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OPTIMUM MILITARY SPACE FORCE STRUCTURE CHARACTERISTICS

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ABSTRACT

This paper describes the characteristics of operational military space systems in the conceptual (year 2015) future. Many studies have been completed in recent years, and more are currently under way. All seem to have arrived at similar conclusions, however. Therefore, this paper summarizes what appears to have become a shared vision of the future.

Air Force Space Policy tells us that there are four mission areas for activity: Space Support, Force Enhancement, Space Control, and Force Application. The shared vision described here covers only the first two. Desired characteristics of launch vehicles, satellite control systems, and those spacecraft designed to assist terrestrial forces are presented.

INTRODUCTION

In today's "normalized" Air Force, operating and using commands must define their conceptual requirements for space systems before development and acquisition agencies design and build them. It is necessary to first know what a system must do in order to decide how a system will be made and in what quantities. These initial concepts are validated in Statements of Operational Need (SONs), giving a top level outline of capabilities needed, while avoiding any advocacy for specific hardware solutions.

Operational requirements are also necessary later in the design process after design options are chosen. Ever more detailed requirements must lead development of ever more detailed designs.

These more detailed requirements eventually address themselves specifically to individual systems -- identifying communications data rates, geographical coverage, operational characteristics, etc. Formally, such detailed statements are set down in System Operational Requirements Documents (SORDs).

This report intends to examine military space operations in the conceptual future. There is no intent here to provide detailed (SORD) requirements for systems. Rather, the focus is on concepts. The report summarizes requirements expressed in many individual SONs, draft SONs, and study conclusions. It will concentrate on general capabilities that are required to accomplish given missions in the face of projected threats.

No recognition will be made here regarding current systems or capabilities. Fiscal constraints, however, will be considered. The report attempts to define an optimum military force to meet the projected threat - - the "perfect (fiscally constrained) world."

This is an important point to consider. Most planning efforts start with the current situation and attempt to project or forecast trends. Instead, this report assumes we live in the future world circa 2015, and describes the optimum force structure which should then exist. There are three main reasons for taking this approach. First, it frees us from built-in preferences for present systems. Second, it allows us to move past too evident near-term obstacles. Third, the time is ripe. It appears that a fairly consistent vision of the future is generally shared throughout the present Air Force. Enough studies have been completed in the past with such similar conclusions that a general concensus seems to exist. Therefore, what is really set down here is a summary of what has become a shared vision. This vision should be validated as our goal. If this can be accomplished, then we may work backwards and more easily discover milestones along the path from the present to that shared vision of the future. A roadmap can be built leading us from here to there.

In the interest of brevity and avoiding security classification, certain essential sections will not be addressed. For instance, the future threat is not defined in this report. It will be outlined in a separate document. Nor will overall integration of space strategy with other JCS strategies (Airland Battle, etc.) be documented. This, in short, is a statement which defines required systems capabilities without explaining their use.

A few more words are necessary to put this effort into perspective. The goal of operational space planners is to achieve "assured mission capability." This is the ability to perform assigned space missions, as required, throughout the conflict spectrum. In order to do this, a combination of strategies is needed: Survivability, Proliferation, Alternate Means, and Launch, comprise the basic strategies available. Each has a specific definition and list of activities. It is assumed that the reader understands these or can find them elsewhere. They will not be expounded upon in this report.

To repeat the central point of this introduction, we must understand that once operating and using commands agree on a "perfect world," defined in terms of required capabilities, then developing and acquiring organizations can define options for achieving those goals. Using today's systems as a baseline, they can trace a roadmap to move efficiently toward the required force structure. Important milestones become obvious. Annual priority lists should develop with more consensus. Agreement on the big picture, in short, enables easier agreement on details.

So, in its "bare bones" state, this report will outline only system requirements in terms of capabilities which are needed.These operational capabilities will be described for two of the four space mission areas: Space Support and Force Enhancement. Space Control, and Force Application will be added later. Capabilities which cross mission lines will, of course, be identified.

SPACE SUPPORT

Space Support includes two broad areas: transportation of assets to space, and control of assets on orbit.

