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Introduction

Not since the end of World War II has the United States military experienced such major changes. The changes are being driven by both internal national factors, and external international Cold War downsizing. The specifics of what the changes are and the explicit forcing factors have been understood for some time. What has not been understood thoroughly, is how the United States military will continue to maintain personnel and hardware effectiveness in such a dynamic environment, specifically amidst a steadily diversifying threat base and declining acquisition budget.

Recently, there have been several efforts directly concerned with how the U.S. military space programs must change, i.e., provide more support to the military user with a declining space system acquisition budget. The two most significant efforts were a "Visions Study," conducted by the Air Force Space and Missiles Center Planning Directorate in Los Angeles, and the "Re-Invent Space" supported by the joint services U.S. Space Command in Colorado Springs. Both studies assessed major paradigm shifts in all aspects of our current approach to conducting the military space business. Many of their findings and recommended areas of needed change are now being pushed forward for consideration by the newly formed Space Architecture office in Washington.

Having been a participant and understanding many of the common elements of the aforementioned, I am attempting to step back and take a fundamental look at what can be done realistically in the near term – recognizing that major changes in the military space business base will require a considerable amount of time.

The primary objective of this paper is to address the initial elements needed to parametrically understand and trade the effects of developing technologies against new system acquisition.

An initial starting point will be to envision the military space system product line in relation to developing technology elements and product/engineering commitment (ref Figure 1). Three problem areas which warrant change are: First, our present approach takes too long to develop and deploy space systems; second, many initial design or concept decisions are made on technology applicability in the exploratory development phase; and third, the majority of development and production costs are locked in before full scale development milestones. Such an approach precludes one from modifying a Cadillac to a Volkswagen after the full-scale development decision has been made.

Most previous efforts in the aforementioned studies and analyses have addressed potential ways of reducing the development cycle timeline based on acquisition reform or have compressed the early development phase by utilizing much more mature technology development. Additionally, a major effort has gone into exploring the feasibility of converting the entire military space system business base from vertical program office structure to horizontal functional program offices. Another departure needed to address the threat of drastically reduced funding and loss of supporting infrastructure would be a system-of-system space architecture concept which would group all space functions such as communications, navigation, weather and surveillance into one constellation under common ground and operational control.

