Tactical Air Warfare of the Future *

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The future of tactical air warfare in the 21st century is determined by the starting point in force and equipment structure, the imperatives of tactical air warfare, and upon the development strategy that both we and our opponents follow from now until the 21st century. The latter will be bounded by the environment in which our development strategy is carried out. The above three factors are discussed in view of the lessons learned from history and current experience, in order to develop concepts of tactical air warfare for the early 21st century. In addition to the tactical fighter forces, the impact of AWACS, drones, real-time reconnaissance systems now in the embryonic stage, electronic-warfare systems, and elements of the command and control system are discussed. Specific examples from our current operating experience will highlight the challenge of incorporating innovative operating techniques in the early stages of design. From the operator's point of view, the correct direction of technological development is suggested and the resulting operator's picture of 21st century tactical air warfare is described.

I AM delighted to have the opportunity to inject this operator's point of view into the stream of thought of the AIAA. I am convinced this stream of thought will impact on shaping the forces which we will have at our disposal for deterring potential enemies, or failing that, for prosecuting tactical air warfare in the early 21st century, the period toward which my remarks will be directed.

It is extremely tempting to let the imagination run wild: to conjure up a vision of lasers, of exotic engines and structural materials, of RPV's and drones, of programmable missiles – all equipped with new weapons and new warheads as yet undefined, but having a great selective lethality against a large variety of targets; to speak of tactical antimissile missiles and of ground-based, airborne, and space sensors with undreamed-of capability; to visualize the operation of all these weapons being controlled by a highly centralized automatic system of control that has been cleverly programmed in advanced in such a way as to insure the war will be won.

That vision is tempting, and it would be fun, but it would probably not be very useful in view of the already-demonstrated capability of the scientific community to fashion such exotic visions on a scale far grander than I could ever hope to achieve. Being noncompetitive in that game, I will express my views on those factors that will control the shape of future tactical air warfare, and on the environmental influences that I believe will play an important role. I will suggest certain components of a strategy for development that I consider important if that strategy is to be successful. The resulting structure of our tactical air forces will be the most likely picture of tactical air warfare in the early 21st century if that strategy for development were to be executed.

The shape of tactical air warfare in the early 21st century will be controlled by the imperatives of tactical air warfare, by today's starting point in force and equipment structure, and by the development strategy that both we and our opponents follow from now until then. I will discuss these in order.

The end goal of tactical air warfare consists of detecting, identifying, engaging, and destroying ground targets of the enemy's system for waging war. If that is a reasonable goal for our fighter forces, then it follows that it is a reasonable goal for enemy forces as well. It is from this latter factor that we derive the often less-appreciated task of keeping enemy air forces off the backs of our own ground forces. Because tactical air warfare can be differentiated from strategic air warfare in terms of the length of the conflict, which in itself places a premium on repeated usability of the weapon delivery vehicles, attrition management, and the destruction of the enemy's tactical fighter forces before he can destroy ours, achieves a correspondingly high significance. These truths should still prevail in the early 21st century.

Turning to the starting point, let's quickly review where we stand in our ability to prosecute tactical air warfare. The tactical fighter force of the 21st century will, to a large degree, inherit some of the forces already in being or which are forecast to be in the operational inventory in the very near future: examples include the F-15, F-16, and the EF-111. The F-15 and F-16 represent the current state of the art in aerodynamic, structural, and propulson sophistication; the F-111D represents the ultimate in electronic sophistication as of a very few years ago, although this is rapidly changing. Such aircraft as the EF-111 will significantly increase the electronic-warfare capability of our tactical fighter forces. We have in AWACS a quantum jump in our ability to control the disposition of the tactical fighter force as a whole.

It has become clear in recent years that real-time intelligence information concerning the location and direction of movement of enemy ground and air targets is necessary to efficiently operate tactical fighter forces in wartime. Such real-time reconnaissance systems are now in the embryonic stage with considerable developmental effort still required to make them operationally acceptable.

The first problem in destroying targets is to locate those targets with some precision. Then follows a fairly extensive process of identifying those targets and assigning weapons against them. Finally, as our control system is currently structured, the weapon system assigned against the target must reacquire that target and release a weapon or weapons against it. Currently, this entire process has many faults. First and foremost, it is time consuming. This condition demands that the delivery vehicle for the weapon assigned against the

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*Editor's Note: This paper is not the usual archival technical article. Yet, as Editor, it is my opinion that the paper contains a significant message for the tactical aircraft segment of the aerospace industry. Consequently, General Hughes' paper is selected as the lead article. As a reader of the *Journal of Aircraft*, your comments are solicited.

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target reacquire the target. Except for the special case of fixed targets, it is very likely that the target itself has fouled our best-laid plans by the simple expedient of moving. Therefore, reduction in the time between initial acquisition and weapon impact on the target must be a goal toward which we can profitably expend a great deal of effort.

