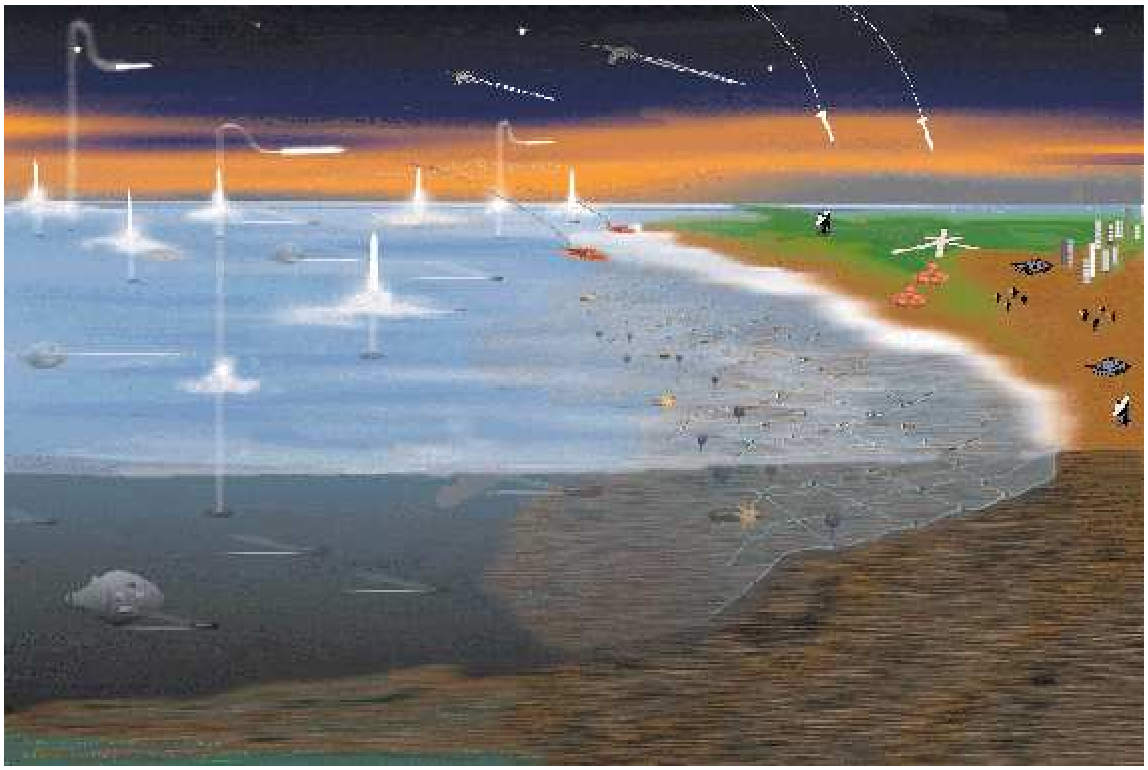
The Shape Of Things to Come?

Top NASA Scientist Discusses The Future of Undersea Warfare



by Dennis M. Bushnell

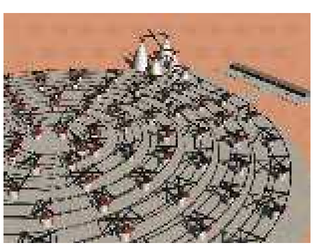
Since the 1950s, when more than 50 percent of the nation's work force became engaged in some type of "information-intensive," activity, the United States (and the world) have been in the midst of an unprecedented Technological Revolution, currently centered around Information, Biological, and Nanoscale technologies. These technologies are all pushing the frontiers of the miniscule in a synergistic "feeding frenzy" among each other, and are causing tremendous changes in all areas of human endeavor. One of these areas is warfare. The character of these new technologies is altering both the context of potential conflicts and the diversity, effectiveness, survivability, and affordability of the techniques and material applicable to waging war.

In today's environment, some 70 percent of all research is now conducted within a "commercial" framework outside the United

States and is thus readily available to likely adversaries. In terms of sheer size, several economies (Japan, China, and the European Union, for example) are approaching the magnitude of ours, and may even exceed it. Moreover, inexpensive, highly-motivational, web-based distance learning on demand promises to greatly accelerate these trends. With respect to techniques and materiel, the Info/Bio/Nano-technology revolution(s) are providing:

- Increasingly small, ubiquitous, inexpensive, networked, scientific and commercial, land-, sea-, air-, and space-based sensors applying multiple physics and hyper-spectral techniques
- Robotics and automation "in the large"
- Long-range precision strike
- Inexpensive mini/micro/nano"everything," including platforms, sensors, and weapons
- Wholly new classes of biological weaponry
- Hard-to-jam optical communication and navigation systems
- Greatly enhanced explosives and "volumetric" munitions... and finally,
- A fourth "weapon of mass destruction" in the form of physical or electronic information operations (IO)

Current estimates indicate that over the next 25 years, computing will increase in speed by some six orders of magnitude, and communication speeds will increase by four orders of magnitude as optical systems replace microwaves. Further, the use of large active-volume or broad-area techniques and advanced energetic materials in weaponry will increase their destructive power by up to four orders of magnitude.



