Advanced Concepts Group

News & Views

January 2004 Volume 6, Issue 1

The Keys to the New Era of War Against Terrorism

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In September 2002, the President declared in his *National Security Strategy* document (www.whitehouse.gov/nsc/nss.pdf) that we would not wait for our enemies to strike, but would "…act against such emerging threats before they are fully formed." But how do we do that unless we know who and where those enemies are? The President went on to say that they are "…shadowy networks of individuals that can bring great chaos and suffering to our shores for less than it costs to purchase a single tank." He added, "…we must be prepared to defeat our enemies' plans, using the best intelligence and proceeding with deliberation."

That is only half of the declared national strategy; the other half is "…to bring the hope of democracy, development, free markets, and free trade to every corner of the world." But creating democracy and free markets is difficult and time-consuming. It seems to me that if we don't "defeat our enemies' plans" first, then the shadowy guys will erase the hope by spreading destruction and chaos faster than we can build schools and roads.

Creating institutions and practices such as "…the rule of law, limits on the absolute power of the state, freedom of worship, equal justice, respect for women, religious and ethnic tolerance, and respect for private property" that do not now govern the behavior of much of the world are laudable goals. But I doubt if we can make much progress when car bombs are exploding in shopping malls, restaurants, and even schools. We need to get on with the war against our enemies. At the same time, there has to be a better definition of "them" than "evil-doers" or "shadowy individuals." The *National Security Strategy* paper says that the enemy is terrorism, and "…not a single political regime or person or religion or violence…the struggle…will be fought on many fronts against a particularly elusive enemy over an extended period of time." But an "enemy" so elusive that it is a tactic rather than a person or group makes a difficult target indeed.

The *Strategy* offers somewhat more specific guidance as to where to look for the shadowy ones by saying that we will, among other things, support "…moderate and modern government, especially in the Muslim world, to ensure that the conditions and ideologies that promote terrorism do not find fertile ground in any nation." That does narrow the scope of our attention, but it still does not help us figure out precisely how to act preemptively to forestall

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hostile acts by our adversaries. We cannot launch preemptive strikes against all evil-doers and shadowy networks in the world. Where to start?

In January 2003, the President assigned new tasks to the U.S. Strategic Command (USSTRATCOM) that led that organization to reshape itself into "…an entirely new command, instrumental in fighting the war on terrorism, deterring a wider array of potential adversaries, and focused on recasting the nation's global military capabilities for the demands of the 21st century." This is how Adm. James O. Ellis, USSTRATCOM Commander, described his work in congressional testimony (www.senate.gov/~armed_services/statemnt/2003/April/Ellis2.pdf). He said that in implementing the Nuclear Posture Review he would advocate "…the development of advanced offensive and integration of defensive capabilities in order to meet the President's goal of reducing our reliance on operationally deployed strategic nuclear weapons." The new capabilities would include "…conventional, non-kinetic, special operations and nuclear…" He went on to emphasize "…conventional ballistic missiles, Common Aerospace Vehicles, hypersonic aircraft, and unmanned combat aerial vehicles…to improve our global strike capabilities." It would certainly be useful to be able to reach out and in a short time strike any target anywhere in the world with high precision and low collateral damage, but first we need to find that target—about which the information may be very perishable.

In his testimony and on another occasion when I heard Adm. Ellis speak about future weapons, he emphasized tools that seemed to me to be more relevant to finding and dealing with a shadowy enemy. He said, "Quite simply, I believe that integrated IO [Information Operations—computer network attack and defense, electronic warfare, psychological operations, strategic deception and operational security] comprise the next revolution in war fighting." He also emphasized the need for a new national-level C4 [command, control, communications, and computing] system that "must allow increased access to a broader array of federal agencies, provide improved information flow, enable rapid decision making, and support the requirements of our network-centric forces in the Information age." Since information, including intentionally deceptive information, can be delivered at the speed of light, this might be the right strategic weapon for an elusive enemy, as long as our understanding of the mind of the enemy is vastly improved, and our decision process is not the time-limiting step.

A deep understanding of what makes the enemy tick, and an agile and highly connected information system seem to be the keys to this new era of war against terrorism, but we first need to find the "shadowy networks of individuals." Here Ellis called for "…intrusive ISR [Intelligence, Surveillance, and Reconnaissance], incorporating space-based, air-breathing, terrestrial, and maritime elements…" In concluding, Ellis said, "**We no longer live in a world where strategic is synonymous with nuclear**, and we are integrating and interlinking the command's broad portfolio of missions to better and more flexibly meet the deterrent needs of the nation." When he said "intrusive ISR," I immediately thought about our concepts for networks of thousands or hundreds of thousands, or even millions of Sense-Decide-Act-Communicate (SDAC) systems. I am convinced that developing and deploying these SDACs is something the U.S. can do in the next five years, and that such systems will eventually make even elusive shadows appear on our screen.

