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[Note: The opinions contained in this article represent the views of the author, not of DOD or the U.S. Government.]

This paper has been developed in four separate but interrelated parts. Each part could stand alone. Together, the four sections cover broad subject areas rather than focusing on narrow issues. These subject areas mutually affect each other, however. Taken together, they make a strong statement about certain directions for the USAF in space.

I. Planning for Conflict

The first prerequisite to supporting warfighters from space is to ensure that required space assets will be available when they are needed. This means first that they can be deployed to cover any area of conflict, and second that they can survive long enough to perform their mission.

Given the theme for this panel, there will undoubtedly be a number of calls for rapid response, survivable launch systems to support a variety of Tacsat concepts. The underlying assumption behind these notions is that today's so-called peacetime systems are neither responsive nor survivable. Therefore, new systems -- Tacsats -- are needed, which would be designed for responsiveness and survivability. Certainly, Tacsat concepts are worth considering. They have their place in a discussion of warfighting support. That does not mean, however, that such ideas, advocating sweeping changes in the present way of doing business, offer the only options.

First, consider survivable launch. Why is it necessary? For pre-nuclear scenarios, both sides retain homeland sanctuary. Respective launch sites remain intact -- with little need for survivability. For scenarios calling for satellite replacement in the midst of a nuclear exchange, the threat of continuing ASAT attack (forcing continued launch of replacement satellites) is highly improbable. The following rationale applies:

Space threats which pose a physical danger to satellites -- requiring their replacement -- need a network of space surveillance sensors to track orbital targets. These sensors would have to survive in order to successfully prosecute an attack with the required precision. Although future sensors may be space based, current sensors are commonly ground based radars, each of which would be extremely difficult to protect. Further, an integrated command and control system would have to survive along with launch vehicles and ASATs themselves. Such a list of interrelated, ground based vulnerabilities in a global nuclear scenario is simply too long, too fragile, and too uncertain for reliable nuclear war planning.

Of course, the nation may still need to replace failed satellites after a nuclear attack. This calls into question a trade in effectiveness between on-orbit spares sufficient to survive a pre-nuclear ASAT onslaught and post-nuclear survivable launch. So let us turn to that subject next.

In dealing with questions of survivability, a primary assertion of this paper holds that it is currently safer to store satellites on orbit than on the ground. For example, on-orbit assets can be disguised, can be made maneuverable so as to frustrate an attack, and can use a number of other built-in survivability techniques (decoys, hardening, etc.) to avoid destruction. Low altitude satellites, however, are another matter. There may be no alternative to replacing them via responsive (versus survivable) launch systems if they are required for warfighting. This will be discussed later. Finally, ground spares for satellites could conceivably be stored in survivable locations and use survivable launch systems after nuclear attack. The need here is for a cost trade. This paper postulates, however, that development of a survivable launch infrastructure should not draw off precious funding unless we are forced to do so by direct enemy development of systems which obviate cost effective measures to build survivability into satellites.

Given the foreseen threat, adding increments of additional survivability to DOD satellites appears cheaper than building a survivable launch infrastructure. Our strategy should be to continue our baseline programs at prudent levels, invest in generic technology, watch our enemies, and change directions only if forced or if new opportunities arise. This conclusion becomes even more apparent as the primary threat of nuclear war with the Soviet Union decreases under the impetus of sweeping political change on the other side of the Iron Curtain. In short, building a nuclear survivable launch infrastructure is simply not warranted at this time. Technology development for such capability, yes, but full scale development, no.

If Tacsats are not required for survivability, then, what about responsiveness? The answer is clear. Military space systems must become more responsive. Let us start with high altitude spacecraft.

As stated earlier, satellites at semi-synchronous and geosynchronous altitudes are relatively safe from attack, and use of on-orbit spares can compensate for premature peacetime failure. So today's highly capable assets and their evolutionary follow-ons at high altitude primarily require extremely economical, highly reliable launch systems in order to maintain robust constellations at affordable costs.

However, geosynchronous, equatorial satellite coverage is not necessarily global. Gaps at polar latitudes are particularly common. Nor do today's primary systems provide the dedicated service and system capacity to guarantee full support to a regional commander in conflict. In short, today's peacetime infrastructure could well require reinforcement -- either for reasons of coverage or capacity -- during periods of conflict.

Low altitude systems are vulnerable to attack. Use of on-orbit spares, if also stored at low altitude, may not be able to overcome attack attrition at cost-effective rates. For these systems, responsive replacement from the ground, using either Tacsats or satellites with increased built-in survivability, may provide the best answer.