The "Slingatron" launcher offers the

The overall impacts of these largely-commercial and globally-available capabilities on the outlook for military operations are far-reaching. In particular, these technologies will enable much more effective "warfare on the cheap," in which "peer competitors" are no longer defined by their possession of megatons of Industrial Age artifacts in steel potential for rapid-fire intercontental bombardment using advanced boost-glide vehicles and unconventional payloads.

and aluminum. They create dangerous implications for any attempt to carry late-20th century U.S. power-projection concepts into the 21st century. Numerous systems are emerging that could be used in tandem to wreak havoc on U.S. air and sea-surface logistic and strike platforms, both en route and in the operational theater. Non-stealth and undefended logistics platforms are particularly at risk. What will be "new" in this future threat environment are the omnipresent, omniscient sensor suites mentioned previously and the sheer number and variety of long-range and pre-positioned precision munitions that can be brought to bear. Unless platforms and weapons enjoy the sanctuary of the deep ocean, being targeted will be a "given" in the out-years. New age weapons and munitions will include:

- Lurking, semi-submerged, anti-air or anti-surface missiles in the water column, with off-board targeting by netted sensor "webs"
- Transoceanic unmanned underwater and air vehicles (UUVs and UAVs)
- "Brilliant" mines
- Long-range cruise and theater ballistic missiles
- Very long-range "guns," using Blast-wave Accelerator and Slingatron technology

Just consider the last. The Blast-wave Accelerator was analyzed at the University of Texas/Austin by Professor Dennis Wilson and is under study by both the Army and NASA for inexpensive access to space. The concept involves sequential detonation of charges behind a projectile (without a barrel) yielding ICBM or IRBM speeds after only 100 to 200 feet of acceleration. Essentially this is a "rocket" in which the external structure and propellant never leave the launcher - only the warhead. The latter could be proected in flight by a technique test-flown by NASA in the 1960s at 18,000 to 25,000 feet per second - injection from the nose of a thin stream of liquid water, which can be thrust-vectored. The 1,000-pound projectile would operate in a boost-glide, vice ballistic, trajectory and offer not only stealthy launch - no plume - but also exceptional flexibility, affordability, and survivability, while retaining the ability to be recalled. The Slingatron, also being studied for inexpensive space access, would use an oscillating horizontal tube - much like a "hula-hoop" - to accelerate projectiles in a spiral path until launch velocity is reached. Such an arrangement appears capable of lofting hundreds to thousands per minute of ten-kilogram projectiles over even intercontinental ranges.

As an example of progress in unmanned aerial vehicles (UAVs), the University of Washington recently flew a UAV across the Atlantic on only 1.5 gallons of fuel and intends to make a trans-Pacific attempt next. Increased precision, along with technology advances in materials, are also enabling a "mini-ICBM" option with terminal guidance for mid-ocean strike. Another potentially potent innovation is the Vortex Combustor under development at Penn State's Applied Research Laboratory, which burns nanoscale aluminum particulates and sea-water to provide inexpensive air-independent propulsion (AIP) for both submarines and very long range UUVs.

One way for the "Enemy-After-Next" to defeat or deter U.S. power projection with relatively little expenditure is to ensure that our forces do not "arrive at the party." The notional weapons described above - and others - are all based on enabling technologies already "in the pipeline," and they will make crossing the ocean in the air or on the surface like running the gauntlet. Attrition by enemy action could well begin within the continental United States (CONUS) itself and then over the continental shelf, since we typically deploy from a relatively small number of ports and airfields, thus simplifying the pre-positioning of smart, "pre-need," anti-air and anti-surface missiles and a variety of mines. As we will discuss below, "kill" mechanisms will probably not be restricted to high explosives.

The "density" of the threat will grow even more dangerous with increasing proximity to enemy-held coastlines. This is the "area denial" problem discussed for some time now by the Defense Department's Office of Net Assessment, among others. Well before mid-century, "country-sized" magazines may be available to loose "hordes" of inexpensive, long-range precision weapons with advanced warheads bearing a "devil's brew" of lethal components:

electromagnetic-pulse generators and radio frequency blankers, IW payloads, mines, fuel/dust/air or other volumetric explosives, chemical/biological/microwave anti-functionals and antipersonnel weaponry, as well as carbon fibers and "blades."