If and when we find suitable targets, then what do we do? Do we strike and destroy the target, or threaten to strike in order to change the inclination to carry out terrorist acts? The *National Security Policy* says, "Traditional concepts of deterrence will not work against a terrorist enemy whose avowed tactics are wanton destruction and the targeting of innocents; whose so-called soldiers seek martyrdom in death and whose most potent

protection is statelessness." That being the case, we must have in our arsenal new information-technology based weapon systems that are useful to us and credible to our enemies. We don't yet have all of the physical tools we need for this war, but they are not beyond our future capabilities.

This still leaves a need to be a lot more precise about defining who is the enemy, and doing it in a way that does not make the problem worse by "creating the fertile ground" for growth of the "ideologies that promote terrorism." These sorts of tools are needed to wage a war about ideas, culture, psychology and not just things. Unfortunately, and not surprisingly, people are a lot more complex and adaptive than the widgets and gadgets. This broader and more fundamental aspect of our strategy has yet to be fully developed, but it is already included in what I called the other half of the national strategy, namely "bringing hope of democracy, development, free markets, and free trade" to those who can be influenced—which assumes those attributes of the modern world are what they really want and would accept, even if it is in some way connected with the U.S., whom they don't trust. These difficult issues will benefit from more clarity in our national debate, and more comprehensive systems solutions to these admittedly "wicked problems" that are going to be with us for many years. We will continue to focus on these issues in this newsletter, and in the articles that immediately follow. Your response will, hopefully, add to our understanding. ■

What Are We Fighting For?

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The Bush Administration has failed to win strong support for its Global War on Terrorism, both at home and abroad. People are uncomfortable with more than just unilateralism and the war with Iraq. The Administration's response to 9/11 concerns people variously for its erosion of civil liberties, its hawkishness, its expense, and its unclear effectiveness. There's every indication that Iraq and the War on Terrorism will be the principal issue of the democratic primary and the general election to follow. The policy that emerges with the winner is anybody's guess.

This is disturbing because there is a real danger in the world. It is a large multi-national group of Fundamentalist, Militant, Terrorist, Murderous Evil-Doers who believe mankind should be governed by Islamic law (Sharia) and see it as their duty to destroy those who disagree or disobey. In the ACG, we have been calling them the FM's, for short. What makes this group more dangerous than other violent extremist groups is the much larger group of people who sympathize with them and their cause and support them. Here we have many of the ingredients for a fascist empire. (By fascist, I mean that this group wants total centralized control, it has a "superior breed" conviction, and it will commit any manner of atrocity on its enemies and its own subjects. This is not speculation, as—unlike Germany, Italy, and Japan of the 1930's, these

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Arnaud de Borchgrave on Pakistan

Excerpted from an article by Borchgrave, entitled, Pakistan: Over the Cuckoo's Nest, *UPI; Nov. 28, 2003 (http://www.newsmax.com/archives/articles/2003/11/27/214524.shtml)*

"As a trustworthy leader, bin Laden scored higher than George W. Bush in most Muslim countries. There are no quick fixes for change. Despite all the constantly repeated assurances given to the U.S. about reform, Pakistan's madrasas, or religious schools, are still churning out 750,000 jihadi-prone male teenagers a year with the same hateful views of America, Israel and India. The fossilized clerics in charge have stood their ground - with Wahhabi clergy money still reaching them from Saudi Arabia. An estimated total of 5 million young men have passed through the system over the past 13 years."

fascists do not attempt to deceive us about their ends or the means they plan to use to achieve them. They write them down and record them on tape, post them on websites, and pass them to the media.) As our thinking gets precise, so must our acronym. We will therefore add an "F" for "fascist" and call this group the FFMs.

It does not appear that the Bush Administration is worried about an FFM empire. On the contrary, it is preoccupied with weapons of mass destruction and the specter of another terrorist attack. Meanwhile, Russia, the EU, and China are preoccupied with the U.S.

One reason the Bush Administration is short of support in the face of this threat is the peculiar manner in which it has defined the enemy and its objective in this campaign.

The Enemy

As has been widely noted, the enemy the Bush Administration names is not the FFMs or any other group of people; and it is not an ideology; it is a method—terrorism. Eliminating a method is not the kind of stuff that swells young hearts to bravery and patriotism. And eliminating terrorism is not the Administration's real objective, as evidenced by its near indifference to terrorism in Columbia, Italy, Ireland, Chechnya, et al.