SPACE TRANSPORTATION. Future DOD space transportation systems may be defined in terms of operability and availability. Non-DOD systems (NASA and commercial) offer potential additional capability. Agreements for emergency use of these systems during times of national crisis are required. For dedicated DOD systems, however, the following applies:

A: OPERABILITY. Military systems, once developed and turned over for operations, are supported by military logistics organizations, maintained at high readiness states by military personnel, and operated by designated operational commands. This should hold true for space transportation just as it does for air transportation. It should be accomplished by "normalizing" space systems-- turning them over to operational commands -- and continually evolving systems with more operational characteristics as defined below.

Logistics support for space transportation includes all activities required to deliver vehicles, equipment, and material to Main Operating Bases (MOBs). Air Force Logistics Command (AFLC) will be responsible for acquisition and continuing support of all material, supplies, and spare parts for operational military space transportation systems. Logistics support for space will be incorporated into existing AFLC procedures and organizations. Provisions will include not only those supplies necessary for routine, peacetime operations, but war readiness stocks will be maintained as well. Where survivability of space transportation is required, necessary plans will be made for assured, survivable, wartime supply stocks to be on hand.

Maintenance support includes all activities required to place space transportation systems in a flight readiness state and maintain them in that condition. Maintenance of space transportation systems must be performed by routinely trained and assigned military personnel. Entry level maintenance airmen and NCOs assigned space transportation units will be required to have no more than a high school education and will be trained at existing Air Training Command (ATC) schools of no more than six months duration. Systems will be designed for simplified fault diagnosis and ease of spare part replacement. "Remove and replace" units will be built to eliminate human error and to facilitate rapid completion of tasks. If the above characteristics are designed into systems, significant O&M cost avoidance is expected. Safety should be considered from the beginning of the design process to eliminate or reduce hazards to the maximum extent practiceable. For mobile or survivable space transportation systems, War Readiness Supply Kits (WRSK) should be made available with all tools and critical parts required for field conditions.

Operations of military space transportation systems includes the following activities: maintaining connectivity to higher headquarters to receive launch orders, final preparation for launch (to include any required final movement to launch points), the actual launch itself, and monitoring of flight vehicles during the transportation system's mission. Operational command centers will be able to monitor the readiness of vehicles and cargo, select those required for launch, direct the launch, monitor the mission, and report progress to higher authorities. Operational launch crews will be kept to minimal numbers -- as a goal, less than twenty. Crews assigned to monitor the actual flight of launch vehicles will not be specifically assigned to launch operations. Instead, crews normally assigned to command and control of military spacecraft on-orbit will have training, equipment, capacity, and flexibility to monitor launch operations as they occasionally interplay with normal spacecraft control functions. Hardware and procedures for launch vehicles themselves will be standardized across transportation systems to the maximum extent practiceable. Support facilities will be austere and interoperable. Simplified procedures will permit operations by military crews, routinely trained at ATC schools with a maximum course length of six months. Again, if the above characteristics are designed into systems, significant O&M cost avoidance is expected.

Mobile and/or survivable space transportation systems will be served by crews of no more than ten people, and be self-contáined to the extent that all of the above listed operational activities may be performed by the assigned crew.

Security includes both maintenace of secrecy and physical protection of space transportation systems and supporting infrastructure. Security will be a prime consideration during the design process, and developed according to the level required by the operations to be performed. Routine, peacetime launch systems will be treated and protected as Class A resources. Survivable systems will be designed to operate during or following conflict. [Technical specifications for developing a survivable (mobile) space launch capability must be documented and analyzed for cost by Systems Command. DARPA has already gained some preliminary information from the SSLV and Pegasus efforts.] Once costs and achieveable capabilities are known with some confidence, then relative benefits of maintaining wartime on-orbit capability using survivable launch options may be compared to other options.

B. AVAILABILITY. Availability includes all activities required to place assets into space when required.

Availability first includes all activities conducted prior to flight. Restrictions to availability prior to launch can include logistics and maintenance problems with the vehicle and its supporting infrastructure, weather constraints, launch base security brakdowns, and communications outages. Cost has an impact on availablility, and therefore, there is a need to keep costs as low as possible. The operator's requirement for each discrete segment of the space transportation system calls for a state of availability or readiness of 90 percent.

Assured availability depends on assured logistics support. Therefore, multiple sources of all critical components, supplies, and material is required.

