will carry the spoken word and data throughout the distributed system (without gongs and drums). The cohort will see in the day and night and in all weather through the eyes of sensors operating in all parts of the spectrum: optical, infrared, microwave, acoustic, seismic, and magnetic (but no banners or flags).

** In night fighting, then, make much use of signal-fires and rums, and in fighting by day, of flags and banners, as a means of influencing the ears and eyes of your army.*

Comment: With the plentitude of **night vision sensors**, the night will look barely different from the day.

** A whole army may be robbed of its spirit; a commander-in-chief may be robbed of his presence of mind.*

Comment: A robotic army **cannot** be robbed of its “spirit” because it does not need spirit to function. An autonomous robotic army can function well even if its human commander loses his presence of mind.

** Now a soldier’s spirit is keenest in the morning; by noonday it has begun to flag; and in the evening, his mind is bent only on returning to camp.*

Comment: The robotic soldier’s “spirit” **never** flags and it does not need to rest.

** It is a military axiom not to advance uphill against the enemy, nor to oppose him when he comes downhill.*

Comment: With the **3-D battlespace** and mechanized platforms in the air and on the ground, “uphill” and “downhill” become mostly a question of whether there are advantageous **fields of fire** and lines-of-sight. There are fewer mobility and physical endurance problems.

** There are five dangerous faults which may affect a general: (1) recklessness, which leads to destruction; (2) cowardice, which leads to capture; (3) a hasty temper, which can be provoked by insults; (4) a delicacy of honor which is sensitive to shame; (5) over-solicitude for his men, which exposes him to worry and trouble. When an army is overthrown and its leader slain, the cause will surely be found among these five dangerous faults. Let them be the subject of meditation.*

Comment: The robotic cohort will **eliminate** at least some of Sun Tzu’s five dangerous faults (recklessness, which can still cause wasted resources). For example, the commander need not be afflicted by cowardice when he is ensconced in a control center at a safe distance from the combat; and where it would be difficult for the enemy to provoke him into precipitous action. Also, he would have empathetic impulse to be over-solicitous to his robotic paladins.

** Sun Tzu said: we may distinguish six kinds of terrain, to wit: (1) accessible ground; (2) entangling ground; (3) temporizing ground; (4) narrow passes; (5) precipitous heights; (6) positions at a great distance from the enemy.*

Comment: **Accessible ground**, which can be freely traversed by both sides, can be exploited to a maximum extent by the robotic combat system and its embedded geographic information system (GIS). It can maneuver rapidly in 3-D battlespace; detect, locate, and identify targets with multi-spectral sensors; and kill a range of targets (from troops to heavy armor) at long standoff distances, while presenting fleeting, stealthy targets to the enemy.

Entangling ground can be easily abandoned but difficult to re-occupy. This included urban terrain, with a complex infrastructure of buildings, streets, and tunnels. The robotic force can better deal with the dangers of attempting to occupy such entangling ground, with no prospect of human casualties from house-to-house combat, ambushes, and snipers. Micro robots performing RSTA, in the air and on the ground, can infiltrate heavily fortified areas - even into buildings. Robotic weapons platforms, UGVs and UAVs, can clear the enemy, block-by-block, in what is ordinarily a tedious and highly dangerous mission.

Temporizing ground, a position such that neither side will gain by making the first move, offers a major advantage to the robotic force, which has infinite patience. Occupying ground, a robotic force expends a minimum of energy (mostly to power sensors and processors) and does not need to eat or be warm to stay alive and combat ready. It will not be worn down psychologically, tempted by bait or defeated by boredom or fear or a growing urge to surrender.

Our forces should occupy **narrow passes** first, strongly garrison them, and then await the advent of the enemy. Again, robotic forces, having greater mobility, can reach difficult to reach narrow passes first, establish strong defensive positions with a 3-D battlespace, and then display great patience and tactical prudence while waiting for the enemy.

Likewise with **precipitous heights**: the robotic force can arrive more easily and establish a stronghold while patiently awaiting the enemy.

For conventional forces, being situated at a **great distance** from the enemy tends to render the opposing forces more or less equal, even if one has superior manned air power. But agile, fast moving robotic forces can close rapidly with the enemy from a distance, an enemy about which they have already gathered a great deal of information, and **seize the tactical advantage**.

** When a general, unable to estimate the enemy's strength, allows an inferior force to engage a larger one, or hurls a weak detachment against a powerful one, and neglects to place picked soldiers in the front rank, the result must be rout.*

Comment: Estimating the enemy's strength is fundamental to any military operation. It depends on: obtaining data; transforming data to information; and transforming information to intelligence. With geographically dispersed, multi-spectral, multi-platform **sensor fusion**, the ability to integrate HUMINT, and powerful distributed processing, the robotic force will be better able to estimate the enemy's strength and avoid a rout.