Military Space
Acquisition/Technology/Expenditure Process

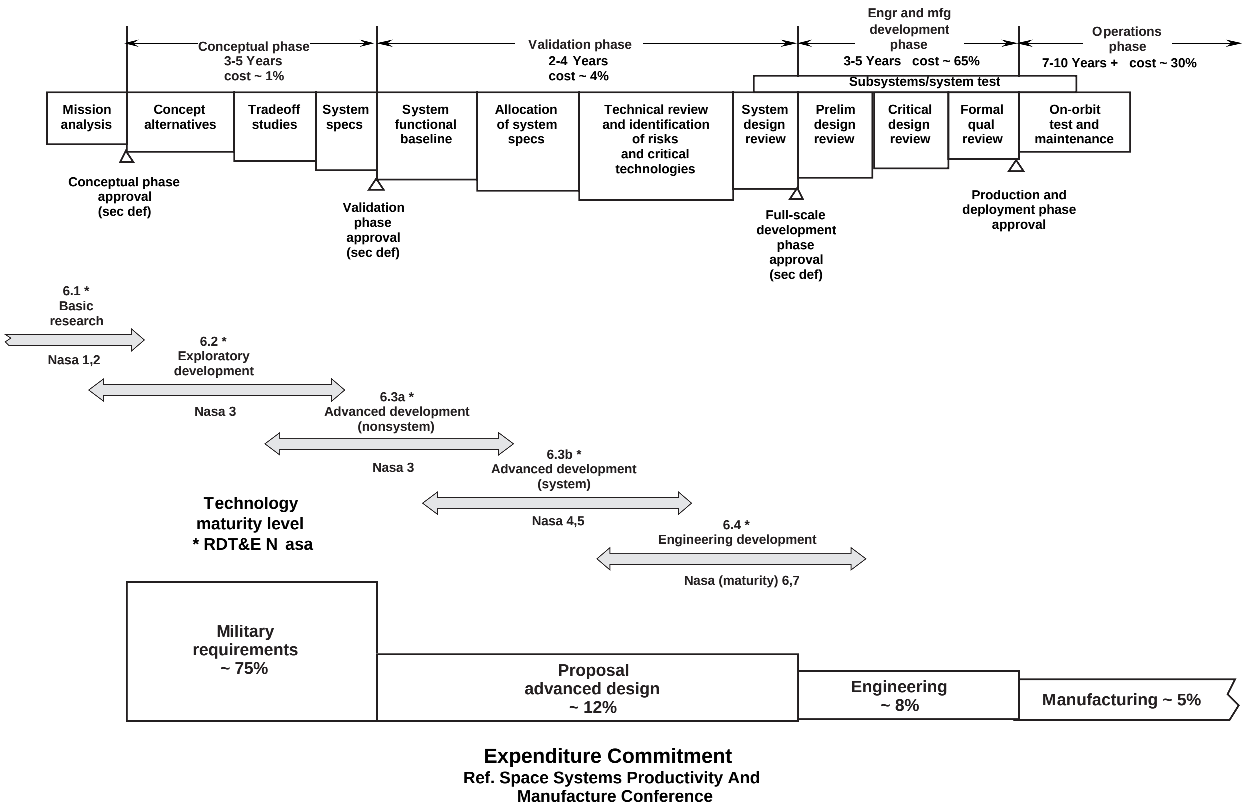

Figure 1.

As important as the previously mentioned approaches will be in producing the needed change, there appears to be a key “kernal” across all issues which would greatly enhance any future space architecture or needed modification to the military space business base. Specifically, the ability to make timely parametric trades across all elements of a space architecture. Such capability, to continuously utilize computer aided modeling and trade analysis of existing space assets in relation to new systems and technology application being considered, would provide a major building block in supporting any change. Figure 2 is representative of the total space architecture parametric trade space which must be considered. From a total system perspective: spacecraft payload, launch capability, ground control, user interfaces, and infusion of commercial space assets and technology are all elements which need to be considered.

Before considering any initial steps from a technology perspective in obtaining automated computer aided capability, it is beneficial for one to understand the rationale for such strong arguments requiring this analytic capability. As previously mentioned, one of the things that most of the major studies have looked at in terms of a change in the design approach for space systems, is to disregard a vertical or stovepipe design in nature, and to start looking at horizontal (functional) system development. This philosophy, if extended to configurations of space constellations, becomes a system-of-systems (Figure 3) type architecture. Such a radical departure from our present way of doing business represents a significantly different way of approaching space system development as well as introducing a higher level of complexity beyond which we are presently in with relation to military space acquisition. Also, from a C^3I standpoint, the implementation of a new multi-function integrated constellation greatly increases the orbital and terrestrial connectivity and interoperability requirements (Figure 4). Such an implementation represents an additional magnitude of complexity which must be figured into the trade space because it strengthens the argument for needed automated modeling capability. System of networks analysis is extremely complex and is beyond the capability of most system analysts, no matter how extensive their experience base.

Additional benefits promoting the necessity to automate design are the integrated utilization and implementation of new commercially available space assets such as communications, weather, and earth surveillance. As most people are aware, both the commercial space communication markets and new potential global connectivity are expanding rapidly.

Effective integration of such capability into the military space mix will require careful consideration in order to assure system and network effectiveness. Up to this point, military satellite communication systems have been developed primarily within the services based upon specific user requirements. The potential of a hybrid mix of military and commercial communications capability will result in a totally “different animal” in terms of control, security, survivability, and reliability. And, as acquisition dollars diminish, commercial communication may not be the only new asset integrated; the military use of commercial weather, augmented navigation, and surveillance may have to be incorporated into new architectures as well. Such integration measures will add additionally to the system analysis requirements of looking at a very complex trade space.