Where weather is a concern, each segment of the space transportation system must be capable of launching through prevailing local weather conditions 95 percent of the time.

For those segments of the space transportation system which must be survivable (see following sections of this report), standards equal to those of strategic offensive forces which operate through space (i.e. ballistic missiles) are required.

Availability includes responsiveness. Routine, peacetime launch calls will require no more than 30 days advance notice. Where payloads of similar size can be carried on the same type of launch vehicle, cargo substitution times must be less than seven days. No vehicle requiring a launch pad should occupy that pad for more than five days under routine conditions.

Peactime launch systems should be designed so that they can attain an alert status in times of crisis. Launch from alert status will take no more than five days for specialized cargo (number and type of cargos to be specified later). Normal (operational payload) launch calls from alert will be handled within 72 hours.

For mobile and/or survivable systems, launch from alert status will take no longer than fifteen minutes. When in operational (loaded) status short of alert, launch calls will take no longer than three hours. Turnaround or reload following launch will take no more than 24 hours.

Performance is a measure of placing assets on orbit when required. Mobile and/or survivable space transportation systems will be able to lift at least 1500 pounds of cargo to low earth orbit (400 NM polar). Peacetime systems will have a range of lift capability from 3000 to 220,000 pounds (400NM polar). Numbers of each size of vehicle depend on the mission model (to be delivered later) and technical and cost trades performed by Air Force Systems Command (AFSC).

Reliability is a measure that includes all activities during and after launch until the cargo is delivered to its destination in space. Overall space transportation system reliability will be greater than 98 percent.

For consistency of logistics, maintenance, and operations, standardized, baseline systems are required. Specialized vehicles, configured for unique cargoes, are not acceptable.

SPACECRAFT CONTROL. Once delivered to a specified operational location in space, spacecraft must be accurately tracked as to position, maintained in the proper location, monitored for state of health, commanded to resolve anomalies as required, and controlled to provide mission data. Operability and availability once again provide meaningful measures of merit.

A. OPERABILITY. In the area of spacecraft control, experience has been gained in the areas of military logistics, maintenance, and operations. More consolidation and standardization of effort is required, however, to develop a truly operational military force structure.

Tracking, monitoring for health, and commanding must be standardized across all military spacecraft. Ground equipment should be interoperable and allow any node to perform all routine functions for any satellite. Air Force Space Command (AFSPACECOM) will control all common user spacecraft (multiple service, command, and/or organizations involved) as well as those developed specifically for Air Force use. Therefore, AFSPACECOM common formats, communications frequencies, protocols, bandwidths, data rates, hardware configuration, and procedures will be followed.

Simplified operations will allow routinely trained and assigned military personnel to perform normal, peacetime tasks without reference to satellite-specific documents. This capability must be designed into all future systems. O&M cost avoidance is expected. Information will be presented and commands entered in plain English. [By 2015, it is expected that the spoken word will be understandable in digital, machine language. Therefore, most down-reporting and up-commanding should be audial.] For special circumstances (e.g. anomaly resolution) expert systems will assist in diagnosis of problems and recommendation of actions. Crew sizes will be kept small. Mobile, survivable control elements will participate in day-to-day activities in order to exercise their capabilities and rehearse command and control procedures.

AFLC will support all operational spacecraft control nodes with required supplies. Upgrades necessary to maintain normal operations, war readiness material, and WRSK kits for deployable units will also be provided by Logistics Command.

Maintenance should include provision for equipment self-diagnosis. "Remove and replace" units will be built to eliminate human error and to facilitate rapid completion of tasks. Entry level maintenance personnel will be required to have no more than a high school education and will be trained at existing ATC schools of no more than six months duration.

Security includes both maintenace of secrecy and physical protection of spacecraft control systems and supporting infrastructure. Security will be a prime consideration during the design process, and developed according to the level required by the operations to be performed. Routine, peacetime systems will be treated and protected as Class A resources. Survivable systems will be designed to operate during or following conflict.

B. AVAILABILITY.

Each control node will be designed for high reliability. Success in the reliability category is measured by the ability to complete a "pass" -- that is to accurately set up and track a scheduled spacecraft, contact it to gather state of health information, and upload routine commands. The required success rate for each control node is to complete 95 percent of all scheduled "passes" at the scheduled time.