In calling terrorism the enemy, the Administration may be trying to avoid the appearance of being against Arabs and Islam. Alternatively, the Bush Administration may simply be following a doctrine of limited war and looking for clear operational objectives (get in and get out). Nonetheless, our real enemies are FFM's. But if we were to "call a spade a spade," we would have to be prepared for a long, all-out war. Instead, we fixate on limited objectives like ridding Iraq of WMD's, even when these objectives are not our main ones.

The Objectives

The Administration talks most about two objectives in this war. The immediate objective is preventing catastrophic acts of terrorism, preventing a repeat of 9/11. The Administration seeks to destroy those who might have the means and motive to repeat 9/11, and it seeks to harden the country such that catastrophic terrorist acts are nearly impossible. Americans worry about the feasibility and expense of such an approach and about the infringements upon their privacy, civil liberties, and convenience. Europeans see the U.S. response as an overreaction and are not willing to endorse the strong offensive measures the U.S. proposes. And many here and abroad worry that the offensive part of the strategy may give birth to more terrorists than it kills.

The second (and long-term) objective of the Administration is to promote democracy, capitalism, and civil liberties worldwide to foster peace and prosperity and eliminate the conditions that foster terrorism. This objective is noble and inspiring and would have been far better received had it not been part of a national security (i.e., military) strategy with an explicit pre-emptive-strike component. Unfortunately, the lingering impression is that the U.S. wants to spread "its way," and it is willing to kill and conquer to do so. This starts to sound disturbingly like our description of the bad guys.

The bottom line here is not hard to find: Americans and their allies are willing to support the spread of democracy, capitalism, and civil liberties; they are just not willing to start wars over it.

Neither of these objectives adequately or clearly justifies current U.S. action in the world.

The Real War

To support a war, people need something much simpler, clearer, and more focused than the Bush strategy. They need to know whom they're fighting, why, and what they can hope to achieve. In this simpler version, the real enemy is the FFM's, and the real objective

is to prevent this group from growing into a formidable empire that enslaves millions and threatens us and our way of life. We cannot let politics or politically correct sensibilities prevent us from saying this.

This would not merely be a change in rhetoric, it would be a change in policy: If the enemy is fascism, then the enemy is *not* all evil murderous dictators; the enemy is *not* all nations that support terrorism; and the enemy is *not* all unbalanced dictators with weapons of mass destruction; the enemy is *not* all nuclear proliferants; the enemy is *not* all nations who might crimp our oil supply. (Europeans are not afraid of Bush *only* because he wears a cowboy hat and comes from a state with more gun dealers than booksellers—they really can't figure out where he's pointing that gun and what he's trying to do with it.)

Most importantly, the enemy is *not* Islam; and the enemy is *not* Arabia. In fact, there's nothing the FFM's hate *more* than an Arab Muslim who does not believe and practice as they do. And lucky for us, the FFM's have gone back to killing moderate Islamic people, giving us a chance to make some friends among those who live and suffer on the front lines of this conflict.

Is Time on Our Side?

Even once we have our enemy and our goal straight, the right path is not clear. If, for example, either the Saudi or Pakistani regime falls and radical right Islamist elements take over, should we use force or diplomacy? All this depends on one's perspective of the magnitude of the threat and whether we can afford to wait, whether we believe time is on our side and the movement will die off, or whether we believe that it will grow strong if left unchecked. If you think the worst that can happen is another 9/11, then stopping that event is probably not worth risking World War III (and this is where I believe the Bush Administration stands). If you think an empire really could rise (and it would not necessarily have to be a modern nation with a modern military force to be a serious threat), then this is no longer about terrorism, and limited objectives are inadequate.

The FFM movement is still quite far from being an empire and is fortunately not particularly capable technically or militarily. It has nonetheless proven formidable, popular, and enduring. It can only become an empire if it grows its popular support, and so the real war is for the hearts and minds of Islamic moderates. (See October 2003 *News & Views* article, *A War of Resolve?*, www-irn.sandia.gov/pubs/ACG/Pages/20031020.html). Preventing this growth is what matters. Herein lies the only sensible justification for the war in Iraq: setting up a prosperous capitalist democracy with civil liberties in the heart of the Islamic world, which would pour cold water on the fascist fire.

If time is on our side, then the sensible policy is one of containment and limited objectives. The biggest risk in this scenario is not the current FFM threat, but our own power turned against us. It is the risk that the violence in Iraq, Afghanistan, Palestine and elsewhere will anger so many more people that we tip the balance (and time is no longer on our side) and create FFM growth. Therefore, in this scenario, the Administration must be careful to engage militarily only when there is reasonable hope that some Islamic moderates will step forward and praise U.S. actions. The "time on our side" strategy is a containment strategy. Containment is clearly a strategy of self-interest—limiting the threat from the FFMs to the U.S. It is therefore not surprising that Islamic people, Arabs, and the international community are skeptical about U.S. intentions and staying power as we pursue such a policy.