An important point concerning the "where we are" in tactical fighter force structure concerns developments in weaponry. Since the objective of the tactical fighter force is the destruction of targets, we must eventually be able to deliver some weapon in sufficiently close proximity to the target to destroy it. The question is, "What is sufficiently close?" This depends, of course, on the kill mechanism of the weapon, its power, and the target's vulnerability. In the moderately distant past, effort was expended toward the end goal of increasing the power of the weapon. The undesirable side effect of this is the almost unacceptable degree of collateral damage associated with the end result of that trend – nuclear weapons. In the very recent past, we have taken other possible approaches, which were to increase the efficiency of the kill mechanism and, even more importantly, to make the weapons considerably more accurate. The guided weapons family has had and will continue to have profound influence on the delivery vehicle force structure requirements. Continued development in this area will no doubt be one of the key aspects of our developmental program.

Two environmental factors will have a primary influence on our developmental strategy. The first factor is a well-recognized fact of life and concerns the availability of hydrocarbon fuels – the energy problem. I will not pursue the issue further except to say that all future airframe and propulsion development will be strongly influenced by this factor alone, and any projected developments that do not take into account the expense involved with high energy consumption will fail.

The second environmental factor requires greater development. I am convinced that, for fundamental reasons, both the United States and the Soviet Union will be faced with using a declining fraction of their gross national product for the procurement and operation of their war machinery. After one goes through all of the analyses, and makes all of the studies, the bottom line is that the force structure in the early 21st century will be shaped by the necessity of operating with reduced manpower. For quite different reasons, yet to be discussed, greater numbers of machines will have to be operated with that reduced manpower pool.

I think you will agree that structuring forces to operate greater numbers of machines and designing greater numbers of machines that can be operated by fewer and fewer people is not an insignificant task. My real concern is that, in our exuberance in looking at all of the kinds of extremely sophisticated gear that could be produced for waging warfare in the early 21st century, we will ignore what I consider to be an absolute imperative – making the equipment that we do produce far more reliable so that it can, in fact, be operated with reduced manpower.

Let's pause now for a short interim summary of where we are, the development environment, and where we must go. In reverse order:

The end goal of our development and procurement efforts should be to provide a total system for waging tactical warfare. The system should be able to operate in any environment, withstand the best efforts of potential enemies to make it malfunction, and should be totally responsive to command.

The development and procurement effort will take place in an environment of a declining fraction of the GNP being spent on defense, with the implied result of operating the defense establishment with reduced manpower. This situation, in turn, leads to the requirement for increasing the "tooth to tail" ratio. Energy availability will have a similarly pervasive influence on all airframe, engine, and support equipment technology development.

Based on where we currently stand in that development effort, I believe we must place greatest emphasis on command and control system development, on electronic warfare, on continued development of guided and cluster conventional munitions and, most importantly, on making the equipment which we do produce reliable in the extreme. To an ever-increasing extent, we must use off-the-shelf technology to insure the greatest possible reliability and to increase our numerical strength.

Turn now to development strategy. It seems to me that we must be highly selective in deciding how to spend our research, development, and procurement dollars. There is such a wide variety of technologies available, each of which promises the ability to perform feats of some magnificence in specific areas, that we are tempted to simply develop all, or at least a large fraction, of these technologies. I have the very strong belief, however, that we must rebuff that temptation and select a few technologies from the almost unlimited pot. Then we must concentrate our energies on developing these technologies in a well-planned, systematic fashion to produce a workable war machine. Those technologies selected must have widespread applicability, must make substantial contributions to the performance of the various systems comprising our war machine, must not be very easy to counterattack, and should have the additional characteristic that the U.S. can easily take and maintain a technological lead in that area in a relatively painless and cost-effective fashion.

When we examine all the available technologies in the light of these criteria, it seems to me that one particular technology stands out beyond the rest by almost an order of magnitude. We are experiencing in this country today an almost explosively widespread availability of computational or control electronic devices based on large-scale integration and of new low-power memory devices. Advances in the state-of-the-art just in the past year have staggered the imagination.

Widespread applicability? It appears to me that there is hardly an element of the system for waging tactical air warfare for which this technology could not fundamentally increase the performance and operational utility. When I can today, at my local electronics store, buy a central processor unit which is not much larger than my thumb, which uses almost no power, and costs only $24.95, then suddenly I perceive interesting possibilities: 1) self-contained, throw-away digital computers in missiles or any other guided weapons, yielding the possibility of such capabilities as self-contained precision emitter locating, position information storage, and post-shutdown attack; 2) widespread use of self-contained synthetic-aperture techniques for increasing resolution of sensors; 3) secure electronic global positioning grid and data transmission networks of almost infinite redundancy which, when combined with creative sensor technology, would allow for near-real-time reconnaissance, command and control, weapon assignment, and attack functions under all weather conditions, with unmanned as well as manned delivery vehicles; and 4) in electronic warfare, real-time threat analysis, countermeasures control and, more importantly, immediate threat counterattack. The list goes on and on, in each classical area of tactical air warfare.

Substantial contributions to the performance of each element? No question!

Easy to counter? Probably not, if we're clever in how we go about designing things; we can make most devices self-contained and, where necessary, terribly redundant.