Dependence upon vulnerable overseas stations will be eliminated. Each control node will be located within United States territory and be capable of performing all required satellite contacts without reliance upon any ground site or communications transfer point outside of that territory. At the same time, an ability to stay in continuous contact with satellites at any point in their orbits is required.

Satellite autonomy is necessary for survival of capability in time of conflict- - when ground control nodes may no longer be capable of performing their functions. Technical, cost, and performance trades are needed regarding the required degree of space vehicle satellite autonomy. If possible, the following capabilities should be provided: spacecraft should be able to survive and continue to operate on orbit without ground contact for six months. Minimal drift in position is desired. If anomolies are encountered, satellites will be capable of "safing" themselves until contact is made. [Control of mission data is not part of this requirement.]

Survivable satellite control and mission control nodes on the ground are required. They will be small, simplified, and standardized. Each AFSPACECOM mobile satellite control node will be capable of performing routine functions for every AFSPACECOM-operated spacecraft. They will not be capable of performing all complex functions (e.g. major anomaly resolution), but will incorporate expert systems to allow maximum performance of non-routine functions. Survivable, warfighting control elements for both spacecraft control and mission control will be exercised on a day-to-day basis. Assured connectivity with higher headquarters is needed.

FORCE ENHANCEMENT

Force enhancement, the second space mission area, involves use of space assets to assist terrestrial forces in the accomplishment of their missions. Missions include surveillance and warning from space (both tactical and strategic), communications, navigation assistance, and environmental monitoring. Requirements for this mission area are completely dependent upon definition and advocacy by global Unified and Specified (U&S) Commands -- the warfighting users. These requirements undergo continual, incremental changes. The United States Space Command (USSPACECOM) is charged with monitoring these requirements, keeping them up to date, and leading other U&S commands in advocacy for these space systems. The "scrubbing" and consolidating of these requirements is still in progress and needs to be completed. Therefore, the following requirements should be considered preliminary in nature and will be updated as more information becomes available.

Over time, DOD has evolved a strategy of consolidating maximum possible force enhancement capacity on individual satellites designed for high reliability and long life. This strategy has maximized use of existing infrastructure to fulfill user requirements at the highest possible cost efficiency. The growing dependence upon and integration of space assets into warfighters' operations, however, is demanding more responsiveness, survivability, and ease of operation for these systems. Therefore, a requirement is evolving for responsive vehicles to quickly replace or reconstitute lost capability and to surge existing capability. Responsive, survivable systems would supplement and complement multimission, long lived satellites as required by field commanders.

SURVEILLANCE AND WARNING. Both dedicated and shared systems are needed for this function.

A. DEDICATED STRATEGIC SYSTEMS. Wide area surveillance systems are needed. They will provide information both to USCINCSPACE and to other theater CINCs according to geographical areas of interest. As opposed to "national" programs, these dedicated DOD surveillance systems will be controlled by AFSPACECOM. Therefore, all will employ standard control interfaces, will include autonomy sufficient for six months operations without control, and will be capable of internetting so as not to require overseas control nodes. They will also be simplified and ruggedized for a standardized launch environment. Dedicated downlinks to terrestrial users will be provided and assigned on a priority basis. Information on disposition and movement of air, sea, and ground forces will be collected and disseminated as required. Tracking targets of interest, while not necessarily continuous, will be updated frquently. Numbers of targets and percentage of global coverage required at any one time, along with other requirements, are found in AFSPACECOM WASBSS SONs. Survivability of these systems, as well as their spacecraft and mission control nodes, is required. They are expected to be high priority targets for an adversary's antisatellite systems. Satellite hardening, maneuver, and proliferation should be considered, as well as maintaining a reserve capability on the ground for quick reaction launch. Technical and cost trades are needed.