If time is not on our side, then our goal must be to stop the FFM empire from forming, even if this requires all-out war.

Regardless of whether we believe time is on our side, the U.S. would be far better off with the clear goal of preventing an FFM empire than its current murky strategy. ■

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- QUOTE OF THE DAY -

"When I was young, I was amazed at Plutarch's statement that the elder Cato began at the age of 80 to learn Greek. I am amazed no longer. Old age is ready to undertake tasks that youth shirked because they would take too long."

- Groucho Marx

Is There a Future for a National Security Systems Lab?

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The large national defense labs as they function today are irrelevant in the Global War on Terrorism (GWOT). Specific technologies will find application in fighting terrorism, and that is worthy in its own right, but that isn't a rationale for sustaining multibillion dollar-per-year systems labs. Today's threat (actually a system of threats) is evolving faster than the rate at which our systems engineering tools can generate responses—not to mention getting ahead of it. Is there a role for large systems labs in such a fast changing world if all these facilities can deliver are system solutions to last year's problems?

The claim of "systems lab" status has been made by all of us in the big labs. What does "system" mean? What does "solution" mean? A system solution is typically the application of sophisticated project management tools with tight hierarchical control of tasks and resources to create a product that is itself made up of many smaller components (i.e. a Boeing 777 or an aircraft carrier). A solution is usually defined as the hardware/software product whose performance fulfills all aspects of the customer's requirements document. For instance, Sandia's system engineering experience comes predominantly in nuclear weapons with a number of significant smaller programs (satellites, sensors, and security systems to mention a few). I don't want to minimize these Sandia accomplishments, but what is our record? How does Sandia stack-up compared with other entities in system integration or engineering? We like to argue that we're better than most, but what about a comparison with the aerospace giants?

Even more important, are we really *dealing* with the totality of system issues, including the "people" part of these systems? We turn to project management tools that are linear, and there is the rub. Management is expected to do two major things: get machine-like rigor and predictability in the "people" part of the system and manage the relationship with the customer so that the project team can do the real work. The first is accomplished through clear and crisp roles and responsibilities, a well-defined accountability structure, and an unambiguous hierarchy of management. The second responsibility is critical to the success of this linear endeavor. Management is expected to push on the customer to generate a thorough and complete requirements document. Once that is agreed upon, management must push back hard in resisting changes to the requirements. This is critical to avoiding the disruptions that occur when requirements change.

In our national security programs, we can make this kind of system engineering work faster, and this can be a winning strategy when the adversary is faced with the same dilemma. But what if the changing requirements brought by the customer are an honest reflection of how fast the world is changing? What if the adversaries aren't depending on new systems solutions designed and implemented using traditional methods? Can we shorten the development cycle enough to keep up with the evolution of a continuously changing adversary? Somehow we have to re-imagine what the "system" is and what a "solution" is.

In fact, there is a different way of viewing these systems that include "people." At core, this is a shift from imagining systems in mechanical metaphors toward imagining them with organic metaphors. In this context, the system is the people and the hardware/software (they are multi-minded and multi-machine systems or, "M4," systems). These larger and more inclusive systems are non-linear, non-reducible, and not predictable in detail. But they are capable of novel and creative outcomes. (To read more about complex systems, see the November 2003 *News & Views,* http://www-irn.sandia.gov/pubs/ACG/Pages/20031120.html.)

While theories, methodologies, and techniques don't yet exist for the big lab

application to these complex systems, our adversaries are becoming very good at it. Events in Iraq reflect a microcosm of this. News reports are full of stories about how the insurgents adapt almost daily to the U.S. force protection tactics, and we are learning that any improvement in adaptability has life and death value. The U.S. Marine Corps experience contrasted with the U.S. Army experience in Iraq is a testament to this.[1]

Letting go of long-held notions of linear, reducible predictability is hard, but it's no longer an option. Our adversaries seem to have discovered a truth about what it takes to succeed in dealing with complex systems, and we have to change our methods accordingly. Novelist Michael Crichton has described this:

> Complex systems tend to locate themselves at a place we call 'the edge of chaos.' We imagine the edge of chaos as a place where there is enough innovation to keep a living system vibrant, and enough stability to keep it from collapsing into anarchy. It is a zone of conflict and upheaval, where the old and the new are constantly at war. Finding the balance point must be a delicate matter—if a living system drifts too close, it risks falling over into incoherence and dissolution; but if the system moves too far away from the edge, it becomes rigid, frozen, and totalitarian. Both conditions lead to extinction. Too much change is as destructive as too little. Only at the edge of chaos can complex systems flourish.

Our capacity to make a meaningful contribution to national security in the new century is contingent on our ability to embrace these ideas of complex M4 systems and make the evolving nature of the environment an asset rather than a fateful irritation.