Up to this point we have been arguing the need for automated analysis capability of military space architecture based on projected future events which may have a considerable variability. From a present day standpoint, one is handicapped when assessing existing system concepts

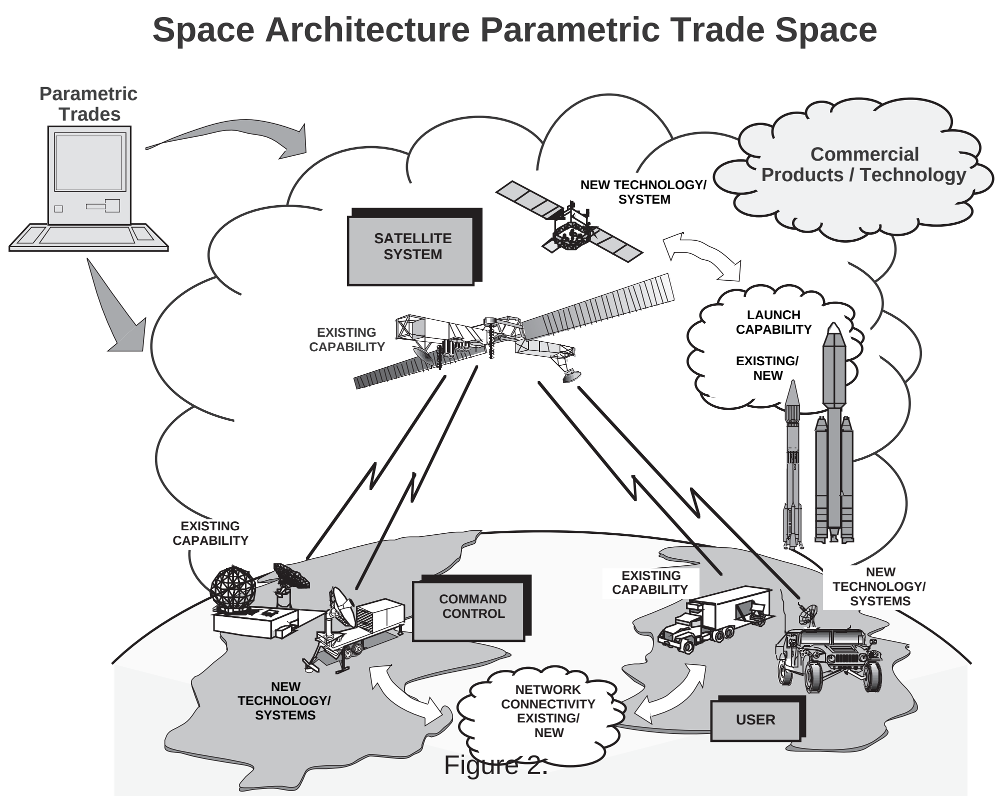

Figure 2:

being considered for military space application. One such concept is the space based wide area surveillance (SBWAS) which has been under consideration for many years. Figure 5 is the total system C^3I concept for such a system which was under development at the Air Force Space and Missile Planning Directorate in Los Angeles. Our inability then and now has been to evaluate effectively such a complex design against existing assets, user needs, and the ability to integrate product in existing C^3I infrastructure. This architecture represented the necessity, based on funding, to incorporate C^3I into existing strategic and tactical data distribution infrastructures, an approach which will undoubtedly be needed in future developments.