B. SYSTEMS DEDICATED TO TACTICAL USERS. Rapid response tactical surveillance systems are required to supplement and reconstitute dedicated wide area surveillance systems. These are envisioned as unispectral systems,possibly augmented by multispectral sensors, capable of approximately one meter earth resolution and three meter relative position accuracy. Their primary mission will be battlefield surveillance. (See Defense Science Board Summer Study 1988, and USAF SON 902-87 for details.) The second use is for damage assessment following a general nuclear exchange. For this purpose, survivable launch and satellite control systems are required. The same spacecreaft can be used for both purposes. These surveillance systems will be controlled by AFSPACECOM. Therefore, all will employ standard control interfaces, will include autonomy sufficient for six months operations without control, and will be capable of internetting so as not to require overseas control nodes. They will also be simplified and ruggedized for a standardized launch environment. Dedicated downlinks to tactical users will be provided.

C. SHARED SYSTEMS. Information gathered by tactical missile warning, ballistic missile defense, space control, and/or national systems will also be of interest to U&S commanders. Rapid dissemination of information from these systems to field commanders is essential. Normal transmission of mission data to primary users of these systems will not be interrupted. Rather, that information will also be sent to a dedicated USSPACECOM operations center where data tailored to each using U&S command will be stripped, formatted, and retransmitted. Standardization of equipment, procedures, formats, and protocols is required.

COMMUNICATIONS. Both dedicated and shared systems also contribute to satisfaction of communications requirements.

A. DEDICATED SYSTEMS Communications satellites owned by the Department of Defense (DOD) will serve a variety of military and national users. All dedicated communications satellites will be operated by AFSPACECOM. Therefore, all will employ standard control interfaces, will include autonomy sufficient for six months operations without control, and will be capable of internetting so as not to require overseas control nodes. They will also be simplified and ruggedized for a standardized launch environment.

Control of the communications packages themselves, however, will vary, depending upon primary use and function. All dedicated communications satellite systems as well as their spacecraft and mission control nodes must be survivable. Technical, cost, and performance trades are required to determine the best means of accomplishing this goal. Communications coverage required is 100 percent of the globe, 100 percent of the time. Various frequencies and bandwidths may be employed to satisfy heavy, routine, peacetime demands. The measures of merit for providing this service are cost and efficiency. For wartime use, however, frequencies, bandwidths, and throughput will be designed to counter electronic jamming and atmospheric scintillation, as well as to prevent interception of signals by an adversary. Wartime throughput required to satisfy national command authorities (NCA) as well as U&S command requirements need to be collected, consolidated, and validated by USSPACECOM in cooperation with its components, the JCS, and the Defense Communications Agency.

B. SYSTEMS DEDICATED TO TACTICAL USERS. If, after a rigorous analysis of future requirements, a shortfall in wartime communications capability is found to exist, rapid response tactical communications systems will be required. These are envisioned as augmentation systems used to surge existing capability or to rapidly replace or reconstitute lost capability. They would be used first for battlefield communications. (See Defense Science Board Summer Study 1988 for details.) The second use is for reconstitution of terrestrial forces following a general nuclear exchange. For this purpose, survivable launch and satellite control systems are required. The same spacecreaft can be used for both purposes. These communications systems will be controlled by AFSPACECOM. Therefore, all will employ standard control interfaces, will include autonomy sufficient for six months operations without control, and will be capable of internetting so as not to require overseas control nodes. They will also be simplified and ruggedized for a standardized launch environment. Dedicated downlinks to tactical users are required.

C. SHARED SYSTEMS. Civil, commercial, and allied systems offer potential additional communications capability for DOD. In many instances, these systems are already in use for routine, peacetime purposes. If further compatibility with DOD requirements can be achieved, use of these systems may obviate the need for dedicated tactical communications systems. In this case, enhancements to selected systems in this category would be required to enable them to perform a wartime augmentation role. They must be simplified and ruggedized for a standardized launch environment. Additionally, Memoranda of Agreement (MOAs), standard procedures, and standardized satellite control interfaces are required to enable wartime use. Air Force Systems Command assistance is required to implement these changes, interface with the various organizations involved, and plan for normal turnover to AFSPACECOM as required. Wartime control of these selected systems will be accomplished from existing, survivable AFSPACECOM conrol nodes. This control capability will be exercised on a routine basis.

NAVIGATION. Although several commercial and allied systems exist, all DOD requirements can be satisfied by the Global Positioning System (GPS) and its planned upgrades. Additionally, all DOD terrestrial vehicles are expected to employ autonomous onboard navigation gear, as required, to supplement GPS data.