Reference:

1. Middle East Institute Report, *The Sunni Insurgency in Iraq,* by Ahmed S. Hashim, 8/15/03, http://www.mideasti.org/articles/doc89.html; PBS *News Hour* interview with Major General James Mattis, USMC, 9/26/03, http://www.pbs.org/newshour/bb/middle_east/july-dec03/marine_9-26.html; NY Times, *Marines Plan to Use Velvet Glove More Than Iron Fist in Iraq*, 12/10/03. ■

The Oil Crisis of 2006

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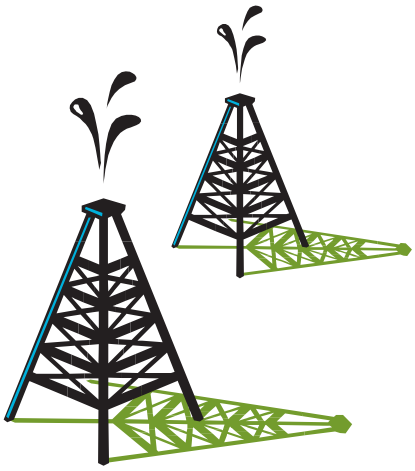
If the DOE Hydrogen Initiative is successful, then by around 2040 hydrogen fuel might replace the 10-11mbbl/d (million barrels a day) that the U.S. imports (but, other things being equal, by that time the U.S. might be importing an additional 10 mbbl/d because its economy and oil use will have grown and its domestic supply shrunk). But if we are concerned about dependence on foreign, particularly Middle East, oil, then 2040 seems like a long time to wait. Perhaps we need to plan for the short term as well as the long term.

Indeed, already 30 years ago the U.S. suffered considerable economic losses because of an OPEC oil embargo led by Saudi Arabia. In the international oil market as it is structured today, a repeat of an oil embargo targeted against a specific nation (such as the U.S.) does not seem feasible—it is highly likely that oil sold to non-embargoed nations will quickly be sold again to embargoed nations.[1] However, if the overall supply is restricted, the price of oil to all importers will go up accordingly. Both the U.S. and the global economy would suffer, not only directly from the increased cost of oil, but also indirectly because of the importing (and exporting) countries reduced ability to buy things from one another.



According to an Energy Information Administration estimate (http://www.eia.doe.gov/security/rule.html#size), for every one million bbl/d of oil supply disrupted and not made up for by other supplies, world oil prices might increase $3-$5 per barrel. Over months or years, a 10% rise in the price of oil (as this is written, oil is about $34 per barrel) could lower the U.S. real GDP growth rate by .05 to 1.0 percent. In recent years, the "energy intensity" (ratio of energy consumption to GDP) of the

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U.S. has been declining modestly. Developing countries (including China, which produces many of the goods consumed in the U.S.) are relatively more energy intensive, and would be hit harder by oil price rises.

From the standpoint of Middle East oil producers (especially Saudi Arabia), who have very large reserves and expect to sell oil for a very long time, constricting supply to raise prices has its limits as a rational strategy. Higher prices mean higher revenues as long as the quantities sold remain high. But higher costs also induce changes in consumer economies: inflation increases and economic productivity decreases, lessening the demand for oil. Higher prices also make diversified sources of oil and alternative sources of energy economically more competitive, thus threatening to lower the long-run demand for OPEC oil.

Conversely, increasing oil production to lower prices means lower revenue per barrel of oil sold, but has the benefit of encouraging consumption and decreasing the competitiveness of more expensively produced oil and alternative energy sources. Thus the long-run dependence of consumers on Middle East oil is enhanced. But if a rational decision to cut Saudi oil production does not seem plausible, how about an irrational one? For example, suppose a radical Islamist regime took over Saudi Arabia, and decided that that country should return to traditional ways rather than attempting to "modernize" economically. (For a recent historical example of a regime that was willing to accept reduced oil revenues for political purposes, consider the Iraqi government from 1991-2003). A supply disruption need not come from a governmental decision to reduce production. Terrorists or revolutionaries might sabotage production facilities to try to bring down the ruling regime. Sabotage that managed to contaminate such facilities with radiological materials might prevent production for a particularly long time. Again, Saudi Arabia stands out as the most important region of threat, not only because of the size of its oil exports, but also because of its internal production chokepoints and because of the uncertain long-term viability of the ruling family. One could also imagine, later if not sooner, a more traditional military conflict between, say, Iran and Saudi Arabia that led to damage to the production facilities of both. A war might also close the Strait of Hormuz, through which some 13 mbbl/d pass.