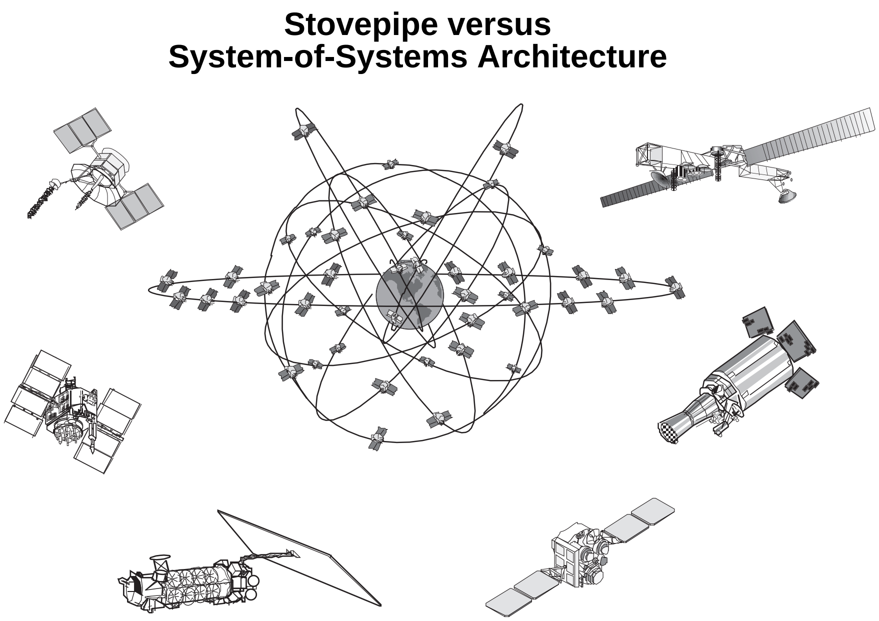

Figure 3.

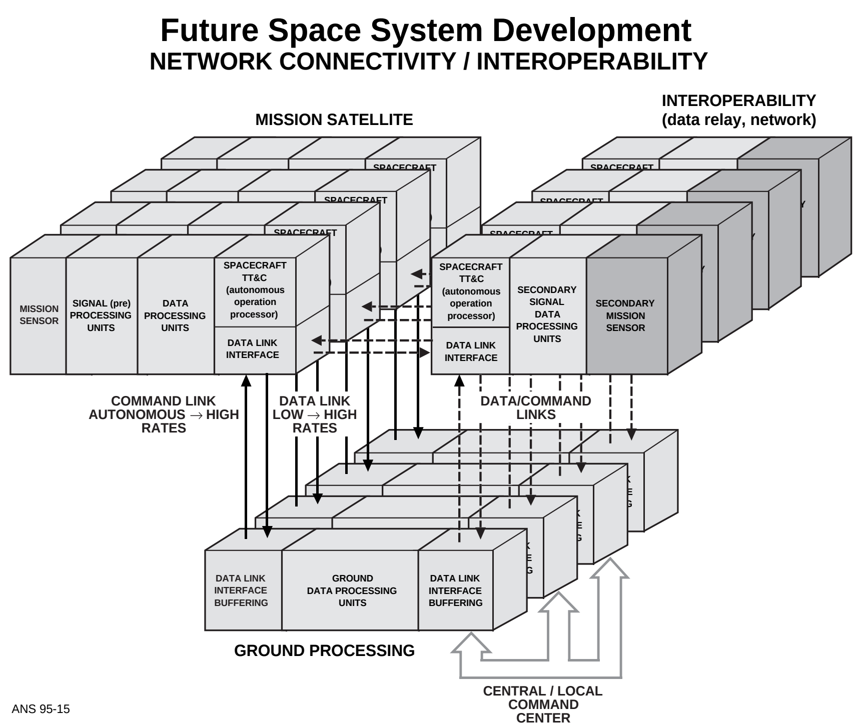

Figure 4.

The above mentioned justifications for computer-aided development are primarily based on design, system integration, and cost. One consideration, which is non-technical in nature, but which will probably offer the strongest argument for an automated approach, is the program support needed to withstand budget battles and congressional scrutiny.