** The natural formation of the country is a soldier's best ally; but a power of estimating the adversary, of controlling the forces of victory, and of shrewdly calculating difficulties, dangers and distances, constitutes the test of a great general.*

Comment: Embedded **artificial intelligence tools** and techniques (such as expert systems, neural networks, and genetic algorithms, and value-driven logic), along with **decision-making tools** (such as those for risk analysis and measures of uncertainty) will allow the system to better estimate the adversary and calculate the metrics and variables needed for victory.

** Regard your soldiers as your children, and they will follow you into the deepest valleys; look upon them as your own beloved sons, and they will stand by you even unto death. If, however, you are indulgent, but unable to make your authority felt; kind-hearted, but unable to enforce your commands; and incapable, moreover, of quelling disorder; then your soldiers must be likened to spoilt children; they are useless for any practical purpose.*

Comment: Robotic forces will **follow the commander** "even unto death" without even being subjected to a paternalistic leadership style - or without the danger of becoming "spoilt children."

** Hence the saying: if you know the enemy and know yourself, your victory will not stand in doubt; if you know Heaven and know Earth, you may make your victory complete.*

Comment: Knowledge, more so than raw power, is the key to victory in peace and war - especially in the 21st century. The future combat system of integrated, netcentric robots will value knowledge above all else. The weapons must only be competent, but the **knowledge system** must always be at the cutting edge.

** Sun Tzu said: the art of war recognizes nine varieties of ground: (1) dispersive ground; (2) facile ground; (3) contentious ground; (4) open ground; (5) ground of intersecting highways; (6) serious ground; (7) difficult ground; (8) hemmed-in ground; (9) desperate ground.*

Comment: When the enemy is fighting in his own territory it is **dispersive ground**. The invading force is at a disadvantage (and is cautioned by Sun Tzu not to fight) in not knowing the territory as well as the natives, in not knowing the best tactical positions, fields for maneuver, and logistics routes. The enemy can take refuge among the civilian population, appearing and disappearing with the tactical advantage of surprise. The robotic force, with its sensor tentacles, 3-D battlespace, and willingness to take “casualties,” can reduce the enemy’s advantage on his own ground.

When the force has penetrated into hostile territory, but at no great distance, it is **facile ground** (and cautioned by Sun Tzu to keep moving). There remains danger for the invading force, which again can be ameliorated if it is a robotic force able to see the enemy and know his order of battle.

Ground the possession of which imports great advantage to either side is **contentious ground** (which, if the enemy possesses it, the force is admonished by Sun Tzu not to attack). The robotic force should not be wasted, even it does not suffer human casualties. But there may be tactical reasons to attack where the enemy has a significant advantage, as on “contentious ground.” Machine casualties can be sustained if necessary for the greater campaign.

Open ground provides each side with freedom of movement, and Sun Tzu cautions against trying to block the enemy’s way. But with future combat system capabilities, such as the Cyberfield (a dynamic barrier UGV and UAV system for accomplishing area denial by functionally replacing the minefield), the enemy can be blocked on open ground.

The **ground of intersecting highways** is ground which forms the key to three contiguous states, so that he who occupies it first has most of the territory at his command (and for which Sun Tzu recommends joining hands with your allies). In the balkanized states and breakaway territories of the 21st century, the robotic force can team with conventional local forces to achieve victory - or peacekeeping - in difficult, fragmented places.

When an army has penetrated into the heart of a hostile country, leaving a number of fortified cities in its rear, it is **serious ground** (in which Sun Tzu suggests gathering in the plunder). It is no longer considered in good form to “gather in the plunder,” but there are dangers in bypassing “fortified cities.” The robotic force can better mop up the enemy in the cities, and not leave them as a chronic threat and source of terrorist attack.

Difficult ground is that of mountain forests, rugged steeps, marshes, and fens - country that is hard to traverse (over which Sun Tzu recommends keeping steadily on the march). The mobile force, with small, maneuverable UGVs having amphibious wheels able to traverse marshes and broken ground, will be better able to negotiate difficult ground.

Hemmed in ground is reached through narrow gorges, and from which the force can only retire by tortuous paths, so that a small number of the enemy would suffice to crush a large body of men. (Sun Tzu suggests resorting to stratagem on hemmed in ground). The robotic force does not place human troops at risk in this dangerous terrain, and can better prevail through the use of deception and stratagem.

Desperate ground is where the force can only be saved from destruction by fighting without delay (which is what Sun Tzu recommends). The robotic force will be able to engage in battle with short notice - it will always move in a high state of combat readiness.