How likely is political turmoil in Saudi Arabia? Nobody knows for sure, of course, but recently published articles draw a foreboding picture. In last May's *Atlantic* magazine, Robert Baer wrote, "…sometime soon, one way or another, the House of Saud is coming down." (This article is not available online, but an interview with Baer is: http://www.theatlantic.com/cgi-bin/send.cgi?page=http%3A//www.theatlantic.com/unbound/interviews/int2003-05-29.htm.) More recently, Michael Scott Doran wrote in *Foreign Affairs* (http://www.foreignaffairs.org/20040101faessay83105-p0/michael-scott-doran/the-saudi-paradox.html) that "Saudi Arabia is in the throes of a crisis."

Long-term attempts to reduce U.S. dependence on imported oil (such as increased U.S. production, efficiency measures, hydrogen from coal) may be desirable, but they will not be of much help if a Saudi crisis leads to a multi-month reduction of several mbbl/d in the global oil exports. What could we do? Our most important hedge against this contingency is the Strategic Petroleum Reserve (http://www.fe.doe.gov/programs/reserves/), which currently contains about 639 mbbl of oil (the full capacity.

which the U.S. plans to fill, is 700 m), or about a 58-day supply of U.S. oil imports. This oil could be released into the economy, at rates determined by the government, to soften the price impact of a disruption in world oil exports. In addition, the oil importing members of the International Energy Agency (IEA) have agreed to maintain a 90-day stock of emergency reserves (http://www.iea.org/about/files/factshee1.pdf) and to cooperatively allocate those reserves in case of major disruption. It remains to be seen, however, how this cooperation would work.

What do we do if the oil export disruption lasts longer than 58 days or 90 days or whatever the emergency reserves happen to be at the time? One answer in the past has been to ramp up oil production to meet some of the shortfall. Unfortunately, the only country in the world with significant reserve production capability (and that is only about 2 mbb/d) is Saudi Arabia, which is the source of the disruption we are hypothesizing here.

The second major response to a significant oil supply disruption would be to restrain demand: use less oil. The declared U.S. policy of response to a major oil supply disruption, as stated in the IEA's document on oil supply security (http://www.iea.org/books/studies/2001/oilsecu.pdf), would be to utilize the emergency reserves and to rely on markets to restrain demand. That is, as the price of increasingly scarce oil goes up, people will buy less. Then, perhaps, the new market price of oil will reach an equilibrium at a level that does not result in major economic damage.

Certainly, letting the price rise to match the reduction in supply is better than the policy tried during the 1973 embargo: attempting to put governmental price controls on the oil. Still, rising oil prices move money from the other parts of the economy into the accounts of oil producers (both domestic and foreign). Some people will get richer, some poorer; inflation will increase, GDP growth decrease. Other countries plan additional measures to restrain oil demand. One such measure is to attempt to persuade consumers to use less, for the good of the nation. A second is enforced rationing, which can be administered in various ways: reducing speed limits (to reduce gasoline consumption); odd/even license number refueling on different days; large-scale allocation of supplies to those believed to be in most need or be making the most economically productive use of the energy. One problem with rationing is that, from the standpoint of economic efficiency, it substitutes bureaucratic judgments and political influence for market mechanisms. Another problem is that it can lead to black markets.

A third response to supply disruption would be to try to end the disruption forcibly. This would involve militarily seizing wells, pipelines, and port facilities. If this were done to counter a cut-off decision by a hostile government, it would have to occur before the regime could sabotage the production infrastructure. If the infrastructure had already been damaged, the U.S. (and possibly its allies) would need an emergency restoration capability that would, it is to be hoped, be able to get the oil flowing again. It took about 8 months to put out the oil well fires that Iraq set in Kuwait in 1991, and longer than that to restore full production. A more systematic job of sabotage might take longer to repair.

What do you think is the best way for the U.S. to prepare for the contingency that Saudi oil exports were severely reduced, not merely for the 2 or 3 months covered by our strategic reserves, but for 6 months or a year? Is this something we should worry about? What mix of precautions and emergency preparations would make the most sense? The ACG plans to explore these questions further.

Reference:

1. Report of Workshop held at Sandia in 2003: Thomas H. Karas, *Energy and National Security* (SAND2003-3287, September 2003, http://www.sandia.gov/ACG/workshops/SAND2003-3287energynatlsecrpt. pdf). ■

"What do we do if the oil export disruption lasts longer than 58 days or 90 days or whatever the emergency reserves happen to be at the time?"