Responsive launch would maintain low constellations at acceptable numbers during a prolonged attack. Survivable launch, however, would not be required because: 1.) ASAT will not continue to operate after loss of homeland sanctuary, and 2.) Constellations should remain robust enough not to require post-nuclear strike replacement.

So, missions which are performed by both high and low altitude spacecraft would benefit from responsive sparing from ground "alert" during conventional conflict. Certainly, nearly every recent study has concluded that responsive military space systems are needed, and their absence is a shortfall in today's required capability. The open question remaining is whether such systems should be comprised of limited capability Tacsats or fully capable satellites. Trade studies on this point are not conclusive.

While answers to these questions are being sought, the main point of this paper stands. Warfighters receive excellent support from space today. The increment of additional support they need may be just as well provided by evolutionary changes to the current force structure as by creation of an all new, survivable Tacsat architecture. If the nation is ready to make a large investment in a new military space capability, then perhaps providing a highly responsive and reliable launch system that would lower the cost of access to space by an order of magnitude should be our number one priority. That way, on-orbit sparing could become an affordable reality and contribute effectively to realistic military strategies.

II. Planning for a Multipolar World

The East-West, bipolar, global political structure that has prevailed for the past forty years is undergoing a striking metamorphosis. Nuclear weapons cannot be disinvented, but the dark threat with which we have learned to live seems to have brightened and transformed -- perhaps bringing new opportunity. Nevertheless, human nature has not fundamentally changed. Nor has an equitable division of scarce global resources been adjudicated. History has shown that where gifts of the environment are limited and human demand is great, pursuit of national security is certain to take the form of competition or conflict.

It has become axiomatic in recent days to say that the future world will be multipolar rather than bipolar in nature. Regional conflict and shifting alliances will shape the future political order. Instability will prevail instead of the predictable central stability to which we have grown accustomed. Perhaps today's allies will at times become adversaries. And adversaries could become allies. More nations will develop nuclear capability, and more will acquire access to space.

In this future, U.S. military force is seen as reverting to something like Eisenhower's "New Look" concept: concentrating force within the continental U.S. rather than using forward basing; developing light, rapid deployment forces rather than heavy, in-place units. Long range nuclear retaliatory forces will remain important for deterrence, but long range conventional forces will constitute the new game in town.

In this world, U.S. services would be called on to operate effectively under greatly changed circumstances. Preplanned operations against well understood enemies may not be possible. Military reaction to fast-changing political situations may be demanded.

To be truly effective, though, rapid deployment joint service units would have to deploy simultaneously from disparate bases, coordinate their plan enroute, and employ concentrated firepower with precision in timing and location halfway around the world -- all this within hours of initial notification. While such operations were considered so difficult as to be impossible in the recent past, they are more plausible today.

Of course, such forces would require specific and dedicated help in order to perform well with short notification over long distances. They would, in short, need space support. One recurring argument heard in recent months holds that in today's climate of rapidly dwindling military budgets, certain defense sectors must, in fact, be increased. Space systems are among these. The primary reasons are two.

First, space systems provide global information. As Lieutenant General A. Casey, Commander of Space Division predicted in 1987, "The day is coming with wide area surveillance from space, that there will be no place to hide on this globe." Since potential hotspots could bubble up with greater unpredictability, global information on military forces, types of equipment, technological developments, and surprise movements will become of increasing importance for deterrence. Deterrence is our primary aim, and it deals in perception. Potential enemies must believe we are watching them -- that they cannot surprise us. Then they will find it harder to attack at all.

At the same time, verification of treaty provisions and monitoring of a growing number of nuclear capable nations will be required. The bottom line is that in the future, information will, indeed, equate to power. It is apparent that information will become of increasing importance. And global, real time information will require more space systems, not less.

Secondly, rapid deployment of U.S. forces will need space support to coordinate their activities. Communications, global in coverage, secure in transmission, and available while on the move will be fundamental. Precise, reliable, global navigation will likewise fall into the mandatory category. Navigation, positioning, and targeting must relate to a common grid for accurate coordination, and allow for flexibility in determining new routes. Updated weather data enroute will be needed. Hours old reports simply will not be good enough. Current information on enemy disposition will also be necessary. Finally, real time, enroute threat warning will be needed to protect extended lines of communications.

As stated earlier, more spacefaring nations are bound to appear. Already we count China, Japan, India, Australia, Israel, and Iraq, along with the primary space group of the U.S., USSR, and Europe (ESA). Others will follow, and in a climate of shifting alliances, potential threats could emerge from surprising quarters. Furthermore, as the highest, most far-reaching arena for conflict, space will likely constitute the first campaign of the future, just as air superiority was (is) the first campaign up to the 1970s and 1980s. Now it may become necessary to gain space superiority before prosecuting terrestrial operations, just as it was previously necessary to gain air superiority before attacking by land.