Automated design capability would go a long way not only in handling daily program inquiries, but also in providing the non-technical budget community a design-to-cost analysis needed to assure and provide the effectiveness required by the military given present budget constraints.

A First Step

In directing the initial step to implementing the aforementioned capability, it is extremely important that one understands the present climate and factors influencing most program acquisition developments now as well as for the next decade. First, and most importantly, as a nation, we can no longer devote years to produce concept definition, development modifications, nor can we spend “months” answering budget impact issues. We are, and will continue to be, in an extremely dynamic budget climate. The era of being weighted down by current and previous study efforts to generate another briefing which undoubtedly will be negated by the next briefer, needs to end. It is imperative, considering the present and future climates, to have the ability to respond rapidly to programmatic issues, i.e., effects of major budget cuts, application of a new available technology, new or modified user requirements, etc. Most large industries, whose business is driven by design-to-cost, have and continue to produce all product development in a “paperless” environment. The U.S. military will also have to change from a design-to-requirements philosophy to a design-to-budget environment. This environment will necessitate and be more productive with a paperless design approach.

Secondly, it is also important to understand that there will be very little functions (including technology requirements) which are realistic in variability in the military space acquisition budget.

Future Military Space System Deployment
Requires Significant Network Architecture Trade Capability

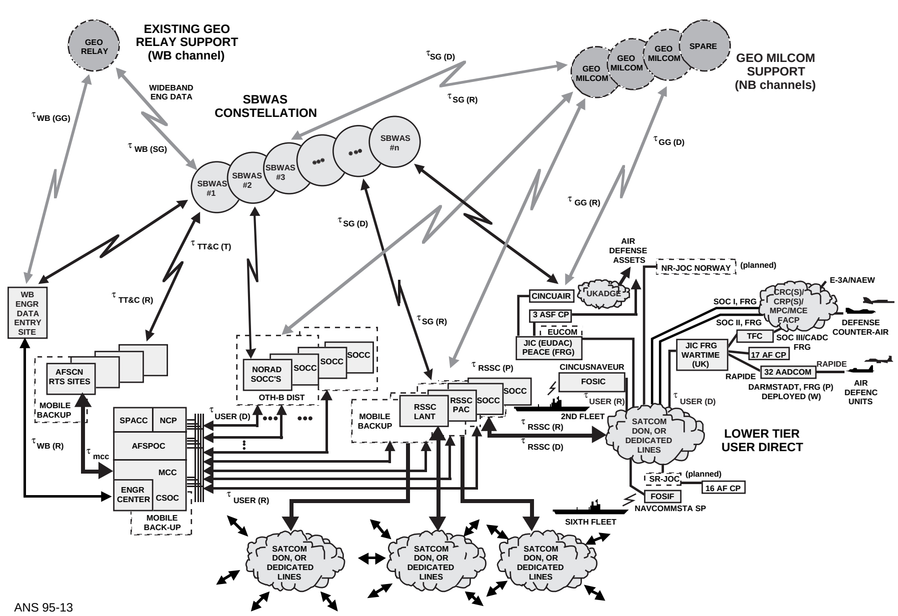

Figure 5.

That is to say, most existing program budgets are locked into funding until the first part of the 21st century. Available dollars, for new starts will be at a minimum and controlled very carefully until the national budget deficit and agenda change. One of the few factors which will be available, besides the direct influx of commercial products and utilization of commercial systems, is the application of technology to existing systems, both in terms of retrofitting new capability to an existing military space asset and to crafting a value added function to a developing commercial system.