** Throw your soldiers into positions whence there is no escape, and they will prefer death to flight. If they will face death, there is nothing they may not achieve. Officers and men alike will put forth their utmost strength. Soldiers, when in desperate straits lose the sense of fear. If there is no place of refuge, they will stand firm. If they are in hostile country, they will show a stubborn front. If there is no help for it, they will fight hard.*

Comment: Robotic vehicles need not be placed in untenable positions to prevent them from deserting in fear - they have **no fear** and always stand firm and fight hard.

** The principle on which to manage an army is to set up one standard of courage which all must reach.*

Comment: Robotic systems all have one standard of courage: **implacable fidelity** to accomplishing the mission, whatever it is, and whatever the circumstance.

** By altering his arrangements and changing his plans, he keeps the enemy without definite knowledge. By shifting his camp and taking circuitous routes, he prevents the enemy from anticipating his purpose.*

Comment: Inscrutable robotic forces can shift direction, maneuver over unexpected terrain, feint and evade, and **confound** the foe.

** The different measures suited to the nine varieties of ground; the expediency of aggressive or defensive tactics; and the fundamental laws of human nature: these are things that most certainly be studied.*

Comment: No different than in the time of Sun Tzu, we must contemplate warfare: the affect of robotic combat systems on tactics, strategy, doctrine, organizational structure, politics, and the psychology of the enemy must be **studied carefully** before fielding these systems.

** Confront your soldiers with the deed itself; never let them know your design. When the outlook is bright, bring it before their eyes; but tell them nothing when the situation is gloomy.*

Comment: Unlike Sun Tzu, the commander of robotic forces must let them know completely the design of the campaign. At every step, the system of systems knows the reality of its status,

whether good or ill. It is only with **truth** that the distributed machine can function as it should; human psychological games are irrelevant.

** Success in warfare is gained by carefully accommodating ourselves to the enemy's purpose.*

Comment: With multi-spectral sensing and machine intelligence, the robotic force will be better able to discern the enemy's **purpose** and readily adapt to it.

** If the enemy leaves a door open, you must rush in.*

Comment: Agility and adaptability will allow the robotic force to be **opportunistic** and take advantage of the enemy's errors.

** In order to carry out an attack, we must have means available. The material for raising fire should always be kept in readiness.*

Comment: While Sun Tzu was concerned with a combustion type fire, his maxim is also valid for weapons fire. Ammunition and other **supplies** must be readily available for robotic forces as they are for conventional forces. Robotic convoys and logistics systems can be used to bring materiel efficiently into dangerous territory for resupply and maintenance.

** Move not unless you see an advantage; use not your troops unless there is something to be gained; fight not unless the position is critical. No ruler should put troops into the field merely to gratify his own spleen; no general should fight a battle simply out of pique.*

Comment: Just as human troops should not be wasted for trivial purpose (or innocent people caused to be killed), robot troops should not be **frittered away** or sent to wreak havoc without just cause.

** But a kingdom that has once been destroyed can never come again into being; nor can the dead ever be brought back to life.*

Comment: The robotic force need **not mourn** its dead.

** Hence the enlightened ruler is heedful, and the good general full of caution. This is the way to keep a country at peace and an army intact.*

Comment: The **wisdom of Sun Tzu is still valid**. The robotic force can lead to greater peace, but it also can lead to more war. Intervention in far away places becomes easier, whether justified or not. We can inflict cruelties and multiply enemies; even a robotic army cannot defeat the world. It must be used wisely and with restraint, as specified by doctrine and a **political philosophy** yet to be determined.

** Sun Tzu said: raising a host of a hundred thousand men and marching them great distances entails heavy loss on the people and a drain on the resources of the state. The daily expenditure will amount to a thousand ounces of silver. There will be a commotion at home and abroad, and men will drop down exhausted on the highways. As many as seven hundred families will be impeded in their labor.*

Comment: It is no longer tenable to **draft** soldiers; and the **expense of a volunteer army** is growing prohibitive as well. Demographics, economics, and societal expectations are encouraging the **replacement of soldiers with machines**.

** Hostile armies may face each other for years, striving for the victory which is decided in a single day. This being so, to remain in ignorance of the enemy's condition simply because one grudges the outlay of a hundred ounces of silver in honors and emoluments, is the height of inhumanity.*

Comment: Sun Tzu encouraged the use of spies (who need the “silver in honors and emoluments”) to obtain information that may be crucial for victory. Despite the multi-spectral sensors, the robotic force will not eliminate the need for **human spies** and human-obtained intelligence (HUMINT).

** Thus, what enables the wise sovereign and the good general to strike and conquer, and achieve things beyond the reach of ordinary men, is foreknowledge.*

Comment: Perfect foreknowledge only belongs to the gods. But information, carefully gathered and analyzed, can be **transformed into knowledge** sufficiently to achieve a high probability of success. The future combat system of integrated robots and netcentric-distributed intelligence, must value the generation of knowledge - and **foreknowledge** - above all.