All the above indicates that military space systems need to become more responsive, more directly accessible to terrestrial units, more pervasive, and more integrated into warfighting plans and doctrine. It also suggests that survivability must be taken more seriously. Although the sophisticated Soviet threat may be dwindling, a more diversified, albeit crude, threat could develop quickly. Finally, Space Control must be considered a prerequisite for other military operations.

III. Planning for the Inevitable

> 99.9% reliability equals 999 duds out of a million grenades; two landing errors per day at Los Angeles or New York; 20,000 wrong medical prescriptions every year; unsafe drinking water one hour per month; and 2,000 lost articles of mail per hour, every day of every year.
>
> -- General Bernard Randolph

The next catastrophic failure of the Space Shuttle will occur between 1991 and 1993. That is, if the reliability of the Space Transportation System (STS) falls somewhere between 96% and 98.5%, and if the expected flight rate is accomplished on schedule, then enough flights will have been launched during that period as to make an accident highly likely.

Of course, it is possible that the reliability figures quoted above fall well off the mark. If another 200 successive flights come off without failure, then the conclusion will certainly be much less sombre. But the STS is a 1960s technology machine, using components very similar to those used in other launch vehicles; and enough data has been collected on rocket powered boosters, both foreign and domestic, as to make reasonable allowance for variation. Therefore, it does not seem unreasonable to assume that the Shuttle will fail again during the mid-1990s.

At the same time, failure of a Titan IV is also likely by the mid-1990s. Space launch has not yet become routine.

The point of this paper, however, is not to debate statistical possibilities of failure. Rather, the point is to consider that the likelihood of failure in all current systems is high enough in the near future as to bring prudent men to contemplate what will happen when failures occur. What plans have we made for the inevitable?

Medium launch vehicles (MLVs) have a history of relatively short down times after a failure. All MLVs also have margin in their projected launch schedules. Therefore, when failures occur in this family, they should recover quickly, without leaving a backlog of grounded payloads. STS and Titan IV occupy the other end of the spectrum. When they fail next, repercussions will echo for years.

For Shuttle, several commentators have forecast that another failure could well bring a halt to the entire program. Certainly, if another failure occurs within 25 to 50 flights, it will be taken as evidence enough of unreliability as to cause the nation to consider whether continuation is worth it -- whether the public will stand for regular tragedies and the accompanying mental anguish on a continuing and regular basis.

Beyond the human toll, at the current cost of an orbiter, along with the spacecraft it carries, we need to discover the system's true cost effectiveness. Can the nation afford to fly the STS if the cost of failure is included? We don't know -- yet, because its unreliability remains unproven. But we should be prepared for the possibility that a failure in the next three years will peg it as too high a price to pay. Then what?

Certainly, in such a scenario, many payloads simply won't be launched. The current Shuttle manifest already lacks room for many commercial payloads, even though military use of the STS has dwindled to nearly zero. The current manifest, in fact, supports space station deployment flights above all else in the last half of the '90s. At the same time, NASA is recommending even more reliance on the STS. The Human Exploration Initiative to Moon and Mars, should it be approved, is entirely dependent upon a vastly increased launch capability -- primarily Shuttle derived. That initiative would seem to be at risk from the start.

Could the nation simply turn to Shuttle C if failure of manned flights are temporarily interrupted? No, for it relies on the same economics as Shuttle. The cost of orbiters is simply too high to pay if they turn out to have lower than expected reliability. Other current expendables? The capacity of those systems, even with heavy investment in infrastructure, would fall woefully short of the required additional traffic flow -- and man-rating would add enormous cost with questionable gain.

The truth is that the nation has not adequately allowed for an alternative to the Space Shuttle. When the inevitable happens, we will find no readily available option.

Similarly, when the first Titan IV fails, a parallel conclusion will become manifest. No recovery flight rate has been built into the Titan schedule. It has no designed-in resiliency. None of the currently planned Titan IV payloads has been able to provide for a backup launch capability on an alternate booster. So, when Titan fails, DOD will simply have to launch payloads late. Given that the current manifest is overbooked -- that it already falls several payloads short by the turn of the century -- the additional, accident-induced delay will bring with it a great deal of pain. This pain will be felt in terms of critical operational impact for DOD and its warfighters.