After recognizing what is ultimately needed, one must have the ability to do total architecture trades (Figure 2). A first step, which could prove extremely valuable in the near

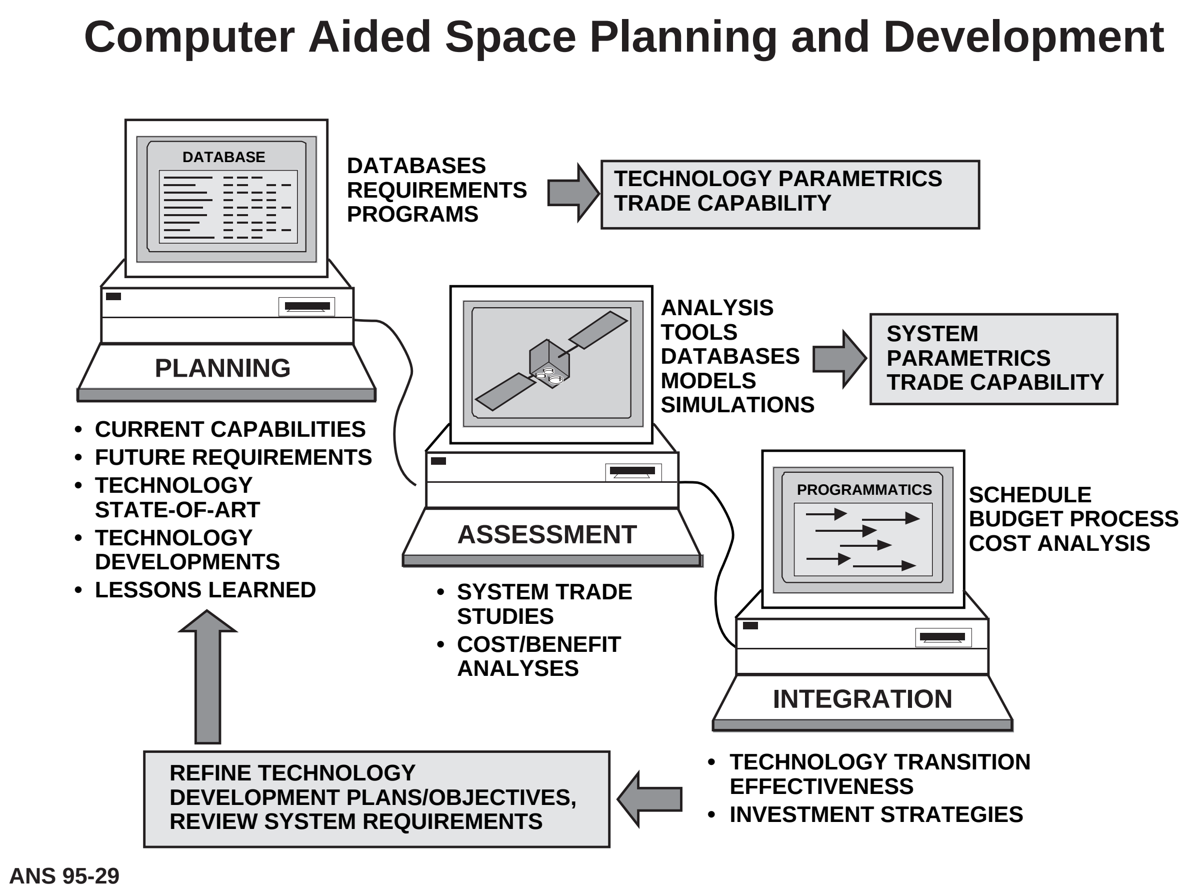

Figure 6

term, would be the ability to automate technology planning, development and system application. Specifically, this ability would be to incorporate organizational planning data bases with system effectiveness and assessment capability through technology integration including the effects of system schedule and cost analysis. Such a potential approach, which includes the essential elements to automate the process, is included in Figure 6. This would represent stand alone capability to parametrically trade the effectiveness of developing technology against system application and cost.