GPS upgrades will incorporate enhanced survivability measures for both the spacecraft and control nodes. Spacecraft control will be accomplished from standardized, interoperable AFSPACECOM control centers. Therefore, these centers will employ standard control interfaces, and spacecraft will be capable of internetting so as not to require overseas control nodes. The satellites will also be simplified and ruggedized for a standardized launch environment. Operations and maintenance in control centers will be greatly simplified over today's standards. (See previous section on satellite control requirements.) Wartime control will be accomplished from survivable units shared with other satellite systems. Satellite autonomy will be improved, to include longer periods between navigation uploads.Global coverage is required 100 percent of the time. Sufficient spacecraft spares will be maintained to ensure this coverage throughout the conflict spectrum. Trade studies are required to determine whether ground or on-orbit sparing should be used.

ENVIRONMENTAL MONITORING. Both dedicated and shared systems are currently in use.

A. DEDICATED SYSTEM. The criticality of a dedicated, DOD environmental monitoring space system will remain high. Vulnerability must be reduced and survivability enhanced. Maneuverabilty of spacecraft is desired. Alternate constellation configurations from that used today need study. Back-up systems -- either spares or other (shared) satellites -- are required. Studies are needed to determine how to best store dedicated DOD environmental sensing satellites on orbit. The preferred initial choice is to store at high altitude, then move to an operational orbit when needed. The data requirement is for global coverage, twice daily. This system will be controlled by AFSPACECOM. Therefore, it will employ standard control interfaces, will include autonomy sufficient for six months operations without control, and will be capable of internetting so as not to require overseas control nodes. Control from shared, mobile nodes will be exercised daily. Satellites will be simplified and ruggedized for a standardized launch environment. With the space segment and control segment made more survivable, the user segment needs emphasis. Direct downlinking is only one method of providing user data. Survivable transmission from a survivable CONUS node over wartime communications lines should be fully examined as an alternative.

B. TACTICAL AUGMENTATION SYSTEMS. If survivable, on-orbit sparing concepts prove infeasible for primary environmental monitoring spacecraft, or if a surge capability is mandated by users, a supplementary system may be required. Such a system could employ orbits different from those used for primary systems in order to provide more continuous coverage over areas of particular interest. Multispectral sensors might even permit augmentation of tactical missile warning along with environmental sensing, while still using simplified and standardized spacecraft. These vehicles would preferably be stored on earth in order to allow flexibility of placement according to geographical area of need. These supplemental systems would be controlled by AFSPACECOM. Therefore, all would employ standard control interfaces, include autonomy sufficient for six months operations without control, and be capable of internetting so as not to require over-seas control nodes. They would also be simplified and ruggedized for a standardized launch environment. Dedicated downlinks to tactical users would be required.

C. SHARED SYSTEMS. To the maximum extent practiceable, all other available environmental sensing systems, both space-based and terrestrial-based, will be incorporated into an integrated DOD environmental monitoring system. This includes civil, commercial, and allied systems. To a large extent, this is done today. Survivable transmission of this integrated product to users is required. Enhancements to selected space systems in this category are also required to enable them to perform a wartime augmentation role. Presently, both TIROS and GOES fall into this category. They must be simplified and ruggedized for a standardized launch environment. Additionally, Memoranda of Agreement (MOAs), standard procedures, and standardized satellite control interfaces are required to enable wartime use. Air Force Systems Command assistance is required to implement these changes, interface with the organizations involved, and plan for normal turnover to AFSPACECOM. Wartime control of these selected systems will be accomplished from existing, survivable AFSPACECOM conrol nodes. This control capability will be exercised on a routine basis.

CONTROL OF REMOTELY PILOTED VEHICLES (RPVs). While not presently advocated as a requirement, remote control of RPVs via satellites appears to offer significant benefit. This area requires further study and analysis. Range and stealth of RPVs is steadily increasing, making their use over enemy territory more practcal. Use of GPS and other navigational enhancements allow precise, autonomous flight, but real-time downlink of data via satellite relay also indicates a need for real-time flight path alteration. This would allow reattack for closer looks at areas of unexpected interest. Part of the study in this area should include capability and cost trades with dedicated battlefield surveillance systems described earlier.