Of course, the nation could develop alternatives. Let's look first at the Shuttle. Post-failure demands in the mid-1990s will require airplane-like reliability, a true abort capability, lower life cycle costs, and manned access. Until 1988, the National Aerospace Plane (NASP) program was on schedule to support a development decision by 1993, and it was aimed at meeting all these post-failure criteria. It still might. It could provide an elegant solution for an STS replacement, particularly if augmented by heavy lift expendables to assist with space construction and fueling. Economic analysis indicates that, since it is fully recoverable, it would more than pay for itself in under ten years. However, technological risks, particularly in the areas of propulsion and materials, have slowed its development.

For contingency planning purposes, however, we could follow a prudent path toward a lower technology version of NASP as a fallback in case of STS termination. Several alternatives have already been examined. We need only choose one, and bring the design work forward to the point where we could stand only production lead-time away.

Certain companies have examined their ability to build Single Stage To Orbit (SSTO) vehicles using current propulsion (SSME) and vertical ascent profiles which do not dictate use of exotic materials -- thus avoiding the two primary areas of NASP technological risk. These companies have actually built sections of their design solutions. If design work was done in advance, we could stand at three years production lead-time away from first launch -- about the same that is required to build a replacement STS.

Similarly, we could produce a small, manned vehicle and launch it from the back of an airplane. Tests of this sort were conducted with the orbiter. Pegasus offers another useful example. We even see the Soviets pursuing this as a low cost, low tech method of getting into the responsive, airplane-like, manned space vehicle arena during the 1990s. Complemented with unmanned, expendable flights to haul cargo, this solution could satisfy the need for keeping man involved in a half-completed space station should STS fail during the last half of the 1990s.

As for a Titan IV replacement, one obvious answer stands out -- the Advanced Launch System (ALS). Titan is limited by its capacity (throughput), its old design and technology (1950s), its dangerous (both to humans and the environment) fuel (N_2O_4 and UDMH), and its entrenched standard operating procedures. In this case, a new system is needed.

An ALS can be built with very low risk in technology, schedule, or cost. It would serve both NASA (planetary missions, moon flights, space station construction) and DOD (the entire Titan IV mission model plus room for both resiliency and growth). A new family of advanced launch vehicles would grow together using modular components. The first vehicle would be aimed at the heart of our known lift shortfall and those firm, budgeted payloads in the foreseeable future. But new opportunities would be easily accomodated. As to economics, the higher a new launch system's flight rate, the quicker the amortation of its costs, but in no case for ALS would that fall more than ten years beyond its initial launch.

In summary, the nation will experience launch vehicle failures during the coming decade. Failures of both the Space Shuttle and Titan IV will be so painful as to call into question their continued viability. The nation will look for alternatives. It's up to us in the space business to ensure that reasonable options are available.

IV. Planning to Invest

A. INVEST IN THE FUTURE, NOT THE PAST

As described earlier, the United States faces a rapidly changing world in terms of national security policy. This change carries with it a profound shift in budgetary terms. Today, more than ever, the U.S. must be wary of preparing for the next war with the last one (the Cold War) in mind. We simply cannot afford it.

The theme of this panel, "DOD Space Operations: Capability for the War Fighting CINC," is meant to examine current DOD capability, highlight serious shortfalls, and prescribe requirements for the future. By focusing on shortfalls, an impression may be fostered that current systems are not serving warfighters well. But we must resist the temptation to patronize warfighting CINCs, prescribing for them new systems and architectures which they either do not want, which may not answer their needs, or which they may not be able to afford.

Certainly, geopolitical changes forseen will require more reliance on space systems than before. As the static confrontation of massed armies dissolves into a more fluid situation, global in scale, area CINCs must rely more on space for information and support. This is the situation this panel must address, not the old one we faced just last year. In a sense, the requirements we have gathered to date, although helpful in our work here, have been overcome by ongoing and unexpected change in the world situation.

B. ONE OPTION: INVEST IN INCREMENTAL VERSUS WHOLESALE CHANGE

In the first section of this paper, an argument was made against stating requirements for a launch system capable of surviving in a nuclear environment. This offers a perfect example of how recent change can effect our planning. We can all agree that the nuclear threat, while not totally banished, has been reduced by a significant degree. It would seem imprudent to deploy a nuclear survivable launch system in the face of such projections.