Our Machines, Our Future, Our Selves

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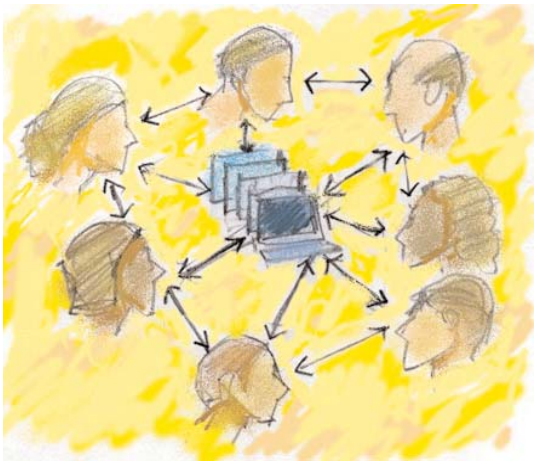
"A *HuMachine* is a person or group assisted by computational and sensor systems that must be able to sense human characterists and behavior."

Symbiosis is "a relationship of mutual benefit or dependence", according to Bartleby's Dictionary. Are humans and computers engaged in a symbiotic relationship? Let's explore this a little. Would it be possible for Western culture as we know it to exist without information technology (IT)? No, our societies are already IT-dependent in countless ways: transportation, food production, communications, utilities, commerce, education...the list is practically endless. If all computers and software were somehow disabled tomorrow, social and economic cataclysm in the IT economies would follow.

In 1960, J. C. R. Licklider predicted that human-computer "symbiotic partnership will perform intellectual operations much more effectively than man alone can perform them." This prediction was largely true: our intellectual achievements have indeed been greatly enhanced by technology. But have we reached true symbiosis? Since computers are not a separate *species* obtaining essential relational benefits (they are yet only complex *tools*), it is not strictly correct to classify us as symbionts in the sense of biology. If artificial consciousness is ever generated, this situation might well change, but for the foreseeable future, computer technology will simply be indispensable to life as we know it. As societies and individuals, we will become ever more deeply dependent on IT, to the point that we must honestly rename ourselves *homo sapiens cyborg*. Of course, isolated cultures without functional dependence on information technology will continue to exist. Barring technological catastrophe, these will increasingly become curiosities in protected reserves rather than independently viable societies.

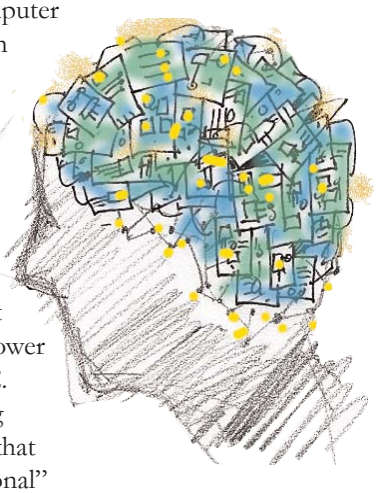
It is perhaps inevitable that we will continue to be transformed by our technologies. For example, the information technology revolution is making rational genetic engineering possible. We may one day augment natural selection processes and engineer our own genomes to eliminate hereditary diseases. We might even enhance the physical or intellectual capacities of our offspring. Well before those technologies mature, to be banned or adopted, I think that a new kind of personal information technology will lead the social transformation process. This new technology will be realized in systems I call *HuMachines*. A *HuMachine* is a person or group assisted by computational and sensor systems that must be able to sense human characteristics and behavior. With greater sensor power, computational resources will then be able to assist and enable human performance in novel ways. A personal assistance technology could know when we are sick, distracted, or too tired to carry out a critical team role in our workplace or at home. Based on long-term observation and automated modeling, it could notify us that we are talking too much in a meeting, or that our blood pressure rises whenever we have to use PowerPoint. With a robust voice and gesture system interface, creativity would not be inhibited or altered by the dictates of a keyboard or a software syntax. This level of assistive technology will require fundamental advances in sensor hardware and software, and will require an understanding of both neurophysiology and social processes that elude us. In the ACG, we have begun to explore the concept of



enhanced personal and group performance by prototyping a *HuMachine* called Mentor/Pal©.

Following a three-month process of group study in the ACG, we developed the concept for a system to observe and coach people engaged in complex collaborative activities. We wanted a sensor system that was noninvasive so that natural behaviors would not be impeded for activities such as brainstorming, scenario development, and simulation games. The prototype was built with off the shelf components and custom software by Dr. David Warner and his *MindTel* team, based on an inexpensive networked PC platform. The system records the activities of four people as they work together. The system sensors include face video, audio, keystroke, and mouse movement. Each person is equipped with a sensor suite for recording electro-cardiogram, breathing, blood pulse volume/oxygenation, electromyelography, 3 electrode EEG signal, and galvanic skin response. Accelerometers on the head and hands record movement. The initial observations used a commercial video game for collaborative play; a game activity allowed us to track the performance of both individuals and groups quantitatively. We gradually increased the difficulty of the game and shifted team membership to mildly stress the group, and observed what took place.[1] The apparent links we saw between sensor data and human performance suggest to us that personal sensing in a team setting is an incredibly promising technology. In 2004 we will integrate simultaneous four-person 128-channel EEG recording in Prof. Akaysha Tang's laboratory at UNM, correlating brain events, physiologic dynamics, and social phenomena. We will begin a comprehensive study of collaborative behavior and develop assistive methods to improve group and individual performance. To complement this applied research, Sandia is supporting a CalTech graduate fellowship to study the neurology of learning processes under Sandia's Campus Executive program, and UNM-CalTech collaboration is planned. Our project is not in a "traditional" Sandia discipline, but we think it might reflect a new field where Sandia can truly excel and lead technology development in support of our national security mission.