Can we maintain the lead? It seems highly unlikely that anyone in the world will be able to overcome our lead in this area. The primary reason for the maintenance of our lead in this area harks back to another effect of the second environmental factor which is the declining fraction of the budget spent on defense. Whereas in the past, the lead in technological development has almost invariably been spurred by military considerations, it appears to me that global economics will dictate that increasing expenditures for research and development will come from private enterprise

and be directed toward normal everyday capitalistic consumer satisfaction concerns rather than toward military concerns. The end effect of all this will be that an increasing fraction of militarily useful devices and technology will come from research and development efforts in the civilian sector. To the extent that our massive economic engine and the fertile imaginations of our engineers, technicians, and scientists in private industry continue to prosper, and given that we are reasonably astute in how we spend that declining fraction of the total output of the country on defense, we should be able to maintain indefinitely our technological lead in the areas where it counts.

Now, let's assume we decide to proceed in that direction. Let's develop our sensor technology so we can detect and identify everything; let's put computers in delivery vehicles and weapons; let's tie the whole works together within the precision positioning grid by the secure data-link system and allow commanders to influence how the war progresses by giving them the right kind of information for decision-making and the means of quickly injecting those decisions into the battle at the appropriate level. Then, let's put this into an imagined war and see what happens. We can imagine drones flying about with onboard sensors, some carrying weapons. We can imagine automatic world-wide landing systems for our manned aircraft. We can imagine automatic counterattack of the enemy's active defensive systems whenever he even comes up with an emitter to look at us and before he can launch a weapon at us. We can imagine destroying the enemy before he can move!

But the more likely result is that it won't work. It just won't work.

That is, it won't work unless we take a few lessons from history in dealing with such matters. In the past, in our understandably exuberant ambition to exploit a new-found miracle technology, we've generally been guilty of making three significant errors. In the design of our systems, we haven't sufficiently taken into account that: 1) there should be a compatible interface between all elements of our tactical air warfare systems; 2) somebody will have to operate and maintain the systems; and, most importantly, 3) if we are actively engaged in warfare, an intelligent and informed enemy will have already expended great effort to assure that he has the means at his disposal to disable the system.

We have a couple of examples of all this from our current operating experience. Let's talk first about the compatible interface between all elements of our tactical air warfare systems. In the case of the F-111D, just to pick an example, we have a set of sophisticated onboard digital computers. We change the programs of these computers approximately once every 18 months in order to improve the capabilities of the aircraft and weapon delivery, etc. All this is as it should be, the real advantage of software over hardware changes purportedly being that software is quite easy to change in comparison. In point of fact, our system for improving software could itself stand a great deal of improvement, since we find that software changes haven't come all that easily. But that's a separate problem. The problem to which I am referring is that we made, under separate contract, a simulator for the F-111D using a different type and a different design concept for the digital computers that run the simulator. The result is that we find that software development for the aircraft has been completed, with the result that simulator software lags aircraft software by approximately two years. In short, the simulator doesn't simulate the aircraft properly. Wouldn't it have been easier if we had simply equipped the simulator with a set of line-replaceable computers identical to those in the aircraft and had provided the proper interface for those computers, so that we simply reprogrammed the simulator computers at the same time we reprogrammed the aircraft computers?

There are many other examples of the kinds of errors that I mentioned above. It seems to me that in most cases these errors are easy to eliminate as long as we do it early and think the problem through in the design stages. The only real problem that I can see is that it will require extreme mental discipline to take the following steps which I believe will be necessary to assure a workable end product. 1) We must make software transfer and the interface between the various components of all of our systems an integral part of the design. 2) We must take greater care to design operating procedures and maintenance data information control procedures into our system at a very early stage. 3) As a part of design discipline, we must make a structured search for cheap easy countermeasures that the enemy might make for any system which we design, and we must do this as an integral part of the development/procurement process.

Whatever system we wind up with at the turn of the century will be limited only by how well we avoid these past errors.

Notice that I haven't said much about exotic developments in airframe and propulsion technology, new aerodynamic designs, etc. I do, in fact, consider these to be quite important, but I believe that the greatest gains will again be made in increasing the reliability of all of the components such as engines, airframes, etc., as well as by bending our efforts toward production technology, so that our numerical strength in all of the weapons systems that we do develop will be considerably higher than it is currently. This must be if we are to avoid having zero capability if our magnificent, sophisticated overall system should fail or if it should yield to some unforeseen technological development on the part of the enemy. We simply must be able to have the various units still moderately effective, at least with operation in an autonomous or semiautonomous mode. It is for this reason that manned fighter aircraft will still have an important role to play at the turn of the century.

From the tone and content of the foregoing, it is possible that you have gained the impression that I am against technical sophistication. While it is true that I think we should be very wary of technical sophistication for the sake of technical sophistication alone, I am at heart terribly impressed with the technical promise of the next three decades. Let's just not foul it all up by repeating the mistakes of the past 30 years. We don't have to; we can do better. Let's do it.