Likewise, with a lessening of tensions between the superpowers, a reduction in the sophistication of the space threat should be forecast. At the same time, the potential for co-orbital ASAT attack, while not necessarily increased, certainly has to be considered more diversified in terms of nations of origin. Today, the likelihood is greater of small scale, surprise attack against selected satellite targets. We may not need large scale proliferation in regard to the numbers of DOD space systems, alà Tacsat. On-orbit spares and other evolutionary changes may suffice. On-orbit spares would allow DOD to immediately rectify unexpected failures or combat losses. They would make constellations robust in terms of both capacity and survivability. They would allow for a steady buildup with level funding profiles. They would build on current infrastructure investment without requiring radical change. In short, on-orbit spares are a good idea for any military constellation, and they look particularly attractive in the future, changing environment.

C. JOINT FUNDING POSSIBILITIES

Besides survivability issues, DOD would also be well advised to think about joint funding possibilities. For instance, military systems might be developed in closer cooperation with NASA, attempting to solve national problems, not just DOD problems. If any portion of NASA's Human Exploration Initiative -- flights to Moon and Mars -- are approved, DOD should also benefit from advanced launch and orbital transfer capabilities that will have to be developed. On-orbit assembly and servicing may likewise hold benefits for DOD. So joint funding might better enable both agencies' programs to survive in a tough fiscal environment, while also ensuring enough excess capacity to ensure expanded military needs in times of conflict.

D. AN OPPORTUNITY FOR TECHNOLOGY DEVELOPMENT

Another possibility is to consider that a lessening of tensions in today's world, offers an opportunity to take advantage of the breathing space to focus on technology. If we accept the notion that there is less overall danger to the United States today, and that we possess sufficient military capability, then perhaps there is room to rely on current systems longer without modernization. Maybe we can forego the next incremental change in certain systems and wait for technology developments to bring forth a generational leap. But our criteria should remain steadfast -- cost effectiveness and operability must be delivered.

Certainly, it would be prudent to at least invest in focused technology development while pursuing incremental change. The idea would be to live within a constrained budget and meet the near term threat while devloping a capability to meet a more capable threat should that need arise. In other words, technology development should be used as part of a responsive strategy, reacting to both fiscal prudence as well as a realistic view of enemy capability.

E. STANDARDIZATION FOR ECONOMY

Current space systems, developed as high tech, one of a kind, R&D oriented programs, need to take on operational characteristics. Standardization is fundamental. This applies to systems, interfaces, procedures, training, logistics, and operations. Systems which are not standardized, should at least be interoperable. For example, all USAF satellites should accept commands from all USAF mission control centers. All operations should be made routine, simplified, and repeatable -- which is to say, reliable and affordable.

If space systems were designed with these operational characteristics, they would come much closer to meeting two other fundamental goals: lowering costs and increasing responsiveness. The single greatest barrier to routine access to space today is the cost of getting there. This cost must come down. Similarly, the single greatest barrier to operating in space in full support of military war plans is the designed-in unresponsiveness of current sysems. Military space systems must "stand alert." Here again, standardization is fundamental. Uniqueness drives costs up. Standardization can bring them down.

F. THE CASE FOR ALS

In terms of specific advocacy, certain programs stand out as "enablers" for nearly every major change advocated. For example, Section I advocated launching on schedule at greatly reduced costs, Section II argued for more responsiveness in space systems as well as creating a surge capacity, and Section III spoke of dire consequences which will follow the next failure of both STS and Titan IV. Taken together, these constitute powerful arguments for developing an Advanced Launch System. ALS would **enable** DOD to meet operational goals for space by lowering costs while increasing both responsiveness and reliability. It should be priority one.

G. SUMMARY

In planning an investment strategy for military space systems, we must anticipate future needs and avoid preparing for past conflicts. The future global security environment will most likely see the need for space systems increasing rather than diminishing. The nature of the threat, however, will likely be different, and this will call for careful approaches in space system acquisition.

Current space systems serve warfighters well, although they have shortcomings in terms of survivability, responsiveness, and cost. For most systems, we should therefore pursue a responsive investment strategy -- making prudent, incremental changes to meet the near term threat, while investing in focused technology to meet a more challenging threat should our adversaries make that necessary.

For other systems, however, incremental change may not be sufficient; or we may find an opportunity to leap forward in capability. Either of these situations may justify forgoing upgrades for certain systems, living longer with what we have, putting more effort in technology application, and leaping forward to new, expanded capabilities.

We should look for joint funding possibilities. The need for lower cost, higher capacity launch systems by both DOD and NASA was cited as an example. Joint development of on-orbit servicing and repair technologies may be another.

Certainly standardization and operability need to be pursued. Uniqueness in space systems has led to a lack of responsiveness and affordability in the pursuit of individually suboptimized spacecraft. It's time to reverse that situation.