The next logical step would be to interactively incorporate the entire technology development planning cycle with system developers, operators, and user requirements. Figure 7 represents such an approach, which would require an extensive effort to assure the basic planning terms of system development. That is, the baseline design concepts must be reflective of a realistic acquisition process in terms of producability and cost, a concept of operation which integrates well into the existing and the new space infrastructure, as well as a product which is needed and can be delivered in a timely manner to the warfighter. Such an implementation would not only allow system parametric trades on developing technologies against an existing design baseline, but would also provide a real time on-line interaction test bed for the product developer, system operator, and user community. This approach would allow the key elements of any military space system development, the operator, the user, the technologies, and the product developer, to be integrated with interactive analysis and evaluation capability. For example, the system user could determine what effects a change in warfighter requirements would have on the existing technology base,operator concept of operation, and ultimately, development cost and schedule.

Automated Space System Development

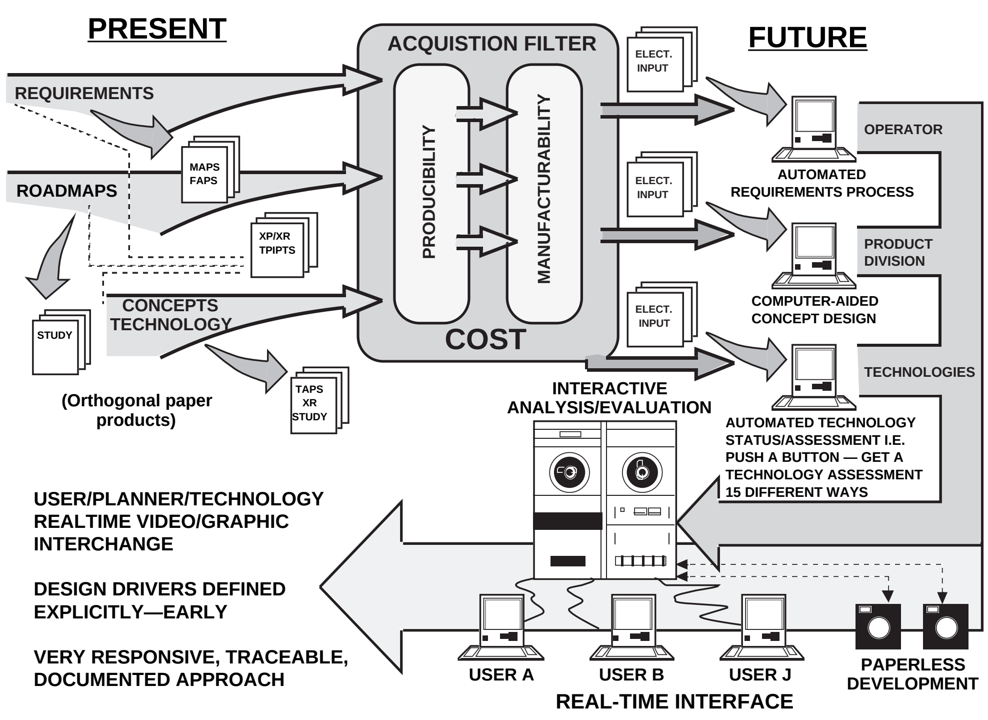

Figure 7

These two approaches would be first steps in trying to automate the development process of military space acquisition. Primary emphasis would address technology development and how it would iterate against system retrofits and new developments. The ultimate capability would incorporate the other key elements to enable first order parametric trade analysis.

Summary

The need in the foreseeable future for military space system development will be to utilize a diminishing budget effectively while providing the essential capability to the warfighter. Such an effort will require new approaches to the existing military space business base. We'll be looking at the integration of space system functions into single constellations and the direct utilization of commercial space assets. Also, we will be seeing that the complexity of a space system, in terms of networking, will be increasing. Networking in the future will be a hybridized mix of both military and commercial assets and the integration of space products into terrestrial connectivity.

Considering the budget constraints and added complexity of future space implementation, the need for more automated system analysis is apparent. In order to develop and deploy military space capability effectively in the future and justify these budgets, automated analysis is essential. With every major industrial base nationally and internationally converting to computer-aided design and manufacturing, it is imperative that the military not delay and make the commitment to such conversion as well.