In the face of such an onslaught, friendly platforms will be hard pressed not to run out of "bullets" just defending themselves, thus causing both unacceptable attrition and the defeat of strike or power projection operations. Beam weapons are sometimes suggested as at least a partial counter to such a threat scenario, but even these have multiple and inexpensive counter-countermeasures available to an adversary. One quickly concludes that late-20th century power-projection or forced entry approaches could be gravely threatened by a determined opponent with access to these new, generally-available technologies.

What, then, might be some alternatives? Possibilities include global-range cruise missiles and exo-atmospheric precision-strike munitions, launched directly from CONUS on conventional or miniature ICBMs, and hypersonic boost-glide projectiles launched from the several types of global-reach guns mentioned above. The latter could be far less expensive and far more survivable than our current options for global precision strike - tanking B-2s and steaming aircraft carriers. Obviously, many information operations could also be prosecuted directly from CONUS.

For shorter time-of-flight munitions, a deep-water "arsenal" submarine deploying various "swim-ins" or "pop-ups" provides a survivable option. Deep-water standoff is necessary because of the danger posed by multi-static, low-frequency active (LFA) acoustics and increasing capabilities for sensing the many non-acoustic "indiscretions" associated with submarines in shallow water. These include hull detection by visual, lidar, infrared, or bioluminescent means; sensing the underwater wake by perturbations in the pressure field; and measuring salinity scars, chemical releases, internal and surface waves, turbulence, magnetic effects, radar returns, and other phenomena. In the context of swarms of inexpensive, omnipresent sensors, based on multiple physics, and operated on a "take-a-vote" sensor-fusion principle to minimize false alarms, survival of shallow-water submarines appears problematical.

Because of increasing area-denial threat, "almost spherical" arsenal submarines could well become our best land-attack option.

Deep-water arsenal submarines would obviously need tremendous capabilities for loading out munitions. Thus, as almost a *reductio ad absurdum* approach in designing such platforms, "almost-spherical" configurations should certainly be investigated.

This shape would yield several synergistic benefits, including minimum wetted area and friction drag, plus the smallest structural weight for increased depth capability. The serious pressure-drag issue with such a shape could be ameliorated to yield very low overall drag by using a fully-integrated "Goldschmied" pump-jet propulsion approach, with thrust vectoring for control. In this configuration, the pump-jet inlet provides potential flow "sinks" inside the body and should convert the back of the pump-jet shroud into a stagnation region instead of a stagnation point. For enhancing the affordability and survivability of such volumetrically-efficient platforms, a number of *ab initio* design features suggest themselves:

- Extreme automation for minimal crew size
- An on-board chemical plant for producing drag- reducing polymer from phyto- and zoo-plankton sieved from the power plant coolant intake
- Active acoustic masking to defeat LFA
- Inclusion of a replenishable, burst-speed "afterburner" system - perhaps a hydrogen-oxygen rocket as an adjunct to a down-sized main propulsion plant
- Manufacture of underwater platforms via robotic/magnetically-

steered, electron-beam, free-form fabrication - essentially "virtual prototyping" of the final product

Admittedly, this concept submarine would be very different from what might result from continuing with our current and evolving design practice. However, along with affordability and survivability, volumetric loadout is the major issue for power projection from submerged platforms. An "almost-spherical," deep-water, arsenal submarine would have sufficient volume for many of the design options listed above; space for adjunct sensors, such as mini UAVs; and large capacity for storing munitions.

Other design alternatives for providing additional volume - such as simply "plugging" existing designs - have already been proffered. But in the opinion of this author, the revolutionary design approach suggested here has enough potential to warrant its inclusion in a design "runoff" for a future, submerged, deep-water "arsenal ship." It could well constitute the only survivable "close-in" strike platform for assuring naval power projection in the future.

Dennis M. Bushnell is the Chief Scientist of NASA's Langley Research Center, Hampton, Virginia. He hails originally from Westbrook, Connecticut, the hometown of David Bushnell of Revolutionary War "Turtle" fame, and they share a common ancestor in William Bushnell (1680-1733) of Saybrook, Connecticut. He is a member of the National Academy of Engineering, a Fellow of the AIAA, ASME, and the Royal Aeronautical Society and is the recipient of the NASA medals for Outstanding Leadership and Exceptional Scientific Achievement.

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