What role could Sandia play in a transformational future where the line between machines and people is a little blurry? For Sandia to remain relevant, we will have to pursue development of basic research expertise in neuroscience. Please note that modern neuroscience is very different from expertise in software engineering, psychology, artificial intelligence, or systems modeling, all circa 1985. Leading neuroscientists tell us emphatically that the human brain is not a computer: its physical basis, its dynamics, and its modes of information processing are utterly dissimilar to those that take place in the static binary realms of explicit software architectures and integrated circuitry. Even with what little we know about the brain, we already are certain that "a wet computer" is possibly the worst analogy we can devise to understand the brain! People and their behaviors cannot be described or recreated by a computer program realized in binary code in a silicon substrate. Our brains and our bodies are as one, it seems. Our "gut" feelings are as essential to our higher thought processes as the power plant is to your PC. New brain imaging methods show us that emotion and "rational" cognition are not compartmentalized, but are intimately connected; to really sense and understand the brain, we must also sense and understand the body and its physiologic processes and systems. Another future Sandia initiative could be the development of sensors for human activity: small, wireless, inexpensive systems to communicate one's physical, emotional, and cognitive states to each other, and to supportive group systems. We already have expertise in sensing vanishingly small quantities of chemical agents and biotoxins in the air. Why not develop sensors to noninvasively monitor our stress and regulatory hormones like



About the ACG *News & Views*

The ACG *News & Views* is published monthly by the Vice President and Principal Scientist to share new ideas, concepts and opinions. We welcome interesting dialogue about the issues/views presented in this publication and encourage our readers to contact us or submit articles explaining their views.

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cortisol, noradrenaline, and oxytocin in real time? Development of these new tools would support basic advances in medicine and lead to novel systems for enhancing and ensuring human performance in of critical surety environments. Once we have invested in fundamental neuroscience and human sensor engineering, we will be equipped for the tremendous software engineering challenges posed by *HuMachine* systems. We will need to invent self-programming and adaptive software that does not actually get written, but will have to evolve in response to its sensor inputs...just like the human brain develops in early childhood, as populations of neurons compete, align, merge, and grow to cognitive maturity. We might even need to develop a new kind of nanotechnology-based neuromorphic circuitry to support this software.

The future of human-machine systems can be a bright one, if we develop technology that enables us to be more fully human instead of clever cyborgs. I don't think that invasive technology will have a role in my lifetime, except for medical necessity. I am not worried about anyone requiring me to get electrodes in my brain so I can keep competitive on the job. But we may have to get used to the fact that adventurous people will push the envelope and experiment with physically-embedded computers and similar invasive technology that they think enhances some aspect themselves. For certain, adversaries will use any such technology if it confers an advantage. For this reason alone (understanding the threat when it arrives), Sandia should invest in basic competencies today.

Constant and accelerating change is inevitable: our ancestors from the year 1700 would have great difficulty understanding the world we live in or the work we do. Today's everyday appliances were the subject of science fiction in 1960. Are *HuMachine* systems today's science fiction? Yes. Will Sandia be busy inventing and deploying them in 2025? Yes. So will the enemies of peace and freedom. Let's get started.

Reference:

1. SAND 2003-4225, *Enabling Technology for Human Collaboration,* http://infoserve.sandia.gov/sand_doc/2003/034225.pdf. ■

So . . . you think you know everything?

- A crocodile cannot stick out its tongue.
- A "jiffy" is an actual unit of time for 1/100 of a second.
- A snail can sleep for three years.
- Butterflies taste with their feet.
- Cats have over one hundred vocal sounds. Dogs only have about 10.
- If the population of China walked past you, in single file, the line would never end because of the rate of reproduction.
- Maine is the only state whose name is just one syllable.
- No word in the English language rhymes with month, orange, silver, or purple.
- The average person's left hand does 56% of the typing.
- The cruise liner, QE2, moves only six inches for each gallon of diesel that it burns.
- The words "racecar," "kayak" and "level" are the same whether they are read left to right or right to left (palindromes).
- There's no Betty Rubble in the Flintstones Chewables Vitamins.
- Tigers have striped skin, not just striped fur.
- "Typewriter" is the longest word that can be made using the letters only on one row of the keyboard.

Now . . . you know everything!